# Table of Contents

Conference Program...........................................................................................................i-iii

Globalization and Food Industry Consolidation: What does industrial organization have to say about market access?
   McCorriston and Sheldon..................................................................................................1

International Price Fixing: Resurgence and Deterrence
   Connor.............................................................................................................................38

Welfare, Market Power, and Price Effects of Product Diversity
   Perloff and Ward.............................................................................................................82

Grocery Retailer Behavior in the Procurement and Sale of Perishable Fresh Produce Commodities
   Sexton, Zhang, and Chalfant..........................................................................................119

Industrial Organization Research: A historical perspective
   Marion..............................................................................................................................171

Predatory Accommodation in Vertical Contracting with Externalities
   Bontems and Bouamra-Mechameche............................................................................189

Advertising in Differentiated Markets
   Hamilton.........................................................................................................................221

Economic Impact of the Development of Private Labels
   Berges-Sennou, Bontems, and Requillart....................................................................263

Private Label Entry as a Competitive Force?
   Gabrielsen, Steen, and Sorgard....................................................................................287

Market Conduct in the U.S. Ready-to-Eat Cereal Industry
   Reimer and Connor....................................................................................................324
Contract Incentives in the Processed Potato Industry
Curtis and McCluskey .................................................................361

Market Structure and Consumer Valuation in the rBST-free and Organic Milk Markets
Dhar and Foltz...............................................................................396

Strategic Patent Breadth and Entry Deterrence with Drastic Product Innovations
Yiannaka and Fulton.....................................................................423

Vertical Integration, Exclusive Dealing and Product Line Differentiation in Retailing
Avenel and Caprice.......................................................................460

The Duopolistic Firm with Endogenous Risk Control
Wang and Stiegert.........................................................................491

Information Sharing and Oligopoly in Agricultural Markets
Hueth and Marcoul.......................................................................534

Price Promotion by Multi-Product Retailers
Richards, Patterson, and Padilla.......................................................560

Bayesian Estimation and Socioeconomic Determinants of Fast Food Consumption
Marsh, Fanning, and Stiegert..........................................................605

Price Dynamics in a Vertical Sector: The Case of Butter
Chavas and Mehta........................................................................627

Regional Concentration in the Global Food Economy
Gehlhar.......................................................................................663

State Trading Enterprises in a Differentiated Environment
Dong, Marsh, and Stiegert.............................................................690
Schedule of Speakers

June 26th (Full Day)

8:00-8:30 Registration, Coffee and Rolls (Second Floor Break Station).

8:30AM-12:15PM Invited Speakers Session

8:30AM – 10:00AM Room 219 Globalization, International Markets, and Power

Ian Sheldon (The Ohio State University) and Steve McCorriston (University of Exeter) "Globalization and food industry consolidation: what does industrial organization have to say about market access?"

John Connor (Purdue University) “International price fixing: resurgence and deterrence.”

10:00AM - 10:15AM Break

10:15AM-12:15PM Room 219 Vertical Impacts of Retail Market Power

Jeff Perloff (University of California-Berkeley) and Mike Ward. “Welfare, market power, and price effects of product diversity.”

Richard J. Sexton (University of California-Davis) "Grocery retailer behavior in the procurement and sale of perishable fresh produce commodities."

Bruce Marion (University of Wisconsin-Madison) “Industrial organization research: a historical perspective.”

12:30PM-2:00PM Lunch in the Fluno Center
Afternoon: Parallel Sessions

2:00 PM -3:30PM  Room 219  Oligopoly and Retail Markets

Philippe Bontems and  Zohra Bouamra-Mechemache: (INRA; University of Toulouse)  
“Predatory accommodation in vertical contracting with externalities.”

Steve Hamilton (U of Central Florida) and David Sunding (U of California-Berkeley)  
“Advertising under oligopoly.”

2:00PM -3:30PM  Room 221  Economics of Private Labels

Fabian Bergès-Sennou, Philippe Bontems and Vincent Réquillart (INRA; University of Tolouse)  
“Economic impact of private labels.”

Tommy Staahl Gabrielsen (University of Bergen) and Lars Sørgard (Norwegian School of Economics and Business Administration).  “Private labels, price rivalry, and public policy.”

3:30PM -4:00PM Break  coffee and rolls

4:00PM -5:30PM Room 219  Empirical Studies of Industrial Organization Topics

Jeff Reimer (University of Wisconsin-Madison) and John Connor (Purdue University).  
“Market conduct in the U.S. ready-to-eat cereal industry.”

Jill McCluskey (Washington State University).  “Contract incentives in the processed potato industry.”

4:00PM -5:30PM Room 221  Patents

Jeremy Foltz and Tirtha Dhar (University of Wisconsin-Madison)  
“Market structure and consumer valuation in the rBST-free and organic milk markets.”

Amalia Yiannaka (University of Nebraska-Lincoln) and Murray Fulton (University of Saskactchewan)  
“The Strategic role of the patent breadth decisions and market entry deterrence.”

Break for the Evening

June 27th (Half Day)

8:30AM-10:00AM  Room 219  New Theoretical Developments

Stephane Caprice (INRA, University of Toulouse) and Eric Avenel (UMR GAEL INRA, UPMF of Grenoble)  “Vertical integration, exclusive dealing and product differentiation in retailing.”

Shinn Shyr Wang and Kyle W. Stiegert (University of Wisconsin-Madison)  
“Duopolistic firm with endogenous risk control.”
8:30AM-10:00AM Room 221  Empirical Studies of Industrial Organization

Brent Hueth and Philippe Marcoul. (Iowa State University)
“Information sharing and oligopoly: the role of bargaining associations.”

Tim Richards and Paul Patterson (Arizona State University)
“Price promotion by multi-product retailers”

10:30AM-12:00PM Room 219  Methodologies and Issues
Thomas Marsh, Jasper Fanning (Kansas State University) and Kyle Stiegert (University of Wisconsin-Madison) “Bayesian methods and socioeconomic determinants of fast food.”


10:30AM-12:00PM Room 221  International Markets Issues

Mark Gehlhar, ERS-USDA
“Regional concentration in the global food economy.”

Fengxia Dong, Thomas Marsh (Kansas State University) and Kyle Stiegert (University of Wisconsin-Madison) “State trading and market power in international malting barley markets.”

Conference Adjourns

Information

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Reservation Information:

Register for conference online at from our website: http://www.aae.wisc.edu/fsrg/

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Globalization and Food Industry Consolidation: What Does Industrial Organization Have to Say About Market Access?

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Invited paper for First Biennial Research Conference
Food System Research Group
June 26-27, 2003

University of Wisconsin-Madison

JUNE 2003
Globalization and Food Industry Consolidation: What Does Industrial Organization Have to Say About Market Access?

Abstract: This paper focuses on the interface between the industrial organization of the food sector in developed countries and the issue of market access for developing countries. Noting that the food sector in developed countries can be characterized as a successive oligopoly, we explore the issue of market access where some developing countries can export high-value processed goods and others export raw agricultural commodities. Tariffs apply on the imports of both these goods such that we have the possibility of tariff escalation, an issue often highlighted by trade and development economists as a barrier to developing countries wishing to up-grade their export profile. We outline in the paper a theoretical framework in which we explore aspects of market access when the domestic food sector is successively oligopolistic. Employing a market access rule that market access concessions should not be discriminatory, we show that reducing tariffs on each of these goods by equivalent amounts will result in biased market access. Conversely, if market access concessions between developing countries are to be neutral, tariff reductions should be differential and tariff escalation should increase. This is in contrast to traditional views on the tariff escalation issue but arises due to the feedback effects tariff reductions at different stages of the marketing chain have in this vertically related set-up. The overall implication of the paper is that to provide appropriate analysis on traditional policy issues, researchers should take into account the industrial organization of the markets on which they focus.
**Introduction**

In recent years, there has been a considerable amount of research on market structure issues in food and related markets, this literature being comprehensively summarized in Sexton and Lavoie (2001). Research on the impact that market structure issues in the food sector have on traditional policy analysis carried out by agricultural economists has, however, been relatively thin which is particularly true if one were to focus on the international consequences of domestic market structure. While those interested in market structure issues have largely focused, at least implicitly, on domestic anti-trust implications, a corresponding criticism can be leveled at those primarily interested in agricultural trade policy analysis, the models used here seldom departing from the competitive benchmark. Taken together, agricultural economics research at the interface between industrial organization and trade, or globalization issues more generally, has largely been unexplored. Of course, this is not to say that such research has been non-existent, but the predominant focus for agricultural economists interested in industrial organization has been on domestic issues while agricultural trade economists have largely ignored issues relating to domestic market structure.1

Yet issues at the interface of trade and industrial organization in food and agricultural markets are potentially relevant both in relation to trends in agricultural trade and for understanding current trade policy issues. For example, a large proportion of international trade in food and agricultural products, particularly between developed countries, is in processed food products thus implying the direct involvement of the food industry in trade. The food industry is

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1 In the context of the mainstream economics literature, there is a substantial body of research on industrial organisation and trade. For example, the international economics literature is replete with papers where oligopoly theory has become widely used. Much of this research has focused, however, on aspects of strategic trade policy and, more recently, on the impact on anti-dumping policies. Industrial organization economists have also begun to deal with issues relating to the international consequences of domestic anti-trust policy.
also highly concentrated in many developed countries both at the retailing and processing levels, with consolidation in the industrial food sector having increased in recent years. This consolidation has also reflected aspects of globalization as a significant part of this consolidation has taken the form of cross-border mergers and acquisitions. Taken together, the underlying data would suggest increasing trade in processed food products involving an increasingly concentrated food sector.

As far as current trade policy issues are concerned, the current Doha Round of trade negotiations of the World Trade Organization (WTO) has been labeled the ‘development round’ a key aim of which is to increase developing countries’ access to developed country markets. The distinction between raw commodity and processed food exports has also surfaced here with development economists, and policy advisors more generally, advocating that developing countries should diversify their exports away from reliance on raw agricultural exports, at least in terms of ‘up-grading’ their export portfolio to export more processed or higher value food products.\(^2\) In this regard, however, several barriers are perceived to exist. First, developing country exporters often face the problem of tariff escalation where tariffs on the processed good are higher than those on the raw commodity. In this context, the traditional trade policy literature suggests that reducing tariffs on the raw commodity while keeping tariffs on the processed good unchanged, or reduced by a lesser amount, will increase the level of effective protection and thus act as a disincentive to developing countries exporting higher value processed food products.\(^3\)

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\(^2\) We use the term ‘policy advisors’ rather broadly to include organizations such as the World Bank and UNCTAD as well as academics.

\(^3\) Effective protection is the extent to which value-added is protected. This will depend on the level of value-added produced by an industry, i.e., the share of raw or intermediate inputs purchased from other sectors domestic and foreign, as well as the level of tariffs on final and intermediate goods. Tariff escalation refers to the extent to which the tariff on the final good exceeds the tariff on the raw or intermediate good.
Second, recent research on developing country issues, not necessarily confined to work done by economists, has recognized additional barriers faced by exporters keen to access developed country markets. Using a somewhat more eclectic ‘value chain’ framework, this paradigm explicitly recognizes that issues relating to market power at various stages of the food chain, not just levels of tariffs or the problem of tariff escalation, matter in addressing market access opportunities for developing country exporters. However, while the ‘value chain’ approach is useful for highlighting various trade and market structure issues facing developing country exporters, it lacks a formal structure that industrial organization or trade economists would readily recognize, nor does it give clear policy insights beyond somewhat vague pointers as to what developing country exporters should perhaps do to access downstream food markets in developed countries.

The objective of this paper is to explore tying some of these issues together. More explicitly, we consider the issue of market access to developed country markets where food industry structure is characterized by imperfect competition at both the retailing and processing stages, i.e., we have successive oligopoly. Developing countries export raw commodities and processed food products, though we assume below that these are different countries and where tariffs are applied on both goods, i.e., the issues of tariff escalation and effective protection form a key ingredient in this analysis. Setting the issue of market access, imperfect competition and effective protection in a formal framework leads to important insights. First, in the context of a model of successive oligopoly, an equal reduction in tariffs on the processed food product and raw commodity are not equivalent in guaranteeing increases in market access for raw agricultural and processed good exporters respectively. Second, the extent to which this is true depends on

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4 See Kaplinsky (2000) for a good discussion of these issues.
the nature of competition in the developed country markets. Third, to the extent that the processed food exporter and the raw commodity exporter are different countries, tariff reductions that maintain the same level of effective protection are likely to be discriminatory in terms of market access considerations. This is in contrast to the general perception of trade policy that reducing tariffs by the same amount is necessary to avoid increasing the disincentives to processed good exporters. If the primary focus is on market access, which we argue below should be the appropriate focus of trade negotiations, varying the level of tariff reductions will be necessary to avoid discrimination between developing country exporters. This in turn has a political economy consideration: developing country negotiators should not focus solely on market access commitments offered by developed countries, but also be aware of what each developing country receives in terms of market access contingent on their export profile, if negotiated market access outcomes are to avoid being discriminatory.

The paper is organized as follows. In section 1, we outline some trends in trade flows in raw commodities and processed food products, and the role therein played by developing countries. In section 2, we report some data relating to market structure of the food industry in developed countries, focusing primarily on the US and European Union (EU). In section 3, we summarize some recent concerns facing developing country exporters concerning the issues of tariffs and tariff escalation. A more formal modeling approach is outlined in section 4 which is used to explore the issues of tariff concessions and market access when the importing country’s food industry structure is characterized by successive oligopoly. Key results that arise from this theoretical model are presented in section 5. In section 6, we summarize and conclude and consider some avenues for future research on this issue.
1. **Trade in Food and Agricultural Products**

In this section, we provide some data on exports of food and agricultural products by developing countries, with particular emphasis on their exports to developed countries, by way of background to the issues relating to developing country access to developed country markets. In general, the key characteristic of trade in this sector, defined as all food items in the 3-digit SITC categories 0, 1, 22, and 4, is that developing countries account for a considerably smaller share of the value of world exports of food and agricultural products as compared to developed countries. As is shown in Table 1, on average, the developing countries accounted for 31 percent of the value of world exports of all food items over the period 1990-2000. In contrast, over the same period, the developed countries accounted for 66 percent, on average, of the value of world exports of all food items.

With respect to trade in specific food and agricultural products, a very clear pattern also emerges. As shown in Table 2, the developing countries have significant shares of the value of world exports for those raw commodities in which they have a traditional comparative advantage, averaging 65, 57, 77, 66, 85, and 78 percent respectively for rice (042), sugar (061), coffee (071), cocoa (072), tea (074) and spices (075) over the period 1990-2000. In contrast, the developed countries dominate the share of the value of world exports in high-value and processed food and agricultural products. The obvious exceptions to this are fresh and frozen shellfish (036), prepared and frozen fish (037), and other fixed vegetable oils (424), where the developing countries on average accounted for 66, 54, and 82 percent respectively of the value of world exports over this period. In addition, as shown in Table 3, the developed countries also typically dominate the share of the value of world imports in high-value and processed food and agricultural products, whereas the developing countries are major importers of non-processed...
grains such as wheat (041), rice (042), barley (043), maize (044), and wheat flour (046) and other cereal meals and flour (047), averaging 61, 67, 46, 48, 75, and 60 percent respectively of the value of world imports over the period 1990-2000.

In summary, this overview of trade in food and agricultural products shows that, in aggregate it is dominated by the developed countries. In addition, when trade is disaggregated to specific product groups, the developed countries account for most of the value of world trade, both exports and imports, in high-value and processed food and agricultural products, whereas the developing countries account for a large proportion of the value of exports in traditional unprocessed commodities such as rice, sugar, coffee, cocoa and tea, most of which have continued to suffer from declining world prices over this period (UNCTAD, 2000). It is against this background, that economists and policy advisors have advocated that developing countries upgrade their exports into the more highly processed food sectors.

2. Market Structure of Developed Country Food Processing and Retailing

Having noted the relatively low market share in developed countries of developing country exports of food and agricultural products, we now focus on the extent to which food processing and retailing in developed countries is concentrated, with specific focus on these sectors in the United States and the EU. This sets the background for some of the wider concerns relating to market access by developing countries and the theoretical model presented below.

(i) Food Processing

The food-processing sector in both the United States and the EU is highly concentrated (Cotterill, 1999). In the United States, a small number of large firms dominate the sector, with the top-20 food and tobacco-manufacturing firms accounting for over 52 percent of the sector’s
value added in 1995. If food manufacturing is separated from beverage and tobacco manufacturing, the top-20 food manufacturing firms accounted for 37 percent of value added in 1997, while the top-20 beverage and tobacco-manufacturing firms accounted for 79 percent of value added (US Census Bureau, 2001). In Table 4, we list those specific food products where the 4-firm concentration ratio was over 60 percent in 1997, the average being just below 76 percent.

Turning to food manufacturing in the EU, the data in Table 5 show that typically at the country level, average seller concentration is higher than in the United States, ranging from an average 3-firm concentration ratio of 55 percent in Germany to 89 percent in Ireland, with an average 3-firm concentration ratio across 9 EU countries of 67 percent. As in the United States, these averages hide some high levels of seller concentration for specific products in each EU country, most notably baby foods, canned soup, pet food and coffee. It should be noted, however, that while seller concentration at the product level is high in many individual EU country markets, there are few examples of firms that dominate sales across EU countries as a whole (Cotterill, op. cit.).

(ii) **Food Retailing**

In the case of food retailing, there are quite important differences between market structure in the United States and that in the EU. As Table 6 reports, 5-firm seller concentration in food retailing at the national level is much higher in EU countries than it is in the US, with average 5-firm seller concentration in the former being 65 percent, compared to 35 percent in the latter. However, at the EU-wide level, 5-firm seller concentration is much lower at 26 percent (Hughes, 2002). In addition, in the US, it is important to examine concentration in food retailing at the local and regional level. Cotterill (op. cit.) reports that in 1998, 4-firm seller concentration
averaged 74 percent across the top 100 US cities, while across major US regions 4-firm seller concentration averaged 58 percent.

As well as the high levels of concentration in US and EU food retailing, it is important to recognize, that several firms in this industry, which were previously national in origin, are now becoming international in scope. Hughes (op. cit.) reports that in the 1980s, food retailers in the EU, such as the French firm Carrefour, began expanding beyond their national base, while the US-based firm Wal-Mart expanded into Canada and Mexico. This phenomenon continued in the 1990s, with EU-based retailers such as Royal Ahold and Sainsbury expanding into the US market (Cotterill, op.cit.), Carrefour and Royal Ahold expanding into various developing country markets in Central and Latin America (Chavez, 2002; Farina, 2002; Gutman, 2002), and US-based Wal-Mart expanding into the EU (Hughes) and into Central and Latin America (Chavez, op. cit.; Farina, op. cit.).

In summary, the food manufacturing and retailing sectors in the United States and EU are highly concentrated, such that the vertical structure of the food marketing system in developed countries can appropriately be characterized as one of successive oligopoly. This of course means that the vertical structure of the food chain as a whole matters in addressing aspects of market access for exporting countries.5

3. Access by Developing Countries to Developed Country Markets

In this section we consider some of the issues involved when developing country exporters are faced with the problem of market access in the context of a vertically related market. We

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5 One issue that we do not discuss here relates to the nature of vertical ties between each stage of the vertical food chain. The model presented below assumes arm’s length pricing whereby it is the horizontal dimension of competition at each stage that matters. Some discussion of the relevance of vertical contractual arrangements can be found in Sheldon and McCorriston (2003).
consider two issues: first, the levels of tariffs and the problem of tariff peaks facing developing country exporters; and, second, the problem of tariff escalation.

(i) **Tariffs and Tariff Peaks**

The traditional focus of trade models is on explicit trade barriers such as tariffs and quantitative restraints. Following the Uruguay Round of GATT, there was a process of tariffication whereby a range of non-tariff barriers including quantitative restraints were converted into tariff equivalents. A first step, therefore, in considering market access issues facing developing countries is to focus on the level of the tariffs they face when exporting to developed country markets.

A recent survey by USDA (2001) indicates that on average, world tariffs in the food and agricultural sector stand at 62 percent for bound, most favored nation (MFN) rates. However, average food and agricultural tariffs for WTO members by region vary from 25 percent for North America and 30 percent for the EU to 113 percent for South Asia. This compares with average developed country MFN tariffs of 5 percent across all sectors (Hoekman, Ng, and Olarreaga, 2002). It should also be noted that tariff levels in developing countries are also high, in many cases higher than those in developed countries, such that developing country access to other developing countries, may actually be more restricted than to developed countries.

While the level of average tariffs is in some way informative, it should be noted that products in this sector are often characterized by tariff peaks in the developed countries, i.e., where the tariffs on some imported products far exceed the average level. For example, as reported by Hoekman, Ng and Olarreaga (*op. cit.*), the United States, the EU, Japan and Canada have respectively 48, 290, 178, and 85 tariff peaks for food and agricultural products, with the maximum tariff rates being on butter (Canada, 340 percent), edible bovine offal (EU, 250
percent), raw cane sugar (Japan, 170 percent) and peanuts in the shell (US, 120 percent). As noted by Hoekman, Ng and Olarreaga, many of these tariff peak products are of interest to developing country exporters such that market access may be more limited than what the average tariff rates imply.

However, an additional aspect of market access relates to preferential treatment. Many developed countries also provide limited preferential access for food and agricultural products under both the Generalized System of Preferences (GSP), and reciprocal trade agreements such as NAFTA. For example, the EU has a myriad of preferential access agreements that cover a large number of developing countries with some developing countries being more favored than others. In Table 7, average MFN tariffs by Harmonized System 2-digit food and agricultural products are listed for the EU and the United States, along with margins for less developed country (LDC) preferences. Across all products, the average MFN tariff on food and agricultural products is 38.3 percent in the EU, and 30 percent in the United States, with developing countries getting preferences that imply on average they pay duty up to 50 percent of the MFN tariff. However, there are some clear tariff peaks in the EU for products such as meat and edible offal (02), cereals (10), and oil seeds (12) where preferential access for the developing countries is small, and likewise in the United States for oil seeds.

In conjunction with the trade data, the tariff data suggest that developing country access to developed country markets for food and agricultural products could be improved through trade liberalization, particularly in the case of products that exhibit tariff peaks in developed countries and limited preferential access beyond MFN tariffs. This, however, is not the only consideration.
(ii) **Tariff Escalation**

For developing countries attempting to diversify and up-grade their exports from raw agricultural commodities to processed food products, one of the most often-mentioned difficulties is that of tariff-escalation. Tariff escalation occurs when tariffs on imports of processed goods are higher than the tariffs on the corresponding raw commodity. This issue has been well-known from the work of Balassa (1965) and Corden (1971). UNCTAD (2002) has recently cited this issue as one of the main problems facing developing country exporters in diversifying their export profile.

The recent evidence on the extent of tariff escalation is rather mixed. For many agricultural commodities supported by government intervention in the developed countries, the tariff on the raw commodity is often exceptionally high. For example, USDA (*op. cit.*.) report higher levels of tariffs on grain compared to grain products in several developed countries including the United States and the EU. Nevertheless, tariff escalation is still perceived to be a major issue facing developing country exporters. In Table 8 we report the highest post-Uruguay Round tariff escalation estimates for a series of commodities for the US, Japan and the EU. The estimates show high levels of tariff escalation across all three countries. The table also highlights that the level of tariff escalation has decreased following the Uruguay Round with some of the commodity groups facing the highest levels of tariff escalation also being the ones exhibiting the highest levels of reduction.

UNCTAD (2002) also reports high levels of tariff escalation for products exported solely from developing countries. For example, for coffee, tea and spices, the level of tariff escalation in Japan and the EU rose from averages of 0.11 per cent and 1.63 per cent for raw material imports in these two countries respectively to 8 per cent and 20 per cent in the case of the final product. Taken together, and in spite of the decline in tariff escalation following the Uruguay
Round, tariff escalation remains a problem for developing countries diversifying their exports and attaining market access for the processed good.

4. Theoretical Framework

(i) Schematic Outline

It is perhaps useful to outline the modeling framework by representing the scenario we are addressing in Figure 1. In this market there are two domestic firms at the retail stage, and two domestic firms at the processing stage, i.e., there is successive oligopoly. The two firms at each stage do, however, differ in terms of where they buy their inputs. At the processing stage, firm 1 buys inputs from the domestic agricultural sector while firm 2 buys the inputs of the raw commodity from a foreign supplier. Subsequently, these two firms compete and sell the processed good to the firms in the downstream retail sector. In the downstream retail sector, there are again two firms that compete at this stage, the distinction between the two firms being from where they source their inputs. Firm 1 buys from the domestic upstream stage while firm 2 sources its inputs from the world market. The retail firms may or may not add value and may be involved solely in distribution. Since this stage is closest to the consumer, we assume that the import by firm 2 is of a relatively high-value, processed good. At each stage, firms take the input prices, whether sourced from the world or domestic market, as given.

As far as the supply of the imported good is concerned, we assume that the suppliers of the raw commodity and the higher value good are different developing countries, say due to past investment in the food sector or lack of it. This avoids detailing any specific strategy of what combination of goods to produce. However, market access at each stage is affected by tariffs, with a tariff imposed on the processed import and on the raw commodity import. Thus tariff
escalation and effective protection can be characterized in this model. If the tariff on the processed good is higher than on the raw commodity, there is tariff escalation and the level of effective protection afforded to the downstream firm 1 exceeds the level of nominal protection.

Taken together, the set-up of the model as presented in Figure 1 captures most of the issues referred to in sections 2 and 3 of the paper. First, developing countries may export raw commodities or more highly processed products but face the problem of tariffs imposed at each stage and where tariff escalation may persist. Corresponding to the characteristics of the food sector in the developed countries, we have imperfect competition at each stage of the vertically linked food chain. Hence, we have successive oligopoly. Finally, we have a framework more directly appropriate for considering the impact of trade reform than standard trade models employ as the model explicitly recognizes the relevance of market power and the role of tariffs on raw commodities and processed goods in determining market access at each stage of the food chain. With this model, we can ask questions about ensuring equivalent market access for raw commodities and processed goods if trade reform leads to commitments on tariff reductions particularly on products of interest to developing country exporters.

(ii) The Model

Assumptions

As noted above, we have a model of successive oligopoly, i.e., both the upstream (processing) and downstream (retailing) stages are imperfectly competitive. We assume that the technology linking each stage is one of fixed proportions. Formally, $x_1 = \phi x^U$, where $x_1$ and $x^U$ represent output of downstream firm 1 and the upstream stages respectively, and where $\phi$ is the constant coefficient of production. To ease the exposition, $\phi$ is set equal to one in the framework outlined below.
In terms of the game-theoretic structure of the model, the timing of the firm’s strategy choice goes from upstream to downstream. We outline the model in general strategy space since we wish to capture the nature of competition in influencing the market access outcomes. Specifically, given costs and the derived demand curve facing the upstream sector, upstream firms simultaneously choose their strategy to maximize profits, which generates Nash equilibrium at the upstream stage. The processed good prices are taken as given by the downstream firms that, simultaneously chooses their strategy to maximize profits, thus giving Nash equilibrium at the downstream stage. In terms of solving the model, equilibrium at the downstream stage is derived first and then the upstream stage.

*Equilibrium in the Downstream Market*

The model is written in general form following Bulow, Geanakopolos and Klemperer (1985). $s_1$ is the strategy choice of the firm buying from the domestic upstream stage and $s_2$ is the strategy choice of the firm importing from the world market. The revenue functions can be written as:

$$\text{(1)} \quad R_1(s_1, s_2)$$

$$\text{(2)} \quad R_2(s_1, s_2).$$

We assume downward sloping demands and substitute goods.

Given (1) and (2), the relevant profit functions are given as:

$$\pi_1 = R_1(s_1, s_2) - c_1 s_1 \quad \text{(3)}$$

$$\pi_2 = R_2(s_1, s_2) - c_2 s_2 - t^p s_2, \quad \text{(4)}$$

where $c_1$ and $c_2$ are the downstream firms’ respective costs. Firms’ costs relate to the purchase of the intermediate input. Note that firm 2 also faces a per unit tariff on the processed import which is given by $t^p$. 

16
The first-order conditions for profit maximization are given as:

\[ R_{1,1} = c_1 \]  \quad (5)  
\[ R_{2,2} = c_2 + \pi^p, \]  \quad (6)

Equilibrium in the downstream stage can be derived by totally differentiating the first-order conditions (5) and (6):

\[
\begin{bmatrix}
    R_{1,1} & R_{1,12} \\
    R_{2,21} & R_{2,22}
\end{bmatrix}
\begin{bmatrix}
    ds_1 \\
    ds_2
\end{bmatrix}
=
\begin{bmatrix}
    dc_1 \\
    dc_2 + dt^p
\end{bmatrix}.
\]  \quad (7)

The slopes of the reaction functions are found by implicitly differentiating the firms’ first-order conditions:

\[
\frac{ds_1}{ds_2} = r_1 = -\frac{R_{1,12}}{R_{1,11}} \quad (8)
\]

\[
\frac{ds_2}{ds_1} = r_2 = -\frac{R_{2,21}}{R_{2,22}}. \quad (9)
\]

With this set-up, we can deal with both strategic substitutes and strategic complements where the variable of interest is the crossartial effect on marginal profitability, i.e., \( \text{sign } r_i = \text{sign } R_{i,ij}. \) Consequently, with reference to equation (8) and (9), if \( R_{i,ij} < 0, \) then \( r_i < 0. \) In this case, we have the case of strategic substitutes, and the reaction functions are downward sloping. However, if \( R_{i,ij} > 0, \) the reaction functions are upward sloping and we have strategic complements. The distinction between strategic substitutes/complements relates to the “aggressiveness” of firm’s strategies. With strategic substitutes, firms’ strategies are less aggressive than those associated with strategic complements. Following Bulow et al. (ibid.),
assume that the strategy space relates to quantities. With strategic substitutes (complements), an increase in the output of firm 1 would be met by a decrease (increase) in that of firm 2.

Given (7), the solution to the system is found by re-arranging in terms of $ds_1$ and inverting where $\Delta$ is the determinant of the left-hand side of (7):

$$
\begin{bmatrix}
    ds_1 \\
    ds_2
\end{bmatrix} = \Delta^{-1}
\begin{bmatrix}
    R_{22} & -R_{12} \\
    -R_{21} & R_{11}
\end{bmatrix}
\begin{bmatrix}
    dc_1 \\
    dc_2 + dt^p
\end{bmatrix}.
$$

(10)

To simplify the notation re-write (10) as:

$$
\begin{bmatrix}
    ds_1 \\
    ds_2
\end{bmatrix} = \Delta^{-1}
\begin{bmatrix}
    a_2 & b_1 \\
    b_2 & a_1
\end{bmatrix}
\begin{bmatrix}
    dc_1 \\
    dc_2 + dt^p
\end{bmatrix},
$$

(11)

where,

\[a_1 = R_{11}, \quad a_2 = R_{22}\]
\[b_1 = R_{12}, \quad b_2 = R_{21}.\]

For stability of the duopoly equilibrium, the diagonal of the matrix has to be negative, i.e., $a_i < 0$, and the determinant positive, i.e., $\Delta = (a_1 a_2 - b_1 b_2) > 0$. Given these conditions, further comments can be made about the reaction functions. $r_i = -(b_i)/a_i$ from (8) and (9). If $a_i < 0$, then for strategic substitutes, $b_i < 0$, in order to satisfy $r_i < 0$, and $b_i > 0$ in order to satisfy $r_i > 0$ for strategic complements. The expression for $r_i$ can be substituted into (11) in order to make the comparative statics easier to follow:

$$
\begin{bmatrix}
    ds_1 \\
    ds_2
\end{bmatrix} = \Delta^{-1}
\begin{bmatrix}
    a_2 & a_1 r_1 \\
    a_2 r_1 & a_1
\end{bmatrix}
\begin{bmatrix}
    dc_1 \\
    dc_2 + dt^p
\end{bmatrix},
$$

(12)

**Equilibrium in the Upstream Market**

Given the fixed proportions technology and $\phi = 1$, total output in the upstream sector is given by $x^U = x_U$, where the combined output of the two upstream firms $x_1^U + x_2^U = x^U$. The processed
good is assumed to be homogeneous so that downstream firm 1 is indifferent about the relative proportions of \( x^U_1 \) and \( x^U_2 \) used at retail. Assuming that the downstream firm faces no costs other than the price paid for the processed good, the inverse derived demand function facing firms in the upstream sector can be found by substituting \( p_i^U \) for \( c_i \) in (5) and (6) where superscript \( U \) denotes the upstream sector. Firms’ profits in the upstream sector are, therefore, given by:

\[
\pi_i^U = R_i^U (s_1, s_2) - c_i^U s_i^U 
\]

(13)

\[
\pi_2^U = R_2^U (s_2) - c_2^U s_2^U - t^r s_2, \quad \text{ (14)}
\]

where \( c_1^U \) and \( c_2^U \) are the upstream firms’ costs respectively. Again note that the firm that imports the raw commodity from the world market also faces the cost associated with the tariff.

Given this, following the outline above, equilibrium in the domestic upstream market is given by:

\[
\begin{bmatrix}
    ds_1^U \\
    ds_2^U
\end{bmatrix} = (\Delta^U)^{-1}
\begin{bmatrix}
    a_i^U & a_i^U r_i^U \\
    a_2^U r_2^U & a_1^U
\end{bmatrix}
\begin{bmatrix}
    dc_i^U \\
    dc_2^U + dt^r
\end{bmatrix}. \quad \text{(15)}
\]

5. Market Access with Successive Oligopoly

In terms of thinking about the issues facing developing country exporters of raw commodities and processed goods when the home market is characterized by successive oligopoly, it will be useful to focus more directly on market access issues. As Bagwell and Staiger (1999) note, GATT/WTO rules are fundamentally about market access commitments. What comes out of the model employed here is that in the context of successive oligopoly, reducing tariffs on the processed good and raw commodity by equivalent amounts may hinder market access for one of the developing country exporters. Consequently if market access is the principal focus of the
Doha Round of trade negotiations, to avoid discriminatory market access in favor of one developing country at the expense of another, equivalent market access commitments for each exporter can only be sustained by reducing the tariff on each import by differential amounts. As we show below, there are several factors that determine the appropriate reductions in tariffs including the incidence of upstream tariffs on the downstream sector, the strength of the ‘back-shifting effect’ as tariff reductions on the processed good have an impact on the derived demand facing the upstream sector and, hence, the demand for the imported raw commodity. The nature of competition between firms at each stage of the vertically linked food chain also matters.

Consider the following hypothetical scenario. Trade negotiators in the Doha Round are intent on increasing developing countries access to developed country markets. But they recognize that some developing countries export more highly processed goods while others export raw commodities. Reducing tariffs is the principal way of encouraging market access. But they also recognize that when each export enters the importing country’s food chain, reducing tariffs at one stage has an impact on imports at the corresponding upstream or downstream stage. They may also know that the nature of competition at each stage influences the outcome. Consequently, if they were to reduce tariffs on the raw commodity keeping the tariff on the processed good unchanged, imports of the processed good will fall as the competitiveness of the downstream firm that purchases its inputs from the domestic sector has now improved. Hence market access would be biased in favor of the raw commodity exporter at the expense of lower imports from the processed good exporter. Similarly, if the trade negotiations lowered the tariff on the processed good keeping tariffs on the raw commodity import unchanged, this would increase imports of the processed good at the expense of imports of the raw commodity. This arises because the increase in imports of the processed good reduces the sales of firm 1 in the
downstream sector, which shifts back the derived demand in the upstream sector, thereby reducing imports of the raw commodity. Potentially therefore, developing countries have conflicting interests depending on the type of good they export to the developed country market.

To avoid such conflict, therefore, the trade negotiators consider a market access rule to avoid any conflicting interest between these developing countries. If tariffs on imports from developing countries are to avoid any discrimination in market access, then the net change in market access following tariff reductions on raw and processed goods should be unchanged. Specifically:

$$ \Delta MA' (dt') + \Delta MA^p (dt^p) = 0, $$

(16)

where $\Delta MA'$ is the change in market access of the raw commodity import which depends directly on, the change in the raw commodity tariff $(dt')$, and where $\Delta MA^p$ is the change in the market access of the processed good which depends directly on the change in the tariff on the processed good $(dt^p)$. Since we noted above these tariff changes can have offsetting effects in the corresponding upstream or downstream sector, we set the net change that the trade negotiator would aim for, in order to avoid any discriminatory effects, equal to zero. Of course, one may argue that changing tariffs on raw commodities and processed goods by equal amounts would result in an equivalent increase in market access. As we show below, in the context of successive oligopoly, this will not be the case. In turn, if the focus is on market access considerations without discriminating between developing country suppliers, the reduction in tariffs for imports at each stage will not be equal.

We amend the trade negotiator’s rule as given above. We set it such that we consider what would be the appropriate reduction in the tariff on the processed good ($APT$) that would offset the reduction in the tariff on the raw commodity $(dt')$ while keeping the change in market access

21
the same at both stages. As the market access rule relates directly to import volumes, we assume that the strategy space is in quantities. Replacing $s_i$ with $x_i$ in the upstream and downstream industries respectively, we can re-write our market access rule as\(^6\):

$$[(dx_2 / dc_1)(dc_1 / dt')]dt' + APT(dx_2 / dt^p) = 0.$$  \hspace{1cm} (17)

The first argument is the effect of the tariff on the raw import on imports in the downstream market: clearly the change in the raw commodity tariff ($dt^r$) changes upstream prices, which then affects competition in the downstream sector. By changing the competitiveness of downstream firm 1, this affects the level of imports of processed goods by downstream firm 2, $x_2$. The second argument is the effect of the tariff on imports of the processed good. Setting the rule equal to zero and solving for $APT$, gives the appropriate amendment in the processed good tariff to keep the change in market access in both the upstream and downstream markets the same for a given change in the tariff on the raw agricultural import. Re-arranging (17) we have:

$$APT = \frac{-(dx_2 / dc_1)(dc_1 / dt')dt'}{(dx_2 / dt^p)}.$$  \hspace{1cm} (18)

However, it should be noted that while the upstream tariff has an impact on the downstream market via the change in the downstream firm’s costs, the change in the processed good tariff will also have an effect on the upstream price via the ‘back-shifting’ effect. Therefore, we need to expand the denominator to give:

$$APT = \frac{-(dx_2 / dc_1)(dc_1 / dt')dt'}{[(dx_2 / dt^p) + (dx_2 / dc_1)(dc_1 / dt^p)]}.$$  \hspace{1cm} (19)

\(^6\) It should be noted that the distinction between strategic substitutes and complements can still arise in quantity space with strategic complements being an outcome if the demand function is sufficiently convex.
Suppose for the moment we ignore the ‘back-shifting’ effect. Note that to keep market access the same we should not necessarily reduce the processed tariff by the same amount as the raw tariff. This is due to the possibility that the incidence of the upstream tariff on upstream prices, i.e., the downstream firm’s costs may change by less than 100 percent as given by the term \((\frac{dc_1}{dt'})\).

The direct effect of the processed good tariff affects imports of the processed good but this is offset by the ‘back-shifting’ effect. The ‘back-shifting’ effect reduces upstream prices, because the inverse derived demand function shifts back. In turn, this reduces the downstream firm’s costs, which in turn reduces imports. So while the reduction in the processed good tariff increases processed good imports, the ‘back-shifting’ effect serves to ameliorate the effect to some degree. So the amendment in the processed good tariff may have to be greater to offset this ‘back-shifting’ effect as long as the incidence is less than the direct effect on processed good imports.

Expression (19) can be re-written to derive explicit results. Specifically, we have⁷:

\[
APT = \frac{-\Delta^{-1}a_2r_2(\frac{dc_1}{dt'})}{\Delta^{-1}a_1 + \Delta^{-1}a_2r_2(\frac{dc_1}{dt'})} dt',
\]

which can be simplified to (assuming \(a_1 = a_2\)):

\[
APT = \frac{-r_2(\frac{dc_1}{dt'})}{1 + r_2(\frac{dc_1}{dt'})} dt'.
\]

**Result 1:** If we have strategic substitutes, a reduction in the tariff on the raw agricultural import should likely be matched with a *reduction* in the tariff on the processed good. If we have strategic complements, a reduction in the raw agricultural good tariff should be matched with an *increase* in the tariff on the processed good.

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⁷ To conveniently separate the effects, we do not write out the tariff pass-through and the back-shifting effects in explicit form.
The sign of $r_2$ is the key to this result. With strategic substitutes, $r_2 < 0$, so the numerator is positive. Also the denominator is positive as long as $r_1 \{dc_i / dt^p\} < 1$ which will likely be the case under most reasonable circumstances. Therefore, a tariff reduction at the upstream stage should be matched by a tariff reduction at the downstream stage. In the strategic complements case, the tariff on the processed good imports should be raised if market access is to stay the same as the numerator will be negative. This may seem an unlikely result, but it can be explained. In this multi-market set-up, the tariff reduction in one market has an effect on the related market. In the strategic complements case, competition is pretty aggressive such that reducing tariffs on raw commodity imports would also increase processed good imports. Given our rule aimed at keeping market access constant for both types of goods, this suggests increasing tariffs on processed good imports to offset the pro-competitive externality associated with the tariff reduction in the upstream stage. Note that this did not arise in the case of strategic substitutes as the appropriate APT was to match a reduction in a tariff on the raw commodity with a reduction in the tariff on the processed good as the multi-market effect here was negative. In the strategic complements case, this multi-market effect is positive thus changing the sign of the APT.

Result 2: In the strategic substitute case, the reduction in tariffs on processed good imports should likely be less than the reduction in tariffs on raw imports. This is because the absolute value of $r_2$ is less than 1. The denominator will also be less than 1 under most reasonable circumstances but as long as $r_2 (dc_i / dt^p)$ is not ‘too large’, the APT will be less than $dt'$. In the strategic complement case, the increase in the tariff on the processed import should be less than the reduction in the tariff on the raw good.

Note closely what this result implies. Consider first the strategic substitute case, which is the more intuitive result. What it implies is that to avoid any discriminatory effect between

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8 If there was ‘over-shifting’ of the back-shifting effect and $r_2$ was sufficiently large, then this would reverse the result for the strategic substitutes case.
developing countries, which export food and agricultural products to different stages of the food chain, tariffs on raw commodities and processed goods should be reduced by different amounts. But note that the tariff reduction on the processed good should be reduced by less than the tariff on the raw commodity. In the context of the traditional trade policy literature, tariff escalation should therefore increase to avoid discriminatory effects in terms of market access. In the context of successive oligopoly, with strategic substitutes, tariff escalation is per se not a bad thing as long as both tariffs are reduced. However, in the strategic complements case, tariff escalation should also be an outcome, this time with the reduction on the tariff on the raw commodity matched by an increase in the tariff in the processed good.

5. **Summary and Conclusions**

The aim of this paper has been to consider the implications of the industrial organization of the food sector in developed countries for market access for developing country exporters. To do so, we have attempted to bring together some discordant themes in the literature into a unified framework. Specifically, we have explicitly accounted for the fact that the food sector in developed countries is more appropriately characterized by successive oligopoly. We have also noted that in the context of on-going trade negotiations, that market access considerations for developing country exporters are high on the trade negotiating agenda. In addition, we have also endeavored to accommodate the fact that developing countries export raw and processed goods and that they are constantly being encouraged to up-grade their export portfolio and concentrate less on exports of raw commodities. In this context, we have also accommodated the possibility of tariff escalation in this framework.
Based on a (hypothetical) market access rule aimed at avoiding discriminatory market access between different developing country exporters, we have generated the following results:

(i) changes in tariffs at different stages not only affect tariffs directly at the stage at which they are applied but also affect the imports at the preceding or subsequent stage; (ii) even if tariffs on imported raw commodities and processed goods are reduced by the same amount such that the measure of effective protection stays the same, the impact on market access on imported raw commodities and processed goods will differ; (iii) the extent to which the impact of tariff reductions at each stage differ will depend on the nature of competition, specifically whether we have the strategic substitute or strategic complements case.

Taken together, the results suggest that tariff escalation may be a desirable outcome if discrimination between developing country exporters is not to arise. This result seems at odds with the traditional literature and observations made by commentators of the trade negotiating process. But the result here comes from the fact that we have explicitly accounted for the interaction of tariffs at different stages in the context of a successive oligopoly where policy changes at one stage will impact on the market equilibrium at another. The overall moral of this story is that appropriate consideration of the industrial organization of food markets should be made when considering the outcome of policy reforms. Simple benchmarks that ignore market structure issues may lead to misguided policy outcomes.

Of course, the model presented here is itself, simplified and was employed to highlight a specific issue. There are clear possible extensions in this regard. We mention two in the context of the model we have presented. First, in our model of successive oligopoly, competition occurs ‘horizontally’ and we make no allowance for the range of vertical contracts that link the two stages together. These cover various forms of vertical restraints through to vertical integration.
As is well known to industrial organization economists, these vertical contracts can have pro- or anti-competitive effects and thus, may affect the outcomes presented above. Second, the importers of the raw commodity and processed goods took world prices for these imports as given. There are two additional issues worth exploring here. For example, the foreign importing firm may vertically integrate with the developing country supplier, an issue highlighted by the value-chain approach. Alternatively, the importing firm may have some degree of monopsony power such that terms of trade effects may arise. Each of these may have an impact on determining market access considerations in this set-up. No doubt there are other possibilities, our view here is that exploring the interface between industrial organization and traditional policy issues, in our case here, trade policy will be an area of research deserving further attention.

Finally, the analysis presented here was on the premise of a market access rule consistent with the recent work of Bagwell and Staiger (op. cit.), specifically that trade negotiations are primarily about market access issues. As set up, the rule was aimed at avoiding discriminatory market access for developing countries in the context of trade negotiations. However, market access is often discriminatory in nature reflecting either the bargaining power of certain countries in trade negotiations or even the nature of current trade arrangements. For example, as shown in Table 7, preferential access to developed country markets varies by commodity group. To the extent that the range of preferences varies by country, some developing countries will have more favored market access than others. As such, considering variations to the non-discrimination rule may be of interest in future research, even if confined to fully analyzing the impact of preferential trade arrangements in the context of successively oligopolistic markets.
References


Table 1: Share of World Exports of All Food Items\textsuperscript{1}, 1990-2000 (\%)

<table>
<thead>
<tr>
<th>Country Grouping</th>
<th>1990</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developing</td>
<td>29.2</td>
<td>32.9</td>
</tr>
<tr>
<td>Developed</td>
<td>67.7</td>
<td>64.7</td>
</tr>
<tr>
<td>EU</td>
<td>44.7</td>
<td>40.7</td>
</tr>
<tr>
<td>United States</td>
<td>12.9</td>
<td>12.5</td>
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</table>

Source: UNCTAD (2003). \textsuperscript{1} Defined as SITC codes 0+1+22+4
<table>
<thead>
<tr>
<th>SITC</th>
<th>Developed Countries</th>
<th>Developing Countries</th>
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<tbody>
<tr>
<td>001 Live animals for food</td>
<td>57.17</td>
<td>79.03</td>
</tr>
<tr>
<td>011 Meat, fresh, chilled, frozen</td>
<td>83.59</td>
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<tr>
<td>012 Meat dried, salted, smoked</td>
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Table 3: Share of World Imports by SITC, 1990-2000 (%)

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<th>Developed Countries</th>
<th>Developing Countries</th>
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<td>046</td>
<td>Wheat etc, meal or flour</td>
<td>16.64</td>
</tr>
<tr>
<td>047</td>
<td>Other cereal meals, flour</td>
<td>38.04</td>
</tr>
<tr>
<td>048</td>
<td>Cereal etc preparations</td>
<td>74.07</td>
</tr>
<tr>
<td>054</td>
<td>Vegtb etc fresh, simply prsrvd</td>
<td>81.40</td>
</tr>
<tr>
<td>056</td>
<td>Vegtb etc prsrvd, preprd</td>
<td>75.52</td>
</tr>
<tr>
<td>057</td>
<td>Fruit, nuts, fresh, dried</td>
<td>84.01</td>
</tr>
<tr>
<td>058</td>
<td>Fruit prsrvd, preprd</td>
<td>87.71</td>
</tr>
<tr>
<td>061</td>
<td>Sugar and honey</td>
<td>35.96</td>
</tr>
<tr>
<td>062</td>
<td>Sugar preps non-chocolate</td>
<td>72.15</td>
</tr>
<tr>
<td>071</td>
<td>Coffee and substitutes</td>
<td>88.43</td>
</tr>
<tr>
<td>072</td>
<td>Cocoa</td>
<td>87.81</td>
</tr>
<tr>
<td>073</td>
<td>Chocolate and products</td>
<td>83.85</td>
</tr>
<tr>
<td>074</td>
<td>Tea and mate</td>
<td>35.44</td>
</tr>
<tr>
<td>075</td>
<td>Spices</td>
<td>57.14</td>
</tr>
<tr>
<td>081</td>
<td>Feeding stuff for animals</td>
<td>57.21</td>
</tr>
<tr>
<td>091</td>
<td>Margarine and shortening</td>
<td>57.00</td>
</tr>
<tr>
<td>098</td>
<td>Edible products, preps nes</td>
<td>68.90</td>
</tr>
<tr>
<td>111</td>
<td>Non alcoholic beverages nes</td>
<td>75.26</td>
</tr>
<tr>
<td>112</td>
<td>Alcoholic beverages</td>
<td>86.03</td>
</tr>
<tr>
<td>121</td>
<td>Tobacco, unmanufactd, refuse</td>
<td>77.16</td>
</tr>
<tr>
<td>122</td>
<td>Tobacco, manufactured</td>
<td>51.26</td>
</tr>
<tr>
<td>222</td>
<td>Seeds for soft fixed oils</td>
<td>78.26</td>
</tr>
<tr>
<td>223</td>
<td>Seeds for other fixed oils</td>
<td>69.33</td>
</tr>
<tr>
<td>411</td>
<td>Animal oils and fats</td>
<td>51.42</td>
</tr>
<tr>
<td>423</td>
<td>Fixed vegetable oils, soft</td>
<td>49.42</td>
</tr>
<tr>
<td>424</td>
<td>Other fixed vegetable oils</td>
<td>48.60</td>
</tr>
<tr>
<td>431</td>
<td>Procesd animl and veg oil, etc</td>
<td>63.08</td>
</tr>
</tbody>
</table>

Table 4: Product Concentration Ratios in US Food Manufacturing\(^1\), 1997

<table>
<thead>
<tr>
<th>Product</th>
<th>CR4 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dog and cat food mfg.</td>
<td>63.4</td>
</tr>
<tr>
<td>Malt mfg.</td>
<td>66.5</td>
</tr>
<tr>
<td>Wet corn milling</td>
<td>73.7</td>
</tr>
<tr>
<td>Soybean processing</td>
<td>73.4</td>
</tr>
<tr>
<td>Other oilseed processing</td>
<td>72.7</td>
</tr>
<tr>
<td>Breakfast cereal mfg.</td>
<td>86.7</td>
</tr>
<tr>
<td>Sugar cane mills</td>
<td>61.8</td>
</tr>
<tr>
<td>Cane sugar refining</td>
<td>96.4</td>
</tr>
<tr>
<td>Beet sugar mfg.</td>
<td>82.7</td>
</tr>
<tr>
<td>Chocolate and confectionary mfg.</td>
<td>86.6</td>
</tr>
<tr>
<td>Condensed/evaporated dairy mfg.</td>
<td>68.8</td>
</tr>
<tr>
<td>Cookie and cracker mfg.</td>
<td>64.6</td>
</tr>
<tr>
<td>Snack food mfg.</td>
<td>63.0</td>
</tr>
<tr>
<td>Brewing</td>
<td>90.7</td>
</tr>
<tr>
<td>Distilling</td>
<td>64.8</td>
</tr>
<tr>
<td>Cigarettes</td>
<td>98.0</td>
</tr>
<tr>
<td>Average</td>
<td>75.9</td>
</tr>
</tbody>
</table>

Source: US Census Bureau, 2001. \(^1\) Share of value added accounted for by the 4 largest firms.
### Table 5: Concentration Ratios\(^1\) by Product in EU Countries

<table>
<thead>
<tr>
<th>Product</th>
<th>Ireland</th>
<th>Finland</th>
<th>Sweden</th>
<th>Denmark</th>
<th>Italy</th>
<th>France</th>
<th>Spain</th>
<th>UK</th>
<th>Germany</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baby food</td>
<td>98</td>
<td>100</td>
<td>100</td>
<td>99</td>
<td>96</td>
<td>93*</td>
<td>54</td>
<td>78</td>
<td>86</td>
<td>91</td>
</tr>
<tr>
<td>Canned soup</td>
<td>100</td>
<td>85</td>
<td>75</td>
<td>91</td>
<td>50</td>
<td>84</td>
<td>--</td>
<td>79</td>
<td>41*</td>
<td>87</td>
</tr>
<tr>
<td>Ice cream</td>
<td>--</td>
<td>84</td>
<td>85</td>
<td>90</td>
<td>73*</td>
<td>52</td>
<td>84</td>
<td>45</td>
<td>72</td>
<td>76</td>
</tr>
<tr>
<td>Coffee</td>
<td>91</td>
<td>72</td>
<td>71</td>
<td>70</td>
<td>60</td>
<td>100</td>
<td>--</td>
<td>74</td>
<td>67</td>
<td>75</td>
</tr>
<tr>
<td>Yoghurt</td>
<td>69</td>
<td>83*</td>
<td>90</td>
<td>99*</td>
<td>36</td>
<td>67</td>
<td>73</td>
<td>50</td>
<td>76</td>
<td>70</td>
</tr>
<tr>
<td>Chocolate confectionary</td>
<td>95</td>
<td>74</td>
<td>--</td>
<td>39</td>
<td>93</td>
<td>61</td>
<td>79</td>
<td>74</td>
<td>--</td>
<td>74</td>
</tr>
<tr>
<td>Pet food</td>
<td>98</td>
<td>80</td>
<td>84</td>
<td>40</td>
<td>64*</td>
<td>73</td>
<td>53</td>
<td>77</td>
<td>87</td>
<td>79</td>
</tr>
<tr>
<td>Breakfast</td>
<td>92</td>
<td>--</td>
<td>52</td>
<td>70</td>
<td>88</td>
<td>70</td>
<td>82</td>
<td>65</td>
<td>67</td>
<td>73</td>
</tr>
<tr>
<td>Tea</td>
<td>96</td>
<td>90</td>
<td>63</td>
<td>64</td>
<td>80</td>
<td>82</td>
<td>62</td>
<td>52</td>
<td>55</td>
<td>72</td>
</tr>
<tr>
<td>Snack foods</td>
<td>72</td>
<td>70*</td>
<td>80</td>
<td>78</td>
<td>71</td>
<td>50</td>
<td>56</td>
<td>73</td>
<td>48</td>
<td>68</td>
</tr>
<tr>
<td>Carbonates</td>
<td>85</td>
<td>50</td>
<td>62</td>
<td>--</td>
<td>60</td>
<td>69</td>
<td>79</td>
<td>55</td>
<td>60*</td>
<td>71</td>
</tr>
<tr>
<td>Butter</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>100</td>
<td>--</td>
<td>32*</td>
<td>--</td>
<td>65</td>
<td>30</td>
<td>65</td>
</tr>
<tr>
<td>Pasta</td>
<td>83</td>
<td>97</td>
<td>82</td>
<td>61</td>
<td>51</td>
<td>57</td>
<td>65</td>
<td>37</td>
<td>49</td>
<td>65</td>
</tr>
<tr>
<td>Frozen meals</td>
<td>--</td>
<td>--</td>
<td>63</td>
<td>--</td>
<td>90</td>
<td>62</td>
<td>39</td>
<td>39</td>
<td>65</td>
<td>62</td>
</tr>
<tr>
<td>Wrapped bread</td>
<td>85</td>
<td>44</td>
<td>47</td>
<td>59</td>
<td>80</td>
<td>70</td>
<td>96</td>
<td>58*</td>
<td>9</td>
<td>59</td>
</tr>
<tr>
<td>Biscuits</td>
<td>83</td>
<td>73</td>
<td>51</td>
<td>44</td>
<td>55</td>
<td>61</td>
<td>53</td>
<td>42</td>
<td>50</td>
<td>58</td>
</tr>
<tr>
<td>Canned fish</td>
<td>--</td>
<td>70</td>
<td>72</td>
<td>49</td>
<td>68</td>
<td>43*</td>
<td>33</td>
<td>43*</td>
<td>--</td>
<td>55</td>
</tr>
<tr>
<td>Mineral water fruit</td>
<td>--</td>
<td>100</td>
<td>74</td>
<td>70</td>
<td>37</td>
<td>--</td>
<td>31</td>
<td>14</td>
<td>22</td>
<td>50</td>
</tr>
<tr>
<td>Juice</td>
<td>--</td>
<td>70</td>
<td>50</td>
<td>65*</td>
<td>62</td>
<td>26</td>
<td>38</td>
<td>35</td>
<td>46</td>
<td>48</td>
</tr>
<tr>
<td>Canned vegetables</td>
<td>--</td>
<td>68</td>
<td>47</td>
<td>50</td>
<td>36</td>
<td>29</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>47</td>
</tr>
<tr>
<td>Average</td>
<td>89</td>
<td>79</td>
<td>69</td>
<td>69</td>
<td>67</td>
<td>63</td>
<td>61</td>
<td>56</td>
<td>55</td>
<td>68</td>
</tr>
</tbody>
</table>

Source: Cotterill (1999). \(^1\) 3-firm concentration ratios, except * which are 2-firm.

### Table 6: Seller Concentration in US and EU Food Retailing, 1990s

<table>
<thead>
<tr>
<th>Country</th>
<th>CR5 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>79</td>
</tr>
<tr>
<td>Belgium-Luxembourg</td>
<td>57</td>
</tr>
<tr>
<td>Denmark</td>
<td>78</td>
</tr>
<tr>
<td>Finland</td>
<td>96</td>
</tr>
<tr>
<td>France</td>
<td>67</td>
</tr>
<tr>
<td>Germany</td>
<td>75</td>
</tr>
<tr>
<td>Greece</td>
<td>59</td>
</tr>
<tr>
<td>Ireland</td>
<td>50</td>
</tr>
<tr>
<td>Italy</td>
<td>30</td>
</tr>
<tr>
<td>Netherlands</td>
<td>79</td>
</tr>
<tr>
<td>Portugal</td>
<td>52</td>
</tr>
<tr>
<td>Spain</td>
<td>38</td>
</tr>
<tr>
<td>Sweden</td>
<td>87</td>
</tr>
<tr>
<td>UK</td>
<td>67</td>
</tr>
<tr>
<td>EU</td>
<td>26</td>
</tr>
<tr>
<td>United States</td>
<td>35</td>
</tr>
</tbody>
</table>

Source: Cotterill (1999), McCorriston (2002), and Hughes (2002).
### Table 7: Tariff Peaks and Preferential Access in the EU and United States

<table>
<thead>
<tr>
<th>HS 2-digit Product</th>
<th>EU Average MFN tariff (%)</th>
<th>EU LDC preference$^1$</th>
<th>United States Average MFN tariff (%)</th>
<th>United States LDC preference$^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Live animals.</td>
<td>38.2</td>
<td>0.06</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>02 Meat and edible meat offal</td>
<td>71.0</td>
<td>0.08</td>
<td>19.2</td>
<td>0.00</td>
</tr>
<tr>
<td>03 Fish &amp; crustacean, mollusk nes</td>
<td>18.7</td>
<td>1.00</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>04 Dairy prod; birds’ eggs; honey</td>
<td>59.1</td>
<td>0.12</td>
<td>20.9</td>
<td>0.38</td>
</tr>
<tr>
<td>07 Edible vegetables and roots &amp; tubers</td>
<td>25.4</td>
<td>0.79</td>
<td>20.6</td>
<td>0.88</td>
</tr>
<tr>
<td>08 Edible fruit and nuts; melons</td>
<td>20.2</td>
<td>0.66</td>
<td>16.7</td>
<td>0.80</td>
</tr>
<tr>
<td>09 Coffee, tea, mate and spices</td>
<td>16.0</td>
<td>0.50</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>10 Cereals.</td>
<td>75.6</td>
<td>0.06</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>11 Prod mill indust; malt; starches</td>
<td>38.2</td>
<td>0.17</td>
<td>16.3</td>
<td>1.00</td>
</tr>
<tr>
<td>12 Oil seed, oleagi fruits; misc grain</td>
<td>74.4</td>
<td>0.15</td>
<td>77.9</td>
<td>0.00</td>
</tr>
<tr>
<td>13 Lac; gums, resins &amp; other veg</td>
<td>17.8</td>
<td>1.00</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>15 Animal/veg fats &amp; oils &amp; prod</td>
<td>56.0</td>
<td>0.60</td>
<td>19.9</td>
<td>0.50</td>
</tr>
<tr>
<td>16 Prep of meat, fish or mollusks</td>
<td>23.5</td>
<td>0.68</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>17 Sugars and sugar confectionery</td>
<td>37.6</td>
<td>0.14</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>18 Cocoa and cocoa preparations</td>
<td>24.0</td>
<td>0.25</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>19 Prep of cereal, flour, starch/milk prod</td>
<td>34.1</td>
<td>0.37</td>
<td>16.8</td>
<td>0.84</td>
</tr>
<tr>
<td>20 Prep of vegetable, fruit, nuts prod</td>
<td>26.1</td>
<td>0.88</td>
<td>28.7</td>
<td>0.55</td>
</tr>
<tr>
<td>21 Miscellaneous edible preparations</td>
<td>19.2</td>
<td>0.95</td>
<td>19.8</td>
<td>0.74</td>
</tr>
<tr>
<td>22 Beverages, spirits and vinegar</td>
<td>35.7</td>
<td>0.71</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>24 Tobacco and manufactured</td>
<td>56.2</td>
<td>1.00</td>
<td>73.5</td>
<td>0.14</td>
</tr>
<tr>
<td>Average</td>
<td>38.3</td>
<td>0.50</td>
<td>30.0</td>
<td>0.53</td>
</tr>
</tbody>
</table>

Source: Hoekman, Ng, and Olarreaga (2002). $^1$ A value of 1.00 implies imports enter duty free.
Table 8: Levels of Tariff Escalation by Highest Group Post-Uruguay Round

<table>
<thead>
<tr>
<th>Commodity Group</th>
<th>Processing Stage</th>
<th>Level of Tariff Escalation (%)</th>
<th>Reduction in Tariff Escalation Post-Uruguay Round (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dairy and Egg Products</td>
<td>2nd Stage</td>
<td>39.5</td>
<td>-7.0</td>
</tr>
<tr>
<td>Dairy and Egg Products</td>
<td>1st Stage</td>
<td>33.6</td>
<td>-6.1</td>
</tr>
<tr>
<td>Sugar Products and Sweeteners</td>
<td>1st Stage</td>
<td>31.2</td>
<td>-4.9</td>
</tr>
<tr>
<td>Sugar Products and Sweeteners</td>
<td>2nd Stage</td>
<td>27.7</td>
<td>-1.1</td>
</tr>
<tr>
<td>Dairy and Egg Products</td>
<td>3rd Stage</td>
<td>15.6</td>
<td>-2.6</td>
</tr>
<tr>
<td>EU</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit Products</td>
<td>2nd Stage</td>
<td>84.8</td>
<td>-17.7</td>
</tr>
<tr>
<td>Sugar products and Sweeteners</td>
<td>4th Stage</td>
<td>37.2</td>
<td>-2.6</td>
</tr>
<tr>
<td>Dairy and Egg Products</td>
<td>2nd Stage</td>
<td>34.4</td>
<td>-17.3</td>
</tr>
<tr>
<td>Root and Tuber Products</td>
<td>1st Stage</td>
<td>19.8</td>
<td>-11.2</td>
</tr>
<tr>
<td>Tobacco and Pyrethrum</td>
<td>1st Stage</td>
<td>14.1</td>
<td>-23.1</td>
</tr>
<tr>
<td>Japan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dairy and Egg Products</td>
<td>2nd Stage</td>
<td>160.1</td>
<td>-32.8</td>
</tr>
<tr>
<td>Sugar Products and Sweeteners</td>
<td>1st Stage</td>
<td>82.2</td>
<td>-14.8</td>
</tr>
<tr>
<td>Root and Tuber Products</td>
<td>1st Stage</td>
<td>50.3</td>
<td>-10.8</td>
</tr>
<tr>
<td>Hides and Skins</td>
<td>3rd Stage</td>
<td>30.0</td>
<td>-30.0</td>
</tr>
<tr>
<td>Dairy and Egg Products</td>
<td>1st Stage</td>
<td>29.1</td>
<td>-7.7</td>
</tr>
</tbody>
</table>

Source: Lindland (1998)
Figure 1: Schematic Outline of the Model

Retail Demand Curve

Firm 1

Firm 1 (Upstream)

Domestic Agricultural Sector

Firm 2

Firm 2 (Upstream)

Imports (semi-) processed good from LDC

Imports raw commodity from LDC
INTERNATIONAL PRICE FIXING:
RESURGENCE AND DETERRENCE

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Presented at the American Agricultural Law Association annual meeting, Indianapolis, IN, October 26, 2002 and a Purdue University seminar September 18, 2002. Revised for submission to the Antitrust Law Journal in December 2002. The author thanks Robert H. Lande, Valerie Suslow, and participants in the above-mentioned presentations for their encouragement and constructive suggestions. Please do not quote without the author’s permission.
Introduction

In a classic article on U.S. antitrust penalties for price-fixing violations, Robert H. Lande noted three controversies concerning the Sherman Act’s mandatory treble-damages feature for civil suits.¹ First, some believe that the automatic trebling of damages should be reserved for only certain types of antitrust violations, in particular those illegal activities that are hidden, costly for plaintiffs to detect, and expensive for plaintiffs to pursue in the courts. In this view, treble damages may be justified for price-fixing and bid-rigging cases but should not be applied in merger or monopoly cases because the latter are easy to detect. Second, there is the question of standing for indirect purchasers of goods that carry a monopoly overcharge. This issue, about which discussion has intensified since the Supreme Court’s *Illinois Brick* decision in 1977, turns critically on the size of damage multipliers. Supporters of the Court’s reasoning note that extending standing to indirect buyers in federal courts would imply automatic six fold damages or greater. For example, if a manufactured chemical is sold to other manufacturers as an ingredient, and the final product is then sold to a wholesale distributor, and later to a retailer before being purchased by the final consumer, then automatic trebling would result in recovery of twelve fold damages from an effective price-fixing conspiracy by the chemical manufacturers. Twelve fold damages are regarded by many antitrust scholars as clearly excessive from a compensatory point of view, especially as the three stages of commercial intermediaries between the conspirators and consumers may well have passed on 100% of the overcharge created by the conspiracy. Critics of the Court’s *Illinois Brick* decision might well regard twelve fold damages as justified by its deterrence value. Third, some legal scholars have taken the view that automatic treble damages might cause some judges to become biased in favor of antitrust defendants. Except in the most egregious cases of flagrantly illegal antitrust infractions, some jurists may consider punitive awards to be an unjust enrichment of antitrust victims.

The issues outlined by Lande continued to be raised by antitrust writers in the last decade. More importantly, the appearance of a wave of global cartels in the late 1990s and their prosecution raises a

number of legal issues concerning compensation and deterrence that Lande did not contemplate. First, there was no consideration of government fines for price-fixing violations, which is quite understandable because prior to 1996 fines were negligible. As will be explained in this paper, fines imposed by government antitrust agencies in Europe and North America since 1995 have reached levels that could have significant deterrence effects. Second, the truly global scope of many of the cartels also has implications for effective price-fixing sanctions because the geographically broad source of monopoly profits changes the benefit/cost calculus of would-be cartelists. Third, the effectiveness of private federal treble-damages civil suits seems to have improved for plaintiffs in the last decade. And fourth, the likelihood of compensation for indirect buyers has increased because of the aggressive prosecution of price fixing by the state attorneys general under Section 4C of the Sherman Act.

The principal purpose of this paper is to examine the implications of the pandemic of global cartels for the effectiveness of antitrust sanctions.3

Background

International private cartels are at least 125 years old.4 The German-Swiss dyestuffs cartel that was established around 1880 is a prototype for the late 19th century international cartels. It was an amalgamation of two pre-existing national cartels that through predatory behavior against smaller producers in the UK, France, and Italy was able to ensure Western European dominance for its Swiss and German members. Word War I destroyed international cartels of this type, though most of them were re-established in the 1920s.

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3 I do not consider several factors analyzed by Lande supra note 1, such as the time value of money, tax savings by defendants, umbrella pricing effects, and legal and judicial costs.

4 Harm G Schröter, Cartelization and Decartelization in Europe, 1870-1995, 25 J. EUROPEAN ECON. HIST., 129(1999) (traces the development of international cartels in Europe to the 1880s depression). Many cartels, such as the Hansa League and the Organization of Petroleum Exporting Countries (OPEC), operated under the protection of state sovereignty. Other commodity-stabilization cartels are effectively parastatal organizations. This paper discusses only cartel that are not sanctioned by law or protected by government agencies.
The interwar cartels were more ambitious in scope, often incorporating agreements with U.S. manufacturers that divided the markets of Western Europe, Africa, and the New World into two hegemonies. By this time the United States had an effective anticartel law, the Sherman Act of 1890, that made U.S producers wary of joining formed price-fixing agreements with European firms. Many U.S. firms may have believed that cartel arrangements that merely created spheres of influence were legal under the Sherman Act, but events would prove them wrong. From 1946 to 1950, a crusading U.S. Attorney General made the criminal prosecution of scores of these interwar cartels his highest priority. Aided by public revulsion about the assistance given by these cartels to the rise of National Socialism and the rearming of Germany during 1933-1941, the U.S. government enjoyed a long string of successes in the courts.\(^5\) The court victories apparently chilled the formation of international cartels for the next 40 years.\(^6\)

The international cartels discovered and prosecuted since 1995 are qualitatively different from those operating in the interwar period. They are truly global cartels and as such represent the ultimate product of the evolution of the cartel as a form of business enterprise.\(^7\) Contemporary international cartels incorporate a refinement of operational techniques, a global perspective, a multicultural pluralism, a leadership style, a degree of longevity, and a scale of operation that the world has never before seen. Needless to say, global cartels are also the most injurious price fixing ventures yet devised, causing massive losses in market efficiency, losses in income for customers, and losses in faith in the honesty of businessmen\(^8\) and the integrity of market institutions.

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\(^5\) An excellent historical treatment of the international spread of the antitrust idea is in Wyatt Wells, *Antitrust and the Formation of the Postwar World* (Columbia Univ. Press 2002).

\(^6\) The U.S. government attempted to prosecute only three international cartels during 1990-1996, but it was unsuccessful in court because of the difficulty of securing evidence and witnesses outside the United States.

\(^7\) To be more precise, the global cartels of the 1990s had as their goal raising prices in at least North America, Western Europe, and Japan – a group called “the Triad” in the marketing management literature. Typically, these cartels sought price control in all industrialized countries.

\(^8\) I use this gender-laden term purposefully. Among the hundreds of businesspersons named as conspirators in the 39 global cartels I have studied, only one (the CEO of Sotheby’s auction house) is a woman.
The behavior of global cartelists has scandalized the public and provoked the world’s major antitrust agencies to impose unprecedented sanctions.\textsuperscript{9} Beginning with the announcement of the U.S. investigation of the lysine cartel in July 1995, literally thousands of articles have appeared in newspapers and magazines around the world that have covered the machinations of about 30 known global cartels. Three books have been published on the subject two Hollywood movies have or will appear.\textsuperscript{10} Global cartels have become a major focus of antitrust agencies, which have imposed “titanic fines” ($2 billion by the United States, €1.8 billion by the European Union) that have “dwarfed” the actions taken against previously convicted price-fixing conspiracies.\textsuperscript{11} Prior to 1995, U.S. prosecution of foreign companies or persons for price fixing was practically unknown, but since then 50 to 70 percent of the companies indicted by the U.S. Department of Justice have been foreign; moreover, the DOJ has convicted cartel executives from 12 foreign countries, sending many to prison.\textsuperscript{12} International cartels successfully prosecuted by the U.S. DOJ have affected markets with more than $55 billion in sales.\textsuperscript{13}

**Economics of Cartels**

A cartel is an association of two or more legally independent entities that explicitly agree to coordinate their prices or output for the purpose of increasing their collective profits. Some cartels are organized by state agencies or government-owned corporations; other cartels have been formed by multilateral treaties to attempt to smooth commodity price cycles. This paper is concerned only with private business cartels that operate unprotected by the cloak of national sovereignty.

Economics views cartels as a special type of oligopoly, an extra-legal joint venture of businesses that are normally rivals in the same industry. The mission of a cartel is to increase the joint profits of its

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\textsuperscript{9} Scott D. Hammond, *From Hollywood to Hong Kong – Criminal Antitrust Enforcement Is Coming to a City Near You*, address at the Antitrust Beyond Borders conference, Chicago, Illinois (November 9, 2001).

\textsuperscript{10} James B. Lieber, *Rats in the Grain* (Four Windows Eight Walls 2000); Kurt Eichenwald, *The Informant* (Broadway Books 2000); and Connor *op. cit.* are the books. The movies are *Anti-Trust* and *The Informant*.

\textsuperscript{11} Hammond *supra* note 9.

\textsuperscript{12} In 2000-2002, the EC fined 42 companies that were guilty of global price fixing, and 23 (55 percent) were non-EU firms.

members to a level as close as possible to that that a monopolist would earn; the strategy of a cartel is to implement one or more the “restrictive business practices” popularly known as price fixing. Cartels almost always agree to raise their list prices, to lower total production, or both; they may also reinforce this basic decision by fixing market shares for each member, allocating specific customers, imposing uniform selling conditions, sharing sales information, monitoring price agreements, pooling and redistributing profits, adopting a method for punishing deviants, and hiding or destroying evidence of their activities. The time and management resources required to negotiate the formation of a cartel and to carry out the agreements can be substantial.

Economic models of cartels emphasize the necessity of high concentration and of product homogeneity in an industry. Without small numbers of member-sellers and reasonably standardized products, the transactions costs of forming and maintaining a group consensus would become too high relative to the anticipated increase in profits. Moreover, because there is always a profit incentive for cartel members to cheat on the cartel’s agreement (i.e., to sell more or at a lower price than that agreed upon), only small numbers and homogeneity will keep the information costs of detecting cheating within acceptable bounds. Other conditions believed to facilitate the formation or successful operation of cartels include a large numbers of buyers, a small amount of noncartel production capacity, equality of production costs across firms, and relatively stable or predictable demand conditions. High barriers to entry into the industry will facilitate the formation and longevity of cartel agreements.

**Law of Price Fixing**

Section 1 of the 1890 Sherman Act deems cartels *per se* illegal. That is, an explicit agreement to fix prices is a “conspiracy in restraint of trade,” irrespective of the agreement’s actual impacts on market prices or output. Outside the United States, the competition laws of most industrialized nations judge the illegality of a cartel under the rule of reason. In practice, however, non-U.S. competition-law agencies

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routinely prosecute all naked cartels that they discover. In the EU rare exceptions are made for cartels with significant benefits for consumers from technological innovation. Many countries, the United States included, permit registered export cartels to operate.

Strict enforcement of laws against overt price fixing is a public policy widely supported by economists and legal scholars of all stripes. They may differ as to the causes giving rise to collusive behavior and as to the likelihood of long-term success, but they are unified in their evaluation of the negative economic effects of cartels. Effective cartels cause unrecoverable losses in production and consumption, transfer income from customers to the stakeholders of cartel members, and often engage in socially wasteful rent-seeking expenditures.

Products

The food and agricultural cartels of the 1990s share a number of common economic characteristics. However, this paper will focus on the economic dimensions and legal prosecution of four cartels for which the documentation is particularly rich. They are lysine, citric acid, and vitamins A and E.

Lysine is an essential amino acid, a building block of proteins that speed the development of muscle tissue in humans and animals. The form of lysine that we cartelized in the 1990s is a dry powder manufactured by a fermentation process and purchased by manufacturers of prepared animal feeds. Citric acid is an acidulant added to thousands of processed foods and beverages to enhance flavor and retard bacterial growth; a minor portion of industry output is used as an ingredient to replace phosphates in detergents. Citric acid is sold in two forms: a diluted aqueous form shipped in tanks and a dry salt form, usually sodium citrate. Since 1923, citric acid has been manufactured by a fermentation biotechnology. Vitamins A and E are two of about 15 commercially important vitamins or provitamins, proteins found

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15 The optimization problem facing a cartel management committee is formally the same as that facing a monopolist with multiple production locations. In stagnant or declining industries excess capacity may develop that could be ameliorated through merger or cartel-formation. Thus, it is theoretically possible that multi-plant economies could compensate for the net social losses from collusion, but such a scenario seems remote and unsupported by empirical evidence.
naturally in foods that become catalysts in regulating the metabolic functions of humans and animals. Diets deficient in vitamins will cause diseases or functional impairments. Most bulk vitamins are sold to feed manufacturers; food-grade vitamins are added to many processed foods and minor portions are sold to the pharmaceutical industry. Vitamins have been made by synthetic chemistry since the early 1930s, and this is now by far the dominant method of manufacture.\textsuperscript{16}

Brief mention is made of a few additional food-and-agricultural products that were cartelized in the 1990s. Methionine is an amino acid added to animal feeds, swine in particular. Monosodium glutamate (MSG) and nucleotides are amino acids that enhance flavors of foods. Maltol, sodium erythorbate, and sorbates are chemical food additives that flavor or preserve foods. MCAA (monochloroacetic acid) and organic peroxides are chemical intermediates used to produce pesticides. What is strikingly common to all these products is that each of them are minor ingredients or components of more complex mixtures further processed by large numbers of manufacturer-buyers. This characteristic helps facilitate collusion by ensuring highly inelastic demand. In addition, market price information is both poor for buyers and asymmetric. That is, suppliers tend to be better informed than buyers about market conditions and average transaction prices, which gives suppliers advantages in forcing price changes.

\textbf{Market Structure}

The market environments for the lysine, citric acid, vitamins, and other global cartels discussed in this paper made possible and indeed fostered collusive price-fixing behavior by the leading firms in the industry. Two industry features tower above all the others in importance because they are absolutely necessary conditions for cartels to be formed and flourish: high seller market sales concentration and product homogeneity. High barriers to market entry are icing on the cake: with them cartels will be durable, without them new sellers will enter the industry and in time make cooperation in pricing a thing of the past. The remaining structural features of markets shown in Table 1 may be called “plus factors.”

\textsuperscript{16} For more detailed information on the uses, technologies of production, and marketing channels for lysine, citric acid, and vitamins, see Chapters 4, 7, and 10 of Connor supra note 2.
The plus factors are not necessary conditions for the formation of cartels, but they do facilitate the establishment of price agreements and increase the probability of serious price effects.

Table 1. Economic Conditions Facilitating Global Price Fixing: Lysine, Citric Acid, and Vitamin A, Early 1990s.

<table>
<thead>
<tr>
<th>Market Conditions</th>
<th>Lysine</th>
<th>Citric Acid</th>
<th>Synthetic Vitamins A &amp; E</th>
</tr>
</thead>
<tbody>
<tr>
<td>High seller concentration:</td>
<td>CR4 &gt; 95%</td>
<td>CR4 &gt; 80%</td>
<td>CR4 &gt; 95%</td>
</tr>
<tr>
<td>Global market</td>
<td>CR4 &gt; 97%</td>
<td>CR4 = 90%</td>
<td>CR4 = 100%</td>
</tr>
<tr>
<td>U.S. market</td>
<td>4 or 5</td>
<td>4 or 5</td>
<td>3</td>
</tr>
<tr>
<td>Few cartel participants</td>
<td>95-99%</td>
<td>65-70%</td>
<td>95-100%</td>
</tr>
<tr>
<td>High cartel supply control</td>
<td>CR4 &lt; 30%</td>
<td>CR4 &lt; 40%</td>
<td>CR4 &lt; 20%</td>
</tr>
<tr>
<td>Low buyer concentration</td>
<td>Perfect</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Homogeneous product(a)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High barriers to market entry:</td>
<td>$150 mil.+</td>
<td>$150 mil.</td>
<td>Probably</td>
</tr>
<tr>
<td>Large plant scales</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sunk investment costs</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Technology secret</td>
<td>3 years+</td>
<td>3 years+</td>
<td>3 years+</td>
</tr>
<tr>
<td>Building new plants slow</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transparency of market prices to buyers</td>
<td>None</td>
<td>Some</td>
<td>Little</td>
</tr>
<tr>
<td>Large, infrequent transactions</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Major rivals have long history of</td>
<td>3 of 5</td>
<td>3 of 5</td>
<td>Yes(c)</td>
</tr>
<tr>
<td>strategic interaction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual market growth</td>
<td>10%, steady</td>
<td>8%, steady</td>
<td>2-3%, steady</td>
</tr>
<tr>
<td>Cultural propinquity of cartel members</td>
<td>Low</td>
<td>Moderate</td>
<td>High(c)</td>
</tr>
</tbody>
</table>

Sources: Chapters 4, 7, and 10 of Connor supra note 2.
CR4 = Sum of the market shares of the top four suppliers or buyers.
\(a\) Within well recognized industry grades when prices were at cartel-enhanced levels. There were no substitutes when prices were within a normal range.
\(b\) Control by formal members of the cartel. Cargill, a major supplier with up to 20 percent of U.S. capacity, provided passive support for the cartel's pricing decisions.
\(c\) The vitamin conspirators were long time rivals from Western Europe, but in most of the other vitamin cartels Japanese or Northern American companies had to be recruited to the cartels.
Collusive Conduct

There are many specific actions encompassed by the idea of restrictive business practices. The behaviors of the three global cartels featured in this book illustrate nearly all the 24 specific restraints of trade associated with cartels (Table 2). Under the category of setting common prices, all the techniques employed by historical cartels were practiced by the three food-and-feed-ingredient cartels except setting precise transaction prices. However, transaction prices were indirectly set by the cartels because spot purchases were made at list prices and contract prices typically tracked slightly below list prices.

Only a few tactics were not tried by the cartels discussed in this paper. Although no overt agreements were known to have been made on restricting plant investments, evidence in the lysine cartel indicates that expansion rates slowed markedly during the peak years of conspiracy as the higher prices choked off some demand growth. Under the enforcement methods category, none of the three cartels was reported to have employed a trigger-price mechanism or pooled their sales through a common agency.

Costs of Collusion

Many economists, especially those of the Chicago School of industrial-organization economics, assert that the real-world incidence of cartels is low and that their lives are fleeting. These theorists base their predictions on what they believe are insuperable costs of achieving and maintaining a collusive contract, a type of agreement not enforceable by law.\(^\text{17}\) These contracting costs include agreeing on uniform prices or a reduction in output, agreeing to accept firm-specific reductions in production, monitoring adherence to the price or output decisions, developing a method of punishing cheaters, and redistributing the monopoly profits. Unfortunately, the history of the lysine cartel and related global cartels prosecuted in the late 1990s does not support this sanguine view.

Internal memorandums and extensive trial testimony by cartel participants confirm that the conspirators reasonably anticipated that the rewards from price fixing would far outweigh the costs of operating the cartel. At a key meeting in late 1992, a top ADM official predicted that their recently

concluded agreement would generate $200 million in joint profits in a global market for lysine that varied from $500 to $700 million in annual sales. His prediction, from ADM’s perspective, was spot on; ADM would earn just about $200 million in profits from the cartel over three years with its one-third share of sales in the worldwide lysine market.

Direct management costs of operating the cartel were modest. During the four years of preliminary negotiations and actual cartel operation, each of the four (later five) companies sent two men to meetings held on average once every three months. Late in the conspiracy, regional sales managers became involved, but the total number of conspirators never exceeded 40.\textsuperscript{18} Counting the monthly production reports submitted by each firm and other communications, it appears that each corporate member of the cartel managed the conspiracy with an input of 15 to 25 man-days per year. Total labor costs for all corporate conspirators could not have exceeded $1 million for the entire conspiracy period.

Table 2. Restraints of Trade in the Lysine, Citric Acid, and Vitamins Cartels.

<table>
<thead>
<tr>
<th>Types of Collusive Behavior</th>
<th>Lysine</th>
<th>Citric Acid</th>
<th>Vitamins</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Setting Common Prices:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. List price agreement</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2. Transaction price agreement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Agreement on customer discounts</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>4. Agreement on price-protection clauses</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Rigging bids</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><strong>Setting Company Market Shares:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Global sales shares</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>7. Global quantity shares</td>
<td>X</td>
<td></td>
<td>?</td>
</tr>
<tr>
<td>8. Regional or national shares</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>9. Allocating specific customers</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><strong>Setting Production Limits:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Global output reductions$^a$</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. On exports to specific destinations</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>12. On arbitrage by buyers</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>13. On production capacities</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Monitoring the Illegal Agreements:

14. Reporting company production data
15. Sales certification by third parties
16. Inspection of plant records or inventories on site

Cartel Enforcement Methods:

17. Trigger price mechanism
18. Dominant firm threatened excess production
19. Periodic compensation for under-share members
20. Marketing agency for pooling of sales
21. Pooling and division of profits

Cover-up Efforts:

22. Create or exploit an industry trade association
23. Hide evidence of travel, meetings, or communications
24. Employ code words or code names

Source: Chapters 5, 8, and 11 of Connor supra note 2 and Kolasky supra note 13.

X = Behavior observed or highly probable in cartel above.
? = Some unconfirmed reports of such behavior.
\textsuperscript{a} Production limits are set below historical rates of growth in the market.

It is certainly true that the cartel members squabbled frequently and that the two smallest members, both South Korean companies, were strongly inclined to cheat on the price and market-share agreements. Infighting led to one sharp price war for a few months in 1993, the second year of the conspiracy. This brief war cost the cartel two or three months of monopoly profits, but it reminded the smaller members of the cartel of why they had joined the cartel in the first place. The lysine cartel was clearly more disciplined in the two years after the brief price war than the first seven or eight months of the conspiracy.

A number of techniques adopted by the cartel and the impressive diplomatic skills of the cartel’s dual leaders, ADM and Ajinomoto, kept the effects of cheating to tolerable levels. Among the most important practices that cemented cartel harmony was the tonnage quotas agreed upon in late 1993. Combined with accurate monthly sales reports and politic concessions of additional quotas to the two Korean firms, the market-share agreements would be honored with impressive precision throughout 1994 and 1995. The formation of an amino acid trade association under European Commission sponsorship
provided excellent cover for the group’s illegal meetings in Europe and elsewhere. A compensation system was adopted to punish members that exceeded their quotas, but it was never necessary to implement the scheme. ADM, with its new efficient plant and ample excess capacity, frequently reminded the cartel of its willingness to flood the market with lysine; its threats were credible because it had twice driven the world price of lysine to below its own average total cost of production, inflicting the others with operating losses. Moreover, ADM had taken the rare step of inviting its rivals in the lysine market to an intimate tour of its capacious production facilities. Finally, it should be recalled that for the three largest Asian companies in the 1992-1995 cartel, they had had a great deal of experience in organizing price-fixing schemes for two decades. ADM too, it is now known, was a serial price fixer.

**Performance: Market Effects**

The global food-and-feed cartels of the 1990s achieved their goals brilliantly. During the conspiracy periods, the cartel managers were able to perform market magic. They raised the transaction prices of their companies’ products simultaneously nearly everywhere in the world to levels well above the economic costs of production and distribution, thereby expanding the pool of industry profits to levels that were several times what natural market forces would have yielded. What a thrill it must have been to these salesmen to manipulate markets that formerly had been mere constraints on their pricing discretion.

At the same time, their customers were faced with substantial price increases that no amount of searching, bargaining, and negotiating would lower. In many cases, the food and feed manufacturers that purchased the cartelized products found that only one supplier would deign to negotiate a deal. Even the largest buyers, long used to getting concessions on list prices or other terms of sale, found that no amount of negotiations would yield favorable discounts from the world’s suppliers. All the offers were suddenly identical.

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19 ADM conspired to fix prices in the markets for sodium gluconate and citric acid; highly possible cases include corn sweeteners, monosodium glutamate, methionine, other nucleotides, carbon dioxide gas, and wine alcohol.
Customers of effective sellers’ cartels are negatively affected in two ways. First, and quantitatively larger, purchasers of cartelized products overpay for the goods they continue to buy during the conspiracy period. This is the customer overcharge. A customer overcharge is a transfer of income from buyers as a group to the sellers as a group. As a cartel’s collusive behavior begins to raise prices above competitive levels, the joint profits of the cartel members rise roughly by the same amount that buyer’s purchases fall. If a cartel is able to operate at peak efficacy, the sum of its members’ profits will be almost as high as a monopolist would be able to extract in the same market. In equilibrium, the monopoly profits going to the conspirators will be equal to the sum of the lost revenues of direct and indirect buyers and the effective reduction in purchasing power by the ultimate consumers.

The second negative impact on buyers is the so-called “dead-weight loss” or “social loss.” This injury to buyers is an indirect consequence of higher prices. Under normal demand conditions, as a cartel is effective in raising market price, the quantity of sales will fall. The value of these lost sales is the dead-weight loss to customers. Because it represents both lost production as well as lost consumption, all social groups are injured: owners of the productive units, workers, intermediate buyers, and consumers. Consumers must use the disposable income they would have spent on the overpriced good on some other good they regard as inferior. Of course, cartel participants do not make profits on sales they do not make.

Table 3 summarizes the market effects of 31 international food-and-feed-ingredient cartels that were discovered during 1996-2002. The average duration of these cartels was about 8 years; the longest conspiracy was in the sorbates market, which lasted nearly 18 years. The durability of the international food-and-agriculture cartels shown in Table 3 is considerably higher than domestic cartels discovered in Germany and the United States. The longer span is rather surprising because the greater need for international travel and for electronic communications between meetings in the case of international

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20 Richard A. Posner, supra note 17 at 299-302. If some sellers do not join the cartel, their customers are still injured if the noncartel sellers follow the cartel’s price increases. Although overcharges are conventionally viewed as pure income transfers, many economists agree with Posner that much or all of the overcharge is a social cost. Under U.S. antitrust law, cartel members are responsible for their own overcharges as well as those by nonmembers.

cartels would appear to have raised the likelihood of exposure. The superior longevity of international cartels must be related to higher barriers to entry into the cartelized industries, many of which seem protected by sophisticated production technologies (in the chemical industries) or large economies of scale (e.g., beer).

The average number of participants in these food-and-agriculture cartels was 3.3, and the range was from two companies (four cases) to eight. The fact that these cartels comprised six or fewer members comports nicely with theoretical models of cartel formation.\(^\text{22}\)

The small number of cartel participants is a consequence of the high degree of seller concentration already noted above in Table 1. Global concentration in the lysine, citric acid, and vitamins A & E markets as measured by the four-firm concentration ratio (CR4) averaged above 92 percent. In all but one case (citric acid), the three-to-five formal members of the cartel controlled more than 95 percent of global supply of the cartelized products.\(^\text{23}\)

Whether global or regional concentration is the more appropriate concept in these cases is an interesting question. High global concentration is clearly a necessary condition for achieving an initial collusive consensus, if only because the products were highly tradable internationally. Lysine, citric acid, bulk vitamins, and most of the other food-and-feed ingredients were storable commodities with prices high enough relative to transportation costs that significant shares of domestic supply were imported or exported. However, once global price fixing began, the focus of decision making shifted to regional markets (continents, countries, or groups of countries). Price fixing at regional levels was made more

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\(^{22}\) R.A. Selton, *A Simple Model of Imperfect Competition, Where 4 Are Few and 6 Are Many*, 2 INTL. J. OF GAME THEORY, 141(1973) (developed a cartel model that predicted that the maximum number of sellers would be five equal-size firms). Louis Phlips, *Competition Policy: A Game-Theoretic Perspective* (Cambridge Univ. Press 1995) (suggests that the threshold is six firms). However, the international cartels of the 1990s had fewer members than discovered and prosecuted U.S. cartels. Samples studied by Fraas and Greer *supra* note 21 also confirmed that most cartels had few members, but in about one-third of their cases the cartels operated with more than six sellers.

\(^{23}\) In the citric acid cartel, there is evidence that one leading producer, while not an active formal member, did cooperate in a passive fashion with the cartel and may have explicitly agreed to do so.
complicated by fluctuations in currency exchange rates but was made easier by virtue of the fact that regional concentration was equal to or higher than global concentration.24

“Affected market sales” (the manufacturers sales during the period of effective collusion) varied considerably across the food-and-agriculture cartels. Worldwide affected sales for cartelized lysine totaled $1,950 million ($650 million per year) and for citric acid totaled $7,900 million ($1,975 million annually). While these are important markets, they are dwarfed by the cartelized sales of vitamins, which totaled an impressive $28 billion for all 12 vitamins or about $275 million per vitamin per year. Other notably large affected markets were for monosodium glutamate or MSG ($17,100 million), monochloroacetic acid or MCAA ($4,500 million), and sorbates ($3,000 million). Several other cartels affected much smaller global markets (e.g., sodium gluconate) or markets of unknown size. All told, the food-and-agricultural cartels of the 1990s raised the wholesale prices on at least $70 billion in global commerce. On average, 23 percent of these purchases occurred in North America, 31 percent in Europe, and the remainder in Asia and Latin America. Because the direct buyers (tens of thousands of food processors and feed manufacturers) inevitably passed on these price increase to wholesale and retail distributors, the world’s consumers of foods and medicines very likely were overcharged on at least $200 billion of their retail purchasers.


<table>
<thead>
<tr>
<th>Cartel Product</th>
<th>Years</th>
<th>No. of Companies</th>
<th>U.S.</th>
<th>EU</th>
<th>World</th>
<th>Customers’ Overcharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A</td>
<td>(1989-99)</td>
<td>3</td>
<td>850</td>
<td>1,730</td>
<td>5,740</td>
<td>1,600</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>(1989-99)</td>
<td>4</td>
<td>1,700</td>
<td>2,875</td>
<td>10,840</td>
<td>3,800</td>
</tr>
<tr>
<td>14 other vitamins</td>
<td>(1990-99)</td>
<td>20</td>
<td>2,450</td>
<td>3,700</td>
<td>11,440</td>
<td>2,100</td>
</tr>
<tr>
<td>Lysine</td>
<td>(1992-95)</td>
<td>5</td>
<td>460</td>
<td>605</td>
<td>1,950E</td>
<td>240E</td>
</tr>
<tr>
<td>Methionine &lt;sup&gt;b&lt;/sup&gt;</td>
<td>(1989-99)</td>
<td>5</td>
<td>2,900</td>
<td>3,200</td>
<td>7,900E</td>
<td>1,580E</td>
</tr>
<tr>
<td>Citric acid</td>
<td>(1991-95)</td>
<td>4</td>
<td>1,400</td>
<td>1,200</td>
<td>4,300E</td>
<td>700E</td>
</tr>
<tr>
<td>Sorbates</td>
<td>(1979-96)</td>
<td>6</td>
<td>1,000E</td>
<td>1,100E</td>
<td>3,000E</td>
<td>1,200E</td>
</tr>
<tr>
<td>Maltol</td>
<td>(1989-95)</td>
<td>2</td>
<td>70?</td>
<td>0E</td>
<td>70E</td>
<td>10E</td>
</tr>
</tbody>
</table>

<sup>24</sup> Regional concentration was considerably higher where the region contained a plant operated by a cartel member, was somewhat higher if the region had importers located close at hand, and was about equal to global levels if the region was “equidistant” from the cartel’s production points in a cost sense.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium erythorbate</td>
<td>(1992-94)</td>
<td>2</td>
<td>150E</td>
<td>170E</td>
<td>450E</td>
<td>50E</td>
<td>450E</td>
<td>150E</td>
<td>1,500E</td>
<td>150E</td>
<td>15,883</td>
<td>80-90</td>
</tr>
<tr>
<td>Sodium glutamate</td>
<td>(1987-95)</td>
<td>6</td>
<td>8E</td>
<td>250E</td>
<td>400</td>
<td>80E</td>
<td>250E</td>
<td>400</td>
<td>80E</td>
<td>80E</td>
<td>21,030</td>
<td>15,883</td>
</tr>
<tr>
<td>Monosodium glutamate(^b)</td>
<td>(1990-99)</td>
<td>3-8</td>
<td>4,300E</td>
<td>3,000E</td>
<td>17,100E</td>
<td>2,000E</td>
<td>4,300E</td>
<td>3,000E</td>
<td>17,100E</td>
<td>2,000E</td>
<td>67,090</td>
<td>21,030</td>
</tr>
<tr>
<td>Belgian breweries(^d)</td>
<td>(1993-98)</td>
<td>4</td>
<td>NA</td>
<td>1,500E</td>
<td>1,500E</td>
<td>150E</td>
<td>1,500E</td>
<td>150E</td>
<td>1,500E</td>
<td>150E</td>
<td>13,690</td>
<td>67,090</td>
</tr>
<tr>
<td>Luxembourg breweries</td>
<td>(1985-98)</td>
<td>4</td>
<td>0</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>15-25E</td>
<td>13,690</td>
</tr>
<tr>
<td>Organic peroxides</td>
<td>(1997-98)</td>
<td>2-4</td>
<td>450</td>
<td>300E</td>
<td>1,000</td>
<td>?</td>
<td>300E</td>
<td>1,000</td>
<td>?</td>
<td>?</td>
<td>13,690</td>
<td>67,090</td>
</tr>
<tr>
<td>Wine alcohol</td>
<td>(1992-98)</td>
<td>3+</td>
<td>0</td>
<td>NA</td>
<td>NA</td>
<td>50%</td>
<td>NA</td>
<td>NA</td>
<td>50%</td>
<td>50%</td>
<td>13,690</td>
<td>21,030</td>
</tr>
<tr>
<td>Nucleotides</td>
<td>(1992-96)</td>
<td>3</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>5-10?</td>
<td>NA</td>
<td>NA</td>
<td>5-10?</td>
<td>5-10?</td>
<td>13,690</td>
<td>67,090</td>
</tr>
<tr>
<td>Danish-Dutch beer market(^d)</td>
<td>(1993-2000)</td>
<td>2</td>
<td>0</td>
<td>1,400E</td>
<td>1,400E</td>
<td>150E</td>
<td>1,400E</td>
<td>150E</td>
<td>1,400E</td>
<td>150E</td>
<td>13,690</td>
<td>13,690</td>
</tr>
</tbody>
</table>


E = Estimate by author
NA = Not available or not applicable
? = Uncertain
\(^a\) Other products include: C, B4, B3, B1, B2, B5, B6, B12, D, Folic acid, 2 Carotenoids, premixes, and biotin (H). The 16 vitamins markets were cartelized by at least 8 groups consisting of an average of 3.7 companies per cartel.
\(^b\) Only 3 convicted by an antitrust agency but strong evidence that a larger cartel operated. Excludes China.
\(^c\) Middle of range of estimate.
\(^d\) Not global cartels, but members from two or more countries.

Finally, data are available on the dollar overcharges achieved by many of these international cartels. Of the 23 cartels, the U.S. overcharges are known with a fair degree of precision for 16 of them (lysine, citric acid, 12 vitamins, methionine, and sorbates). Global overcharges are then estimated by considering the geographic distribution of affected sales. For the 16 cases, direct customers were overcharged $11,220 million during the cartel periods. The overcharge rate (the dollar overcharge divided by affected sales) varied from 35 percent for vitamin E to 12 percent for the lysine cartel. The weighted average rate for the 16 cartels with fairly accurate overcharge information was 24.7 percent of affected sales worldwide. For whatever reason, this overcharge rate appears to be more than double the rate typically observed historically.\(^{25}\) An average overcharge rate of 25 percent would make it difficult

\(^{25}\) The U.S. Sentencing Guidelines for corporations that violate federal antitrust laws incorporate a presumptive rate of 10 percent. In the EU, a maximum fine of 10 percent of company sales is permitted for antitrust infringements.
for government antitrust agencies to impose fines high enough to make corporate price fixers disgorge all of the monopoly profits accumulated by a global cartel, especially if the agencies use national sales of the violators as the base upon which the fines are computed. That is, the high degree of effectiveness of global cartels calls into question the ability of government fines to deter recidivism.

The number and size of international cartels in food and agricultural markets far outweighs the cartels discovered in all other markets. The 14 non-agricultural conspiracies exposed since 1995 involved 56 to 60 companies, but most of the affected markets were relatively small in terms of sales or geographic size. It appears that global sales during the conspiracies will be in the $12 to $15 billion range; the graphite-electrodes case accounts for more than one-third of the total. The size of the customer overcharges is likely to total $3.5 to $4.0 billion. Thus, affected global sales of international cartels are highly concentrated (more than 80 percent) in food and agricultural markets.

**Crime and Punishment**

In a standard textbook on antitrust policies written in the early 1980s, the author tells the story of the international uranium cartel of 1972-1975. This cartel was comprised of 29 suppliers of uranium, 17 of them U.S. firms, that was successfully sued for treble damages by the largest U.S. buyer of uranium. The fact that the U.S. DOJ never indicted the cartel

> “… demonstrates that the strict [U.S.] policy against price fixing largely exempts foreign cartels, even if they have U.S. members ... and probably affect prices in the United States.”

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How different the attitude is two decades later. Since 1995, the U.S. DOJ has had a large number of legal victories against harmful, secretive global cartels. The Antitrust Division, together with its sister competition agencies in many other jurisdictions, has steadily expanded its investigatory methods, powers to negotiate guilty pleas, and harshness of penalties for noncooperative violators.

Antitrust authorities have been goaded into action by the disrespect shown by cartelists to competition laws and those who enforce them. Speech after speech by top antitrust officials betrays a visceral antipathy for global price fixers. The global conspirators are consistently described in highly emotive language as brazen, cold-blooded, contemptuous of the law, disdainful of their customers, and eager to break their own companies’ rules. Particularly surprising to antitrust prosecutors is the involvement of the most senior officers of colluding firms in the management of the cartel. At the same time, these global cartelists have shown a fear for the ability of U.S. authorities to detect their illegal activities by avoiding meetings on U.S. territory and by trying to hide the existence of the cartel from U.S. employees; these practices were particularly evident after the lysine-cartel investigation became public in 1995. Elaborate measures were taken to cover up the cartel’s activities wherever the conspiracy took place.

Once the threat of global conspiracies came to be recognized by the newly appointed head of the Antitrust Division in 1992-1993, the agency reordered its priorities fairly quickly. Prior to 1995, less than 1 percent of the corporations accused of criminal price fixing were foreign-based firms; after 1997, more than 50 percent were non-U.S. corporations. Fines imposed on global price fixers escalated steeply from 1996 to 1999, with new record amounts collected nearly every year. In 1999 alone, the $900-million-plus collected from international price fixers was far more than the entire 108 years of U.S. antitrust enforcement. Nearly four-fifths of the DOJ’s fines for criminal price fixing were imposed on non-U.S. firms in the late 1990s. The use of personal fines and prison sentences has also escalated; since 1995, the U.S. government has sent more than 30 executives to prison for price-fixing, and a high proportion are not U.S. citizens. Perhaps more importantly, the success enjoyed by the U.S. DOJ has been increasingly mimicked abroad by the antitrust agencies of Canada, the EU, Mexico, Korea, Brazil, and Australia. In
2001, the EU collected more than €1.8 billion in price fixing fines; from 1998 to 2001, the total was €2.5 billion.27

This section presents some original data on the prosecutions by the U.S., Canada, and EU of international cartels, most of them global in scope.28 The purpose is to show the pattern of anticartel enforcement by government agencies of three jurisdictions that have the most active programs to deter price fixing. These data are necessary to develop a fuller understanding of the potential for effective cartel deterrence in the long run.

The U.S. Department of Justice

The U.S. Sherman Act became law in July 1890. While the U.S. Congress has implemented many clarifying amendments over the years, the section of the Sherman Act that prohibits all agreements, contracts, or conspiracies in restraint of trade has remained virtually untouched in its original form. “Naked” cartels, those arranged through direct explicit communications between independent firms, are per se violations of U.S. law; no amount of evidence concerning circumstances in the industry or effects of the agreement on markets will be considered evidentiary in determining guilt. If the conspiracy is serious enough and the evidence of intent strong enough, corporations and individuals may be charged by the DOJ as a criminal matter. In practice, the DOJ files about 95 percent of all price-fixing cases as criminal matters, and nearly all other antitrust violations are treated as civil matters, for which the burden of proof is merely the preponderance of the evidence. All other parties that bring suits against price fixers, including other federal agencies and state attorneys general, may file only civil complaints.

Although preceded by antitrust laws passed by 13 states of the United States and at least two other countries (France and Canada), the Sherman Act became the first truly effective anticartel statute.

28 Recall that under the U.S. DOJ’s definition of “foreign” or international at least one target (corporate or individual) of an investigation or conviction must have non-U.S. registration, citizenship, or residence. Global cartels are subsets that aimed at affecting prices in three or more continents or consist of members drawn from three or more continents, usually Europe, North America, and Asia.
By 1897 the U.S. DOJ had successfully prosecuted the first of many domestic price fixing conspiracies. The famous *American Tobacco* case decided by the Supreme Court in 1911 had some international elements; two of the defendants were UK firms. However, except for the period of five years following the end of World War II, the DOJ prosecuted very few international cartels, even though the Sherman Act applies to any conspiracy that affects U.S. markets. It appears that international cartels formed between 1945 and 1990 were few, very well hidden, or had no U.S.-corporate membership. Moreover, in the three or four cases of global cartels that were prosecuted between 1950 and 1995, the DOJ lost the cases because the witnesses were foreign or key evidence located abroad could not be obtained by prosecutors.  

The notable success in prosecuting global cartels after 1995 may be traced to several improvements in the law and in investigatory techniques. First, the Sherman Act’s penalties were steadily increased by amendments in 1955, 1974, 1987, and 1990 (Table 4). In 1974, corporate fines were increased twenty-fold and personal participation was made a felony (prison sentences were raised from a maximum of one year to three years). In 1987, a federal judicial commission further raised the possible fines on corporations up to a maximum of double the cartel’s overcharge, a level that could far exceed the previous statutory cap of $1 million; larger personal fines also became feasible. In 1990, the Sherman Act received a centennial “birthday present” of yet larger statutory fines from the Congress. Thus, from 1974 to 1990, the maximum corporate liability for U.S. price fixing rose from $50,000 to twelve times the cartel’s overcharge.  

Second, around 1993 an enforcement policy shift took place in the DOJ that placed a higher priority on investigating international antitrust violations and that instructed the FBI to employ all the tools of their trade to collect evidence. Prior to 1993, price-fixing fines had been cheerily paid with all

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29 In the *Industrial Diamonds* cartel case, the case was dismissed in large part because a key witness residing in Europe refused to testify and many inculpatory documents were in South Africa beyond the reach of U.S. subpoenas.  
30 Government fines are based on double the overcharges to U.S. buyers, but the DOJ has the discretion to use global affected sales in place of U.S. sales; the former are typically at least three times domestic sales. Treble damages for direct buyers may be followed by treble damages for indirect purchases in state courts or *parens patriae* suits.
the embarrassment associated with a parking ticket. The FBI had treated price fixers with the gentleness accorded a shoplifter. But after 1992, price-fixing probes had all the trappings of a major conspiracy by the worst types of organized criminals. Armed with intimidating new powers to sanction firms and their managers, prosecutors bargained hard to obtain confessions and to “flip” conspirators into useful witnesses against their co-conspirators. The 1993 revision of the DOJ Corporate Leniency Program described below was a particularly important investigative innovation. Prosecutors became sophisticated in their use of amnesty, leniency, or other blandishments to induce cooperation. By 2001, nearly 70 percent of all corporate price-fixing defendants were foreign-based.

Table 4. Criminal Penalties for Price Fixing, U.S. Sherman Act, 1890-Present.

<table>
<thead>
<tr>
<th>Year Enacted</th>
<th>Maximum Fines for Companies</th>
<th>Maximum Penalties for Individuals</th>
<th>Prison (Months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1890</td>
<td>$5,000 per count(^a)</td>
<td>$5,000 per count</td>
<td>12(^b)</td>
</tr>
<tr>
<td>1955</td>
<td>$50,000 per count(^d)</td>
<td>$50,000 per count</td>
<td>12(^b)</td>
</tr>
<tr>
<td>1974</td>
<td>$1,000,000</td>
<td>$100,000(^c)</td>
<td>36(^c)</td>
</tr>
<tr>
<td>1987</td>
<td>Larger of $1,000,000 or double the harm with multipliers(^d)</td>
<td>Larger of $100,000 or 5% of the harm with multipliers(^d)</td>
<td>36(^c)</td>
</tr>
<tr>
<td>1990</td>
<td>Larger of $10,000,000 or double the harm with multipliers(^d)</td>
<td>Larger of $350,000 or 5% of the harm with multipliers(^d)</td>
<td>36(^c)</td>
</tr>
</tbody>
</table>

\(^a\) In serious cases, prosecutors can file multiple counts against firms involved in one conspiracy. Not used much in recent years.

\(^b\) Misdemeanor

\(^c\) Became a felony for individuals.

\(^d\) The base fines are calculated using either double or 5% of the estimated monopoly overcharge. The base fines are multiplied by upper and lower figures that depend on the degree of “culpability” (larger numbers for several exacerbating factors and smaller ones for exonerating factors). In the 1990s, the multipliers have often been between 1.5 and 4.5. If the overcharge is not known, it is presumed to be 10% of affected sales, which yields a base fine of 20% of affected sales, and a typical fine range of 30% to 90% of cartel sales. However, if a cartel creates a 25% overcharge, then the base fine is 50% of affected sales and the final fine range will be 75% to 225% of sales. “Sales” is usually U.S. only, but may be global cartel sales. In rare cases individuals can be fined up to $25,000,000 depending on their cartel’s overcharge amount.

The U.S. DOJ’s criminal price-fixing record is summarized in Table 5. During 1980-1999, the Antitrust Division convicted more than 50 price-fixing crimes per year on average.\(^{31}\) Until late 1996, nearly all the cases prosecuted were domestic schemes that involved modest sales in the affected markets. Indeed, during the 1980s, more than 80 percent of the price-fixing cases involved bid-rigging, mostly

\(^{31}\) The DOJ convicts more than 80% of those indicted for antitrust. Nearly all convictions are through plea bargains.
construction firms colluding on government projects or suppliers to local school districts; fewer than 15 percent were directed against conventional corporate cartels.

After 1990, enforcement patterns returned to the more traditional pattern of prosecuting horizontal collusion by corporate perpetrators. More importantly, starting with the lysine cartel in September 1996, the most important U.S. price-fixing convictions have been global conspiracies in food-and-feed ingredients. Ten such cartels have been fully or partially prosecuted in the six years since 1996. \(^{32}\) Total corporate fines imposed in the ten food-and-feed cartels was $1,326 million on 33 multinational corporations (five more companies were granted amnesties). In addition, the U.S. DOJ has convicted members of ten global cartels in other markets. However, the food-and-agricultural cartels accounted for 81 percent of the cartelized sales and 85 percent of all the fines on discovered international cartels.


<table>
<thead>
<tr>
<th>Years</th>
<th>Total Criminal Cases Filed</th>
<th>Cases in Which Fines Imposed</th>
<th>Cases in Which Prison Sentences Imposed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total Number</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&lt; 1 yr.</td>
</tr>
<tr>
<td>1970-1979</td>
<td>176</td>
<td>156</td>
<td>25</td>
</tr>
<tr>
<td>1980-1989</td>
<td>623</td>
<td>513</td>
<td>196</td>
</tr>
<tr>
<td>1990-1999</td>
<td>416</td>
<td>324</td>
<td>61</td>
</tr>
<tr>
<td>Global only, 1996-1999</td>
<td>10</td>
<td>10</td>
<td>3(^c)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970-1979</td>
<td>42(^a)</td>
</tr>
<tr>
<td></td>
<td>88.6</td>
</tr>
<tr>
<td></td>
<td>14.2</td>
</tr>
<tr>
<td></td>
<td>96.0</td>
</tr>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>4.0(^b)</td>
</tr>
<tr>
<td>1980-1989</td>
<td>84(^a)</td>
</tr>
<tr>
<td></td>
<td>82.3</td>
</tr>
<tr>
<td></td>
<td>31.5</td>
</tr>
<tr>
<td></td>
<td>93.4</td>
</tr>
<tr>
<td></td>
<td>5.1</td>
</tr>
<tr>
<td></td>
<td>1.5</td>
</tr>
<tr>
<td>1990-1999</td>
<td>68(^a)</td>
</tr>
<tr>
<td></td>
<td>77.9</td>
</tr>
<tr>
<td></td>
<td>14.7</td>
</tr>
<tr>
<td></td>
<td>77.0</td>
</tr>
<tr>
<td></td>
<td>19.7</td>
</tr>
<tr>
<td></td>
<td>3.3</td>
</tr>
<tr>
<td>Global only, 1996-1999</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>100.0</td>
</tr>
<tr>
<td></td>
<td>30.0</td>
</tr>
<tr>
<td></td>
<td>33.3</td>
</tr>
<tr>
<td></td>
<td>33.3</td>
</tr>
<tr>
<td></td>
<td>33.3</td>
</tr>
</tbody>
</table>


\(^a\) Proportion of criminal cases to total DOJ antitrust cases.

\(^b\) An unusual case; individual found guilty of racketeering as well as price fixing.

\(^c\) Seven persons have been indicted in a fourth, the sorbates case, but are fugitives as of 2002.

\(^{32}\) Data in this paragraph from Connor (2002) *supra* note 2, Tables 3, A.1, A.2, and A.3.
Since 1969, the DOJ has obtained fines from a high share (83 percent) of the corporations found guilty of criminal price fixing (Table 5). The global cartels prosecuted in the late 1990s were clearly all fairly serious cases because all of them resulted in fines for the corporate participants. Indeed, all cartel members were fined except for those offered amnesty (Table 6).

Prison sentences are imposed by the courts, which almost always follow the DOJ’s recommendations in these matters, in a minor share (23 percent) of all price-fixing convictions. The threat of prison is still reserved for the most serious types of price-fixing, namely, those involving large economic injuries or cases in which the cartel managers resisted pleading guilty and cooperating with prosecutors. Moreover, the frequency with which prison sentences were imposed is significantly higher for the late-1990s global cartels; the share of long sentences imposed on the cartel ring leaders is particularly striking. In the one case where the managers resisted making deals for pleading guilty, the lysine cartel, the three ADM executives lost at trial and were sentenced to a collective 99 months in prison; ADM’s Vice Chairman was the first person in antitrust history to receive the maximum 36-month sentence.


<table>
<thead>
<tr>
<th>Case Filed</th>
<th>No. of Fines</th>
<th></th>
<th>Prison Sentences Imposed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Corporate</td>
<td>Persons</td>
<td>Year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a</td>
<td>Year</td>
</tr>
<tr>
<td>1996 Lysine</td>
<td>5</td>
<td>6¹</td>
<td>1999</td>
</tr>
<tr>
<td>1996 Citric acid</td>
<td>5</td>
<td>4</td>
<td>--</td>
</tr>
<tr>
<td>1997 Sodium gluconate</td>
<td>5</td>
<td>5</td>
<td>--</td>
</tr>
<tr>
<td>1998 Heavy-Lift marine</td>
<td>1</td>
<td>1</td>
<td>--</td>
</tr>
<tr>
<td>construction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1998 Heavy-Lift marine</td>
<td>2</td>
<td>2</td>
<td>--</td>
</tr>
<tr>
<td>transport</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1998 Graphite electrodes</td>
<td>7</td>
<td>3</td>
<td>1999</td>
</tr>
</tbody>
</table>

³³ Table 5 includes every global cartel case filed after September 1996 and largely concluded by mid 2002.
³⁴ Anthony V. Nanni, Squeezing the Cartels: Criminal Enforcement Gets Tough, LEGAL TIMES (April 20, 2002), 30. Only one corporate cartel participant risked a jury trial, and it lost badly. Mitsubishi Corp. had very little direct involvement in the global graphite-electrodes cartel, yet it was fined $134 million in 2001.
Criminal indictments and convictions of food-and-agricultural price fixers display an interesting geographic pattern (Table 7). Out of 76 cases, 30 (39 percent) of the corporations are headquartered in Asia, 29 (38 percent) in Europe, and 17 (23 percent) in North America. Relative to the sizes of their national chemical industries, Japan, South Korea, Switzerland, and the Netherlands seem to be overrepresented.


<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Corporations</th>
<th>Individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Japan</td>
<td>24</td>
<td>22</td>
</tr>
<tr>
<td>2.</td>
<td>United States</td>
<td>16</td>
<td>13</td>
</tr>
<tr>
<td>3.</td>
<td>Germany</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>4.</td>
<td>France</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>4.</td>
<td>South Korea</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>4.</td>
<td>Switzerland</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>7.</td>
<td>Netherlands</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>8.</td>
<td>Belgium</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>9.</td>
<td>Canada</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>9.</td>
<td>United Kingdom</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>11.</td>
<td>Italy</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>


Superscripts indicate persons indicted but not convicted (either awaiting trial, awaiting sentencing, or fugitives). Some may be fined or imprisoned after mid-2002.
In general, the fines collected from individual criminal conspirators are modest compared with their corporate salaries, often between $75,000 and $150,000. However, there are two noteworthy examples of high fines paid by the ringleaders of global cartels. The first, in 1998, was a fine of $10 million paid by the German Chief Executive Officer of SGL Carbon, the instigator of the graphite electrodes cartel (Table 8). He paid a fine well above the statutory cap of $350,000 to avoid a prison sentence. Second, in 2002, the Chairman of Sotheby’s auction house was convicted at trial for fixing the fees for selling precious works of art. His fine of $7.5 million was the first *litigated* example of the alternative fine statute being applied for price fixing. This statute permits personal fines of up to $25 million, depending on the size of the overcharge caused by the cartel’s operations.

The conviction and imprisonment of non-U.S. executives for criminal price fixing by U.S. authorities is an extraordinary development in recent enforcement history (Table 8). During 1995-2002, the U.S. DOJ has arranged guilty-pleas from dozens of top executives who were nationals of 12 foreign countries: Germany, Belgium, the Netherlands, England, France, Switzerland, Italy, Sweden, Canada, Mexico, Japan, and South Korea (Hammond 2002a). Many of these executives worked in the United States, but some traveled from their residences abroad to submit to the jurisdiction of the U.S. court, plead guilty, and pay fines. Although some are indicted fugitives, nearly 80 percent of all price fixers of food- and-agricultural cartels are foreign nationals. Moreover, about ten foreign nationals from Canada, Germany, Switzerland, and Sweden have served significant prison sentences in the United States. One reason for foreigners’ willingness to serve time in U.S. prisons is that if they reside or even *pass through* countries that have criminal statutes for price fixing, they may be extradited to the United States (Nanni 2002a). The United States has explicit treaties with Canada, Ireland, and Japan that permit extradition for antitrust violations, though none of these has yet been invoked. In 2002, Interpol added U.S. antitrust
fugitives to its “Red Notice” watch list for the first time. When foreign executives plead guilty for price fixing, they are frequently granted the right of free passage across U.S. borders for their cooperation.

Corporate sanctions need not stop with fines. In a little publicized conviction of bid-rigging against the U.S. Agency for International Development on building projects in Egypt, a U.S. court required two convicted firms to pay for large advertisements in the *Wall Street Journal* and *New York Times* that detailed their shameful transgressions. The U.S. DOJ intends to seek similar court orders in appropriate cases. Corporate governance restructurings, divestitures, or disgorgement are possible additional sanctions that courts may require.

Table 8. U.S. Convictions of Individual Price Fixers, Selected Global Cartels.

<table>
<thead>
<tr>
<th>Name</th>
<th>Nationality</th>
<th>Corporate Position</th>
<th>Sanctions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fines</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>U.S. dollars</em></td>
</tr>
<tr>
<td>LYSINE (1999):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Michael D. Andreas</td>
<td>U.S.</td>
<td>Vice Chairman, ADM</td>
<td>350,000</td>
</tr>
<tr>
<td>Terrance Wilson</td>
<td>U.S.</td>
<td>Pres., Corn Products Division, ADM</td>
<td>350,000</td>
</tr>
<tr>
<td>Mark Whitacre</td>
<td>U.S.</td>
<td>Pres., Bioproducts Division, ADM</td>
<td>350,000</td>
</tr>
<tr>
<td>Kanji Mimoto</td>
<td>JP</td>
<td>Div. Mgr., Ajinomoto</td>
<td>75,000</td>
</tr>
<tr>
<td>Hirozaku Ikeda</td>
<td>JP</td>
<td>Div. Mgr., Ajinomoto</td>
<td>0</td>
</tr>
<tr>
<td>Katsutoshi Yamada</td>
<td>JP</td>
<td>Mng. Dir., Ajinomoto</td>
<td>Fugitive</td>
</tr>
<tr>
<td>Masaru Yamamoto</td>
<td>JP</td>
<td>Div. Mgr., Kyowa</td>
<td>50,000</td>
</tr>
<tr>
<td>Jhom Su Kim</td>
<td>SK</td>
<td>Pres., Sewon America</td>
<td>75,000</td>
</tr>
<tr>
<td>CITRIC ACID (1997-98):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hans Hartmann</td>
<td>DE</td>
<td>Pres., Bayer subsidiary</td>
<td>150,000</td>
</tr>
<tr>
<td>Udo Haas</td>
<td>DE</td>
<td>Managing Director, Roche subsidiary</td>
<td>150,000</td>
</tr>
<tr>
<td>Rainer Bilchbauer</td>
<td>CH</td>
<td>President, Jungbunlauer</td>
<td>150,000</td>
</tr>
<tr>
<td>Silvio Kluzer</td>
<td>CH</td>
<td>Mng. Dir., Eridania sub.</td>
<td>40,000</td>
</tr>
<tr>
<td>VITAMINS (1999): c</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kuno Sommer</td>
<td>CH</td>
<td>Mng. Dir., Roche</td>
<td>100,000</td>
</tr>
<tr>
<td>Roland Brönnimann</td>
<td>CH</td>
<td>Div. Pres., Roche</td>
<td>150,000</td>
</tr>
<tr>
<td>Andreas Hauri</td>
<td>CH</td>
<td>Mktg. Dir., Roche</td>
<td>350,000</td>
</tr>
<tr>
<td>Reinhardt Steinmetz</td>
<td>DE</td>
<td>Div. Pres., BASF</td>
<td>125,000</td>
</tr>
<tr>
<td>Dieter Suter</td>
<td>CH</td>
<td>Div. Pres., BASF</td>
<td>75,000</td>
</tr>
<tr>
<td>Hugo Strotmann</td>
<td>DE</td>
<td>Group V.P., BASF</td>
<td>75,000</td>
</tr>
<tr>
<td>SORBATES (2001):</td>
<td></td>
<td>Genl. Mgr. Sales +</td>
<td>Fugitive</td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
<td>--------</td>
<td>-----------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Yuji Komatsu</td>
<td>JP</td>
<td>Dep. Sales Mgr., Ueno</td>
<td>Fugitive</td>
</tr>
<tr>
<td>Yoshihiko Katsuyama</td>
<td>JP</td>
<td>Genl. Mgr., Ueno USA</td>
<td>Fugitive</td>
</tr>
<tr>
<td>Wakao Shinoda</td>
<td>JP</td>
<td>Salesman, Organic Chem. Div., Daicel</td>
<td>Fugitive</td>
</tr>
<tr>
<td>Hitoshi Hayashi</td>
<td>JP</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ART AUCTIONS (2002):</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Alfred Taubman</td>
<td>US</td>
<td>Chairman, Sotheby’s</td>
<td>7,500,000</td>
<td>12</td>
</tr>
<tr>
<td>Sir Anthony Tenant</td>
<td>UK</td>
<td>Chairman, Christies’</td>
<td>Fugitive</td>
<td>0</td>
</tr>
<tr>
<td>Dianna Brooks</td>
<td>US</td>
<td>CEO, Sotheby’s</td>
<td>Pending</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SODIUM GLUCONATE (1997):</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cornelius Nederveen</td>
<td>NL</td>
<td>Mgr. Dir., Glucona</td>
<td>100,000</td>
<td>0</td>
</tr>
<tr>
<td>Marcel van Eekhout</td>
<td>NL</td>
<td>Mgr. Dir., Glucona</td>
<td>100,000</td>
<td>0</td>
</tr>
<tr>
<td>Bertrand Dufour</td>
<td>F</td>
<td>Mgr. Dir., Roquette</td>
<td>50,000</td>
<td>0</td>
</tr>
<tr>
<td>Akira Nakao</td>
<td>JP</td>
<td>Asso. Div. Dir., PMP</td>
<td>200,000</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GRAPHITE ELECTRODES (1998-99):</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Robert Krass</td>
<td>US</td>
<td>Pres., UCAR Intl.</td>
<td>1,250,000</td>
<td>17</td>
</tr>
<tr>
<td>Robert Hart</td>
<td>US</td>
<td>COO, UCAR Intl.</td>
<td>1,000,000</td>
<td>9</td>
</tr>
<tr>
<td>Robert Koehler</td>
<td>DE</td>
<td>CEO, SGL Carbon</td>
<td>10,000,000</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: Not shown here are convictions of Canadian and Swedish executives who were imprisoned.

a Largest litigated personal antitrust fine.
b Largest personal antitrust fine.
c Two anonymous executives are indicted fugitives.

In summary, the financial penalties applied by the U.S. DOJ to global price fixers in the late 1990s were unprecedented in their harshness. Average corporate fines for members of global cartels in the late 1990s were many times higher than the fines collected in 1990-1996 (Table 9). The main reason for the escalation in fines in the late 1990s was the extraordinary escalation in legal standards, the expanded size of the markets affected, the high overcharge rates, the longevity of many of the conspiracies, and, if truth be told, the rising intolerance of the judicial system for thieves dressed in expensive suits. This rise is especially notable in light of the fact that, correcting for inflation, average corporate fines were essentially unchanged for the first 90 years of the 20th century.

Unique to the United States is its history of imposing serious sentences on individual price fixers. Both the fines and prison sentences were higher for the managers of global conspiracies than for
managers of domestic conspiracies (Table 9). In 2001, the average U.S. prison sentence for convicted price fixers was 15 months. Only Canada and Israel have jailed managers of global cartels outside the United States since 1995. The UK and Australia are contemplating making prison sentences possible for serious price-fixing violations. Whether this newly harsh regime of sanctions will have a lasting impact on deterrence is a matter for speculation at present.  


<table>
<thead>
<tr>
<th>Years</th>
<th>Fine Per Company</th>
<th>Fines Per Person</th>
<th>Prison Sentence Per Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>1890-1899</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1900-1919</td>
<td>20,000</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1920-1939</td>
<td>77,800</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1940-1949</td>
<td>52,000</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1950-1959</td>
<td>40,000</td>
<td>NA</td>
<td>0</td>
</tr>
<tr>
<td>1960-1969</td>
<td>131,000</td>
<td>NA</td>
<td>0.1</td>
</tr>
<tr>
<td>1970-1979</td>
<td>301,000</td>
<td>5,000&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2</td>
</tr>
<tr>
<td>1980-1989</td>
<td>368,000</td>
<td>NA</td>
<td>4E</td>
</tr>
<tr>
<td>1990-1996</td>
<td>1,000,000</td>
<td>67,000</td>
<td>5E</td>
</tr>
<tr>
<td>1997&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7,000,000</td>
<td>125,000</td>
<td>0</td>
</tr>
<tr>
<td>1998&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11,000,000</td>
<td>131,000</td>
<td>0</td>
</tr>
<tr>
<td>1999&lt;sup&gt;b&lt;/sup&gt;</td>
<td>38,000,000</td>
<td>1,871,000</td>
<td>19</td>
</tr>
</tbody>
</table>


NA = Not available, but a small amount.

<sup>a</sup> From the Folding Carton case.

<sup>b</sup> Global cartels (Connor 2001:Table 13.A.1). The corporate lysine case is placed in 1997, but the individual sentences were delayed to 1999.

Canada and the European Union

Space does not permit more than a few generalizations about the prosecution of global cartels by the Canadian Competition Bureau (CCB) and the European Commission. The CCB has successfully prosecuted most of the same global cartels that were convicted by the U.S. DOJ with a lag of about one

35 Data are incomplete for 2000-2001 because several indicted global cartel cases are not finished, but the upward trend in sanctions is not likely to persist in 2000 or 2001.

36 A detailed treatment of these two antitrust agencies is given in Connor supra note 2, 29-35. For a recent treatment of EC cartel enforcement and deterrence see Wouter P.J. Wils, Does the Effective Enforcement of Articles 81 and 82 EC Require Note Only Fines on Undertaking but also Individual Penalties, in Particular Imprisonment?, PROCEEDINGS, 2001 COMPETITION LAW AND POLICY WORKSHOP (2001).
year. Fines have averaged about 20% of Canadian affected sales and about 6% as high as U.S. fines, but the CCB has been sparing in its use of prison sentences for price fixers. A class action has been successfully pursued in the citric acid market, and lysine and vitamins class actions are currently in process.

The EC is relatively slow, but after lags of about three years from U.S. convictions, it has imposed about 1.5 billion euros in global price fixing fines. Average fines are about 75% as high as imposed by U.S. antitrust authorities, and there are no criminal sanctions. Moreover, private antitrust suits, while legal in some Member States, are of no quantitative consequence in the EU. Thus, the overall pattern of global-cartel enforcement is for the U.S. to take the lead and for CCB and EC fines (closely proportional to parallel U.S. fines) to be imposed one to three years later. The EC’s methionine investigation is a rare exception to this pattern, with the EC running in advance of the U.S. investigation.

**Deterrence**

The corporate fines and personal sanctions handed out to global price fixers since 1995 were beyond and above the worst nightmares of corporate defense lawyers might have had in the early 1990s. Corporate cartelists, when they are unmasked by antitrust investigators, are now routinely paying fines that exceed their monopoly profits earned in North America and in Western Europe. Indeed, in North America, when the private treble-damages suits by buyers or the state attorneys general are factored in, prosecuted price fixers are nowadays normally disgorging close to double their illegal “earnings” (Connor 2001:469-476). Nevertheless, serious doubts remain that even the heightened fine structures observed since 1995 are sufficient to prevent recidivism (repeat offenses of the same crime).

**Theory**

A rational policy with respect to the design of legal sanctions would admit to two principal objectives: deterrence and compensation of victims. The EC’s cartel decisions are explicit in mentioning deterrence as the main objective of its determination of fine levels; to the extent that these

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37 A third motivation is sometimes mentioned, viz., funding the costs of detection and prosecution. In U.S. law, these costs are borne by both the government and by plaintiffs’ lawyers. To the extent that these costs are incurred by plaintiffs, they may be regarded as compensatory.
fines are used to defray the EU budget, European consumers are at least indirectly compensated. In the United States, treble damages (i.e., settlements equal to three times the victims’ economic losses) were explicitly instituted in the 1890 Sherman Act to compensate buyers from cartels as well as to deter firms from forming cartels ex ante. However, the advent in the 1990s of the double-the-harm standard for setting government fines has led some legal writers to criticize cartel sanctions as having reached supradeterrent levels.

These criticisms confuse the ex post liabilities faced by discovered cartel members with the ex ante decision making process that deterrence-fines are supposed to affect. True, the theoretical maximum fines and private settlements faced by prosecuted cartelists have reached surprisingly high multiples of cartel overcharges in the U.S. legal system. A domestic cartel successfully prosecuted in the United States is liable to pay up to double the cartel’s overcharge to the federal government and triple the overcharge to direct buyers who file civil suits. In addition, the cartel can be sued by the state attorneys general for another set of treble damages incurred by indirect buyers. Thus, domestic cartels are obligated to pay as much as eight times their illegal monopoly profits if they are found guilty. Moreover, suppose the cartel is a global one with a typical one-third of its sales in the United States. Then, the U.S. DOJ has the option of calculating its fine on the basis of global overcharges (which are likely to be three times the domestic overcharges). In this case the federal fine could rise to six times a cartel’s U.S. overcharges. It is the possibility of fines and settlements totaling eight to twelve times a cartel’s U.S. monopoly profits that leads critics to make claims of overdeterrence.

38 In 2001, EU antitrust fines amounted to 2 percent of its annual budget.
40 These are called parens patriae actions. Indirect buyers include both corporate and consumer purchasers. In 2000, 45 states joined together to sue the six largest companies in the vitamins cartels. Indirect buyers may also sue in about 16 state courts. Pass-on by direct buyers is no defense for these actions.
However, deterrence effects of anticartel policies must be evaluated _ex ante_, that is, from the perspective of a company considering forming or joining a price-fixing conspiracy. Such a company must evaluate the probable additional profits from the cartel relative to the _probable costs_ associated with being discovered and prosecuted. The evidence is that potential conspirators are adept at calculating the annual profits from an effective cartel, though they might have uncertainty about the scheme’s longevity. As to the probability that a cartel will be discovered, most evidence seems to suggest a 10- to 20-percent chance. Moreover, even if cartelists are indicted by the U.S. DOJ, the chances of being convicted are less than 100 percent. The DOJ likes to boast that more than 80 percent of its indictments end in guilty pleas, which is true because the _per se_ evidence is so damning in most cases that defendants usually negotiate a guilty plea. On the other hand, when accused price fixers choose to litigate a criminal price-fixing case, the government wins their cases less than half the time. Thus, cartelists adept at covering up their clandestine meetings or able to afford the best legal defense teams might well judge their chances of conviction to be in the 50 to 75 percent range.

The decision facing a firm trying to decide whether to form a cartel or join an existing cartel may be explained using a benefit-cost framework. Let \( E(B) \) be the expected financial benefits, that is, the net present value of the expected monopoly profits accruing to the firm from an effective cartel. Let \( E(C) \) be the expected monetary costs of forming or joining the cartel, where the managerial costs are assigned to be negligible. Then the firm will opt to enter a cartel agreement if

\[
E(C) < E(B)
\]

In the simplest version of this decision model, one used by Richard Posner,

\[
E(C) = p \cdot F,
\]

---

41 Historically the average global cartel lasted about eight years, with a range of two to 18 years.
42 See Peter G. Bryant and E. Woodrow Eckart, _Price Fixing: The Probability of Getting Caught_, 73 REV. ECON. AND STAT., 531(1991); Connor (2001) _supra_ note 2, 29. The highest rate is suggested to be 0.33 by Cohen and Scheffman _supra_ note 39.
where $p = \text{the probability of U.S. government discovery and conviction}$ and $F$ is the fine imposed for the violation.\textsuperscript{44} A more complete version of this model is

$$E(C) = p \cdot c \cdot E(F),$$

where $p$ is the probability of detection and $c$ is the probability of conviction or settlement. $E(F)$ depends on the culpability factors and the size of the affected sales or overcharge (a range known with near certainty from the U.S. Sentencing Guidelines) and the firm’s position in applying for leniency. $E(F)$ could be zero if the firm is granted amnesty, but even then the expected private settlement costs, $E(S)$, are not zero. Moreover, the firm may incur significant legal defense costs and related managerial time losses as well as post-indictment reputational costs, $E(R)$. Thus, in the case of a domestic conspiracy,

$$E(C) = p_g \cdot c_g \cdot E(F_g) + p_p \cdot c_p \cdot E(S) + E(R),$$

where subscripts $g$ and $p$ refer to government and private legal actions. In the usual follow-on suit, $p_p = 1$ and $c_p$ will be very high (close to 1), but in some cases where the government does not indict $p_p$ and $c_p$ are low positive numbers, much closer to zero than to 1.

In the context of global cartels, the decision-making model has added geographical components:

$$E(C) = p_u \cdot c_u \cdot E(F_u) + p_u \cdot c_u \cdot E(S_u) + p_e \cdot c_e \cdot E(F_e) + p_a \cdot c_a \cdot E(F_a) + E(R),$$

where $u = \text{U.S. and Canada}$, $e = \text{EU}$, and $a = \text{Asia}$. Because of the absence of effective private damages suits outside of North America, $E(S_e) = E(S_a) = 0$. Because most companies are listed on at most one stock exchange, $E(R)$ refers to stock-price effects in the firm’s home country. Unlisted cartel members suffer little $E(R)$, and in my view the reputational effects for public companies, if any, seem to dissipate within five years.\textsuperscript{45} Because of weak enforcement in Asia, $E(F_a) = 0$. Given the standards that have

\textsuperscript{44} Posner (2001) \textit{supra} note 17 at 47. This formulation assumes that the justice system is costless and errorless, that offenders and victims are risk-neutral, and that the conspiracy was condoned by the company’s top managers.

\textsuperscript{45} Reputational effects may be nonlinearly related to the size of a fine, especially if the fine represented a new record amount. ADM’s $100$-million fine assessed in October 1996 certainly fits this description. It was only beginning in
evolved for corporate sanctions for global cartels, E(C) can be converted to a function of the private financial “benefit” of price fixing, where E(B) is the overcharge paid by direct buyers during the conspiracy period. For a convicted cartelist, the maximum ex post costs of global collusion will be

\[
E(C) = E(F_u) + E(S_u) + E(F_e) + E(F_a)
\]

\[
= (1.06)(2B) + (1.06)(3B) + (0.78)(E(F_u)) + 0
\]

\[
= 6.9B
\]

That is, where \( p = c = 1 \) and the U.S. DOJ imposed the maximum double-the-overcharge (2B) fine on domestic sales with no leniency discounts, a firm might have to pay as much as seven times its monopoly profits in fines and settlements.

In the case of a more appropriate ex ante analysis, F(C) will be considerably lower than 6.9B because \( p \) and \( c \) are less than unity. My best prediction for \( p_{gu} \) is a value between 0.10 and 0.30, with the higher value due to the recent success of the leniency programs adopted by most antitrust agencies; given the improved degree of international cooperation in anticartel enforcement, it is reasonable to assume \( p_{gu} = p_{ge} = p_{gs} \). For conviction, \( 0.5 < c_{gu} < 0.9 \) seems a reasonable range, and because most U.S. treble-damages suits are follow-on actions, \( c_{pu} = 1 \) is not unreasonable. Actual fines paid in the United States and EU can be used to derive expected fines, and these can be converted to an overcharge basis (B).\(^{46}\)

Past practice suggests that for the average cartel participant \( F_u = 0.18B \) to 0.64B; in the EU, \( F_e = 0.2 \) to 0.7B; and in Asia, \( E(F_a) = 0 \). Ringleaders of cartels have paid relatively high fines per dollar of overcharge, and small followers low fines. In North America, private suits against global cartels have yielded settlements of from 1.0 to 2.0 overcharges. These parameters imply that ex ante:

\[
E(C) = 0.12B \text{ to } 0.95B.
\]

\(^{2000} \text{ or } 2001 \text{ that financial profiles of ADM or its top executives failed to include references to ADM’s 1996 price-fixing convictions. See also Cindy R. Alexander, On the Nature of the Reputational Penalty for Corporate Crime: Evidence, XLII J.L. AND ECON, 489(1999) (which empirical study finds, for five publicized price-fixing convictions between 1984 and 1990, no reputational effects for the corporate defendants).}

\(^{46} \text{ U.S fine practices can be found in Tables 13.1 to 13.3 of Connor supra note 2, and for EU Table 14.1 (ibid.) suggests that } E(F_u) = 0.35B \text{ to } 0.74B. \text{ For the U.S., } F_u \text{ was 0.33B for lysine, 0.30B to 0.64B for citric acid, and 0.18B to 0.44B for vitamins.}
Thus, minor participants in global cartels can reasonably expect to incur fines and settlements far below their expected cartel profits. Even under the most optimistic assumptions about discovery, lenience, and prosecution rates, the average conspirator can reasonably expect to make a profit on the typical global price-fixing scheme. Only ringleaders of cartels that resist cooperating with prosecutors risk financial costs in excess of their expected profits. One example is ADM’s participation in the lysine cartel.47

Given the rational expectations about the certainty of punishment just mentioned, what is an appropriate level of financial sanctions to deter price fixing before it starts? At a minimum, to ensure absolute deterrence of a global cartel, total financial sanctions should be twenty times the expected U.S. cartel profits (the overcharge); at the upper end, deterrence would require penalties equal to sixty times U.S. overcharges.48 These extraordinary multiples demonstrate that, from a purely benefit/cost approach, even the theoretical U.S. legal sanctions of eight to twelve times overcharges is insufficient to deter recidivism.

Practice: The United States

Recidivism in global price fixing is depressingly common. In part, this may be caused by the highly diverse businesses found in most large multinational firms. Price fixing in the 1990s bears all the marks of contagion, between and within enterprises. For example, soon after Hoffman-La Roche and BASF implement price fixing in vitamins A & E, the positive financial results prompted them to form at least five more highly complex cartels in eight other vitamins industries a year later. Furthermore, Roche’s success in vitamins instigated one top Roche executive to write a memorandum to the head of the company’s citric acid marketing department encouraging him to form a citric acid cartel. Soon after ADM and Roche began fixing the price of citric acid in 1991, the ADM vice president in charge of citric acid taught ADM’s head of the lysine department how to form and run the lysine cartel (see Figure 1

47 See Connor supra note 2, Table 19.4. ADM probably profited from its role in the citric acid cartel.
48 These estimates assume that a global cartel’s U.S. profit comprise one-third of its total monopoly profits worldwide. Strictly national cartels would require seven- to 20-times penalties. These estimates ignore the legal fees paid by defendants. If legal fees are substantial, the required multiple to deter would be somewhat lower.
above). At least a dozen firms convicted of global price fixing in the 1990s have become repeat
offenders.

Although the theoretical financial costs of price fixing may strike some as high, the actual
amounts of the fines and private settlements are much lower than what is legally possible in cases settled
before 1990. A wide gap between the maximum penalties prescribed by the law and the actual penalties
imposed has persisted after 1995 in fines imposed on global price fixers.

In the three best documented prosecutions of global cartels, U.S. government corporate fines of
$1,106 million were precedent-shattering. Yet they represented merely 10 to 79 percent of the maximum
possible fines that could have been levied (Table 10). To place them further in perspective, these fines
represented only 2.8 percent of global sales during the three conspiracy periods and only 12.6 percent of
the cartel’s illegal profits. Individual fines and prison sentences were also far more lenient than the law
permits. These fines and sentences averaged 3 to 7 percent of the maximum levels allowed. Moreover,
less than one-fourth of the individual conspirators were sanctioned at all.


<table>
<thead>
<tr>
<th>Cartel</th>
<th>Corporate Finesa</th>
<th>Individual Sanctions</th>
<th>Finesc</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum Actual</td>
<td>Number Max. Actual</td>
<td>Number Months</td>
</tr>
<tr>
<td>Lysine</td>
<td>225-559 92.5</td>
<td>40 7 1440 99 14.0 0.9</td>
<td></td>
</tr>
</tbody>
</table>
| Citric acid| 189-721 105.4    | 12 4 432 0 4.2 0.8  
| Vitamins   | 994-9850 908.5d  | 52 13 1872 22.5 18.2 0.9 |        |
| Total      | 1408-11,130 1,106.4 | 104 24 3744 121.5 36.4 2.6 |        |


a Based on either the usual 20-percent of U.S. affected sales with a culpability score of 9 and multipliers of 1.8 to 3.6 or twice the
U.S. overcharge. In general, had global sales been the basis of the fines, the maximum amounts shown in this table would be
trebled.

b Named conspirators in the DOJ’s proffers to the courts.

c Based on the $350,000 statutory cap, not on the much higher amounts allowed by the alternative sentencing statute.

d A few small companies have yet to plead guilty.

49 As a proportion of U.S. sales and estimated overcharges, the respective percentages are 14.0 of sales and 60 to 74
of overcharges. See Connor supra note 2, Table 19.5.
The major reason for the relatively low government fines is the ancient practice of prosecutors everywhere of offering rewards for a defendant’s cooperation. Such cooperation may be needed to induce price fixers to testify against other, more recalcitrant co-conspirators; it may be given to low-ranking employees in order to prosecute high-ranking executives with greater deterrence value; or it may be justified as a method to conserve constrained prosecutorial resources. What is new is the promulgation of formal leniency programs in the 1990s by the U.S. DOJ and the EC’s DG-IV for price fixing.

Here is how the U.S. Leniency Program works.\textsuperscript{50} If a cartel member is not a ringleader or enforcer in the conspiracy and if the DOJ is not aware of the illegal activity, then the \textit{first} firm to confess is granted automatic amnesty, that is, a 100-percent discount on its fine specified by the U.S. Sentencing Guidelines. In the view of the DOJ, amnesty is valuable because it sets up a “race” to be first to confess and leads to tension and mistrust among cartel members. An extension of this program called “Amnesty Plus” offers amnesty to suspected price fixers if they are the first provide evidence of cartel activity in an unrelated market about which the DOJ was ignorant. The many vitamins cartels were unmasked by this type of amnesty granted to BASF. Indeed, as of 2001, more than half of the 30 grand juries established to investigate alleged cartel activity were set up as a result of the Amnesty-Plus Program.

The Leniency Program also extends concessions to later arrivals on the doorstep of the Justice Department. The \textit{second} member of a cartel to offer its cooperation to prosecutors is entitled to a 50- to 80-percent fine reduction. The \textit{third} and \textit{fourth} conspirators to arrive may expect less generous discounts, but in effect all cooperators but the last firm to hold out are rewarded with substantial discounts. If anything, these leniency discounts, which were approved by a court, are larger than the official policy suggests. While the first and second firms to plea follow the Leniency Program standards, those that plea later receive discounts that exceed the program’s stated guidelines. Similar incentives to cooperate are

\textsuperscript{50} Perhaps the most detailed description of the program is to be found in Gary R. Spratling, \textit{Detection and Deterrence: Rewarding Informants for Reporting Violations}, 69 GEO. WASHINGTON L. REV., 798(2001).
offered to individual conspirators: reduced fines, short prison sentences, or the freedom to cross the U.S. border.\textsuperscript{51}

An example of how a company will fare if it is the last to be sentenced and does not cooperate is provided by the Mitsubishi conviction at trial in February 2001. For its indirect role of aiding and abetting price fixing in the graphite-electrodes cartel, it received a fine of $134 million. What is impressive is that the fine was 76 percent of affected U.S. sales, probably a record percentage, and very nearly at the top of the Sentencing Guidelines range; it was also 7.6 times the assumed overcharge.

The U.S. Leniency Program for price fixing has been widely imitated by antitrust authorities in other jurisdictions. The most important adoption was by the European Union in February 2002.\textsuperscript{52} Its new program makes the process for applying for full immunity far more transparent and predictable. Amnesty is \textit{automatic} for the first company to reveal a cartel if (1) the EC was unaware of the cartel already, (2) cooperation is fully satisfactory, (3) the company immediately ceases price fixing, and (4) the company never coerced other companies to join to cartel. Thus, the new EC policy sets up strong incentives in the “races to be first” (to confess) to Brussels. Moreover, this race complements the race to be first to Washington, DC, Toronto, London, Paris, Brasilia, and at least three other national capitals where a company can earn multiple prizes. The global convergence of antitrust leniency policies has now become the major single source of information of formerly clandestine illegal activities that were nearly impossible to detect. To a large extent, the potentially huge and automatic financial rewards for informing antitrust authorities have made the disease of global price fixing self-medicating.

Finally, to get a complete picture of the actual U.S. financial sanctions for collusion, one must consider the treble-damages suits filed by injured parties. In the three best-documented global cartel cases, private plaintiffs garnered record-making settlements totaling between $1,745 and $2,445 million

\textsuperscript{51} As a general rule, convicted felons may not be issued passports or obtain visas to enter U.S. territories. However, by arrangement with the U.S. State Department, the Antitrust Division may obtain an exemption for some convicted price fixers. This concession has proven to be a valuable incentive to induce cooperation by middle-aged non-U.S. residents.

\textsuperscript{52} The 2002 EC Notice replaced a 1996 leniency program that was not working very well because it retained too much discretion for EC officials and did not guarantee amnesty for the first applicants. Indeed, the EC did not grant any company amnesty until November 2001 when the vitamins cartels were fined. Hammond \textit{supra} note 9.
(Table 11). However, compared to fairly reliable estimates of what U.S. treble overcharges were, these settlements are well below what the Sherman Act promises to direct buyers. Lysine buyers received 35 percent of treble damages, citric acid buyers 32 to 40 percent, and vitamins buyers 32 to 54 percent. That is, injured parties got single damages (or slightly higher), not treble damages.\textsuperscript{53} There is some evidence that the largest direct buyers that opted out of the federal classes obtained settlements that were twice as rich.

Table 11. Potential and Actual U.S. Private Settlements Paid by Three Global Cartels.

<table>
<thead>
<tr>
<th>Cartel</th>
<th>Corporate Settlement Amounts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treble U.S. Damages</td>
</tr>
<tr>
<td></td>
<td>Million dollars</td>
</tr>
<tr>
<td>Lysine</td>
<td>240</td>
</tr>
<tr>
<td>Citric acid</td>
<td>600-750</td>
</tr>
<tr>
<td>Vitamins</td>
<td>3,660-4,515</td>
</tr>
<tr>
<td>Total</td>
<td>4,500-5,505</td>
</tr>
</tbody>
</table>

Sources: Connor (2001:Table 16.A.1).

$^a$ These amounts include federal suits by direct purchasers (both class actions and firms that opted out of the classes), a parens patriae settlement in vitamins, and estimates of indirect-purchaser suits in state courts. The latter amounts may be generous.

\textsuperscript{b} Several cases still in negotiation or litigation.

To summarize, government and private antitrust penalties on the lysine, citric acid, and vitamins cartels amounted to between $2,850 million and $3,550 million. Although by historical standards these amounts were great accomplishments for public prosecutors and private plaintiffs, they fall far short of what the Sherman Act intended. These price-fixing penalties amounted to about 47 percent of affected U.S. sales, or somewhere between 179 percent and 194 percent of the cartels’ illegal profits. Less than double overcharges will not deter absolutely.

\textsuperscript{53} As a percentage of U.S. sales (equals U.S. purchase values), lysine buyers obtained 18.5 percent, citric acid buyers 16.4 percent, and vitamins buyers 23.7 to 42.4 percent. The average was 32.6 percent. (Compare footnote 26 above).
Practice: Canada and the EU

The enhanced fines on global conspirators imposed by the governments of Canada and the EU help deter, but their incremental influence is still not sufficient to prevent the formation of new cartels.

In 1998-2000, the Canadian Competition Bureau (CCB) obtained court orders requiring the lysine, citric acid, and vitamins cartelists to pay a total of C$145.7 million. In addition, class-action suits were filed by direct and indirect buyers; two of these private damages actions were moderately successful. Taken together, the members of the three cartels have paid about U.S. $100 million in fines and settlements to parties in Canada.

In 2000-2001, the same three cartels were fined U.S. $975 million by the European Commission. Although legal in the courts of some of the member states of the EU, no significant private antitrust settlements are expected. The Australian, Mexican, and Brazilian antitrust agencies have launched investigations of the three cartels, but except for small fines for vitamins in Australia, none has yet resulted in significant fines.

The ability of direct buyers who purchase cartelized products outside the United States to obtain compensation is quite limited. Canada, Australia, and several European countries have laws that permit private suits for injuries due to price-fixing overcharges, but mostly these national courts do not award sufficiently large to make such suits worthwhile. Moreover, the possibility of class actions to recover damages is low. However, class actions against the lysine and citric acid cartels have been moderately successful in Canada under a 1992 law. Moreover, a March 2002 decision by the U.S. Court of Appeals for the 2nd Circuit (Kruman v. Christie’s International) has extended the rights of foreign buyers to sue for damages under the U.S. Sherman Act. Oddly, instead of U.S. legal standards spreading to other nations, the U.S. court system itself is becoming a globalized legal institution.

The additional $1.1 billion in non-U.S. fines for price fixing in the markets for lysine, citric acid, and vitamins certainly moves global anticartel policies in the right direction. Nevertheless, the global penalties imposed on the three cartels ($3,950 to $4,650 million) still represent modest amounts when
compared to either worldwide affected sales (9.9 to 11.7 percent) or to worldwide overcharges by the cartels (51 to 60 percent).

The relationship of global public and private penalties to the cartels’ illegal gains is illustrated in Figure 1. Estimated worldwide profits made from collusion are compared to U.S. and non-U.S. penalties for the three cartels. In each case, U.S. penalties are about double the non-U.S. (mainly EU and Canada) penalties. These penalties slightly exceed the cartel’s monopoly profits only in the case of lysine, by about $40 million. However, in the other two cases, cartel crime did pay. The corporate members of the citric acid cartel made a net return of about $370 million; that is, they retained about 53 percent of their illegal profits after paying their fines and private settlements. The members of the vitamins cartels kept more than $4 billion of their illegal profits, or almost 60 percent of their customers’ overcharges.\textsuperscript{54} For ADM, probably the most heavily fined conspirator relative to its size, the antitrust costs of its lysine and citric acid ventures were about equal to its illegal net revenues.

Figure 1. The Bottom Line: Does Cartel Crime Pay?

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1.png}
\caption{Global Profits and Global Penalties}
\end{figure}

Sources: Tables 3 and A.2, Connor (2001).
\textsuperscript{a} Government fines on corporations and private settlements paid to buyers of cartelized products.

\textsuperscript{54} Recall that this is an ex post analysis. Viewed from the dates of cartel formation (1988-1992), the expected profit-retention rate would have been well above 90 percent.
The major objective of anticartel policies should be to lower the benefits (profits) or raise the costs (penalties) of price fixing. Other than vigilance in merger control, public policies can do little to change the structural features of markets that make cartels profitable: inelastic demand, large numbers of buyers, economies of scale, homogeneity, and so forth. Policies can sometimes have effects on trading conditions, such as the publication of transaction prices in markets characterized by lack of transparency. However, the principal role for antitrust is to develop rules, laws, and investigative procedures that make punishment surer and harsher than at present. Reforms should be implemented soon because the present favorable public and legislative support may not persist.

It is clear from the geographic location of cartel meetings that, as a general rule, United States territory was avoided because of its well-deserved reputation for tough anticartel enforcement. Instead, conspirators met in Switzerland, Mexico, Japan, Hong Kong, and several EU cities that were regarded as less risky in terms of the probability of discovery or the size of the expected sanctions. This behavioral pattern is perhaps the best indicator that U.S. anticartel policies are the ones other jurisdictions should emulate. Indeed, without more international uniformity of anticartel enforcement, U.S. firms have a perverse incentive to form or join international cartels rather than less harmful domestic ones.

One investigative technique that has proven especially useful in discovering cartels is the DOJ’s 1993 Leniency Program. Similar programs were subsequently adopted in Canada, the UK, Germany, Brazil, and the EU. A novel variation is the “Amnesty Plus” program that rewards indicted companies if they inform the DOJ about collusive activity in a market not yet being investigated. In 2001, more than half of the DOJ’s 30 global-cartel investigations were the result of Amnesty Plus leads. Other U.S. policies worthy of globalization include: fines based on multiples of overcharges rather than arbitrary percentages, increased penalties for recidivists, encouragement of private antitrust suits, and the criminalization of antitrust violations. This last initiative is especially important because it reduces the number of safe havens for fugitives from U.S. antitrust laws. These policy reforms are especially needed
in Japan (which has an arbitrary fine of 6 percent of sales for price fixing by manufacturers) and other industrialized Asian countries.

U.S. anticartel policies themselves are hardly above criticism. Periods of weak enforcement seem to be associated with clusters of cartel-formation, such as occurred in the 1930s and 1980s. While it is treacherous to second-guess the decisions of DOJ prosecutors, there seems to be a pattern of overly generous fine discounts being given routinely to late-arriving cartel members; actual discounts are often bigger than the stated discount policy. Given the relatively low levels of fines and private settlements outside the United States, consideration should be given to calculating fines routinely on the basis of global sales of the cartelized product, rather than as the rare exception it is today. Then DOJ threats of imposing fines “as high as 80 percent” of the value of affected commerce might really approach full deterrence levels.

Many legal writers believe that personal penalties may have more deterrence value than corporate fines. The present U.S. Sherman Act cap of $350,000 has little punishment value for most multi-millionaire executives convicted for criminal price fixing in recent years. An alternative fine statute, first applied in 2002 litigation, should be made the new standard; at least Congress needs to clarify to the judiciary when it should be applied. As to prison sentences, three years may be too low a limit. Other countries have five-year maximum sentences for the same offense. The DOJ has been criticized for overuse, or at least unjustified use, of grants of immunity for top executives; closer supervision of these concessions by the courts is warranted. On the other hand, a small somewhat clearer policy is needed on granting immunity to “whistle-blowers” or cooperating witnesses, akin to automatic amnesty available for corporations.

Finally, nongovernmental solutions to price-fixing behavior should be explored. Companies should implement internal antitrust compliance programs: training in legal standards of behavior, formal involvement in monitoring of contacts with rivals by corporate counsel, confidential whistle-blower communication methods, guidelines for dismissal of guilty employees, and surprise audits of participation
of employees in trade-association meetings. Governance structures are critical if companies are to avoid future price-fixing allegations. In particular, boards of directors must be composed of a majority of members independent from management and outsiders should be the majorities on the all-important nomination and audit committees of the board.

55 Federal legislation passed by Congress in July 2002 mandates the Securities and Exchange Commission to establish standards of professional conduct for lawyers who practice before the SEC. Lawyers will be required to report evidence of fraud or other misconduct by corporate managers to the firm’s CEO or, if no action is taken, to the board of directors. This rule originated from a letter from 40 law-school professors that cited ethical concerns about the role of lawyers in the Enron Corp. scandal. Richard B. Schmit, Law Asks Corporate Lawyers to Report Fraud by Clients, WALL ST. J. (July 5, 2002), B1.
Welfare, Market Power, and Price Effects of Product Diversity: Canned Juices

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June 20, 2003

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We are very grateful to Mark Denbaly, J. Michael Harris, Veronica Jones, and John Hession of the USDA ERS for supplying us with the data in a useable form. We thank Jay P. Shimshack for extensive and excellent research assistance and useful advice.
Welfare, Market Power, and Price Effects of Product Diversity: Canned Juices

What effect does the introduction or elimination of a differentiated product have on welfare, market power, and prices? Are there too many of too few differentiated products? To address these questions, we estimate a random-parameter, discrete-choice demand model and then use the estimated demand to calculate the effects of entry and exit on consumer surplus, producer surplus, Lerner measures of price markups, and prices in the canned juice industry.

According to many food and beverage manufacturing executives, brands are maintained through product differentiation (e.g., Nijssen and Van Trijp, 1998). Firms constantly innovate to keep up with changing consumer tastes. Products that are not accepted by consumers are quickly dropped. One might think of this approach of constantly providing new products as a flagpole strategy: "Let's run it up the flagpole and see who salutes it."

New products take two forms. To most of us, the phrase "new product" means a new flavor or other change in the contents of a package, however, in industry parlance, the phrase frequently means putting the contents into a different sized container.

Many firms regularly introduce new flavors and other changes in contents. Snapple introduced two new fruit drinks in 2000: Diet Orange Carrot Fruit Drink and Raspberry Peach Fruit Drink (presumably they are reasoning that if they can sell those, they can sell any flavor). Similarly, Proctor & Gamble extending its line of Punica fruit juice drinks in Germany by launching a canned carbonated drink called Punica Fruitshot in an effort to attract teenagers.

In contrast, Welch's, the marketing arm of the National Grape Cooperative Association Inc., has emphasized changing container sizes. By changing sizes, Welch's products broke out of the one section of the supermarket to which they had been relegated. Now, they are in many

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2 "P&G Launches Carbonated Fruit Juice Drink in Germany," Crain Communications Inc., Euromarketing via E-mail, Vol. 111, No. 19, February 18, 2000.
supermarket aisles, vending machines, convenience stores, and membership wholesale clubs. Like many other companies, Welch's is introducing at greater rates recently than in the past. About one-third of Welch's sales in 1999 came from products introduced within the last five years; whereas, new products accounted for about only 10 percent of overall sales in the early 1990s.

Economists have written extensively on the theoretical implications of product differentiation on welfare. Spence (1976), Dixit and Stiglitz (1977), Salop (1979), and Deneckere and Rothschild (1986) show that whether there are too few or too many differentiated products depends on the type of equilibrium and on the exact functional forms of demand and costs.

Surprisingly, there have been relatively few empirical studies of the welfare effects of differentiation and innovation. Hausman (1996) and Nevo (2000) look at welfare effects for ready-to-eat cereals; however, they concentrate on the implications for measuring the consumer price index.

More attention has been paid in the empirical literature to the effects of entry on substitution patterns and prices (especially by marketing economists). For example, Kadiyali, Vilcassim, and Chintagunta (1999) examine the price effects of product line extensions. They study two national yogurt manufacturers and conclude that, when a firm introduces a new product or a variant, it gains price-setting power and that the firms' combined sales increase. Hausman (1996) estimates the price effects of a cereal firm's new product on the prices of its other similar products.

We start by discussing the theoretical implications of a linear random utility demand system for oligopoly equilibrium. We then describe how we can estimate such a demand system using a random-parameter model. Next, we describe trends in canned juice sales by U.S. grocery stores. In the following section, we discuss our estimates of demand. We then calculate the market power, price, and welfare effects.
Linear Random Utility Model

We start by discussing the linear random utility model based on the presentations in Perloff and Salop (1985; henceforth PS) and in Anderson, de Palma, and Thisse (1992; henceforth AdPT). In the PS model, we can write a consumer $j$'s conditional indirect utility as\footnote{The extension of these models to include an outside good is straightforward (cf., Salop, 1979; Perloff and Salop, 1985; Anderson, de Palma, and Thisse, 1992.)}

$$\tilde{V}_j = a - p_i + \theta \zeta_{ij},$$

where $a$ is the attribute or quality of a good (initially the same for all goods), $p_i$ is the real price of firm $i$'s product (initially each firm produces a single product), $\zeta_{ij}$ is a random variable with mean zero, and $\theta$ is the preference intensity: the higher the value of $\theta$, the less important price is in determining which variant a consumer buys. Each of the $n$ firms produces a differentiated product. For simplicity, each of the $N$ consumers buys one unit, so the sum of their demands, $Q$, is $N$. If $\zeta_{ij}$ is distributed IID $\mathcal{F}(\cdot)$ with density $f(\cdot)$ and $m$ is the constant marginal cost, the (symmetric) short-run equilibrium price is

$$p = m + \frac{\theta}{n(n-1)\hat{\Gamma}(n)},$$

where

$$\hat{\Gamma}(n) = \Gamma\int_{-\infty}^{\infty} f^2(\zeta)[F(\zeta)]^{n-2} d\zeta.$$

Thus, the markup in Equation Error! Reference source not found. is proportional to $\theta$ and the price, $p$, is proportional to marginal cost, $m$.

Increasing the number of firms decreases the short-run equilibrium price iff

$$(n+1)\hat{\Gamma}(n+1) - (n-1)\hat{\Gamma}(n) > 0$$

for an integer number of firms, $n$. Even though $\hat{\Gamma}(n+1) < \hat{\Gamma}(n)$ by
inspection, the condition for a price decrease need not hold. Indeed, for some distributions \( F(\cdot) \), price may increase with \( n \). One distribution where the price decreases is the logit.

PS show that, when the number of firms become arbitrarily large \( (n \to \infty) \), the price approaches the marginal cost if (a) \( f(\cdot) \) is bounded from above or if (b) the

\[
\lim_{\zeta \to \infty} f'(\zeta) / f(\zeta) = -\infty \text{ when the support from above is unbounded.}
\]

For example given the upper bound condition in (a), as the number of firms grows very large, consumers find more varieties that they value near the upper bound of the support of the density function, so that competition drives price to marginal cost. A similar intuition applies for condition (b). For probit, condition (b) holds so that the limit is perfect competition. However, if neither condition (a) nor (b) holds, the limiting case is monopolistic competition with price strictly above marginal cost.

With the logit distribution, the equilibrium price falls monotonically with \( n \) to a limit of \( m + \mu \). The limiting case is relevant if either the size of the market becomes arbitrarily large or if the fixed cost becomes arbitrarily small.

Now we consider a generalization of the linear random utility models in PS and AdPT. Each firm sells one or more products, where \( i \) is the product index and \( n \) is the total number of products across all firms. In each period, the indirect utility for consumer \( j \) is

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5 The limit occurs where \( \mu = \sigma \sqrt{6} / \pi \) (AdPT, p. 188). Even more striking as PS show, the limit for the standardized exponential is \( m + \mu \) and the price is independent of \( n \) for \( n \geq 2 \).

6 With free entry, then the long-run equilibrium number of firms is uniquely determined as the implicit solution to (AdPT, p. 189): \( n^2 (n-1) \tilde{\Gamma}(n) = N0/K \) where \( K \) is the fixed production cost per firm.
\[ \hat{V}_{ij} = a_i - p_i + \varepsilon_{ij} + \zeta_{ij}, \]

where \( \varepsilon_{ij} \) is distributed multivariate normal and \( \zeta_{ij} \) is distributed IID extreme value. By using two error terms with different distributions, we avoid forcing the equilibrium to have the particular properties of either the logit or the probit. We could weight these two error terms to allow the model to range between the two extremes.

By integrating to concentrate out \( \zeta_{ij} \), we derive multinomial logit share equation for item \( i \) purchased by individual \( j \):

\[
\hat{S}_{ij} = \frac{e^{(a_i - p_i + \varepsilon_{ij})/\mu}}{\sum_{k=1}^{n} e^{(a_k - p_k + \varepsilon_{k})/\mu}},
\]

where \( \mu \) is the scale parameter on the type 1 extreme value. By integrating over individuals \( j \), we can concentrate out the \( \varepsilon_{ij} \) terms and obtain the item's share:

\[
S_i = \int \hat{S}_{ij} f(\varepsilon) d\varepsilon.
\]

Consequently, if each consumer buys one unit (or any constant number) so that the total number of units purchased is \( N \), then the demand equations are

\[
Q_i = N S_i.
\]

Although one interpretation of \( \mu \) in these equations is the scale parameter, AdPT (p. 78) provide another way of viewing it. They show that a representative consumer's utility function (where we suppress the individual's index) consistent with these multinomial logit share equations is given by
\begin{equation}
U = \begin{cases} 
\sum_{i=1}^{n} a_i Q_i - \mu \sum_{i=1}^{n} Q_i \ln \frac{Q_i}{N} + Q_0 & \text{if } \sum_{i=1}^{n} Q_i = N, \\
-\infty & \text{otherwise}
\end{cases}
\end{equation}

where \(Q_0\) is an outside good. The second term on the right-hand side of Equation (5) is \(\mu N\) times a version of the entropy measure. It captures the variety-seeking behavior of the representative consumer. All else the same, the larger is \(\mu\) (which plays a role similar to \(\theta\) in the PS model), the greater is the preference for diversity. When \(\mu \to 0\), diversity is not valued per se and the consumer buys solely the variant with the largest net surplus, \(a_i - p_i\); and when \(\mu \to \infty\), consumption is divided equally among all available variants.

We can now use these demand equations to derive a firm's multiproduct optimal pricing strategy. We start by examining how an item's share varies with item price, which we obtain by differentiating Equation (3):

\begin{equation}
\frac{\partial S_i}{\partial p_i} = \frac{1}{\mu} \int \tilde{S}_\mu \left( \tilde{S}_\mu - 1 \right) f(\varepsilon) d\varepsilon.
\end{equation}

In setting its prices, the firm must take into account how changing the price of one item in its product line can cannibalize the demand of another item. In each period, suppose that a given firm sells \(h\) products, so that it maximizes its profit of

\begin{equation}
\pi = \sum_{k=1}^{m} \left( p_k - m_k \right) Q_k - hF - \tilde{F},
\end{equation}

where the time parameter is suppressed, \(k\) indexes only those items sold by that particular firm, marginal cost per item is constant at \(m_k\), the fixed cost associated with item \(k\) for that firm is \(F\), and

88
the overall fixed cost for the firm is $\tilde{F}$. The firms' equilibrium is Nash-Bertrand. Using Equation (6), we can write the first-order condition for profit maximization of Equation (7) as

$$\frac{\partial \pi}{\partial p_k} = \sum_i (p_i - m_i) \frac{N}{\mu} \int S_{ij} (S_{ij} - 1) f(\epsilon) d\epsilon + NS_k = 0.$$ 

By rearranging terms, we find that

$$\sum_i (p_i - m_i) = \frac{\mu S_k}{S_k - \int S_{ij}^2 f(\epsilon) d\epsilon},$$

for each firm.

Whether there is too little or too much diversity depends, in part, on whether competition is localized - as in a spatial or Hotelling model (Salop, 1979)—or all firms compete with each other—as in a representative consumer or Chamberlin model (Spence 1975, Dixit and Stiglitz 1976, and Perloff and Salop 1985). Deneckere and Rothschild (1992) construct a model of demand that nests the Salop (1979) and Perloff and Salop (1985) models. Deneckere and Rothschild show that adding an extra brand benefits fewer consumers in a spatial model (where competition is localized) than in a representative consumer model. Consequently, there are too many brands in a spatial model but may be too many or too few in a representative consumer model.

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7 We do not model tie-in sales due to a lack of information. An example is that Tropicana juices benefit from “cross-marketing programs” with other PepsiCo brands, where discounts are given on one brand when another is purchased. Gary Haber, “Florida-Based Juice Maker Tropicana Posts 70 Percent Gain in Earnings,” Tampa Tribune, April 21, 2000.
Estimating the Random-Parameter Model

We want to estimate this model so as to calculate the effect of entry or exit on welfare and elasticities of demand. To do so, we use a random-parameter discrete-choice model of individual consumer behavior that corresponds to our theoretical model (cf, Berry, Levinsohn, and Pakes, 1995; Train, 1998).

Consumers' choices vary, but we do not have information about individuals' choices or their personal characteristics. We only have data on their aggregate consumption. Thus, we model demand as depending on observed and unobserved (by the econometrician) product characteristics and price. We capture these unobserved effects using random parameters.

Consumer $j$ chooses an item $i$ produced each period $t$. Consumer $j$'s conditional indirect utility is

$$\tilde{V}_{ijt} = X_{it}\beta_j + \zeta_{ijt},$$

where $X_{it}$ is a vector of observed product characteristics, $\beta_j$ is a vector of coefficients that are unobserved for each consumer $j$ and that vary randomly over consumers due to differences in tastes, and $\zeta_{ijt}$ is an unobserved random term.

We can arbitrarily choose which distribution to use with our random-parameter model. Many researchers use random-parameter logit (RPL), a generalization of logit, but there are many other possibilities such as random-parameter probit. We assume that $\zeta_{ijt}$ is distributed IID extreme value independently of $\beta_j$ and $X_{it}$.

RPL allows coefficients $\beta_j$ to vary across the population rather than being common for all. We decompose the coefficient vector for each consumer, $\beta_j$, into the sum of the population mean,
\( \beta \), and an individual deviation, \( \eta_j \), that represents the consumer's taste relative to the average tastes of all consumers. We assume that \( \eta_j \) is distributed IID normal. We can rewrite utility as

\[
\bar{V}_{ijt} = X_{it} (\beta + \eta_j) + \zeta_{ijt} \equiv X_{it} \beta + \epsilon_{ijt} + \zeta_{ijt}.
\]

As we show below, we can estimate \( \beta \), but we do not observe \( \eta_j \) for each consumer. Thus, the unobserved portion of utility is \( X_{it} \eta_j + \zeta_{ijt} \equiv \epsilon_{ijt} + \zeta_{ijt} \). This term is correlated over products and time because of the common term \( \eta_j \). That is, we assume that a given consumer has the same tastes over products and time (however, we allow some product characteristics to vary over time by adding interactions between those characteristics and a time trend).

RPL generalizes logit by allowing the coefficients of characteristics to vary randomly over characteristics rather than be fixed. RPL avoids three unattractive restrictions of the usual logit or nested logit models that have traditionally been employed in demand studies (Train, 1998). First, in logit or nested logit models, the coefficients of variables that enter the model are assumed to be the same for all products, which implies that different products with the same observed characteristics have the same value for each factor. Consequently, the logit predicts that a change in the attributes of one alternative changes the probabilities of the other alternatives proportionately (and the nested logit makes the same assumption within a nest). Second, the logit model has the "independence from irrelevant alternatives" (IIA) property, and nested logit has IIA within each nest. Third, where repeated choices are made over time, logit and nested logit assume that unobserved factors are independent over time (in the absence of time trend terms).

In contrast, the RPL allows the unobserved portion of utility to be correlated across products and time. Consequently, RPL coefficients are not the same across all products, and RPL lacks the IIA property of the traditional logit or nested logit models, and choices may vary over
time. For example, we allow consumers' tastes for certain types of products (e.g., sparkling juice drink) to change over time. Indeed, the RPL model can exhibit very general patterns of correlation over products and time. McFadden and Train (2000) show that any pattern of substitution can be represented arbitrarily closely by a RPL.8

Suppressing the time, t, index, noting that \( a_i \equiv X_i \beta \) and \( \varepsilon_{ij} \equiv X_i \eta_j \), and integrating out the \( \zeta_{ij} \) term that is distributed IID extreme value, we can rewrite share Equation (2) as

\[
\tilde{S}_{ij} = \frac{e^{(X_i \beta - p_j + \varepsilon_{ij})/\mu}}{\sum_{l=1}^n e^{(X_i \beta - p_l + \varepsilon_{il})/\mu}}.
\]  

We now integrate out the population distribution of the taste parameter \( \varepsilon_{ij} \), which is distributed IID normal to obtain Equation (3):

\[
S_i = \int \tilde{S}_{ij} f(\varepsilon) d\varepsilon.
\]

We cannot evaluate the product shares directly because the high-dimensional integral is difficult to calculate analytically. Instead, we approximate the product share using simulations. In particular, \( S_i \) is approximated by a sum over randomly chosen values of \( \varepsilon_{ij} \). A value of \( \varepsilon_{ij} \) is drawn from its distribution and used to calculate the share in Equation (3). This process is repeated for 50 draws, and the average of the share \( \tilde{S}_{ij} \) is taken as the approximate choice probability. By construction, we have an unbiased estimator, whose variance decreases as the number of draws increases. The simulated estimator is smooth (e.g., twice differentiable), which

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8 Actual substitution patterns may be complex. For example, Allenby and Rossi (1991) find that consumers are more likely to switch up to high-quality brands than down in response to price promotions.
helps in the numerical search for the maximum of the simulated log-likelihood function. It is strictly positive for any realization of the finite draws, so that the log of the simulated probability is always defined. See Lee (1992) and Hajivassiliou and Ruud (1994) for the asymptotic distribution of the maximum simulated likelihood estimator based on smooth probability simulators with the number of repetitions increasing with sample size. Under regularity conditions, the estimator is consistent and asymptotically normal (McFadden, 1989). When the number of repetition rises faster than the square root of the number of observations, the estimator is asymptotically equivalent to the maximum likelihood estimator.

Similarly, we can calculate the associated expenditure function (cf., AdPT, p. 79):

\[
Z = \bar{U} - N\mu \ln \left[ \int \sum_{i=1}^{n} e^{\left(a_i - p_i + \mu \varepsilon\right) / \mu} f(\varepsilon) d\varepsilon \right].
\]

(10)

for any utility level \( \bar{U} \). This expression provides the dollar value of the exact consumer benefit from increased product variety.

Finally, we calculate the own and cross-price elasticities of demand, which we use later to predict price changes. The own price elasticity for item \( i \) is

\[
E_{ii} = \frac{P_i}{\mu S_i} \int \tilde{S}_{ij} \left( \tilde{S}_{ij} - 1 \right) f(\varepsilon) d\varepsilon
\]

(11)

which must be negative. If we used a traditional logit, this expression simplifies to \( E_{ii} = p_i (S_i - 1) / \mu \). Thus, own price elasticity is roughly proportional to own price. The cross-price elasticity (effect of a change in the price of good \( k \) on the quantity of good \( i \)) is

\[
E_{ik} = \frac{P_k}{\mu S_i} \int \tilde{S}_{ij} \tilde{S}_{ik} f(\varepsilon) d\varepsilon
\]

(12)
which must be positive (all goods are substitutes). With a standard logit, the cross-price elasticity simplifies to \( E_{ik} = p_k S_k / \mu \).

In Appendix 1, we prove that an increase in one good's price, holding all other goods' prices fixed, causes the shares of other goods to rise for any discrete-choice model. For the logit, eliminating a good causes other goods' shares to rise, increasing their own price elasticities. Consequently, the price of all other goods will rise in a logit model where each firm produces a single good. However, in our more general model, the elasticity, and hence price, may rise or fall (as we illustrate with our estimates). Thus, by generalizing the logit model, we obtain greater flexibility in elasticities and pricing.

**Canned Juice Summary Statistics**

We now describe the U.S. grocery store canned juice industry. Throughout this paper, we use grocery store scanner data (Information Resources Incorporated's InfoScan™), which is described in Appendix 2. The data set covers 29 time periods of four weeks each, which we call months (though we should call them "februaries"). Thus, there are 13 months per year and the sample covers about 23 years. The first month in the sample ended on December 8, 1996, and the last one on January 31, 1999.

**Trends**

The following summary statistics are based on the full sample. The estimation results are based on a restricted sample (see Appendix 2).

Branded canned juices had an 80.2% quantity share compared to 19.7% for private labels alone and 19.8% for private labels and generics. Henceforth, we treat both private label and
generics as one group, which we (inaccurately) call private-label goods. Over our time period, the canned juice private label share had an 11.4% annual growth rate.

The average real price of all juices was 53¢ per pint, compared to 57¢ for branded, and 41¢ for private labels. Averaged over the period, private labels’ price was 72.2% of the branded goods' price. Consequently, there is either a substantial cost or quality difference between branded and private label products or the branded goods can exercise substantially more market power than can private labels. There was no price trend overall; the price of branded goods rose at a 1.1% annual rate, while the price of private labels fell at a 1.2% rate.

The quantity shares of the largest firms differ less than in most other food sectors that we have examined.9 The largest firm has a 19.2% share; the second, 17.6%; the third, 11.5%; the fourth, 4.6%; firms 5 through 8 collectively, 10.7%; and smaller branded firms collectively, 16.6%. The largest firm lost 4.1% of its share per year (over the last couple of years), while the next largest lost 5.1% per year. Thus, the industry shares have been become more uniform over time. The Gini coefficient over shares of items was 0.90 and the Gini over firms was 0.94. The items Gini fell at a 0.30% per year, while the firm Gini grew at a 0.08% rate.

We regressed the log of the quantity share of each of the eight largest firms on the log of the private label share and seasonal dummies. The estimated elasticity of the largest firm's share with respect to the private label share was -0.36 for the largest firm and 0.68 for the second largest. The elasticity for the share of the ninth and smaller branded firms was 0.36. On the basis of t-tests, we

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9 Out of 32 food industries chosen randomly, the largest firm had a smaller share than in canned juice in only 8. Of the rest, the share of the largest firm ranged from 25.6% to 78.2%. Moreover, in virtually every other sector, the second largest firm’s share was substantially smaller than that of the largest.
reject the hypothesis that any of these three elasticities is 0 at the 0.05 level. We could not reject
the null hypothesis for the second through eight largest firms. The elasticity of the item Gini with
respect to the private label share is -0.02 (and statistically significantly different from 0), while the
firm Gini elasticity is almost exactly 0.

In each month, the average number of branded canned juice items was 767.2, the number
of brands was 230.2, and the number of brand-name firms was 174.4. The corresponding annual
growth rates were -1.11% (not statistically different from 0), 2.17%, and 1.98%. Quantity in this
sector fell at a -6.46% annual rate.

The average number of items per firm was 4.39, brands per firm was 1.32, and items per
total quantity was 0.79. The number of items per firm fell at 3.09% per year, while the number of
items per quantity grew at a 5.35% annual rate. The elasticity with respect to the private label
share was -0.09 for items (not significantly different from zero), 0.02 for firms (not statistically
different from zero, and -0.23 for items per firm.

The average number of item births per firm per month was 0.15, as was the average number
of deaths, so the total number of items relatively constant over time. The correlation coefficient
for births versus deaths was 0.15 for items, -0.28 for brands, and -0.24 for firms.

On average, the quantity share of births to all items was 0.19, whereas the ratio for deaths
was 0.15. The price of births to that of continuing products averaged 1.04, the same ratio as for
eliminated products to continuing products.

On average 9.7% of items were on sale (temporary price reductions), but this share fell
8.5% annually. The share of items on nonprice promotions (local feature ads and in-store
displays) was 19.5%, which fell at a 9.7% annual rate. The elasticity of the share of promotions
with respect to private label share was 0.58 for sales promotions (not statistically significantly different from 0) and -0.84 for nonprice promotions.

We estimated that the elasticity of the price of individual brand-name firms with respect to private label share (controlling for seasonality). Starting with the largest firm, the (statistically significant different from zero) elasticities were 0.09, 0.17, 0.37, and 0.37. The elasticities for fifth through eighth largest firms and the smaller firms collectively were not statistically significantly different from zero. Thus, as private labels enter, large name-brand firms raise their prices, while smaller ones apparently do not change their prices. Overall, the elasticity of the price of all branded firms with respect to private label share was 0.13. The elasticity of the price of private label goods with respect to private label share was -0.14. Consequently the elasticity of the overall price with respect to private label share was approximately zero (0.02 but not statistically significantly different from 0).

Popular Canned Products

The most popular canned product flavors in order are vegetable, fruit punch, tomato, pineapple, apple, grape, and citrus. The most popular types of canned drinks in our sample in order are juice, juice drink, nectar, and juice cocktail. The most popular counts of cans sold (number of cans packaged together) are 1, 6, 12, 24, and 48 in that order. Table 1 shows the 10 best selling items.

Estimation Results

We used the IRI data to estimate a random-parameter demand model. Each observation is for an item in a given month. An item is a variant of a brand, where items may differ in size, the number of cans in a package, flavor, or in other ways.
The explanatory variables include price, the share of sales for which the item was being promoted (a special display in the store, a local feature advertisement, or both a display and a feature advertisement), size (total quantity in ounces in a package), count (number of cans in a package), size/count (size of each can within a package), a time trend (1, 2,...) interacted with the types of products (juice, nectar, sparkling juice,...), and a dummy for each brand (such as Dole's Pineapple Juice). Our specification does not include firm dummies because they are perfectly collinear with the brand dummies. Similarly, it does not include dummies for flavor because they would be nearly collinear with the brand dummies. The estimated model includes error components for flavors (28), types (8), firms (70), brands (104), items (421), size, count, and size/count.

We use 50 draws for each error component. The maximum likelihood estimates are reported in Table 2, where we report the coefficients as \( \beta/\mu \). On the basis of asymptotic t-tests, we reject at the 0.05 level the null hypothesis that the coefficient is zero for price, count, time \( \times \) juice (which was growing), and time \( \times \) sparkling juice (which was dying at a rapid rate); the scale terms on the error components for flavor, type, and brand; and all but 2 of the brand-specific dummies (which are not reported in the table to save space). One might view a positive brand dummy as a measure of high quality or market power.

The diversity coefficient, \( \mu \), equals the negative of the reciprocal of the price coefficient: \( \mu = 0.275 = -1/[-3.6376] \). Its asymptotic standard error is 0.0058, so we reject the hypothesis that it equals 0. Nonetheless, \( \mu \) is relatively close to 0 (and far from \( \infty \)). When \( \mu = 0 \), the consumer buys only the variant with the largest net surplus and hence does not place a large value on diversity. Thus, we find that consumers place a very slight (statistically significant) value on diversity.
Endogeneity

Unobserved quality variation may introduce spurious correlation between average price and average sales across brands. A low-quality brand would tend to have fewer sales than other brands for some fixed price. However, the low-quality item is likely to be paired with a relatively low price, because price is chosen optimally by the firm. To account for this source of endogeneity, we use a fixed-effects model with a dummy for each brand to capture unobserved quality variation at the brand level.\(^{10}\) The regression coefficients are identified by time-series variation in the explanatory variables and not by cross-sectional variation. As the asymptotic t-statistics on these brand dummies are enormous (often in the hundreds), a Hausman test strongly rejects the alternative hypothesis of random effects.

One might still be concerned about endogeneity and wish to use instruments. Following Hausman (1996), some researchers who have a cross section of city data over time have used argued that city-specific valuations of products are independent across cities but are correlated within a city over time. They then argue that prices of a brand in another city are a valid instrument because prices are correlated across cities due to a common marginal cost. We find the cross-city independence assumption difficult to believe especially for firms that engage in national advertising. An alternative approach is to use cost data that vary across products.\(^{11}\)

\(^{10}\) Because we have 29 time periods, we are not concerned about the identification issue that Chamberlain (1982) raised.

\(^{11}\) We have reestimated the model with farm-gate prices (for oranges, tomatoes, and so forth) as instruments and found very similar results.
Market Power

We can use the estimated demand system to infer the degree of market power and marginal costs if we are willing to make certain strong assumptions. We assume that the manufacturing marginal cost is constant and that grocery stores add a constant markup (which might be the case if they are competitive), so that the total marginal cost of selling a can is $m$. Presumably grocery stores have a fixed-proportions production function where they sell cans in proportion to those they purchase from the manufacturer. If so, the final equilibrium is the same as if a down-stream firm with market power were to vertically integrate into retailing (see, e.g., Carlton and Perloff, 2000).

Given our assumptions, the Lerner measure of market power depends on the elasticities of demand. If a firm makes a single product and maximize its profit, the relevant Lerner index is $L = (p - m)/p = -1/e$, where $e$ is its own price elasticity. On the other hand, if the firm produces many products and engages in a Bertrand-Nash game with other firms, then its first-order conditions for profit maximization are given by Equation (8).

Alternatively, the vector of Lerner markups can be written in terms of cross-price elasticities (see, e.g., Hausman 1996):

$$
\hat{L} = -(E^*)^{-1} S,$$

where $S$ is the vector of the shares of the items and $E$ is a vector whose $k^{th}$ element is $L_k$, the Lerner price-cost markup for item $k$, times $S_k$, item $k$'s share (of the firms total sales). Thus, the Lerner index for item $k$, $L_k$, is the $k^{th}$ row of the (inverted transposed) matrix times the column vector $S$ divided by $S_k$. Essentially what this equation tells us is that the relevant elasticity of demand for
the item is a weighted average of its own price elasticity and the cross-price elasticities of the other items the firm makes. We call this weighted elasticity the multiproduct elasticity.

The matrix $E$ has negative own-price elasticities on the diagonal and positive cross-price elasticities—all items are substitutes—off the diagonal [see Equations (11) and (12)]. As the firm lowers the price of one item, it sells more of that item (because its own price elasticity is negative) but it cannibalizes sales from its other items (due to the positive cross elasticities). Consequently, the multiproduct elasticity for an item is less elastic than is the own-price elasticity.

**Price Effects**

Holding our calculated marginal cost constant, we can use our optimality equations to predict the effect of an entry or exit (which effectively drives the price of the good to $\infty$) on the prices of other products. We allow all prices to adjust until a new equilibrium is achieved. We calculate the average price change from period 0 to period 1 as the change in revenue due to the price change divided by the revenue in period 0:

$$\frac{\sum_i [p_i(1) - p_i(0)] q_i(0)}{\sum_i p_i(0) q_i(0)}.$$ 

Table 3 shows three thought experiments in which we remove existing products. If we eliminate Dole's 46 ounce can of pineapple juice (the second best selling item across all brands), Dole lowers its price on its other product, a six-pack of six ounce cans of pineapple juice, by 4.1%. Other firms raise their prices on their pineapple products by an average of 0.3% and the price on other (non-pineapple) products by an average of 0.8%.
Were we to eliminate Dole and both its products, the price on other pineapple products would rise by 0.8%, while the price on other products would increase by 0.9%. Finally, if we were to eliminate all pineapple juices, the prices of other products would rise by 1.0%.

**Welfare**

Next we use our estimates to examine the various welfare effects of entry and exit, holding price fixed. Given that, by assumption, income is fixed in our model, the compensating variation (CV) and equivalent variation (EV) measures of the change in consumer surplus are the same. They are calculated as changes in the expenditure function in Equation (10). Producer surplus is the price minus the average variable cost (which equals the marginal cost) times quantity. This producer surplus measure is an upper bound on a firm's profit because it does not include firm and brand fixed costs.

**Pineapple Experiment**

We can determine the welfare value of an item, brand, firm, or flavor by asking what happens if it is eliminated (effectively driving the price of this product to a choke price, possibly \( \infty \)). We illustrate this approach in Table 4 using pineapple juice products.

Suppose that Dole were forced to stop selling its 46 ounce can of pineapple juice, which has revenues of $1.5 million dollars per month (5% of the total revenue in our restricted sample). If we hold all other prices fixed, the compensating variation to offset this loss of a product for consumers is about $345,000 per month. If we allow prices to change, then the compensating variation is $495,000 per month (44% more than if we hold prices fixed).

If Dole eliminated this product and total quantity remains unchanged, 5.8% of this quantity would go to Dole's other product, a six-pack of six ounce cans of pineapple juice. Other pineapple...
juices would get 3.4% of the quantity, and all other products collectively would gain the remaining 90.7%. Apparently consumers do not view small cans of Dole pineapple juice as extremely close substitutes for its large cans.

The producer surplus loss is slightly larger without the price effects (-$355,000) than with them (-$796,000). The welfare falls more after the price adjusts (-$796,000) than without the adjustment (-$700,000).

Now suppose that Dole (and hence both of its products) was forced to exit the industry. The consumer surplus loss is $1.18 million per month taking account of price adjustments. The other pineapple juices would gain 3.7% of the quantity and other products would gain 96%. The welfare loss, -$766,000 per month, is actually less than from eliminating only the large Dole can because of the producer surplus gains by other firms.

Finally, suppose all pineapple juices were eliminated. The consumer surplus loss is $1.68 million per month if prices are allowed to vary. Thus, most of the consumer surplus from pineapple juice is attributable to Dole. The welfare loss is -$957,000, not much larger than the loss from eliminating only Dole's 46 ounce can.

**Actual Entries and Exits**

We can also use our model to examine the effects from actual entries and exits. The compensated variation net effects from all the entries and exits in each month exhibit a monotonic downward trend over time. Over the entire period, compensated variation fell by about one percent. We now turn to a case of "near" entry and one of "near" exit.

Jugos was a major "near" entrant during our period, going from trivial sales of Del Valle nectar and nectar drinks to total revenue in the final month of $274,000. As Table 5 shows, the
consumer surplus gain taking price adjustments into account from this firm's entry was $130,300 per month, the producer surplus gain was $51,600 per month, and the welfare gain was $181,800 per month (evaluated in the last period). Thus, consumers gained two and a half times as much as did the firms (in net) from this entry.

Over our period, the size of Conagra's vegetable juice division, which manufactured Hunt's tomato juice, dropped substantially. The firm went from combined revenues of about $410,000 a month in the first month to essentially 0 by the end of the period. Accounting for price adjustments, the consumer surplus loss due to this "exit" was $52,400 per month (evaluated in the first period). The producer surplus loss was $227,900 (the other producers received little benefit) so that the welfare loss was $280,200 per month. Thus, consumers suffered relatively little loss from removing these products—which presumably explains why their sales disappeared.

Valuing the Eight Largest Firms

What would happen if one of the eight largest firms shut down? We answer this hypothetical question in Table 6, where we treat the two divisions of Nestle—canned fruit juice and canned drink—as separate firms (as they are recorded in the IRI data). The first three columns show the changes in producer surplus, consumer surplus, and welfare if we eliminate one of these firms. The last column shows the magnitude of the change in welfare relative to the revenue of that firm. For six of these large firms, other firms would benefit if one of these large firms were shut down. Indeed, total producer surplus rises. However, consumers lose substantially and total welfare falls if any of these firms is eliminated. Indeed, as the (million) dollar amounts in the table are for a single month, the loss to society of shutting down any one of these firms is large. If we plot the consumer surplus losses from eliminating each firm plotted against that firm's revenue, the
dots in the figure lie almost exactly on a straight line with a slope of one, showing that consumer surplus rise in proportion to revenue.

Summary and Conclusions

We estimated a system of demands for canned juices using a random-parameter, discrete-choice model that uses a type one extreme value error and other errors that are distributed normal. Consequently, our demand system allows for much more complex substitution patterns than do standard logit, nested logit, or probit models, and our oligopoly model is not as restrictive as it would be with a standard logit or probit model. We include a larger number of firms and items in our demand estimates than most previous studies. Indeed, most if not all other similar studies have aggregated item level data to the brand level before estimating and include only a small subset of the major brands.

Based on our estimates, we find that consumers put a relatively low value on diversity. Canned juice companies exercise substantial market power, with Lerner indexes substantially above zero. Eliminating an item, brand, or flavor leads to only moderately price changes in other products.

The entry or exit of an item, brand, or firm tends to have a larger welfare effect if price is allowed to adjust. The gain or loss of one of the major firms has large welfare effects—generally in excess of, but of the same order of magnitude as—that firm's revenue. In the next version of this paper, we hope to extend our analysis by explicitly studying whether there is too little or too much variety and by examining the effects of mergers.
Appendix 1: Discrete-Choice Model Results

For any discrete-choice model, an increase in the price of one good implies that the share of each of the other goods must rise. Let the conditional indirect utility for good $i$ be

$$\tilde{V} = X_i \beta - p_i + \epsilon_i.$$  

Then the probability that a consumer chooses good $i$ over any of the other $n$ goods is

$$\Pr\{\tilde{V}_i > \tilde{V}_1, \tilde{V}_i > \tilde{V}_2, ..., \tilde{V}_i > \tilde{V}_n\},$$

or

$$\Pr\{(X_i - X_1) \beta + p_1 - p_i + \epsilon_i > \epsilon_1, ..., (X_i - X_n) \beta + p_n - p_i + \epsilon_i > \epsilon_n\},$$

or

$$\prod_j F\left[\left(X_i - X_j\right) \beta + p_j - p_i + \epsilon_i\right),$$

where $F$ is a cumulative density function. By inspection, $\frac{\partial F}{\partial p_j} > 0$, so the probability that a consumer purchases this good (the good's share) rises as the price of another good increases.
Appendix 2: Data Sources

We use Information Resources Incorporated's (IRI) InfoScan™ data. IRI obtains data on all items scanned at cash registers from 11,300 local grocery stores from across the United States. The data are then scaled up to reflect all the sales in stores with revenues of $2 million and greater.

The InfoScan database contains information on dollar sales and physical volumes of food products at the brand and UPC (universal product code) or item level. The database also contains the share of dollar sales and physical volume sold on promotion (price reduction, special display, retail ads, and any other type of promotion excluding coupons).

IRI obtains between 90% and 92% of its scanner information from major chains that provide IRI with a census: complete information from all of the chain's stores. As these data are inclusive, no scale adjustment is required to convert this information to national levels. Random stratified sampling is used for the remaining (primarily nonchain) stores. A rotating panel design (similar to government surveys) is used where a fraction of the stores are dropped from the panel each month and replaced by others. Information about the entry and exit of stores is obtained from the census and random stratified sampling information and from field personnel. The random stratified sampling data are then projected to national levels.

The individual item data we use were drawn from the U.S. Department of Agriculture's Economic Research Service's version of the InfoScan database, which contains 519 different product types, which are in turn subsets of 166 product categories from 5 major supermarket departments (edible groceries, frozen food, bakery, dairy, and deli). We use data from one category: canned juices.
Local promotion information is collected by IRI field auditors on a weekly basis and used to develop physical and sales volume measures of food products sold under promotion and merchandising. The auditors track and classify the use of displays, retail ads, and any other retailer merchandising efforts. Promotion information is assembled each week and merged with weekly scanner data. The information allows IRI to differentiate regular everyday sales from sales made under promotion or special merchandising. The Economic Research Service database provides 10 promotion measures (5 for dollar sales and 5 for physical volume), which reflect the share of sales and physical volume sold under price reduction, display, feature, feature and display, and any individual or combined use of these promotions. Price reduction refers to items with temporary sale prices; display, to aisle or end displays; feature, to items that are primarily advertised in local papers or paper inserts; feature and display, to items that are both advertised and on display.

All prices are in real dollars. We deflate by the Consumer Price Index, where the index is normalized to equal one in the first month.

We restrict our sample to the 28 best selling flavors. In addition to apple, grape, orange, and tomato, it includes apricot, citrus, fruit punch, guava, tropical, vegetable, white grape and many others. The data set also includes 8 types of drinks including drink, juice, juice cocktail, juice drink, and nectar. A package may have seven different "counts" of containers: 1, 2, 3, 4, 6, 12, or 24. The size per container is recorded in ounces.

We excluded firms that never had any item that sold more than 3,000 pints in any month. The reason for this restriction is that sales of smaller firms are extremely variable, which may reflect substantial measurement errors. In addition, we eliminated items for which, during certain
months, the price exceeded the normal price by 250%, again on the grounds that these variant prices are almost certainly measurement errors.

Using the entire sample, the average number of firms in each month is 174, the number of brands is 230, and the number of items is 767. After restricting the number of flavors, we have 150 firms, 191 brands, and 613 items. After eliminating very small firms and those with implausible price fluctuations, we have 70 firms, 104 brands, and 421 items. The restricted sample has 9,132 observations, which is fewer than 421 items \times 29 \text{ months} because not all items are available in each month.
References


### Table 1: 10 Best Selling Items

<table>
<thead>
<tr>
<th>Item</th>
<th>Size (ounces)</th>
<th>Quantity</th>
<th>Percentage of Best Seller</th>
</tr>
</thead>
<tbody>
<tr>
<td>V8 Canned Vegetable Juice/Cocktail (Campbell Soup Co.)</td>
<td>46</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Dole Pineapple Canned Fruit Juice (Dole Foods Co.)</td>
<td>46</td>
<td></td>
<td>64</td>
</tr>
<tr>
<td>Juicy Juice Fruit Punch (Nestle S.A.)</td>
<td>46</td>
<td></td>
<td>61</td>
</tr>
<tr>
<td>Seneca Apple Juice (Seneca Foods Corp.)</td>
<td>46</td>
<td></td>
<td>52</td>
</tr>
<tr>
<td>Juicy Juice Grape Juice (Nestle S.A.)</td>
<td>46</td>
<td></td>
<td>49</td>
</tr>
<tr>
<td>Campbell's Tomato Juice (Campbell Soup Co.)</td>
<td>46</td>
<td></td>
<td>49</td>
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<tr>
<td>Juicy Juice Cherry Juice (Nestle S.A.)</td>
<td>46</td>
<td></td>
<td>48</td>
</tr>
<tr>
<td>Juicy Juice Berry Blend Juice (Nestle S.A.)</td>
<td>46</td>
<td></td>
<td>48</td>
</tr>
<tr>
<td>V8 Canned Vegetable Juice/Cocktail (Campbell Soup Co.)</td>
<td>69</td>
<td></td>
<td>46</td>
</tr>
<tr>
<td>Hawaiian Punch Canned Juice Drink (Procter &amp; Gamble)</td>
<td>144</td>
<td></td>
<td>44</td>
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<td></td>
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6 count
12 count
Table 2: Maximum Likelihood Estimates

<table>
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<tr>
<th>Continuous Variables</th>
<th>Coefficient (β/µ)</th>
<th>Asymptotic Standard Error</th>
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</thead>
<tbody>
<tr>
<td>Price ($)</td>
<td>-3.6376</td>
<td>0.0762</td>
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<tr>
<td>Feature and Display (% of sales)</td>
<td>0.0360</td>
<td>0.0222</td>
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<tr>
<td>Display Only (%)</td>
<td>0.0117</td>
<td>0.0109</td>
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<tr>
<td>Feature Only (%)</td>
<td>-0.0034</td>
<td>0.0189</td>
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<tr>
<td>Size (ounces)</td>
<td>-0.0108</td>
<td>0.0062</td>
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<tr>
<td>Count (number of cans)</td>
<td>0.0984</td>
<td>0.0348</td>
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<tr>
<td>Size/Count</td>
<td>0.0135</td>
<td>0.0236</td>
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<tr>
<td>Drink H Time</td>
<td>0.0550</td>
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<tr>
<td>Juice H Time</td>
<td>0.1722</td>
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<td>Juice Cocktail H Time</td>
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<tr>
<td>Juice Drink H Time</td>
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<td>0.0692</td>
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<td>Nectar Drink H Time</td>
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<tr>
<td>Nectar H Time</td>
<td>0.0843</td>
<td>0.0688</td>
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<td>Sparkling Juice Drink H Time</td>
<td>-0.2940</td>
<td>0.0143</td>
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<table>
<thead>
<tr>
<th>Error Scale Terms</th>
<th>Coefficient (β/µ)</th>
<th>Asymptotic Standard Error</th>
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<td>Flavor</td>
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<td>Firm</td>
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<td>Type</td>
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<td>Brand</td>
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<td>Item</td>
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<td>0.3786</td>
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<tr>
<td>Size</td>
<td>0.0008</td>
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<tr>
<td>Count</td>
<td>0.0159</td>
<td>0.0674</td>
</tr>
<tr>
<td>Size/Count</td>
<td>0.0566</td>
<td>0.0677</td>
</tr>
</tbody>
</table>

Notes:
(1) The sample size is 9,132. The sample was restricted to those firms that sold more than 3,000 pints in each month.
(2) The brand-specific dummies are not reported to save space (all but two have asymptotic t-statistics that are greater than 2, and most are very large).
(3) The simulation used 50 draws.
Table 3: Price Effects from Eliminating Pineapple Juice Products

<table>
<thead>
<tr>
<th>Eliminate Pineapple Products</th>
<th>Price Effect (%) on</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dole's 6-Pack of 6 oz Cans</td>
</tr>
<tr>
<td>Dole's 46 oz can</td>
<td>-4.1</td>
</tr>
<tr>
<td>All Dole products</td>
<td>-</td>
</tr>
<tr>
<td>All pineapple products</td>
<td>-</td>
</tr>
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</table>
Table 4: Welfare Effects from Eliminating Pineapple Juice Products
($ thousand per month)

<table>
<thead>
<tr>
<th>Eliminate Pineapple Products</th>
<th>Vary</th>
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<tr>
<td></td>
<td></td>
<td>Quantity Only</td>
<td>Quantity and Price</td>
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<tr>
<td><strong>Eliminate Dole 46 oz</strong></td>
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</tr>
<tr>
<td>Consumer Surplus</td>
<td>-345</td>
<td>-495</td>
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</tr>
<tr>
<td>Producer Surplus</td>
<td>-355</td>
<td>-301</td>
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</tr>
<tr>
<td>Welfare</td>
<td>-700</td>
<td>-796</td>
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</tr>
<tr>
<td><strong>Eliminate all Dole</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Consumer Surplus</td>
<td>-916</td>
<td>-1,183</td>
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<tr>
<td>Producer Surplus</td>
<td>210</td>
<td>417</td>
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</tr>
<tr>
<td>Welfare</td>
<td>-706</td>
<td>-766</td>
<td></td>
</tr>
<tr>
<td><strong>Eliminate all pineapple</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Consumer Surplus</td>
<td>-1,391</td>
<td>-1,677</td>
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<tr>
<td>Producer Surplus</td>
<td>497</td>
<td>720</td>
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<tr>
<td>Welfare</td>
<td>-894</td>
<td>-957</td>
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</table>
Table 5: Welfare Effects from Entries and Exits  
($ thousand per month)

<table>
<thead>
<tr>
<th>Varying</th>
<th>Quantity Only</th>
<th>Quantity and Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Entry&quot; by Jugos</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumer Surplus</td>
<td>84.3</td>
<td>130.3</td>
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<tr>
<td>Producer Surplus</td>
<td>85.6</td>
<td>51.6</td>
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<tr>
<td>Welfare</td>
<td>169.9</td>
<td>181.8</td>
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<tr>
<td>&quot;Exit&quot; by Conagra</td>
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<tr>
<td>Consumer Surplus</td>
<td>-20.8</td>
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<tr>
<td>Producer Surplus</td>
<td>-248.9</td>
<td>-227.9</td>
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<tr>
<td>Welfare</td>
<td>-269.7</td>
<td>-280.2</td>
</tr>
</tbody>
</table>
Table 6: Welfare Effects from Removing One of the Eight Largest Firms

Allowing Prices to Adjust
($ real million per month)

<table>
<thead>
<tr>
<th>Change in</th>
<th>Producer Surplus</th>
<th>Consumer Surplus</th>
<th>Welfare</th>
<th></th>
<th>Welfare</th>
<th>Revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nestle Canned Fruit Juice</td>
<td>2.05</td>
<td>-14.69</td>
<td>-12.65</td>
<td>1.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Campbell Soup</td>
<td>0.76</td>
<td>-2.29</td>
<td>-1.54</td>
<td>0.39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procter &amp; Gamble</td>
<td>0.11</td>
<td>-4.32</td>
<td>-4.21</td>
<td>1.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dole</td>
<td>0.69</td>
<td>-1.47</td>
<td>-0.78</td>
<td>0.34</td>
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<td></td>
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<tr>
<td>Nestle Canned Juice Drinks</td>
<td>-0.12</td>
<td>-0.69</td>
<td>-0.81</td>
<td>0.42</td>
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<tr>
<td>Citrus World</td>
<td>0.37</td>
<td>-1.13</td>
<td>-0.77</td>
<td>0.46</td>
<td></td>
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<tr>
<td>Texas Citrus Exchange</td>
<td>1.05</td>
<td>-1.51</td>
<td>-0.47</td>
<td>0.38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Empacadora de Frutas</td>
<td>-0.11</td>
<td>-0.52</td>
<td>-0.63</td>
<td>0.65</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Estimates are for the last month of the period (which ends January 31, 1999).
Acknowledgements: Without implicating them for the study’s shortcomings, we would like to express our appreciation to Roberta Cook-Canela, Carolyn Dimitri, Gary Thompson, Suzanne Thornsbury, and Humei Wang for their thoughts, insights, and helpful comments over the evolution of this study.
Introduction

This study is part of an investigation by the U.S. Department of Agriculture, Economic Research Service (ERS) into competition and pricing practices in the fresh fruit and vegetable (produce) industries. We focus on iceberg lettuce shipped from California and Arizona (CA-AZ), mature-green and vine-ripe tomatoes shipped from California and Florida, and lettuce-based fresh salads. A companion report by Richards and Patterson (RP) analyzes similar issues for Washington apples, California fresh grapes, California fresh oranges, and Florida fresh grapefruit.

A key factor motivating the investigation is the wave of mergers in food retailing that have led to increasing concentration in the sector. A concern is that this concentration may manifest itself both in terms of retailer oligopoly power, in selling to consumers, and oligopsony power, in buying from commodity shippers and food manufacturers. The concerns about oligopsony power are magnified in the produce sector, because the selling side of these markets in most cases is unconcentrated, relative to the buying side. In addition, most produce commodities are highly perishable, meaning that supply at any point in time is very unresponsive (inelastic) to price (Sexton and Zhang (SZ), 1996). The disparity between numbers of sellers and buyers and the need to move product to avoid losses from spoilage limits shippers’ bargaining power in dealings with retailers.

Our investigation of retailers’ behavior in the procurement and sale of iceberg lettuce, mature-green and vine-ripe tomatoes, and lettuce-based packaged salads focuses on 20 retail grocery chains in six U.S. metropolitan markets over the two-year period from January 1998 through December 1999. The market areas include Albany, NY (two chains), Atlanta (three chains), Chicago (three chains), Dallas (five chains), Los Angeles (four chains), and Miami (three chains). In several instances, the same retail chain was studied in multiple cities. By agreement with the data vendor, we are unable to reveal the chain names.

We look separately at retailers’ behavior as buyers from grower-shippers and as sellers to consumers for the aforementioned commodities. To examine possible oligopsony power, we utilize the switching regression model developed by Sexton and Zhang (SZ, 1996) to investigate pricing for perishable commodities. The analysis of retailers’ behavior as sellers relies upon the observation that any seller’s mark-up of a commodity’s price over its marginal cost for acquisition and selling is determined by the elasticity of demand the seller faces for the commodity and a parameter to indicate the extent to which the retailer is exercising the market power indicated by the demand curve. We are able to observe selling price and most aspects of selling and acquisition cost, and can estimate the price elasticities of demand from the data. This information can be used to infer the underlying pricing behavior.

Throughout the analysis, the focus is on the implications of retailers’ behavior for price and economic welfare of producers. The impact of retailer behavior on consumer welfare is also an interesting and important question. However, this question must be analyzed in the context of a broad cross section of items in the store, not merely for a few produce items.

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1 See Kaufman (2000) and Kaufman et al. (2000) for recent summaries of mergers and acquisition activity in U.S. grocery retailing.
Prior Research on Food Retailer Market Power

Rising concentration and consolidation of sales among large supermarket chains in the U.S. have made retailer market power in the food industry a topical issue. At a conceptual level, there should be broad agreement that two basic factors give grocery retailers some degree of market power, in the sense of being able to influence prices. First, the spatial dimension of retail food markets is important, because consumers are distributed geographically and incur nontrivial transaction costs in traveling to and from stores. This condition leads to a spatial distribution of grocery stores, and gives a typical store some degree of market power over those consumers located in close proximity to the store and, hence, the ability to influence prices at least somewhat. Second, retailers have the ability to differentiate themselves through the services they emphasize, advertising, and other marketing strategies. The question, thus, is not whether retailers have the ability to influence price, but, rather, the extent and implications of that influence.

Oligopoly power in food retailing is not amenable to the application of some methods used by economists to examine market power questions, because modern groceries sell a vast number of different products—an average of 30,000 or distinct product codes for U.S. supermarkets. The structure-conduct-performance (SCP) approach is, however, useful because prices can be observed readily and aggregated into indices. These studies seek to explain grocery prices as a function of demand, cost, and market structure variables. Studies such as Hall, Schmitz, and Cothern (1979), Lamm (1981), Newmark (1990), Marion, Heimforth, and Bailey (1993), and Binkley and Connor (1998) have examined average retail food price relationships, using cities as the unit of observation.

Marion et al. (1979), Cotterill (1986), Kaufman and Handy (1989), and Cotterill and Harper (1995), and Cotterill (1999) focused upon the behavior of individual stores, giving them the opportunity for increased precision and relevance in construction and use of explanatory variables relative to earlier studies. Cotterill (1986) found that concentration variables (four-firm and one-firm concentration rates and the Herfindahl index) were positively associated with price and were statistically significant for retailers in Vermont. A parallel study of Arkansas supermarkets by Cotterill and Harper (1995) and Cotterill (1999) reached similar conclusions as to the impacts of retailer concentration on food prices. MacDonald (2000) argues that observed pricing patterns at retail for food items with a strong seasonal component are consistent with models of oligopoly rivalry among retailers.

However, not all studies of grocery retailing have found a positive association between concentration and price. Kaufman and Handy (1989) studied 616 supermarkets chosen from 28 cities selected at random. Both firm market share and a four-firm Herfindahl index were negatively but insignificantly correlated with price. Newmark (1990) also obtained a negative and insignificant coefficient on four-firm concentration in a study of the price of a market basket of goods for 27 cities. Binkley and Connor (1998) suggest one explanation for the conflicting results in terms of the product coverage in the price variable. They found a positive and significant concentration-price correlation for dry groceries, but a negative and insignificant correlation for fresh and chilled food items.

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2 For discussions of food retailing from a spatial economics perspective, see Faminow and Benson (1985), Benson and Faminow (1985), Walden (1990), and Azzam (1999).

3 Studies conducted at the city level finding a positive structure-price relationship include Hall, Schmitz, and Cothern (1979), Lamm (1981), and Marion, Heimforth, and Bailey (1993).
Cotterill's (1993) part 5 contains a debate on the issue of market power in grocery retailing, and Connor (1999) and Wright (2001) provide recent critiques of research into the concentration-price relationship in grocery retailing. To the extent that the positive correlation between pricing and concentration found in the majority of studies is a robust conclusion, it lends credence to the aforementioned concerns that the recent wave of grocery mergers is apt to cause adverse price effects on producers and/or consumers.

Other investigations into food retailer pricing have focused on the transmission of prices from the farm to retail for commodities. This research has emphasized two primary issues: the “stickiness” of retail prices relative to farm prices, and potential asymmetries in the transmission of price from farm to retail. Of particular concern is the allegation that retail prices tend to respond more quickly and fully to farm price increases than to farm price decreases. To the extent that such behavior occurs, it is harmful to producer interests. If the FOB price decreases due to a large harvest, but the decrease is not transmitted to consumers, the additional sales needed to absorb the increased production are not achieved, exacerbating the decrease in the FOB price.

The empirical evidence on asymmetry in price transmission is mixed. Kinnucan and Forker (1987) for dairy products, Pick, Karrenbrock, and Carman (1990) for citrus, and Zhang, Fletcher, and Carley (1995) for peanuts found evidence that retail prices and margins were more responsive to farm price increases than decreases. Ward (1982) reached somewhat differing conclusions for fresh vegetables. More recently, Powers and Powers (2001) found no asymmetry in the magnitude or frequency of price increases, relative to price decreases, for CA-AZ lettuce, based on a sample of 40 grocers for 317 weekly observations from 1986-92.

The implications for competitiveness of food retailing from the research on rigidity of retail prices and asymmetry of transmission of farm-level price changes are not clear. Rotemberg and Saloner (1987) have shown that sellers with market power are more likely to maintain stable prices in response to changing costs than are competitive firms. The incentives are reversed for price changes due to demand shifts, but Rotemberg and Saloner showed that the cost effect dominates, when both cost and demand are subject to fluctuations. Re-pricing or menu costs also contribute to explaining retail price rigidities. Changing prices is costly for retailers, so a product’s price will be fixed unless its marginal cost or demand changes by a sufficient amount to justify incurring the cost of re-pricing. Carlton (1989) summarizes research on this topic, and Azzam (1999) presents an application to food retailing.

Moreover, from a marketing strategy perspective, a plausible pricing strategy in grocery retailing is to stabilize prices to consumers by absorbing shocks in farm-level and wholesale prices for certain frequently-purchased, staple commodities. For example, six of the 20 retailers in our sample did not change the store price for iceberg lettuce over the entire sample period of 104 weekly observations. As we demonstrate subsequently, this type of pricing behavior by retailers is probably harmful to grower/shippers, but viewed in isolation, it can hardly be construed as evidence of market power, as opposed to simply representing a marketing strategy by the retailer to attract and retain customers.

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4 The fundamental intuition is that as the extent of competition increases, individual sellers perceive an increasingly elastic demand. This makes price changes more beneficial because some of the benefits are derived at the expense of competitors.
Asymmetry of price transmission, wherein farm price increases are passed on to consumers more quickly than farm price decreases, is less readily explained. In a standard model of monopoly or oligopoly pricing, the optimal price change in response to a given increase or decrease in marginal costs may not be symmetric, and depends upon the convexity/concavity of consumer demand (Azzam, 1999). This consideration, however, does not explain a delay in responding to a price decrease, relative to a price increase.

To date, very little research has been conducted on the topic of food retailers’ oligopsony power as buyers from food shippers and manufacturers. To an important extent, the issue has surfaced only recently, in response to concerns over slotting and related fees charged by retailers. The issue is quite difficult to address because prices paid by retailers to shippers or manufacturers are typically not revealed. Retailers’ selling costs are also generally confidential and, moreover, almost impossible to apportion to individual products, given the multitude of products sold in the store. Produce commodities provide one of the better opportunities to examine retailer buying power because farm-level prices are typically reported, as are shipping costs to major consuming centers, and sales are often direct from grower-shippers to retailers. SZ (1996) examined pricing for CA-AZ iceberg lettuce for the period from January 1988 – October 1992 and concluded that retailers captured most of the market surplus generated for that period, essentially consigning grower-shippers’ economic profits to near zero over the time period analyzed.

How Market Power Affects Producers and Consumers

SZ (1996) developed a model of price determination for perishable produce commodities that allows for imperfect competition. When a commodity is perishable, it must be sold in the current market period. Thus, total supply can be regarded as perfectly inelastic for all prices in excess of the per-unit cost of harvesting. This scenario is depicted in Figure 1, for per-unit harvest cost \( C^0 \). Aggregate demand for the commodity is depicted as \( D^F = D^F(H_t) \); final-product value, \( P^F \), is a decreasing function of the total harvest volume, \( H_t \). The function \( P^F = D^F(H_t) \) is final demand less per-unit shipping and handling costs. Under conditions of perfect competition in procurement, \( D^F \) represents the farm-level demand for the commodity. \( D^F \) intersects \( C^0 \) at the harvest volume \( H^* \). Under any form of competition, the farm price, \( P^F \), must fall to the level of per-unit harvest costs for crops of magnitude \( H^* \) or greater. Thus, \( C^0 \) represents a floor below which the farm price will not fall. For all harvests when \( H_t < H^* \), a per-unit “surplus” exists, \( S_t = P^F - C^0 \), which is inversely related to the size of the harvest. Figure 1 illustrates this surplus for three alternative harvest volumes, \( H_1, H_2, \) and \( H_3 \).

Under perfect competition, the surplus is captured entirely by the grower-shippers as owners of the asset in fixed supply, namely the available harvest. Under imperfect competition in procurement, the surplus will be divided between grower-shippers and purchasers (e.g., retailers and food service buyers) based on relative bargaining power. The less aggressively buyers compete to procure the product, the greater the share of the surplus they will capture, resulting in a lower farm-level price.

Note from Figure 1 that the magnitude of per-unit surplus is decreasing in the size of the harvest. Thus, under an arrangement where buyers captured a constant percentage of the market surplus, the farm-retail price spread would be a decreasing function of the harvest. SZ (1996), however, hypothesized that grower-shippers’ share of the available surplus would also be a decreasing function of the harvest, because a large harvest of a perishable commodity would diminish sellers’ bargaining power relative to buyers’. In that case, the farm-retail price spread
would decrease less with increases in harvest or perhaps increase, if grower-shippers’ share of the surplus fell sufficiently.

**Figure 1**

*The Short-Run Produce Pricing Model*

Because supply of the commodity in any period is inelastic at prices in excess of the per-unit harvest cost, oligopsony power in the short run affects only the distribution of the surplus between buyers and sellers. The persistent exercise of oligopsony power depresses returns to growing the commodity, and, in the long run, this result will cause producers to exit the industry. Thus, oligopsony power will have the long-run effect of reducing supply, which will cause higher retail prices and a reduction in consumer welfare.

Consider now the specific behavior of food retailers in procuring and selling produce commodities. Denote retail prices and quantities with the superscript ‘R’. Then aggregate inverse retail demand is \( p^R = D^R(Q^R) \), where \( Q^R \) is the volume of the product sold at retail. Denote demand for all other uses of the commodity as \( Q^S = D^S(p^S) \).\(^5\) We assume that these users (e.g., processors and institutions) procure and sell the commodity competitively.\(^6\) Then we can

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\(^5\)We estimate that 60-65% of lettuce sales are to retail and 35-40% to the food service sector. For fresh tomatoes, the approximate percentages are 45-50% to retail and 50-55% to food service.

\(^6\)This assumption is not central to the analysis but seems quite reasonable. None of these buyers are large relative to the market, and sales to secondary purchasers are often made through various terminal markets, long regarded as quintessential competitive markets.
define a residual supply function, $S^R(P)$, for the commodity to food retailers as the total harvest less the secondary-market demand:

$$S^R(P_t) = H_t - D^S(P_t) \quad \text{if } P_t \geq C_0$$

$$S^R(P_t) = 0 \quad \text{otherwise}$$

Effective oligopoly power is exercised when a retailer marks up the commodity in excess of its full marginal costs of acquisition and sale, i.e., farm price, shipping cost, and selling cost. By raising price above marginal cost, a retailer reduces sales of the commodity in its stores. Because the total supply is fixed in any given market period, the result of oligopoly power in selling the commodity at retail is to force the diversion of a greater share of the volume into secondary and lower-value market outlets, such as the food service, institution, and processing sectors.

Similarly, oligopsony power is exercised when retailers, as buyers, recognize their ability to influence the acquisition price for the commodity. Under oligopsony power retailers pay less to acquire the product than its marginal value at retail less marginal shipping and selling costs and, thereby, capture a share of the aforementioned market surplus.

Figure 2 illustrates an oligopoly-oligopsony equilibrium. Technical details on the model illustrated in Figure 2 are provided in Alston, Sexton, and Zhang (1997) and Sexton and Zhang (2001). The retail industry marginal revenue curve is $MR^R = M^R_pQ^R/Q^R$, and the curve labeled $PMR^R > MR^R + (1-\gamma)P^R$ represents the “perceived marginal revenue” curve for the food retailing industry (Melnick and Shalit, 1985), with the parameter $\gamma$, $[0,1]$ indicating the extent of oligopoly power exercised by the industry.
For example, if the retailing industry sells the commodity competitively, then $\text{PMR}^R = P^R$ and $\geq 0$, or if the retailing industry acts as a pure monopolist or cartel, then $\text{PMR}^R = \text{MR}^R$, i.e., $\geq 1$. Within the interval $(0,1)$ higher values of $\geq$ represent greater levels of retailer oligopoly power. $\text{PMR}^R = \text{MR}^R + (1 - \geq)P^R$ thus represents the gross value of a unit of the farm commodity to the industry. To obtain the net value, we subtract per-unit shipping and handling costs, $C^R$, as illustrated in Figure 2.

If retailers procured the commodity competitively, then grower-shippers would be paid a price based on the net $\text{PMR}^R$ schedule: $P^F(Q^R) = \text{PMR}^R(Q^R) - C^R$, depending upon the volume of product marketed at retail. If retailers exercise oligopsony power in procurement, the actual farm price will be less than indicated by the $\text{PMR}^R - C^R$ function. Figure 2 illustrates the residual supply function, $S^R(P)$, derived in equation (1). Applying Melnick and Shalit’s logic to the market for acquisition of the farm commodity, we define the industry’s marginal cost of procuring the commodity as $\text{MC}^F = \frac{\partial P^F}{\partial Q^R}/\partial Q^R$ and the perceived marginal acquisition cost function as $\text{PMC}^F = 2\text{MC}^F + (1 - 2)P^F$. Similar to the interpretation afforded the oligopoly power parameter, $\geq$ the parameter $2$ denotes the degree of oligopsony power and ranges in the unit interval, with $2 = 0$ denoting perfect competition in procurement, i.e., $\text{PMC}^F = P^F$, and $2 = 1$.
denoting pure monopoly or a perfect buyer cartel, i.e., \( \text{PMC}^F = \text{MC}^F \). Within the interval \((0,1)\), larger values of 2 denote greater levels of oligopsony power.

If the retailing industry both procured and sold the produce commodity competitively, the market equilibrium would occur at point A in Figure 2, with volume of sales \( Q^C_R \) and producer price \( P^C_R \). The difference between the harvest volume, \( H \), and the volume, \( Q^C_R \), sold at retail is diverted to processing and food service uses. When retailers exercise both oligopoly and oligopsony power in procurement and sale of the commodity to the degree illustrated by the PMR and PMC curves in Figure 2, the market equilibrium involves sales of \( Q^C_R \) and producer price \( P^M_R \). As noted, market power exercised by retailers will cause relatively more of the total production, \( Q^C_R - Q^M_R \), to move through processing and food service outlets.

It is important to emphasize that either oligopoly or oligopsony power reduces the welfare of producers.\(^7\) Producer welfare is an increasing function of the volume of product moved through retail channels, and either type of market power reduces this movement and diverts more product into alternative outlets.

**Data Sources and Data Issues**

The source of all retailer data utilized in this study is Information Resources International (IRI). IRI provided detailed weekly data on a wide selection of produce commodities and packaged salads for the two-year period from January 1998 through December 1999, 104 observations in total, for 20 retail chains in six U.S. cities.\(^8\) The data are organized by universal product classification (UPC) code or price look-up (PLU) code. For each retailer and each product code, IRI provided weekly sales volume, listed selling price, and number of stores within the chain selling the product in the given metropolitan area. Weekly farm-level data on production and FOB price, weekly terminal (wholesale) price data for major terminal markets, and transportation costs from producing areas to the six consuming regions in the study were obtained from the USDA Federal-State Market News Service (F-SMNS).\(^9\)

We encountered some fundamental problems in working with the IRI data. The fresh tomato and lettuce categories feature PLU codes, as opposed to the more standardized UPC codes. The PLU is typically a four-digit code that is punched into the register as the product is checked at retail. PLU codes were originally not standardized among retailers, but a standardization program has been pursued through the auspices of the Product Electronic Identification Board. However, usage was not fully standardized during the time period investigated here. The problem was particularly acute for tomatoes, where reliable industry sources indicated, for

\(^7\) It also reduces the welfare of consumers, considering the particular commodity in isolation. From consumers’ perspective, reduced movement of product at retail results in higher volumes moved through alternative market channels. Nonetheless consumer welfare is diminished because oligopoly and/or oligopsony in one of the market channels results in a failure to equate consumers’ marginal valuation of the product across the alternative market channels, a necessary condition for consumer welfare maximization. However, as noted, examining only a single or a few commodities is an inappropriate basis to evaluate the effects of retailer behavior on consumers.

\(^8\) In many cases, a particular retail chain is represented in multiple cities. For example, Chain j in City x may have the same corporate ownership as Chain k in City y. We are precluded from making this type of connection when discussing results, because to reveal the cities where a particular corporate chain is operating, in many cases would result in revealing the chain’s identity.

\(^9\) We were not able to obtain shipping cost information for all of the metropolitan areas. When data were unavailable, we substituted data for a nearby city.
example, that some retailers classified vine-ripe tomatoes in the code (4064) reserved supposedly for mature-green tomatoes, instead of the normal (3151) vine-ripe code.

A further problem for both the iceberg lettuce and fresh tomato data is that retailers may assign multiple PLU codes for essentially the same product, based on differences in point of origin, size, or variety, but there is no standardization among retailers as to this practice. Through conversations with personnel in the industries and with the data vendor, and through careful analysis of the data, we were able to resolve many of the issues concerning the PLU codes. Ultimately, however, we cannot have the degree of confidence working with the PLU codes as with standardized UPC codes.

A second concern in working with the IRI data was unexplained, large shifts from period to period in sales volume for several stores. Investigation revealed various possible explanations. In cases where multiple PLU codes were being used for the same basic commodity, sales may vary extensively for particular codes based simply upon how product is classified. Proper aggregation across PLU codes addresses this issue. A low reported sales volume might be due to “stock outs” in a particular code for some time periods. IRI generates unit sales by dividing sales revenue by per-unit price. Thus, any errors in reporting the per-unit price due, for example, to failure to reflect discounts to consumers who purchase with membership cards, or failure to update computers to reflect sale prices, will cause variations in sales revenue that will be attributed incorrectly to variations in volume.

Ultimately, if we were not confident in the reliability of the data for a commodity in a given chain, that commodity-chain was omitted from the analysis. Thus, for each commodity the analysis is based on considerably fewer than the original 20 retail chains for which IRI provided data.

Table 1 provides summary information on FOB and retail prices. Notice that the average variance in the retail prices among the stores in our sample is larger than the variance in the FOB price for each commodity. The relative variability, measured in terms of the coefficient of variation, is, however, always greater for the FOB price.

Table 1
Summary of FOB and Retail Prices by Commodity

<table>
<thead>
<tr>
<th>Commodity</th>
<th>FOB Price</th>
<th>Retail Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA iceberg Lettuce (per head)</td>
<td>$0.2820</td>
<td>$1.1322</td>
</tr>
<tr>
<td>CA Vine-ripe Tomatoes (per lb.)</td>
<td>0.3065</td>
<td>1.5818</td>
</tr>
<tr>
<td>CA mature-green Tomatoes (per lb.)</td>
<td>0.2597</td>
<td>1.8311</td>
</tr>
<tr>
<td>FL mature-green Tomatoes (per lb.)</td>
<td>0.4261</td>
<td>1.6223</td>
</tr>
</tbody>
</table>

1The values reported in the table are the averages across the stores.

Analyses of Farm-Retail Price Spreads
In this section, we report on some statistical analyses of the behavior of the farm-retail price spread (or margin) for the commodities under investigation. Under any theory of pricing from farm to retail, variations in the margin over time will be due at least partly to changes in the marginal costs of transporting the product from shipping points to the retail location and selling it. Indeed, under conditions of perfect competition, variations in the margin should be explained fully by variations in the seller’s marginal cost. However, under a more general model of pricing from farm to retail, additional factors may help to explain the margin.

Of particular interest is the effect of shipments and sales volumes on the margin, given the hypothesis that, under oligopsony power, large shipments reduce producers’ relative bargaining power and, hence, share of the market surplus. Conversely, under perfect competition in the procurement of a produce commodity, the volume of shipments would have an effect on the margin only to the extent that marginal costs of marketing and selling the commodity were related to the volume shipped and sold. The margin would be an increasing (decreasing) function of shipments if industry marginal costs were an increasing (decreasing) function of shipments. Although we lack hard evidence on this point, it is not likely that industry marginal costs would rise with the volume sold. Most produce commodities are shipped by refrigerated truck, and no single industry is a major user of refrigerated shipping, to the point where its actions would affect shipping rates. A similar conclusion applies to retailing costs. A retailer’s handling costs likely rise with the volume handled, but the increase would, at most, be proportional to the increase in volume handled. Thus, based upon consideration of marketing costs, we would expect, under conditions of competition, that the total volume of shipments would have no effect on the margin, or, possibly, an inverse effect, if greater movement stimulated handling economies for retailers.

Under the SZ hypothesis discussed previously, producers’ relative bargaining power is an inverse function of the magnitude of the harvest. This hypothesis presents the possibility that the margin will be an increasing function of the harvest. This outcome will result only if the impact of the larger harvest on sellers’ relative bargaining power dominates its negative effect on the magnitude of per-unit surplus that is available. Thus, a finding that the farm-retail price spread is increasing as a function of the harvest volume represents rather strong evidence that buyers are exercising market power in procurement of that commodity.  

We estimated a simple model of the following form to predict the farm-retail price spread for the stores in the sample:

\[
M_{i,t} = (P_{R}^{i,t} - P_{F}^{i,t}) = \beta_{i,0} + \beta_{i,1} H_t + \beta_{i,2} S_{i,t} + \beta_{i,3} T_{i,t} + \epsilon_{i,t},
\]

where \(M_{i,t}\) is measured in $/unit (heads of lettuce and lbs. of tomatoes), \(H_t\) is the volume in ten million lbs. of the farm commodity shipped during week t, \(S_{i,t}\) is the cost per truckload ($000) of shipping the product from the producing location to store i’s city in week t, \(T_{i,t}\) is a time trend, and \(\epsilon_{i,t}\) is an error term to capture unexplained variation in \(M_{i,t}\). The time trend is included to

10 Conversely, RP argue that retailers’ bargaining power is inversely related to the amount of the commodity that the retailers need to procure in a given time period. For example, if a large percentage of retailers is promoting a particular commodity and, thus, anticipating higher sales, the retailers’ relative bargaining power is diminished and, thus, the margin may be a declining function of the total volume of sales of the product. As RP note, this hypothesis makes more sense in the context of the storable commodities, where higher prices can stimulate movement of product from storage, than for the highly perishable products analyzed here.

11 The USDA F-SMNS reports daily FOB prices for lettuce and fresh tomatoes. Prices are typically reported in a
capture secular changes in the margin, due to changes over the sample period in retailer selling costs or the extent of market power.\footnote{We conducted tests for unit roots in the three price series, FOB, wholesale, and retail, and for the price spread series utilized in the study. Unit roots were rejected in all cases, implying that the series are stationary and justifying analysis in the levels of the data.} Note that equation (2) is not subject to simultaneity bias, because $H_t$ is determined by planting decisions made months previously. Equation (2) was estimated for each of the basic commodities in the study (iceberg lettuce, mature-green tomatoes,\footnote{Mature-green tomatoes are produced domestically in both California and Florida. Florida tomatoes compete seasonally with imports from Mexico. Florida tomatoes are shipped predominantly to eastern and midwestern markets, with the western half of the country served predominantly by tomatoes from California and Mexico. The California marketing season runs from May to December and complements the Florida season, which runs from October through June. See the ERS report by Calvin et al. (2001) for additional description of the industry.} and vine-ripe tomatoes) using seemingly unrelated regressions (SUR).

Tables 2, 3, and 4 summarize the main results of the analysis of farm-retail price spreads. Table 2 contains the means and variances for the price spreads analyzed in this section. Table 3 is a correlation matrix of the price spreads for selected cities, while Table 4 reports the elasticity of the price spread with respect to the total volume of shipments.

Tables 2 and 3 combine to demonstrate the considerable independence that retailers have in setting prices for produce commodities. Because the farm price for a given commodity is assumed to be identical across retailers, differences in the price spread among retailers are due to differences in setting prices at retail. Table 2 shows that, even within a city, there is considerable variation in the mark-up for a commodity. For example, the Dallas 1 retail price for a head of CA-AZ iceberg lettuce reflected on average about a $0.95 mark-up, whereas Dallas 2 had an average $0.64 mark-up. The mark-ups for California mature-green tomatoes among the Dallas chains ranged from $0.68 in Dallas 2 to $1.58 in Dallas 4. The differences in mark-ups are somewhat less among the Los Angeles chains. Iceberg lettuce average mark-ups ranged only from $0.67 to $0.80, while mature green mark-ups ranged from $1.01 to $1.50 per lb. There is, however, a wide difference, $1.35 vs. $2.29, in how the Los Angeles 2 and Los Angeles 3 chains marked up a pound of vine-ripe tomatoes.

The variances of the price spread in parentheses in Table 2 also present an interesting story. A chain that employed a constant mark-up to a commodity and merely passed along changes in its acquisition costs would exhibit a low variance in the margin. Chains that varied prices strategically, e.g., for sales, would exhibit a higher variance. Variances in the price spreads for iceberg lettuce were quite similar, ranging from 0.013 for Miami 2 to 0.051 for Dallas 3. The price spreads for fresh tomatoes were more variable on balance, and differences in price-spread variances were more pronounced among the chains. For example, Chicago 1 had a variance of only 0.006 in its price spread for California vine-ripe tomatoes, whereas variance in the vine ripe price spread for Los Angeles 3 was 0.704.

The correlation coefficients in Table 3 measure the extent to which the price spreads move together over time. In a prototypical competitive market, we would expect to see a high positive correlation among the price spreads, because all chains face similar shocks in the costs of procuring and marketing a commodity. The reality, however, is that the price spreads are not highly correlated, even within a city. For iceberg lettuce, the correlations for the three Dallas chains range from 0.14 to 0.26. Correlation in lettuce price spreads is somewhat higher for the high-low range. The FOB price, $P_i^f$, utilized for purposes of this study is the weekly average of the midpoint of the daily price range.
Los Angeles chains, ranging from 0.31 to 0.68. There tends to be even less co-movement among the price spreads for fresh tomatoes. The two Dallas chains exhibit a negative correlation (-0.32) in their spreads for California vine ripes, and, similarly, two of the three coefficients are negative for the three Los Angeles chains analyzed for vine ripes. Negative correlations are also present for both Dallas and Los Angeles chains for mature-green tomatoes.

The elasticities in Table 4 represent the estimated percent change in the margin due to a one-percent increase in the level of shipments. All elasticities are evaluated at the means of the data. Elasticities based upon significant coefficient estimates are denoted with an asterisk. For the CA-AZ commodities, the elasticity is positive in 29 of 32 cases and is based upon a significant coefficient in 18 of those cases. Specifying the margin to allow a one-week lag in transmission of farm prices to retail tended to weaken but not eliminate the impact of shipment volume on the margin. Thus, the evidence is quite strong that larger shipment volumes are associated with a widening of the margin for the CA-AZ commodities.

The margin for Florida mature-green tomatoes appears to behave differently based upon our limited observations. Shipments volume is associated with an increase in the margin in only one of the three cases, and the effect is not statistically significant. Mature greens provide an interesting comparison, because Florida grower-shippers are organized, whereas their California counterparts are not. In particular, Florida tomatoes are marketed through the auspices of a Federal marketing order, and most grower-shippers belong to a marketing cooperative whose activities are coordinated with the marketing order. An example of the industry’s coordination in marketing was its attempt to enforce a price floor during the 1998 and 1999 marketing seasons.

The volume of shipments increases the price spread for California mature greens in all 11 cities. The effect is statistically significant in seven of those cases. Conversely, the volume of shipments has no consistent impact on the price spread for Florida mature greens. The coefficient is negative in two of the three cases, and the one positive coefficient is small and not statistically significant. Although it is hard to state a definitive conclusion based on these limited results, the evidence does suggest that perhaps the Florida grower-shippers’ organization and coordination in marketing affords them a degree of protection against retailers’ efforts to bid farm prices down during periods of relatively high supply.

Although the preceding results do not speak directly to the issue of retailer market power in procuring and selling perishable produce commodities, they do indicate the considerable independence among the retailers as to setting prices and margins for these commodities—indeed, that does not exist in a quintessential competitive market. Similarly, the pervasive widening of the margin in response to higher shipment volumes supports the hypothesis that large volumes of these perishable commodities are used as a tool to bid down FOB prices and, thus, widen the margins.
<table>
<thead>
<tr>
<th>City</th>
<th>CA Iceberg Lettuce</th>
<th>CA Vine-Ripe Tomatoes</th>
<th>CA Mature-Green Tomatoes</th>
<th>FL Mature-Green Tomatoes</th>
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<tbody>
<tr>
<td>Atlanta 1</td>
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<td></td>
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<td>(0.1016)</td>
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<td>(0.0377)</td>
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<td></td>
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<td>Dallas 4</td>
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\(^1\)Variances are indicated in parentheses.
Table 3: Correlation Coefficients for Farm-Retail Price Spreads in Selected Cities
(a) CA Iceberg Lettuce

<table>
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<tr>
<th></th>
<th>Dallas 1</th>
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<th>Dallas 3</th>
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<th>LA 2</th>
<th>LA 3</th>
<th>LA 4</th>
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(b) CA Vine-Ripe Tomatoes

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(c) CA Mature-Green Tomatoes

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(d) FL Mature-Green Tomatoes

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<th>Miami 1</th>
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<th>Atlanta 1</th>
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<td>Atlanta 1</td>
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Table 4
Elasticities of the Margin With Respect to Shipment Volume

<table>
<thead>
<tr>
<th>City</th>
<th>CA Iceberg Lettuce</th>
<th>CA Vine-Ripe Tomatoes</th>
<th>CA Mature-Green Tomatoes</th>
<th>FL Mature-Green Tomatoes</th>
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</thead>
<tbody>
<tr>
<td>Atlanta 1</td>
<td>0.672*</td>
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<td>0.303*</td>
<td>0.138</td>
</tr>
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<td>0.429</td>
<td>0.474*</td>
<td>-0.067</td>
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<td>Chicago 1</td>
<td>0.422*</td>
<td>0.052</td>
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<tr>
<td>Albany 1</td>
<td>0.232</td>
<td>-0.307</td>
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</tr>
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<td>Dallas 1</td>
<td>-0.011</td>
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<td>0.358*</td>
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</tr>
<tr>
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<td>Dallas 3</td>
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<td>0.217</td>
<td></td>
</tr>
<tr>
<td>Dallas 4</td>
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<td>0.203*</td>
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</tr>
<tr>
<td>Miami 1</td>
<td>0.692*</td>
<td></td>
<td>0.592*</td>
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<td>Los Angeles 2</td>
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<td>0.229</td>
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<td>Los Angeles 4</td>
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<td>0.226*</td>
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Analysis of Retailer Oligopsony Power in Fresh Produce Procurement

In this section we report on an analysis of buyer power in procurement of iceberg lettuce and fresh tomatoes based upon the methodology reported in SZ (1996) and summarized graphically in Figure 1. The SZ model applies to perishable produce commodities, in which supply in any market period can be regarded as perfectly inelastic for all prices in excess of the per-unit harvest costs. If the available harvest is sufficiently high, relative to demand, the farm price will fall to the level of harvest cost (C₀ in Figure 1) under any form of competition, but will not normally fall lower, because price must be sufficient to cover the marginal costs of harvesting. A correctly specified econometric model of price determination for produce commodities must incorporate that in some periods farm price will be determined by the level of per-unit harvest costs.

When the harvest cost constraint does not bind (i.e., for harvest levels less than H*, in Figure 1), the farm price is determined by (a) consumer demand for the commodity in its various final-product forms, (b) costs of shipping, handling, and selling the product, and (c) the extent of competition in the market. If buyers compete aggressively, the farm price will be bid up to the level of final product value less all costs of marketing and selling—the schedule D^F(H) in Figure 1. However, if buyers have market power, they will be able to capture some of the market surplus, S, for the commodity, defined as the final product value, P^R, minus per-unit costs for harvest (C₀) and for marketing and selling (C^R): S_t = P_t^R - C_t^0 - C_t^R.

Economic theory provides little guidance as to how S_t will be shared between buyers and sellers, under conditions of imperfect competition. The hypothesis advanced by SZ was that buyers’ bargaining power would be positively related to the size of the harvest, because large harvests of a perishable commodity diminish sellers’ bargaining power through the pressure created to move the perishable crop to market. Let λ_t denote the share of market surplus captured by producers in period t. The hypothesis of perfect competition in procurement is then λ_t = 1. The hypothesis of an inverse relationship between λ_t and H_t can be depicted through a
variety of functional forms. SZ found that a simple exponential relationship best fit the data: 

$$0 \leq \gamma_1 = e^{-\alpha t} \leq 1,$$

where $\alpha = 0$ corresponds to $t = 1$ and perfect competition, and $\alpha > 0$ indicates the presence of buyer market power.

Let $8$ denote the probability that the FOB price is constrained in any period by the level of harvest costs, $C^0_t$. Then the process describing FOB price determination for a perishable produce commodity, under possible imperfect competition, is summarized as follows:

\begin{align*}
    P^F_t &= C^0_t \quad \text{with prob} = \lambda \\
    P^F_t &= C^0_t + \gamma_t (P^R_t - C^0_t) \quad \text{with prob} = (1 - \lambda).
\end{align*}

For estimation purposes, functional specifications must be chosen for retail demand, marketing cost, and harvest cost functions. Following SZ (1996), we specified the following linear system with additive error terms:

\begin{align*}
    P^R_{i,t} &= a - (1/b_i) H_{i,t} + \epsilon^1_i \quad \epsilon^1_i \sim N(0, \sigma^2_1), i = 1, \ldots, n, \\
    C^R_{i,t} &= c + d T_{i,t} + \epsilon^2_i \quad \epsilon^2_i \sim N(0, \sigma^2_2), i = 1, \ldots, n, \\
    C^0_t &= C^0 + \epsilon^3_t \quad \epsilon^3_t \sim N(0, \sigma^3_t).
\end{align*}

Equation (4) specifies inverse demand in $n$ consuming markets, with final product price in market $i$, $P^R_{i,t}$, specified as a linear function of consumption, $H_{i,t}$, in market $i$. All other determinants of demand are assumed to be constant over the two-year sample period, and their effects are contained within the intercept, $a$. Similarly, all costs of marketing, $C^R_{i,t}$, except for shipping costs $T_{i,t}$ are assumed to be constant over the sample period, and their effects are reflected in the intercept term, $c$, in (5). Finally, per-unit harvest costs are assumed to have a constant mean $C^0$ over the sample period. Given the short sample period and relatively stable prices during the time, these assumptions seem to be quite reasonable. SZ describe aggregation of (4) – (6) to the industry level to obtain the following empirical specification of price-determination model in (3):

\begin{align*}
    Y_1_t &= P^F_t - C^0_t = \epsilon^3_t \quad \text{with prob} = \lambda \\
    (3') \quad Y_2_t &= P^F_t - C^0_t = \epsilon^3_t + \gamma_t [A - \beta H_t - d T_t] + \left[\epsilon^3_t + \gamma_t (\epsilon^1_t - \epsilon^2_t - \epsilon^3_t)\right] \quad \text{with prob} = (1 - \lambda) \\
    Y_t &= \max(Y_1_t, Y_2_t).
\end{align*}

In (3'), $H_t$ is the total harvest, $T_t$ is a quantity-weighted average of shipping costs across the $n$ consuming markets, and $Y_t$ is the farm price net of mean per-unit harvest costs. Farm price would be determined by the equation for $Y_2_t$, in the absence of the constraint that price cannot fall below the harvest cost. However, since no harvest would occur in that event, farm price net of mean harvest cost is the greater of $Y_1_t$ and $Y_2_t$. Based on (3'), in weeks in which the potential supply, $H_t$, exceeds $H^*$, the harvest cost price, $Y_1_t$, exceeds $Y_2_t$, and farm price is determined by

---

14 The specification of final product demand further assumes that the price elasticities of demand, evaluated at a given price level, are identical across consuming markets. This assumption facilitates aggregation of the model across markets.
the level of harvest costs. When $H_t < H^*$, a per-unit surplus exists in the market, and $Y_2 > Y_1$ determines the farm price.

The system in (3') defines a nonlinear switching regression model with heteroskedastic errors. The model was estimated via maximum likelihood using GAMS. See SZ for construction of the likelihood function. Data for the model include farm price net of mean per-unit harvest costs, $Y_t = P_t^F - C_t^0$. Farm price was measured for each commodity in $10$/carton as the weekly average of daily FOB prices reported by the USDA, F-SMNS. Estimates of per carton harvest costs were obtained from either the University of California or the University of Florida Cooperative Extension Service. Weekly shipments were measured in units of 40,000,000 lbs., as reported by the F-SMNS. For shipments emanating from California or Arizona, the weighted average shipping cost, $T_t$, in $1000$ per truck load, was derived as the population-weighted average of truck rates reported by F-SMNS to ship CA-AZ lettuce to five U.S. cities: Atlanta, Chicago, Dallas, New York, and Los Angeles. For shipments emanating from Florida, $T_t$ was based on shipping costs from Florida to Atlanta, Chicago, and New York. The parameters to be estimated include $A = a - c - C^0$, $\alpha$, $d$, $\sigma_1^2$, $\sigma_2^2$, and $F_3$.

CA-AZ Iceberg Lettuce

Figure 3 shows the weekly FOB price per carton and the estimated per-carton harvest cost, $C^0 = 4.45$/carton, for CA-AZ iceberg lettuce. Noteworthy is that the FOB price is near the harvest cost minimum for a rather large number of the 104 weekly observations.

Figure 3

CA-AZ Iceberg Lettuce FOB Price and Harvest Cost: 1998-1999

Estimation results for the general model, and a restricted model with $\alpha$ constrained to equal zero (i.e., perfect competition in procurement) are reported in Table 5. The point estimate of $\alpha$ for the general model is $\hat{\alpha} = 0.833$, with standard error 0.322. The estimate is statistically significant, and the restricted model of perfect competition is thus rejected in favor of the general
model. Consistent with the results reported by SZ, this result supports a conclusion that buyers are able to capture a large share of available market surplus for CA-AZ iceberg lettuce and that, in many periods, the FOB price is constrained to the harvest cost minimum. Producers’ estimated share of the surplus is \( \hat{\gamma}_i = \exp\{-0.833H_i\} \). For the sample period from 1998-99 the range of \( \hat{\gamma}_i \) is [0.138, 0.330], with a mean value of 0.194, i.e., producers capture on average approximately 20% of the market surplus. These surplus estimates are somewhat higher than were obtained by SZ for the period from January 1988 – October 1992, which ranged from 0.031 to 0.145, with a mean value of 0.0649.

Both the aggregate demand slope parameter, \( \alpha \), and the shipping cost parameter, \( d \), have the hypothesized positive signs, but neither parameter was estimated with much precision. The estimated flexibility of the FOB price with respect to the total volume of shipments evaluated at the sample means is \(-2.301\) for the general model, implying an elasticity of farm-level demand of \(-1/2.301 = -0.433\).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>General Model</th>
<th>Restricted Model: ( \alpha = 0 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \alpha )</td>
<td>0.833, 0.322</td>
<td>1.607, 0.403</td>
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<tr>
<td>( A )</td>
<td>4.549, 2.526</td>
<td>0.509, 0.195</td>
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<tr>
<td>( \beta )</td>
<td>0.780, 0.923</td>
<td>0.182, 0.113</td>
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<tr>
<td>( d )</td>
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<td>0.387, 0.039</td>
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<td>( (\sigma_1^2 + \sigma_2^2)^{0.5} )</td>
<td>1.831, 1.174</td>
<td>0.041, 0.011</td>
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<tr>
<td>( \sigma_3 )</td>
<td>0.035, 0.007</td>
<td>0.041, 0.011</td>
</tr>
<tr>
<td>log likelihood</td>
<td>26.458</td>
<td>22.945</td>
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</table>

Following Kiefer (1980), the probability that each observation is derived from the harvest cost regime is \( R_i = \text{prob}\{Y_1 > Y_2, Y_1 \} \) (i.e., \( R_i \) is the probability that we are observing \( Y_1 \) given knowledge of \( Y_1 \)). Figure 4 shows the estimated values of \( R_i \). The rule that minimizes the probability of misclassifying observations between regimes is \( Y_t = Y_1 \) if the estimated \( R_i \) is greater than 0.5. Based upon this rule, 38 of 104 or 36.5% of the observations of the FOB price for 1998-99 (the ones above the \( R_i = 0.5 \) line in Figure 4) are estimated to have resulted from the harvest cost regime.
California Vine-Ripe Tomatoes

Analysis for California vine-ripe tomatoes was limited to the 1999 marketing year (26 weekly observations) because USDA F-SMNS did not report FOB prices for vine ripes prior to 1999. Figure 5 shows the path of 1999 FOB prices and the per-unit harvest cost, estimated to be $4.25/carton. F-SMNS does not disaggregate fresh tomato shipments between vine-ripe and mature-green categories. Thus, $H_t$ is the total weekly shipment of fresh tomatoes in the U.S. Because of the close substitutability between vine-ripe and mature-green tomatoes, use of the combined harvest is probably appropriate, irrespective of the data problem.

Estimation results for the general and restricted model are reported in Table 6. The estimated value of $\hat{\alpha} = 0.054$, with standard error 0.013. The estimate is statistically significant, and the restricted model is again rejected in favor of the general model. Although $\hat{\alpha}$ is statistically greater than zero, it is quantitatively small, and producers’ share of the estimated market surplus is large, ranging from 0.828 to 0.902, with mean 0.861. It appears that retailers exhibited relatively little oligopsony power in pricing vine-ripe tomatoes from California.

The estimates of $\hat{\xi}$ and $\hat{d}$ each have the hypothesized positive signs, although $\hat{d}$ is not statistically significant. The estimated flexibility of the FOB price for California vine ripes with respect to total shipments of fresh tomatoes (i.e., vine ripes and mature greens) is -1.067 based on the general model, i.e., demand is slightly inelastic at the data means. None of the 26 observations for $P_t^r$ is estimated to have resulted from the harvest cost regime.
Figure 5

$/carton

<table>
<thead>
<tr>
<th>Parameter</th>
<th>General Model Estimate</th>
<th>Std. Error</th>
<th>Restricted Model: $α = 0$ Estimate</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
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<td>$α$</td>
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<td>0.013</td>
<td>0.189</td>
<td>0.469</td>
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<tr>
<td>$A$</td>
<td>0.697</td>
<td>0.064</td>
<td>0.179</td>
<td>0.052</td>
</tr>
<tr>
<td>$β$</td>
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<td>0.027</td>
<td>0.677</td>
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</tr>
<tr>
<td>$d$</td>
<td>0.003</td>
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<tr>
<td>$(σ_1^2 + σ_2^2)^{0.5}$</td>
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<td>0.001</td>
<td>0.001</td>
<td>0.071</td>
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<tr>
<td>$σ_3$</td>
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<tr>
<td>log likelihood</td>
<td>21.031</td>
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<td>8.990</td>
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</tbody>
</table>

California Mature-Green Tomatoes

Figure 6 depicts the FOB price for California mature-green tomatoes relative to the estimated harvest cost of $4.25/carton, represented by the dotted line. We experienced some difficulties in estimating the switching regression model for California mature greens. Estimation was successful when the data set was limited to only 1999 observations (26 in total). The estimation results are contained in Table 7.
Although the estimate of $\alpha$ is quantitatively large, ($\hat{\alpha} = 0.339$), it is imprecise (std. error = 0.505) and not statistically different from zero. Accordingly, the competitive model is not rejected in favor of the general model for California mature greens. The estimates of the producers' shares of the market surplus range from 0.307 to 0.475, with a mean value of 0.404. However, these estimates must be interpreted with caution because of the imprecision associated with the estimate of $\alpha$. Neither the demand slope nor the transportation cost parameter was estimated with precision, and the transportation cost parameter does not have the anticipated positive sign. Based on the estimate of $\sigma$, the flexibility of the FOB price with respect to total fresh tomato shipments is estimated to be $-12.86$ at the data means. This estimate seems implausibly large, corresponding to a very inelastic demand.

### Table 7

**Estimation Results for California Mature-Green Tomatoes**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>General Model</th>
<th>Restricted Model: $\alpha = 0$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>Std. Error</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>0.339</td>
<td>0.505</td>
</tr>
<tr>
<td>$A$</td>
<td>-2.992</td>
<td>4.315</td>
</tr>
<tr>
<td>$\beta$</td>
<td>1.201</td>
<td>1.249</td>
</tr>
<tr>
<td>$D$</td>
<td>-2.183</td>
<td>2.619</td>
</tr>
<tr>
<td>$(\sigma_1^2 + \sigma_2^2)^{0.5}$</td>
<td>0.315</td>
<td>0.342</td>
</tr>
<tr>
<td>$\sigma_3$</td>
<td>0.099</td>
<td>0.019</td>
</tr>
<tr>
<td>log likelihood</td>
<td>20.021</td>
<td></td>
</tr>
</tbody>
</table>
Figure 7 contains estimates of $R_t$. Based upon the classification rule, 18 of the 26 total observations are estimated to have come from the harvest cost regime (i.e., FOB price was constrained to the level of harvest costs for roughly two thirds of the 1999 observations). Referring to Figure 6, we see that the price declined early on during the 1999 season and hovered near the estimated per-unit harvest costs for the remainder of the season. In essence then, the market power parameter $\alpha$ and the demand and transportation-cost parameters are estimated from only the eight observations that did not result from the harvest cost ratio. Thus, the imprecision in their estimation is not surprising.

![Figure 7](image)

**Figure 7**

*Estimates of the Pricing Regime for California Mature-Green Tomatoes: 1999*

Florida mature-green tomatoes are marketed under the auspices of a federal marketing order and most grower-shippers are affiliated with a marketing cooperative, which coordinates with the marketing order. The Florida mature-green tomato industry established a voluntary price floor for the 1998-99 and 1999-2000 marketing seasons at $P^F = $5.85 per carton, well in excess of harvest costs, estimated to be $3.57/carton. Figure 8 depicts the FOB price, the $5.85 price floor, represented by the unbroken lines, and the estimated $3.57 per-unit harvest cost, represented by the dotted lines. The figure demonstrates that the price floor was quite successful during the sample period. Price dropped in several weeks to around the level of the floor, but it did not drop perceptively below it. Unlike the cases for CA-AZ iceberg lettuce and California mature-green tomatoes, the harvest cost floor apparently was not a factor at all in establishing the FOB price.

Because it was clear that the industry-established price floor dominated the harvest cost floor as a relevant factor in establishing price for Florida mature-green tomatoes, we utilized $P^F$ instead of the harvest cost floor in estimating the pricing model. Thus, for Florida mature greens, the model to be estimated was

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15 A voluntary price floor was attempted in marketing California mature-green tomatoes for the 1998 season. The floor was set at $3.50 and, based on industry sources, only about two-thirds of shippers participated in the agreement. Since $3.50 is below the estimate of harvest costs, this floor should not and, based on Figure 5, did not impact pricing during 1998.
\[ Y_1 = P_i^F - \bar{P} = \varepsilon_i^3 \quad \text{with prob } = \lambda \]
\[ Y_2 = P_i^F - \bar{P} = \varepsilon_i^3 + \gamma_i [A - \beta H_i - dT_i] + [\varepsilon_i^3 + \gamma_i (\varepsilon_i^3 - \varepsilon_i^2 - \varepsilon_i^1)] \quad \text{with prob } = (1 - \lambda). \]
\[ Y_i = \max(Y_1, Y_2). \]

**Figure 8**

**FOB Price, Price Floor, and Per-Unit Harvest Cost for Florida Mature-Green Tomatoes: 1998-99**

$/$carton

![Graph](image)

The estimation results are provided in Table 8. The estimated value for \( \hat{\alpha} \) is small (\( \hat{\alpha} = 0.212 \)), and is not statistically significant. Thus, the model of competitive procurement is not rejected for Florida mature greens. The estimates of both $ and d are positive as expected, but $ is estimated very imprecisely. The estimated price flexibility at the data means is 0.498, implying that demand is elastic for Florida mature greens.\(^{16}\) Based upon the estimated value of $, producers’ share of any market surplus in excess of the amount created by the price floor ranges from 0.514 to 0.783, with mean value 0.627. However, because of the imprecision in estimation of $, we cannot reject statistically that producers capture the entire surplus, as they would under perfect competition in procurement.

Figure 9 depicts the estimated probabilities that the voluntary price floor determined the FOB price in each period. Ten of the 69 total observations are estimated to have been determined by the price floor.

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\(^{16}\) Note that Florida tomatoes compete seasonally with imports from Mexico. Thus, due to the competition effect, a relatively elastic demand for Florida mature greens is not surprising.
### Table 8
**Estimation Results for Florida Mature-Green Tomatoes**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>General Model</th>
<th>Restricted Model: $\alpha = 0$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>Std. Error</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>0.212</td>
<td>0.226</td>
</tr>
<tr>
<td>$A$</td>
<td>3.670</td>
<td>1.697</td>
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<tr>
<td>$\beta$</td>
<td>0.108</td>
<td>0.243</td>
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<tr>
<td>$d$</td>
<td>1.661</td>
<td>1.008</td>
</tr>
<tr>
<td>$(\sigma_1^2 + \sigma_2^2)^{0.5}$</td>
<td>0.647</td>
<td>0.329</td>
</tr>
<tr>
<td>$\sigma_3$</td>
<td>0.042</td>
<td>0.017</td>
</tr>
<tr>
<td>log likelihood</td>
<td>-17.304</td>
<td></td>
</tr>
</tbody>
</table>

### Figure 9

![Graph showing price variations over time]
Summary of Oligopsony Analysis

Results for CA-AZ iceberg lettuce were consistent with earlier results obtained by SZ (1996), and parameter estimates were plausible both with respect to sign and magnitude. Results for fresh tomatoes were less satisfactory. The market power parameter, "", was statistically significant in only one of three instances (California vine ripes) and was quantitatively small in that case, suggesting that producers captured the lion’s share of any market surplus. The estimate of "" was larger for California mature greens than the estimate for vine ripes, but the former was estimated imprecisely, and we were unable to reject a hypothesis of competitive procurement.

Analysis for Florida mature-green tomatoes demonstrated that the industry’s voluntary price floor was successful in maintaining prices well in excess of the harvest cost minimum. This floor was estimated to have determined price in 10 of the 69 total periods. The estimate of "" for Florida mature greens pertains to surplus in excess of the price floor, rather than the harvest cost floor. This estimate was small and not statistically different from zero, meaning that a hypothesis of competitive procurement could not be rejected in this case either. Estimates of the price elasticity or price flexibility of demand for fresh tomatoes varied widely among the alternative cases considered.

The weaker performance of the pricing model when applied to fresh tomatoes could be due to several factors. Available observations were limited in all cases relative to those for CA-AZ iceberg lettuce. For both California mature greens and vine ripes, estimation was based on only a single marketing season. In addition, the availability of only aggregate fresh tomato shipments causes lingering concerns about the appropriateness of the shipments variable in the analyses for tomatoes.

Although the results for fresh tomatoes must be interpreted with caution for the reasons just noted, they do tend to suggest that fresh tomato grower shippers have fared better on average than iceberg lettuce grower-shippers in capturing a larger share of the available market surplus. This result is consistent with the results reported by Calvin et al. (2000) that tomatoes was the produce sector that had most been able to withstand retailer requests for services and fees. Available evidence suggests roughly comparable grower-shipper structures in lettuce and fresh tomatoes, although tomato grower shippers are probably better organized, as we have discussed. Another prospectively important consideration is that tomato grower-shippers deal with repackers, and do not directly face grocery retailers. It is quite reasonable to think that repackers are a less potent force in bargaining than are the grocery retailers with whom lettuce grower-shippers deal directly.

Retailer Pricing to Consumers: Constant or Stabilized Retail Prices

We now turn to the analysis of grocery retailers’ pricing practices to consumers. In this section, we investigate the implications for producers when some stores hold constant or stabilize retail prices for produce commodities, despite shifts in production and prices at the farm level. We show that, under a rather broad set of conditions, this behavior is harmful to producers. The fundamental point is that, if some share of the sellers of a commodity hold the retail price constant, despite shifts in production and/or aggregate demand, then price must fluctuate more

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17 See Sexton and Sexton (1994) for a discussion on the history of CA-AZ iceberg lettuce grower-shippers’ attempts to organize.
widely for all other sellers in order for the market to clear. This outcome is harmful in most cases to producers relative to the alternative where all sellers allow price to fluctuate in response to market conditions. The logic of this argument applies equally to situations where a subset of sellers does not maintain a fixed price per se, but instead stabilizes it relative to market conditions.

Figure 10 illustrates the basic point for the case of two market outlets. Market 1 is called “food service” and market 2 is called “retail”. \( D^f_1(H_1) \) is final demand in the food service market, less all shipping and marketing costs, and \( D^f_2(H_2) \) is final demand in the retail market, less all shipping and marketing costs. For simplicity, \( D^f_1(H_1) \) and \( D^f_2(H_2) \) are assumed to be identical, and the initial harvest level, \( H_0 \), is divided equally between the two markets. Under perfect competition in procurement, \( D^f_1(H_1) \) and \( D^f_2(H_2) \) are demand curves for the farm product in the respective sectors. Farm price would be \( P_0 \) in each market under competition. Under buyer power in procurement, farm price will be less than \( P_0 \) as discussed previously and as illustrated in Figure 1.

Suppose that production increases to \( H_0 + \) , while demand remains unchanged. If both markets allow price to change in response to the increase in production, each sells \( 0.5(H_0 + \) ) and price in each market falls to \( P_1 \). The increase in producer revenue in each market is the area, ABCD. However, if the retail market maintains a fixed selling price despite the change in production, sales at retail remain at \( 0.5H_0 \), and the per-unit farm value remains \( P_0 \) in the retail sector. For the increase in production to move entirely through the food service market, which now sells \( 0.5H_0 + \) , with farm value in the food service market falling to \( P_2 \).\(^{18}\) The marginal revenue from the new production is now illustrated by the area ABEF in Figure 3, where ABEF < 2(ABCD).

Figure 10 thus illustrates a market setting where the revenue from additional sales is less when one segment of the market maintains a fixed price, causing the additional volume to be sold entirely through the market outlet(s) that maintain variable prices. This result holds broadly. In particular, a sufficient condition for fixed prices to be harmful to producer welfare is that marginal revenue is a decreasing function of sales for all market outlets.\(^{19}\) Although Figure 10 illustrates a situation with elastic demands (i.e., marginal revenue is positive in both markets), the conclusion applies equally to markets with inelastic demands. In this case, additional output causes a reduction in total sales revenues, but the reduction is less if all prices are flexible whenever marginal revenue declines as a function of output. The logic illustrated in Figure 10 also applies equally to decreases in production. Finally, the presence of imperfect competition in any of the procurement markets does not alter this fundamental conclusion. Under the conditions set forth here, fixing prices in a subset of the market outlets reduces the total surplus accruing to the farm commodity. Thus, farm sector income will be lower due to fixed prices, even if the farm sector captures only a portion of the market surplus.\(^{20}\)

\(^{18}\) Because \( P_0 > P_2 \), standard arbitrage would call for product to move from food service to retail, but these forces are frustrated if retailers insist on holding price at \( P_0 \). Only \( 0.5H_0 \) can be sold at retail for price \( P_0 \).

\(^{19}\) Let inverse demand in a market \( j \) be denoted as \( P_j(H_j) \), where \( H_j \) denotes sales in market \( j \). Total revenue in market \( j \) is \( TR_j = P_j(H_j)H_j \). Marginal revenue is \( MR_j = dTR_j/dH_j = P_j'(H_j)H_j + P_j(H_j) \), and \( dMR_j/dH_j = P_j''(H_j)H_j + P_j'(H_j) + P_j'(H_j) \). Thus, \( dMR_j/dH_j < 0 \) whenever \( 2P_j'(H_j) < -P_j''(H_j) \). This condition holds for all concave demand curves, including linear, and also mildly convex demands.

\(^{20}\) It might be argued that consumers prefer stable prices, so retailers who hold prices constant despite fluctuations in market conditions actually increase demand for the product (Okun, 1981). However, as noted, stabilizing prices in
Estimates of the Impact of Constant Prices on Producer Welfare

How important are fixed retail prices in influencing farm income for a produce commodity? We conducted a simulation analysis to gain some insight into this question. Total demand for the farm commodity was specified in linear form as $Q = a - \frac{1}{2} P$ and divided between two sectors: a sector that fixes retail price at a mean value and faces demand $Q_1 = D(a - \frac{1}{2} P_1)$, $0 < D < 1$, and a sector that allows price to fluctuate freely, which faces demand $Q_2 = (1-D)(a - \frac{1}{2} P_2)$.

The parameter $D$ measures the share of total demand that is sold through outlets that employ a fixed retail price.

The mean harvest is $H_0$, which is normalized without loss of generality to be 1.0: $H_0 = Q_1 + Q_2 = 1.0$. Let $\Delta$ denote a random shock to harvest, and assume $\Delta \sim \mathcal{N}(0, \sigma^2)$. Similarly, prices are normalized at the mean harvest to be $P_1 = P_2 = 1.0$. Given these normalizations, the one sector of the market implies even greater price instability in the other sectors, which, under the same logic, would have an adverse effect on demand in those sectors.
relationship among the demand parameters is \( a = 1 + \varepsilon, \) and \( \varepsilon = \varepsilon_{QP}, \) where \( \varepsilon_{QP} = -\frac{\partial Q}{\partial P}(P/Q) = \alpha(P/Q) \) is the absolute value of the price elasticity of total demand evaluated at \((P_1 = P_2, H_0) = (1,1).\)

We used values that apply roughly to CA-AZ iceberg lettuce in selecting values for the parameters \( \varepsilon_{QP}, \) and \( F^2. \) In the sample of retail stores 6/20 or 30\% employed fixed prices for iceberg lettuce during the 104 week sample period. In addition, we estimate that approximately 60\% of iceberg lettuce is sold through retail food stores. Thus, a rough estimate of \( D = 30\% \times 60\% = 18\%, \) assuming that all “food service” outlets have flexible prices. This value for \( D \) applies only to retailers that maintain a constant selling price. Others, while not fixing price \textit{per se,} clearly stabilize it relative to market conditions. To account in at least an approximate manner for this additional impact, we also conducted a set of simulations assuming that \( D = 30\%. \)

As for \( \varepsilon_{QP}, \) SZ (1996) estimated that \( \varepsilon_{QP} = 0.164. \) A somewhat higher estimate, \( \varepsilon_{QP} = 0.433, \) was obtained in the present study. Both values were used in the simulations. The variance, \( \sigma^2_H, \) of actual California weekly harvests of iceberg lettuce for 1998-99 was used to estimate \( F^2. \) First, to normalize harvest so that \( E[H_t] = 1, \) we divide the actual harvest by its mean, \( \bar{H}. \) Since \( \text{Var}\{H_t/E[H_t]\} = \sigma^2_H/E[H_t]^2, \) a reasonable setting for \( F^2, \) the variance of the normalized shock to harvest \( H_t, \) is the variance of the actual harvests divided by \( \bar{H}^2. \)

We simulated a year of harvests by conducting 52 draws of \( H_t \) from a normal distribution with mean 0 and variance \( F^2. \) The simulated harvest in week \( t \) is then \( H_t = 1 + H_t. \) Given the harvest, price and grower revenue were computed for each week under the alternative scenarios where (a) all sellers had variable prices, or (b) a fraction, \( D, \) of sellers fixed price at the mean value. Total revenue under scenario (a) is

\[
R_t^{(a)} = 1 + \Delta_t - (\Delta_t / \varepsilon_{QP}) - (\Delta_t^2 / \varepsilon_{QP}^2).
\]

Under scenario (b), total revenue is

\[
R_t^{(b)} = \rho + \frac{(1 - \rho + \Delta_t)[\varepsilon_{QP}(1 - \rho) - \Delta_t]}{\varepsilon_{QP}(1 - \rho)}.
\]

For each set of parameter values, 100 52-week harvests were simulated. The minimum, maximum, and mean percent loss in revenue from constant/stabilized retail prices for each set of trials is reported in Table 9. The relative loss in revenues from fixed/stabilized retail prices is larger the more inelastic is demand and the greater the fraction of product that is sold through fixed/stabilized-price sellers. When \( D = 0.3 \) and \( \varepsilon_{QP} = 0.164, \) the mean loss in revenues was about 3.5\% but was only 0.6\% when \( D = 0.18 \) and \( \varepsilon_{QP} = 0.433. \) Although not illustrated in Table 9, the adverse effect of fixed/stabilized prices on revenue will be greater the more volatile is periodic supply, i.e., the greater is \( F^2. \)
Table 9
Simulation Results for Analysis of Constant/Stabilized Retail Prices

<table>
<thead>
<tr>
<th></th>
<th>$\varepsilon_{Q,P} = 0.433$</th>
<th>$\varepsilon_{Q,P} = 0.164$</th>
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<tbody>
<tr>
<td>D= 0.18</td>
<td>[0.34, 0.84]</td>
<td>[0.88, 2.89]</td>
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<tr>
<td></td>
<td>0.63</td>
<td>1.78</td>
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<tr>
<td>D= 0.30</td>
<td>[0.66, 1.84]</td>
<td>[1.72, 5.65]</td>
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<tr>
<td></td>
<td>1.24</td>
<td>3.48</td>
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Retailer Pricing to Consumers: Mark-Ups of Price Over Costs

Grocery retailers unquestionably possess some degree of market power, in the sense of having ability to influence prices, both due to spatial differentiation and differentiation in product mix, service levels, customer loyalty, etc. Because it is not possible to analyze the implications of retailer behavior for consumer welfare based upon only a few products, our focus is on the implications of retailer pricing to consumers for producer welfare. Consider the following model setting for food retailing. Consumers and stores are distributed spatially. During each market period, a consumer will visit one or more stores selected from a decision set of stores. Evaluating each store in the decision set, a consumer’s decision on whether to visit a store is based upon his/her perception of (a) the total cost for the planned market basket of purchases, (b) the transactions costs associated with the shopping trip, and (c) additional factors, such as the consumer’s familiarity with the store, the services and selection offered by the store, perceptions of quality of the store’s merchandise (Siroh, McLaughlin, and Wittink, 1998), etc.\textsuperscript{21}

Define $Q_{j,t} = N_{j,t} \bar{Q}$, as the total sales of a particular produce item in store $j$ at time $t$, where $N_{j,t}$ is the number of customers that visit the store in period $t$ and $\bar{Q}$ is the average sales per customer. The partial elasticity of sales with respect to the store’s price, $P_j$, can be expressed as follows:

$$\varepsilon_{Q,P_j} = \varepsilon_{N,P_j} + \varepsilon_{\bar{Q},P_j},$$

where $\varepsilon_{N,P_j}$ is the elasticity of customer visits with respect to price of the produce commodity, and $\varepsilon_{\bar{Q},P_j}$ is the elasticity of mean sales of the commodity with respect to its price. $\varepsilon_{\bar{Q},P_j}$ is widely believed to be small in absolute value (demand is inelastic) for produce commodities. Most consumers view produce, such as lettuce and fresh tomatoes, as staples in their diets. They are also complementary to many types of meals, and they constitute a small part of most consumers’ budgets. Moreover, their perishable nature means that consumers cannot accumulate inventories in response to price promotions.

Not much, however, is known about $\varepsilon_{N,P_j}$. This elasticity is presumably negative—any increase in a commodity price, \textit{ceteris paribus}, will have a negative impact on visits to a store,\textsuperscript{21}

\textsuperscript{21} This consumer-choice framework is very consistent with the model utilized by Messinger and Narasimhan (1997) to study consumers’ choice of supermarket formats. Also see Popkowski Leszczyc, Sinha, and Timmermans (2000) for a recent analysis of consumer grocery store choice and switching behavior.
but the effect of any one price change is most likely very small, except possibly when an item is on ad, and a very low promotional price is offered.

Thus, the partial elasticity of demand for produce items, such as lettuce and fresh tomatoes, facing a typical retailer is expected to be small in absolute value, implying that the retailer has considerable power to raise produce prices above marginal acquisition and selling costs. However, in terms of a store’s overall pricing strategy, it cannot exercise fully its market power for each commodity it sells. Charging the monopoly mark-up of price over full marginal cost, 

\[ C^T, \frac{(P-C^T)}{P} = -1, \]  

for each product in the store would cause a large decrease in \( N \), rendering such an action unprofitable.

A store’s optimal strategy in pricing 30,000 or more product codes is, accordingly, complicated, and, fortunately, not necessary to model, given that our purpose to explore the implications of retailers’ pricing strategies for producers of iceberg lettuce and fresh tomatoes. The essence of our approach is illustrated in Figure 11. \( Q_j \) denotes sales in a representative retail store for a given produce commodity. \( P_j(Q_j) \) is the inverse demand function for the store, indicating the \textit{ceteris paribus} relationship between the price, \( P \), charged by the store and its sales volume. \( MR_j(Q_j) = \partial[P_j(Q_j)Q_j]/\partial Q_j \) is the store’s marginal revenue from sales of the commodity. \( C^T \) represents the store’s total marginal costs of acquiring and selling the commodity, which consist of the FOB acquisition price, per-unit shipping cost, and marginal selling costs. If the retailer elected to set the price of the commodity competitively, it would set \( P_j = C^T \) and sell \( Q^C \) units per time period. If the store elected to exercise fully its monopoly power for this commodity, it would set sales at the output where \( MR_j(Q_j) = C^T \) and set \( P_j = P^M \), selling \( Q^M \) units. As noted, neither strategy is likely to be optimal for the store. Competitive pricing contributes nothing \textit{per se} to store profits, although a low price may help attract more customers to the store. The monopoly price, \( P^M \), contributes to the store’s profits, but the store likely cannot fully exploit its market power for each commodity without driving most customers away from the store.

Suppose the price actually observed is \( P^* \), with per-period sales of \( Q^* \). We then construct the perceived marginal revenue function, \( PMR_j(Q_j) = \gg{MR}_j(Q_j) + (1-\gg{MR}_j(Q_j))P_j(Q_j) \), consistent with the functional forms chosen for \( MR_j(Q_j) \) and \( P_j(Q_j) \), so that \( PMR_j(Q_j) \) intersects \( C^T \) at the observed volume of sales, \( Q^* \). The level of market power implied by the retailer’s pricing decision is then \( \gg{MR} \). The expression for the relative mark-up, taking into account the effect of \( \gg{MR} \) is the following:

\[ (P - C^T)/P = \xi^*/\epsilon_{Q,P}, \]

i.e., the mark-up is always determined jointly by the implied market power and the price elasticity of the demand curve.\(^{22}\)

\( ^{22} \) An alternative approach is to specify a seller’s marginal costs as a function of input prices and estimate a system of equations consisting of an equation for product demand and an equation for seller optimization. Under this approach, information about marginal cost is inferred from the data (e.g., Bettendorf and Verboven, 2000). Applicability of this approach in the present context is very limited for multiple reasons. First, as noted, the retailers’ optimization problem involves multiple products and is not easily specified. Second, it is not clear that a reasonable specification can be obtained for the unobserved portion of retailers’ marginal costs, namely selling costs. Variable costs associated with selling produce include expenditures for labor and energy (e.g., for refrigeration). Neither is likely to have varied much over the two-year period covered by the IRI data, nor do we have access to the prices paid by any of the chains’ for these inputs, thus necessitating the use of proxies if this approach were to be utilized.
As discussed earlier in the paper, the range for viewing the commodity $Q$ in isolation, is $\geq 0$, with $\geq 0$ denoting perfect competition and $\geq 1$ denoting monopoly. These bounds on need not apply in the multi-product context of a grocery retailer. In particular, $\geq 0$ may be observed when a commodity is on sale and being used as a “loss leader” to attract customers to the store, and $\geq 1$ may represent a rational pricing strategy when substitute and complement relationships among products within the store are considered.\(^{23}\)

Store sales are a decreasing function of the implied level of market power, $\geq \ast$, and producer welfare is an increasing function of store sales. Thus, producer welfare is a decreasing function of $\geq \ast$ because market power curtails movement of the product within the store and causes diversion of product to lower-valued uses.

**Figure 11**

**Inferring the Implied Exercise of Oligopoly Power**

The implied values of $\geq \ast$ can be estimated for a store and a commodity for each time period, given (a) price and sales during that period, (b) an estimate of the demand curve facing the retailer for the commodity, and (c) the retailer’s aggregate marginal costs for acquiring, shipping, and selling the commodity. Price and sales per period are available from the IRI data. Store-level demand functions can be estimated using conventional econometric methods, although problems with accuracy of the data will affect such estimation. As to retailers’ costs, FOB prices

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\(^{23}\) For example, suppose a retailer wishes to promote sales of its private label brand of a particular product. Clearly, the equivalent national brands will be close substitutes for the private label. In this case, setting a very high mark-up on the national brand (i.e., $\geq 1$), rather than a very low mark-up on the private label, may represent a rational pricing strategy.
are observed, as are shipping costs, but retailers’ selling costs are not observed, nor is it possible to disentangle most of the costs for selling one commodity from the costs associated with the thousands of other commodities the typical retailer sells.

Inability to observe retailers’ selling costs was handled in the following manner. We derived an upper bound on the implied exercise of a retailer’s market power by ignoring these costs, and treating retailer marginal costs simply as the sum of acquisition and shipping costs. For cities where we had multiple chains with usable data for a commodity, we computed a lower bound on the implied exercise of market power by assuming that the low-price seller of the commodity in the city sold the commodity on a competitive basis, i.e., the low-price seller set \( P_L^C = C_T \). Thus, \( P_L^C \) was used as a proxy for \( C_T \) in computing the implied exercise of market power for all other sellers of the commodity in that city.

**Store-Level Demand Functions**

For each store and each commodity where we believed the data to be reliable, a demand function of the following form was estimated:

\[
Q_t = f(P_t, P_S^t),
\]

Where \( Q_t \) and \( P_t \) are sales and price, respectively, of the commodity, and \( P_S^t \) is the price of a substitute commodity. All other demand determinants (e.g., consumer income) were assumed to be constant over the two-year period covered by the data series. For iceberg lettuce, either the green leaf or romaine lettuce price was used for \( P_S^t \). For mature-green and vine-ripe tomatoes, the price of Roma tomatoes (the largest selling tomato category after vine ripes and mature greens) was used for \( P_S^t \).

The variables in (8) were specified using the Box-Cox transformation to enable testing for the preferred functional form. We also conducted a detailed analysis into the structure of the error term in estimating (8), in particular its autoregressive properties. Finally, even among the data series considered most reliable, we still often encountered missing observations and observations on sales that seemed aberrant (see the earlier discussion of the data). Thus, it was important to have systematic testing in place for outliers. Outliers were detected and omitted from the final estimation using the testing procedure described in Belsley, Kuh, and Welsch (1980).

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24 Some error must be acknowledged in the observation of FOB prices and shipping costs. Because FOB prices are typically reported in a range, with high and low prices averaged to construct our FOB price variable, the acquisition costs for a particular retailer may deviate somewhat from what we report.

25 This approach is similar to the use of competitive “benchmark” prices to measure market power, as discussed by Wann and Sexton (1992).

26 Although the characterization of \( P_L^C \) as a upper bound for \( C_T^C \) will generally be valid, it may not be true in periods when the low-price seller offers a promotional price for the commodity and, thus, may set price below \( C_T^C \). Similarly, to the extent that retailers in a given city differ as to their selling costs, error is introduced into the lower bound calculations.
CA-AZ Iceberg Lettuce

The oligopoly power implied by retailers’ pricing decisions was analyzed for 12 stores. Six stores maintained constant selling prices throughout 1998-99, making it impossible to estimate a demand function. Two other stores reported iceberg lettuce sales that we regarded as implausibly low, and those stores were omitted from the analysis. Durbin-Watson tests revealed the presence of autocorrelated residuals for each of the 12 stores. In four of the 12 cases, there appeared to be second-order autocorrelation. First-order autocorrelation corrections appeared adequate in the other cases. The Box-Cox tests for functional form generally supported use of the double-log model; it was not rejected in nine of 12 cases. Because of the desirability of utilizing a common model across stores, we elected to work with (8) in the double-log functional form and an AR(2) error structure:

\[
\ln Q_t = \beta_0 + \beta_1 \ln P_t + \beta_2 \ln P^* + r_t, \quad r_t = D_{1t} + D_{2t} + \epsilon_t, \quad \epsilon_t \sim N(0, \sigma^2).
\]

Table 10 reports results of the analysis of implied oligopoly power for CA-AZ iceberg lettuce. The coefficients in the double log model are elasticities. Thus, \(\hat{\beta}_1\) is the estimate of the own-price elasticity of demand for each store, and \(\hat{\beta}_2\) is the estimate of the cross-price elasticity of demand. The estimates of the own-price elasticity of demand for lettuce were statistically significant in 10 of the 12 cases. In 8 of the 12 cases the absolute value of the estimated own-price elasticity was less than 1.0, indicating an inelastic demand. In three of the remaining cases, the absolute value was between 1.0 and 1.1, suggesting that own-price elasticity is nearly unitary for those stores.

The coefficient on the substitute commodity price had the hypothesized positive sign in nine of 12 cases, indicating a substitute relationship, but the effect was seldom statistically significant.

Table 10 reports both the range across observations and the mean of the implied oligopoly power parameter for both the upper- and lower-bound computations. The largest mean implied

---

27 Hoch et al. (1995) also used the double log model to estimate product demand functions for individual grocery retailers.
28 The consequence of working with an AR(2) model when the data do not reject an AR(1) specification is a minor loss of efficiency, i.e., an extraneous parameter is being estimated.
29 Some elaboration on the estimation procedure in the presence of autocorrelated errors is necessary. When observations are continuous, estimation methods, such as the Cochrane-Orcutt iterative procedure, are straightforward. Our data sets were discontinuous, both due to missing and outlier observations. Estimation of the models proceeded by first estimating the regression equation by ordinary least squares (OLS) on 104 – m observations, with m denoting the number of omitted observations. \(\hat{\rho}_1\) and \(\hat{\rho}_2\), were then obtained from the following regression on the OLS residuals, \(e_t\), excluding the first two observations and the two observations following any excluded observation: \(e_t = D_{1t} + D_{2t} + \epsilon_t\). \(\hat{\rho}_1\) and \(\hat{\rho}_2\) were then used to transform \(Q_t, P_t\), and \(P^*_t\). For example, \(Q_i = Q_i - \hat{\rho}_1 Q_{i-1} - \hat{\rho}_2 Q_{i-2}\). In addition, the first two observations in each sequence of continuous observations can be transformed as described, for example in Greene (1990). The model was then re-estimated on 104 – 2m observations using \(Q'_i, P'_i\), and \(P'^*_i\). A set of new estimated residuals was then obtained and used to derive updated values of \(\hat{\rho}_1\) and \(\hat{\rho}_2\). The process was continued until successive estimates of \(\hat{\rho}_1\) and \(\hat{\rho}_2\) differed by less than 0.001.
30 Hoch et al. (1995) found considerable variation among price elasticities in various food-product categories for individual Dominick’s stores in the Chicago area. They showed that about two-thirds of the variation could be explained by demographic and competitive environment variables. Although our results apply to grocery chains within a city, not to individual stores, the arguments posed by Hoch et al., as to why price sensitivities will vary across stores, also apply to our context.
oligopoly power is by Chicago 1, with $\hat{\xi} = 0.905$, near the 1.0 maximum for the single-product case, as an upper-bound calculation. The lowest implied oligopoly power is by Miami 1, with $\hat{\xi} = 0.029$. The mean across stores of $\hat{\xi}$ is 0.360.\(^{31}\) The lower-bound computations could be made in only six cases. For the Los Angeles chains, LA 2 had the lowest average price for iceberg lettuce over the sample period. If LA 2 were pricing iceberg lettuce as a perfect competitor, then the market power implied by the other Los Angeles chains pricing is very low, ranging on average over the sample from 0.011 for LA 4 to 0.039 for LA 1. Dallas 2 was the low-price seller in the Dallas area. If Dallas 2’s price were the competitive price, then the average oligopoly power implied by Dallas 1’s and Dallas 3’s behavior are $\hat{\xi}_1 = 0.055$ and $\hat{\xi}_3 = 0.093$, respectively. The average across the six chains for which we have a mean lower bound on implied oligopoly power is 0.040.

### Table 10

**Implied Oligopoly Power for CA-AZ Iceberg Lettuce**

<table>
<thead>
<tr>
<th>Store</th>
<th>Own price Elasticity(^1)</th>
<th>Cross price Elasticity(^2)</th>
<th>Oligopoly power: Upper bound Range Mean</th>
<th>Oligopoly power: Lower bound Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlanta 1</td>
<td>-1.104 (5.603)</td>
<td>-0.070(^2) (0.263)</td>
<td>-0.216, 0.811 0.653 ***</td>
<td></td>
</tr>
<tr>
<td>Chicago 1</td>
<td>-1.503 (3.479)</td>
<td>-0.055(^2) (0.215)</td>
<td>-0.213, 1.119 0.905 ***</td>
<td></td>
</tr>
<tr>
<td>Albany 1</td>
<td>-1.010 (10.679)</td>
<td>0.123(^2) (1.529)</td>
<td>0.218, 0.785 0.557 ***</td>
<td></td>
</tr>
<tr>
<td>Dallas 1</td>
<td>-0.195 (1.930)</td>
<td>0.242(^2) (1.043)</td>
<td>0.021, 0.158 0.124 -0.306, 0.254 0.055 **</td>
<td></td>
</tr>
<tr>
<td>Dallas 2</td>
<td>-1.025 (10.732)</td>
<td>0.386(^2) (2.607)</td>
<td>-0.031, 0.828 0.540 ***</td>
<td></td>
</tr>
<tr>
<td>Dallas 3</td>
<td>-0.602 (4.524)</td>
<td>0.035(^3) (0.269)</td>
<td>0.189, 0.493 0.358 -0.221, 0.602 0.093 **</td>
<td></td>
</tr>
<tr>
<td>Miami 1</td>
<td>-0.040 (0.128)</td>
<td>0.152(^3) (0.477)</td>
<td>0.014, 0.034 0.029 -0.009, 0.018 0.008 **</td>
<td></td>
</tr>
<tr>
<td>Miami 2</td>
<td>-0.300 (1.728)</td>
<td>-0.172(^2) (0.976)</td>
<td>0.110, 0.234 0.202 ***</td>
<td></td>
</tr>
<tr>
<td>LA 1</td>
<td>-0.400 (2.655)</td>
<td>0.046(^3) (0.246)</td>
<td>0.154, 0.327 0.278 -0.616, 0.207 0.039 **</td>
<td></td>
</tr>
<tr>
<td>LA 2</td>
<td>-0.420 (1.632)</td>
<td>0.158(^2) (1.047)</td>
<td>0.116, 0.335 0.273 ***</td>
<td></td>
</tr>
<tr>
<td>LA 3</td>
<td>-0.541 (3.542)</td>
<td>0.001(^3) (0.015)</td>
<td>0.115, 0.435 0.310 -0.240, 0.328 0.035</td>
<td></td>
</tr>
<tr>
<td>LA 4</td>
<td>-0.164 (1.739)</td>
<td>0.014(^3) (0.508)</td>
<td>0.034, 0.132 0.095 -0.066, 0.078 0.011</td>
<td></td>
</tr>
</tbody>
</table>

\(^1\)Absolute t statistics are reported in parenthesis.
\(^2\)Substitute commodity is Romaine lettuce.
\(^3\)Substitute commodity is green-leaf lettuce.

***Denotes the low-price store or the only reporting store in the metropolitan area for this commodity.

\(^{31}\) As a comparison to the case of a single-product seller, $\hat{\xi} = 0.36$ is roughly equivalent to the market power that would be exercised by a three-firm oligopoly under Cournot competition.
Our approach generates conservative bounds on the implied exercise of market power. Because marginal selling costs are not zero, the upper-bound calculations are unquestionably high. Similarly, it seems implausible that a retailer would not attach some mark-up over full marginal cost for a commodity with a relatively inelastic demand, such as iceberg lettuce. Thus, the lower bound calculations likely understate the actual implied exercise of market power. Thus, we are confident in concluding that most of the chains are setting prices for iceberg lettuce in excess of full marginal costs, but the implied exercise of market power is not especially high for most stores. However, the implications of this conclusion for pricing need to be considered in the context of equation (7). Even modest market power in pricing in conjunction with an inelastic demand can cause a large relative mark-up of price over full marginal cost. Consider, for example, a hypothetical retailer facing a demand elasticity of \( \frac{Q}{P} = -0.609 \) (the mean across the 12 stores) and setting price with implied oligopoly power of \( \xi = 0.360 \) (the mean upper bound). These parameters indicate a relative mark-up of \( \frac{(P-C_T)}{P} = 0.591 \), or a price that is more than double full marginal costs.

**Vine-Ripe Tomatoes**

Data thought to be reliable for vine-ripe tomatoes were available for nine chains. As for iceberg lettuce, Durbin-Watson tests generally indicated the presence of autocorrelated residuals. In five of the nine cases, analysis supported a specification of second-degree autocorrelation. Box-Cox tests supported the double-log specification in seven of nine cases. Thus, for consistency, we again chose to work with the demand model specification indicated in (9)—a double-log model, with second order autocorrelation. In all cases, Roma tomatoes were used as the substitute commodity.\(^{32}\)

Unlike iceberg lettuce, a distinctive wholesaling sector exists for fresh tomatoes. Wholesalers or “repackers” sort tomatoes and check for spoilage, appropriate ripeness, etc. From industry sources, we estimated the repacking charge to be $4.00 per carton for the period of the analysis. Thus, the upper-bound estimates of implied oligopoly behavior are based on acquisition cost, as measured by the FOB price and repacking costs, including shipping. Because repackers perform functions that otherwise would be performed by retailers, inclusion of these costs for fresh tomatoes increases the accuracy of the upper bound calculations relative to what was possible for iceberg lettuce. When possible, lower-bound calculations on the implied exercise of oligopoly power were also computed, as described previously.

Results of the analysis are summarized in Table 11. The estimate of the own-price elasticity of demand is statistically significant in six of the eight cases, and the point estimate indicates an inelastic demand in six of the eight cases. The results suggest that the Roma tomato is not particularly important as a substitute commodity. The coefficient was significant in only two cases, and the hypothesized positive sign, to indicate a substitute relationship, emerged in only five of the eight cases.

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\(^{32}\) Ultimately, Chicago 1 had to be omitted for vine ripes because, despite attempting a variety of model specifications, we were unable to fit a downward-sloping demand function to its data.
Table 11
Implied Oligopoly Power for Vine-Ripe Tomatoes

<table>
<thead>
<tr>
<th>Store</th>
<th>Own price Elasticity</th>
<th>Cross price Elasticity</th>
<th>Oligopoly power: Upper bound</th>
<th>Oligopoly power: Lower bound</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range Mean</td>
<td>Range Mean</td>
<td>Range Mean</td>
<td>Range Mean</td>
</tr>
<tr>
<td>Atlanta 2</td>
<td>-0.206 (3.808)</td>
<td>0.12, 0.17</td>
<td>0.15 ***</td>
<td>***</td>
</tr>
<tr>
<td>Albany 1</td>
<td>-1.387 (9.752)</td>
<td>0.69, 1.01</td>
<td>0.86 ***</td>
<td>***</td>
</tr>
<tr>
<td>Dallas 2</td>
<td>-0.971 (2.547)</td>
<td>0.30, 0.61</td>
<td>0.48 ***</td>
<td>***</td>
</tr>
<tr>
<td>Dallas 4</td>
<td>-0.681 (1.090)</td>
<td>0.45, 0.54</td>
<td>0.51 0.189, 0.413</td>
<td>0.333</td>
</tr>
<tr>
<td>Miami 2</td>
<td>-0.145 (2.538)</td>
<td>0.07, 0.11</td>
<td>0.09 ***</td>
<td>***</td>
</tr>
<tr>
<td>LA 2</td>
<td>-1.590 (10.881)</td>
<td>0.58, 1.30</td>
<td>1.11 ***</td>
<td>***</td>
</tr>
<tr>
<td>LA 3</td>
<td>-0.874 (3.414)</td>
<td>0.43, 0.80</td>
<td>0.69 -0.395, 0.688</td>
<td>0.177</td>
</tr>
<tr>
<td>LA 4</td>
<td>-0.445 (1.731)</td>
<td>0.30, 0.37</td>
<td>0.35 -0.146, 0.294</td>
<td>0.057</td>
</tr>
</tbody>
</table>

1Absolute t statistics are reported in parenthesis.

***Denotes the low-price store or the only reporting store in the metropolitan area for this commodity.

The upper-bound estimates of implied oligopoly power vary widely among the chains. The low mean estimate is 0.09 for Miami 2, and the high mean is 1.11, i.e., essentially the equivalent of simple monopoly pricing, for Los Angeles 2. The average of the upper-bound means among the eight stores is 0.53. Given the limited number of stores in the analysis, we were only able to compute the lower bound estimates for three cases. The mean lower bounds on implied oligopoly power ranged from \( \hat{\xi} = 0.057 \) (Los Angeles 4) to \( \hat{\xi} = 0.333 \) (Dallas 4).

Mature-Green Tomatoes

Data considered to be satisfactory were available for 11 stores. We were unable to generate a downward-sloping demand curve for Dallas 3 and, accordingly, it was omitted from the subsequent analysis. The tests for model specification yielded outcomes similar to those obtained for iceberg lettuce and vine-ripe tomatoes—the presence of autocorrelation could not be rejected in all cases with second-order autocorrelation supported in eight of 10 cases. The Box-Cox tests supported use of the double-log model in eight of the 10 instances. Thus, the demand model in (9) was deemed appropriate.

Results of the analysis are summarized in Table 12. The estimated own-price elasticity was negative for the remaining 10 stores, and the coefficient was statistically significant in eight of those cases. As was true for vine ripes, Roma tomatoes were not especially effective in the

\[33^3 \text{As a comparison to the case of a single-product seller, } \hat{\xi} = 0.53 \text{ is roughly equivalent to the market power that would be exercised by a two-firm oligopoly under Cournot competition.} \]
model as a substitute commodity. The estimated cross-price elasticity was positive in only six of the 10 cases, and was statistically significant in four of those instances.

The mean upper-bound estimates on implied oligopoly power varied from 0.076 (Los Angeles 1) to 1.156 (Dallas 4). The average of the upper-bound means across stores was $\hat{\xi} = 0.482$. We were able to compute the lower-bound estimates for six stores. They range from a low of 0.021 (Los Angeles 1) to a high of 0.748 (Dallas 4), with a mean value of $\hat{\xi} = 0.203$.

### Table 12
**Implied Oligopoly Power for Mature-Green Tomatoes**

<table>
<thead>
<tr>
<th>Store</th>
<th>Own price Elasticity¹</th>
<th>Cross price Elasticity¹</th>
<th>Oligopoly power: Upper bound</th>
<th>Oligopoly power: Lower bound</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Mean</td>
<td>Range</td>
<td>Mean</td>
</tr>
<tr>
<td>Atlanta 1</td>
<td>-0.883 (7.617)</td>
<td>0.020 (0.157)</td>
<td>-0.161, 0.744</td>
<td>0.587 ***</td>
</tr>
<tr>
<td>Atlanta 2</td>
<td>-0.481 (3.926)</td>
<td>-0.098 (0.382)</td>
<td>0.169, 0.410</td>
<td>0.340 -0.566, 0.327</td>
</tr>
<tr>
<td>Dallas 1</td>
<td>-0.396 (2.027)</td>
<td>0.091 (0.939)</td>
<td>0.200, 0.396</td>
<td>0.275 0.048, 0.227</td>
</tr>
<tr>
<td>Dallas 2</td>
<td>-0.854 (6.702)</td>
<td>0.537 (4.458)</td>
<td>0.080, 0.591</td>
<td>0.403 ***</td>
</tr>
<tr>
<td>Dallas 4</td>
<td>-1.600 (6.672)</td>
<td>-0.164 (0.625)</td>
<td>0.639, 1.368</td>
<td>1.156 0.249, 1.030</td>
</tr>
<tr>
<td>Miami 1</td>
<td>-0.513 (2.791)</td>
<td>-0.083 (0.508)</td>
<td>0.050, 0.438</td>
<td>0.321 ***</td>
</tr>
<tr>
<td>LA 1</td>
<td>-0.107 (0.441)</td>
<td>0.162 (1.705)</td>
<td>0.051, 0.090</td>
<td>0.076 -0.083, 0.079</td>
</tr>
<tr>
<td>LA 2</td>
<td>-1.025 (5.348)</td>
<td>1.288 (6.391)</td>
<td>0.036, 0.815</td>
<td>0.627 ***</td>
</tr>
<tr>
<td>LA 3</td>
<td>-1.315 (8.390)</td>
<td>0.605 (2.912)</td>
<td>0.386, 1.117</td>
<td>0.906 -0.917, 1.040</td>
</tr>
<tr>
<td>LA 4</td>
<td>-0.174 (0.643)</td>
<td>-0.014 (0.044)</td>
<td>0.070, 0.146</td>
<td>0.125 -0.083, 0.138</td>
</tr>
</tbody>
</table>

¹ Absolute t statistics are reported in parenthesis.

*** Denotes the low-price store or the only reporting store in the metropolitan area for this commodity.

### Summary of Analysis of Pricing Behavior to Consumers

The implications for consumers from retailers’ pricing behavior cannot be discerned from analysis of a few produce commodities. However, the manner in which retailers set prices for these commodities does have implications for producers, and this was the focus of our analysis. Estimation of chain-level demand functions for iceberg lettuce, vine-ripe tomatoes, and mature-green tomatoes revealed inelastic demands in the vast majority of cases. Retailers who face inelastic demands for products have the opportunity to exploit those demands by marking price up in excess of full marginal costs. The extent of this mark-up reveals the market power implied by the retailers’ decision. Because we lacked information on retailers’ selling costs, our estimation of the implied market power cannot be precise. Rather, we generated a set of upper- and lower-bound estimates.
Even based on the upper-bound calculations, it seems clear that retailers’ are not fully exploiting consumers’ inelastic demands for produce commodities in their pricing decision. This result is consistent with the intuitive model of consumer shopping behavior set forth here. Consumers’ willingness and ability to consider multiple stores to conduct a given shopping trip serves as a brake on retailers’ pricing. On the other hand, the estimates indicate that most retailers are setting prices for iceberg lettuce and fresh tomatoes in excess of full marginal costs. The results were rather consistent across the three commodities in the extent of mark-ups indicated. These mark-ups curtail movement of the commodity within the chain and increase the amount of a given harvest that must be diverted to lower-valued uses. Such retailer mark-ups of price are, thus, harmful to producer welfare.

Retailer Pricing Behavior for Bagged Salads

Bagged or packaged salads have been a high-growth segment of the produce industry. Calvin et al. (2000) report that 462 lettuce-based bagged salad items (i.e. UPC codes) existed in 1999, compared to 202 items in 1993. Sales in the fresh-cut salad category reached nearly $1.9 billion in 2000, based on A.C. Nielson statistics. The largest selling category is iceberg-based blends, with a cumulative 39% market share in 2000. Salad blends, featuring a combination of lettuce types, comprised 30% of sales at the same time, with salad kits accounting for 13% of sales.

The technology to prepare bagged salads is not complicated, and many lettuce shippers entered this segment of the industry during its rapid growth stage during the 1990s. The bagged salad sector has since consolidated. Calvin et al. report that the top two sellers (Fresh Express and Dole) held a combined 75.5% share in 1999 of supermarket sales for fresh-cut salads. A third firm, Ready Pac, had a market share near 8%, with private-label brands jointly comprising 9.7%.

Our analysis focuses on the traditional iceberg-based (IBB), fresh-cut salad. It remains the largest seller, each of the top three manufactures produces one or more sizes of this product, and we are able to analyze pricing links to the farm input, iceberg head lettuce, which comprises the essential ingredient to producing an IBB salad.

Our analysis for IBB salads necessarily differs from the preceding analysis conducted for iceberg head lettuce and fresh tomatoes, due to differences in the available information. Notably, we lack information on processing costs and on the pricing arrangements between processors and retailers, including fees paid by processors. Thus, we are unable to conduct formal investigations of oligopoly or oligopsony power. Nonetheless, some useful conclusions emerge based on the information that is available.

Table 13 provides an overview of pricing behavior for IBB salads for the 20 retail chains. The table reports mean price per lb. and variance of price (in parentheses) for each brand of IBB salad carried by the chain, including its own private label. Most stores carried multiple sizes of each brand (e.g., 16 oz., 32 oz., 48 oz.), and the price reported is a sales-weighted average across size categories. The average and variance for the chain’s iceberg head lettuce price is also provided for comparison. An immediate point of interest in Table 13 is the variety of behaviors exhibited among the retailers as to how many and which brands of IBB salads to carry. Among

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34 Thompson and Wilson (1999) estimated the up-front investment costs to process fresh-cut salads to be in the range of $20-30 million.
our sample chains, only the Los Angeles chains carried Ready Pac IBB salads,\textsuperscript{35} and none carried minor brands outside of the top three. Only LA 2 carried all three leading brands of IBB salads. Seven chains carried two brands—Fresh Express and Dole in five of those cases, with Dole and Ready Pac and Fresh Express and Ready Pac in the others. Six chains carried a private label brand. Among those chains, three carried only their private label, two carried their private label and one other brand (Dole, in each case), while the other carried both Dole and Fresh Express. Finally, three chains carried Fresh Express IBBs exclusively, while two carried Dole IBBs exclusively.\textsuperscript{36}

\begin{table}[h]
\centering
\caption{Retailer Mean Price and Variance of IBB Packaged Salads\textsuperscript{1}}
\begin{tabular}{|l|c|c|c|c|}
\hline
 & Private Label & Fresh Express & Dole & Ready Pac & Head Lettuce \\
\hline
LA 1 & 1.404 (0.050) & & & & 1.087 (0.064) \\
LA 2 & & 1.526 (0.063) & 1.416 (0.029) & 1.356 (0.049) & 0.953 (0.022) \\
LA 3 & & & 1.486 (0.008) & 1.490 (0.007) & 1.026 (0.033) \\
LA 4 & & & & 1.490 (0.011) & 1.027 (0.038) \\
Dallas 1 & & & & & 1.233 (0.049) \\
Dallas 2 & & & 1.354 (0.015) & & 0.923 (0.020) \\
Dallas 3 & & & 1.410 (0.053) & & 1.121 (0.060) \\
Dallas 4 & & & 1.901 (0.032) & & 1.253 (0.012) \\
Dallas 5 & & & 1.331 (0.038) & 1.943 (0.115) & 0.950 (0.000) \\
Atlanta 1 & & & 1.702 (0.041) & & 1.193 (0.026) \\
Atlanta 2 & & & 1.724 (0.122) & & 1.252 (0.059) \\
Atlanta 3 & & 1.636 (0.042) & 1.685 (0.121) & & 1.210 (0.000) \\
Chicago 1 & & 1.625 (0.044) & 1.977 (0.146) & & 1.237 (0.006) \\
Chicago 2 & & 1.896 (0.028) & 1.931 (0.019) & & 1.400 (0.000) \\
Chicago 3 & & 2.035 (0.147) & & & 1.100 (0.000) \\
Miami 1 & 1.487 (0.052) & & & & 1.270 (0.047) \\
Miami 2 & & 1.668 (0.080) & 1.605 (0.049) & & 1.004 (0.029) \\
Miami 3 & & 1.394 (0.003) & 1.882 (0.023) & 1.520 (0.002) & 1.210 (0.000) \\
Albany 1 & & 1.630 (0.038) & & 1.619 (0.068) & 1.111 (0.044) \\
Albany 2 & & & & 1.430 (0.079) & 1.290 (0.000) \\
\hline
\end{tabular}
\textsuperscript{1}Variances are indicated in parentheses.
\end{table}

Of similar interest to the decision as to how many and which brands to carry are the decisions as to pricing strategy. Figure 12 illustrates price per lb. for 1998-99 for six chains for each IBB salad brand carried by the chain. The six were chosen because they illustrate the range of pricing behaviors practiced by the 20 chains in the sample. Panel (a) illustrates pricing for LA 1 for its private label, the only IBB salad it carries. While LA 1 charges an average price per lb. that is lower than the price charged by its Los Angeles competitors for the national brands in all but one

\textsuperscript{35}Ready Pac tends to specialize in producing salad blends. Several of the chains which did not carry Ready Pac IBB salads carried other product categories by Ready Pac.

\textsuperscript{36}It is important to emphasize that this information applies only to IBBs. It was quite common among the sample chains to carry other salad items from a processor, e.g., Ready Pac, even though the chain did not carry the processor’s IBBs.
case (LA 2’s pricing of Ready Pac), the price varies considerably from week to week. LA 1 follows a strategy of setting its private label price at about $1.60/lb. for three-to-five week intervals, and then offering a promotional price, often less than $1.00/lb., for a one week period. Albany 2, illustrated in panel (c), uses a somewhat similar strategy for pricing Dole’s IBBs, the only brand it carries.

The converse of this behavior is the every-day-low-price strategy practiced by Miami 3, illustrated in panel (e). Miami 3 carries Dole and Fresh Express, in addition to its own private label. Miami 3 maintained its private label price in the $1.40/lb. range, below the prices it charged for either Fresh Express or Dole. It maintained relatively stable prices for these brands as well, although it set a premium price for Fresh Express, on average $0.26/lb. more than it charged for Dole. This price ranking between Dole and Fresh Express is not, however, consistent among retailers. Of the six chains that carried both, Dole had the higher average price in half of the cases. Dallas 5 in panel (b) illustrates a case where Dole commands the premium price relative to Fresh Express, and both items are subject to periodic price promotions.

Atlanta 3 [panel (d)] carries its own private label and a single brand, Fresh Express. Atlanta 3 has chosen to maintain a rather constant price for its private label of about $1.60/lb., while using Fresh Express’ IBB salad as a promotional item. Although Atlanta 3’s price for Fresh Express was higher on average than its private label price, for many weeks during 1998-99 Atlanta 3 set a promotional price of about $1.00/lb. for Fresh Express that was much less than its private label price. Finally, LA 4, depicted in panel (f), illustrates a strategy whereby Fresh Express is sold at a relatively constant premium price, and Ready Pac is offered as a low-price alternative, which is also featured on periodic price promotions.
Figure 12
Alternative Retailer Pricing Strategies for Fresh-Cut Salads

(a) Los Angeles 1

$/lb.

(b) Dallas 5

$/lb.

(c) Albany 2

$/lb.
Further insight into the coordination or lack thereof in retailers’ pricing decisions for IBB bagged salads is provided in Table 14. This table is organized on a city-by-city basis and contains correlation coefficients for the prices charged by each chain in the city for the brands of IBB salads it carries and its iceberg head lettuce price. Correlations of these prices with the FOB iceberg lettuce price are also provided. Several conventions are utilized in the table to highlight key information. Shading is used to highlight blocks of correlation coefficients for the prices charged by a given store. Correlations of prices charged by different stores for a given brand (i.e., Fresh Express, Dole, and Ready Pac) are indicated by bold face, and correlations of prices for head lettuce across chains are indicated in italics. Empty cells reflect retailers who maintained a constant iceberg head lettuce price throughout the sample period. The central message of Table 14 is that prices within a city for IBB salads tend to exhibit very low levels of correlation. Indeed, in many cases the correlation is negative, indicating prices that move on average in opposite directions.

Correlations of the retail prices with the FOB iceberg lettuce price are provided in the first column of each correlation matrix. In many cases, retailers’ prices for iceberg head lettuce are positively correlated with the FOB price for iceberg lettuce. For example, among the Dallas chains, these correlations range from 0.061 (Dallas 4) to 0.605 (Dallas 2). However, the correlations between the iceberg FOB price and the bagged salad prices are invariably low, and are often negative. The clear message is that the link between the farm-gate price and the retail price for IBBs is almost completely attenuated, even though iceberg lettuce is the central ingredient in an IBB salad. Consider, for example, the Los Angeles chains. Four of the branded salad prices are negatively correlated with the FOB price, and the highest positive coefficient is only 0.110 (LA 1 private label).

Further consideration of the price patterns in Figure 12 helps in understanding the lack of correlation between movements in the FOB price and the chains’ prices for IBB salads. Many chains choose to use IBBs for price promotions. The promotions tend to follow an imprecise, but regular cycle. The correlation coefficients suggest that promotions are not coordinated with movements in the FOB price. The alternative strategy, to maintain stable prices for particular brands of IBBs, also, of course, results in low levels of correlation with the highly volatile FOB price.

Consider now the bold-faced coefficients, indicating correlations between chains’ prices for the same brand of IBB. They, too, are invariably low. Three of four instances are negative for the Dallas chains, three of five are negative for the Los Angeles chains, and two of three are negative for Miami. The correlations of prices within brands are positive, but essentially zero, for both Atlanta and Chicago. Clearly there is no coordination among the chains in making pricing decisions for IBB salads in any of the sample cities. The correlations for iceberg head lettuce prices (indicated by italics) within a city are generally higher, but in all cases they are considerably less than 1.0. Because retailers in the same city face similar or identical FOB prices and shipping costs for iceberg lettuce, the expectation is that retail prices within a city should be highly correlated. The fact that the correlation coefficients are generally in the range of 0.5 to 0.7 indicates that there is considerable independence among retailers in pricing iceberg lettuce.

Albany was omitted from this table because information was available for only two chains, each of which had limited selection of IBB salads.
Finally, the shaded portions of Table 14 reveal little correlation of prices within a chain for iceberg head lettuce and IBB salads. For example, for the Dallas chains, the correlations of the chain’s head lettuce price with its IBB salad price range from –0.193 (Dallas 4) to 0.084 (Dallas 2). It is not clear from a strategic perspective what relationship to anticipate for these within-chain correlations. If a chain were passively setting prices based upon its costs, the prices should all move together, as a function of the FOB price. As Table 17 shows, this tends not to happen. The most likely explanation for the near independence of the IBB and head lettuce price movements within a chain is simply that each price is set independently, with little or no attempt made to develop a coordinated pricing strategy across the iceberg products.
Table 14
Price Correlations for IBB Salads, Iceberg Head Lettuce and FOB Price
Dallas
FOB

FOB
Dallas 1 Private Label
Dallas 1 Head
Dallas 5 Fresh Express
Dallas 5 Dole
Dallas 5 Head
Dallas 2 Dole
Dallas 2 Head
Dallas 4 Fresh Express
Dallas 4 Head
Dallas 3 Fresh Express
Dallas 3 Head

1.000
0.056
0.388
-0.067
-0.274
.
0.078
0.605
0.047
0.061
0.050
0.412

Dallas 1 Dallas 1 Dallas 5 Dallas 5 Dallas 5 Dallas 2 Dallas 2 Dallas 4 Dallas 4 Dallas 3 Dallas 3
Private
Fresh
Fresh
Fresh
Label
Head Express
Dole
Head
Dole
Head Express
Head Express Head

1.000
0.052
0.019
-0.021
.
0.086
0.075
0.016
0.009
0.004
-0.010

1.000
0.031
-0.118
.
-0.088
0.283
-0.141
0.069
0.078
0.279

1.000
0.438
.
0.018
0.091
-0.051
0.068
-0.062
0.030

1.000
.
0.056
-0.208
0.004
0.148
-0.063
-0.038

.
.
.
.
.
.
.

1.000
0.084
0.039
-0.242
0.187
0.051

1.000
0.039
0.008
0.002
0.417

1.000
-0.193
-0.156
-0.072

1.000
0.382
-0.036

1.000
-0.141

1.000

Los Angeles
FOB
LA 1 Private Label
LA 1 Iceberg
LA 2 Fresh Express
LA 2 Dole
LA 2 Ready Pac
LA 2 Head
LA 3 Dole
LA 3 Ready Pac
LA 3 Head
LA 4 Fresh Express
LA 4 Ready Pac
LA 4 Head

FOB

LA 1
Private
Label

Head

LA 2
Fresh
Express

1.000
0.110
0.688
-0.133
-0.169
0.103
0.446
-0.237
0.011
0.534
0.033
-0.201
0.456

1.000
0.073
0.124
0.015
0.021
0.174
0.015
0.133
0.029
0.009
-0.032
0.063

1.000
-0.035
-0.279
0.139
0.613
-0.405
-0.007
0.775
0.027
-0.280
0.660

1.000
0.389
-0.083
0.005
0.179
0.018
-0.047
-0.078
0.221
0.063

LA 1

Dole

LA 3
Ready
Pac

1.000
0.137
-0.332
-0.155
0.058
-0.192

1.000
-0.078
-0.027
0.032
0.046

LA 2

LA 3

Dole

LA 2
Ready
Pac

Head

1.000
-0.063
-0.238
0.385
0.216
-0.465
-0.002
0.214
-0.268

1.000
0.125
-0.330
-0.349
0.122
0.065
-0.014
-0.032

1.000
-0.146
0.072
0.717
-0.008
-0.178
0.659

LA 2

Head

LA 4
Ready
Pac

Head

1.000
0.014
-0.272
0.733

1.000
0.028
0.019

1.000
-0.232

1.000

Miami
FOB

FOB
Miami 1 Private Label
Miami 1 Head
Miami 3 Private Label
Miami 3 Fresh Express
Miami 3 Dole
Miami 3 Head
Miami 2 Fresh Express
Miami 2 Dole
Miami 2 Head

1.000
0.017
0.345
0.036
-0.198
-0.242
.
-0.169
0.081
0.742

Miami 1 Miami 1 Miami 3 Miami 3 Miami 3 Miami 3 Miami 2 Miami 2 Miami 2
Fresh
Fresh
Private
Private
Head
Dole
Head Express
Dole
Label Express
Head
Label

1.000
0.049
0.043
0.136
0.042
.
0.095
-0.138
-0.009

1.000
-0.040
-0.086
-0.125
.
0.085
-0.019
0.559

FOB

Atlanta1
Fresh
Express

1.000
0.102
-0.012
-0.266
-0.058
.
-0.071
0.472

1.000
0.129
-0.122
0.014
.
0.011
0.078

1.000
0.146
0.212
.
-0.054
-0.091
0.128

1.000
0.710
.
-0.050
-0.264
-0.215

1.000
.
0.088
-0.283
-0.230

Head

Atlanta3
Private
Label

Atlanta3
Fresh
Express

1.000
0.296
-0.137
.
-0.017
0.243

1.000
-0.005
.
-0.116
0.003

1.000
.
0.011
-0.021

.
.
.
.

1.000
-0.130
-0.007

1.000
0.032

Atlanta
FOB
Atlanta 1 Fresh Express
Atlanta 1 Head
Atlanta 3 Private Label
Atlanta 3 Fresh Express
Atlanta 3 Head
Atlanta 2 Fresh Express
Atlanta 2 Head

Atlanta1

164

Atlanta3
Head

.
.
.

LA 4

LA 4
Fresh
Express

LA 3

Atlanta2
Fresh
Express

1.000
-0.083

Atlanta2
Head

1.000

1.000


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Conclusions

Consolidation in the food retailing sector and the emergence of various fees paid to retailers by food processors and shippers, particularly in the fresh produce sector, have generated concerns about the state of competition in food marketing. This study has investigated grocery retailer behavior in the procurement and selling of iceberg lettuce, fresh tomatoes, and bagged salads. The emphasis throughout has been on the implications of retailers' behavior for the welfare of producers. Knowing the effects of retailer behavior on consumer welfare would require a comprehensive analysis across all product categories.

The analysis involved three major analytical components. First, we conducted a detailed analysis of farm-retail price spreads (margins) for California-Arizona iceberg lettuce, vine-ripe tomatoes from California, and mature-green tomatoes from both California and Florida. A central point of the price-spread analysis was to investigate the role of total shipments in influencing the price spread. Under competitive procurement of the aforementioned commodities, there is little reason for the shipment volume to affect the margin. However, under imperfect competition, high shipments volume for a perishable commodity may diminish the bargaining power of sellers, relative to buyers, and lead to a widening of the margin. This effect was confirmed for each of the commodities studied. An additional result of note was that transportation costs did not have the effect predicted by a model of perfect competition. Changes in shipping costs tended to have little effect on the price spread. This result is also consistent with imperfect competition in procurement, because buyers with market power rationally absorb a portion of shipping costs. It is also consistent with an objective of retailers to stabilize prices to consumers.

We conducted formal tests for buyer market power in procurement of the fresh produce commodities, based upon the pricing model developed by Sexton and Zhang (1996). Estimation results for iceberg lettuce supported the earlier conclusion of Sexton and Zhang that retailers were able to capture the lion's share (about 80%) of the market surplus, whereas under competitive procurement, the entire surplus would go to producers. These results also lend support to the finding from the price-spread analysis that large harvest volumes served to reduce sellers' relative bargaining power. Application of the model to fresh tomatoes yielded rather mixed results. Parameters were generally estimated imprecisely, and a hypothesis of perfect competition in procurement could not be rejected for either Florida or California mature-green tomatoes. Based on the parameter estimates, producers' share of the market surplus is considerably higher for tomatoes than for iceberg lettuce. Florida's mature-green tomato industry, in particular, appeared to have been effective in utilizing collective action to maintain a floor on its selling price and capture a substantial share of the market surplus in excess of the floor.

Retailers' pricing decisions to consumers are very complex, given the thousands of products sold at retail. However, a fundamental point is that retailer market power in selling to consumers is harmful to producers because it curtails product movement and forces diversion of the product to lower-valued uses. We used a simple framework to develop estimates of retailers' implied oligopoly power in setting prices to consumers for iceberg lettuce and fresh tomatoes. The evidence suggested that retailers are setting prices for these commodities in excess of full marginal costs, but are not exploiting the magnitude of market power available to them, based upon the estimated price elasticities of demand. Also noteworthy was that several retailers maintained constant selling prices for iceberg lettuce throughout our two-year sample period. Although such pricing may be part of a rational retailer strategy to attract and retain customers,
we showed that fixing or stabilizing prices was, in general, harmful to producer welfare, because it leads to greater price volatility in the segments of the market that do not hold prices fixed and, on balance, lower producer revenues from a given harvest.

Our analysis for bagged salads was somewhat heuristic, because we lacked sufficient information to conduct a formal investigation of market power. The analysis revealed a great diversity among retailers as to strategy for the bagged salad segment of the market. Focusing on iceberg-based salads, we showed that chains differed both in terms of pricing and product selection, including whether to carry a private-label brand. The data revealed no evidence of coordination among retailers in setting prices. The analysis also revealed a nearly complete absence of a relationship between the farm-level price for iceberg lettuce and the prices set at retail for bagged salads.

On balance, we believe that the evidence supports a conclusion that buyers are often able to exercise oligopsony power in procuring fresh produce commodities. This result should not be surprising, given the structural conditions in these markets. The apparent success of the Florida mature-green tomato industry in enforcing a price floor and capturing a significant share of the surplus in excess of the price floor demonstrates the potential benefits to producers through the coordinated behavior allowed them under the law.

The structure of grocery retailing necessarily gives large retailers some degree of market power in terms of an ability to influence price. Ample evidence of this power is the wide variety of pricing strategies that were manifest for the commodities included in this study. However, there was no evidence of coordinated pricing or collusion among retailers in a given city. To the extent that retailers are exercising market power, in the sense of marking up prices in excess of full marginal costs, they are exploiting the unilateral monopoly power they possess through geographic and brand differentiation. The pricing behavior is not the result of coordination with other retailers.

Occasional concerns over data quality, and the wide variety of pricing strategies followed by retailers both limit our ability to make inferences concerning market power. As always, it was necessary to make certain assumptions to facilitate testing hypotheses concerning market power. On balance however, retailers' pricing behavior to consumers probably works to the detriment of produce grower-shippers. Mark ups of price above cost curtail product movement to the retail sector. Retail prices held constant in the face of fluctuating farm-gate prices also cause diversion of product to lower-valued uses. The timing of sales promotions for produce items bears little or no relationship to prices at the farm level. Retailers thus appear to be acting in their own perceived best interest in making these pricing decisions. Closer coordination appears to be evolving between grower-shippers and retailers, and perhaps this coordination can result in retail pricing decisions that better serve both retailers’ and producers' interests.
References


Richards, T.J. and P.M. Patterson, 2001, Imperfect competition in fresh produce markets: an empirical analysis of channel performance, working paper, Morrison School of Agribusiness and Resource Management, Arizona State University.


My comments today will provide a historical perspective with two dimensions:

1. How has the field of industrial organization (I.O.) evolved over the last 30 years? What were the important questions in the 1970s, 80s, and 90s? How were the research agendas influenced by politics, public policy, data, theoretical development, and other issues?

2. From its start in 1974, what have been the notable research efforts of UW’s Food System Research Group? What types of issues did we address during 1974-1997? What were some of the highlights of that work?

I acknowledge a clear structuralist and empiricist bias in my perspective. Many of you will differ some in how you might paint the historical landscape.

The Status of Industrial Organization Economics in the 1970s

When I came to Wisconsin in 1974, UW boasted two of the foremost empirical I.O. researchers in the country, Fritz Mueller and Leonard Weiss. Having returned to Wisconsin in 1969 after eight years in Washington as chief economist of the FTC, Fritz maintained many connections in Washington, was intimately familiar with the competition policy arena, and was called on frequently to testify at congressional hearings or to participate in national symposiums.
This gave the Food System Research Group a sense that we were very close to the action. And it certainly influenced our research agenda. Several of our projects were collaborative efforts with Congressional Committees which were interested in certain competitive questions. And our research was mindful of some of the critical economic questions affecting antitrust policy.

At that point in time the I.O. community largely used the S-C-P framework of Joe Bain in its analysis. Much research focused on the influence on market performance of the various market structure dimensions; particularly concentration, market share, entry barriers, and product differentiation.

In the early 70s there was a growing consensus that market concentration was directly linked to market power and to firms’ abilities to extract monopoly rents. Leonard Weiss had completed a comprehensive review in 1971 of empirical studies of market structure’s linkage to various aspects of market and economic performance (Weiss, 1971). This was followed in 1974 by a careful summary of concentration-profit studies in which he concluded:

“In general the data have confirmed the relationship predicted by theory, even though the data are very imperfect and almost certainly biased toward a zero relationship” (Weiss, 1974, p.231).

Both of Weiss’ summary pieces were thorough and balanced reviews. For those of us in the so-called “structural school,” the role of market structure seemed clear. And the appropriate policy prescription also seemed clear: discourage increased concentration in industries, especially where it was unnecessary to achieve scale economies.

For those wondering why the heavy emphasis on market structure, especially market concentration and market dominance, this reflected both the type of research that
was feasible based upon the available data and the perception that market shares were something that antitrust policy could influence. If in fact there was an inverse relationship between concentration and market performance, enforcement agencies could seek to enhance competitive performance by influencing concentration.

Data availability at the time resulted in many studies using census data to conduct cross sectional studies (across industries) of concentration-profit (or price-cost margin) relationships. At that point in time, there were relatively few within industry, across market studies of structure-price or structure-profit relationships.

This then was the stage for the first serious challenge to the accepted view of the role of market structure. The Airlie House conference in 1974 included both Weiss’ summary paper and a paper by Harold Demsetz, “Two Systems of Belief about Monopoly.” Demsetz argued that the positive relationship found in many studies between profits and seller concentration and/or firm market share was the result of firm efficiency, not higher prices. His paper laid the base for what became known as the “superior efficiency” argument. Peltzman (1977), Mancke (1974) and others added to the criticism of concentration-profit studies.

The debate over the role of market structure, particularly market concentration, in influencing market performance continued throughout the 1980s. The agnostic view of the role of market structure, usually identified with the University of Chicago, was given added influence with the election of Ronald Reagan in 1982. The Reagan administration welcomed a conceptual basis for reducing the role of antitrust structural policies.

After reviewing the debate between traditional and revisionist views of industrial organization, Pautler (1983) concluded:
It seems that much of the difference between the traditional and revisionist views boils down to a difference of opinion on two crucial issues: the extent of barriers to entry, and the presumption of efficiency. If barriers are generally low, then high profitability should be a transitory phenomenon or due to nonreproducible advantages of large firms. Where barriers are substantial, both sides would agree that high profitability can be maintained. The difference is that the revisionists see competition eroding any barriers rather quickly (with the exception of governmentally imposed barriers), whereas traditionalists see a broader menu of more durable barriers to entry, including advertising intensity, scale economies, absolute capital requirements, natural-resource monopoly, patent protection, strategic predation, etc.

The revisionist views came largely from two directions: (1) the superior efficiency and low entry barrier argument of the Chicago School, and (2) the theory of contestable markets. These efforts amounted to a direct frontal attack on traditional industrial organization theory.

The theory of contestable markets, developed by Baumol, Panzar, and Willig (1982) was initially embraced by those anxious for an explanation of why dominant firms and concentrated markets might perform competitively. Indeed – perfectly contestable markets allowed us to “have our cake and eat it too”; the benefits of large firms could be enjoyed without sacrificing a decline in competitive vigor. The lack of relevance of this theory to real markets soon became apparent (Shepherd 1984). By the late 1980s, empirical I.O. economists largely dismissed contestable market theory. However, this theory did shift the emphasis placed on different elements of market structure – raising the attention paid to entry and exit barriers. Absent barriers, even monopolists have limited power over price. Unfortunately, entry and exit barriers are very difficult to measure and therefore to empirically study.

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2 For fuller discussion of alternate views of entry barriers, see B.W. Marion, 1987.
Line of Business Studies

A further test of the linkage between concentration and profits was made possible by the rich data supplied by the FTC line-of-business (LB) program. The LB data enabled researchers to include individual firm own-market share, as well as market concentration and other variables, in exploring structure-profit relationships at the firm level for the years 1974-1977. Ravenscraft (1983) found that the effect of concentration disappeared when firm market shares were added to the models. A survey of 15 studies based upon LB data reported that none found a significant positive relationship between profits and concentration when market share was included as an independent variable (Scherer et al 1987).

Because of the unusually good data and the reputation of the scholars involved, these results raised serious questions about the influence of market concentration. Ravenscraft and others familiar with the LB data cautioned that the results might be unique to the three atypical years involved\(^3\). However, the many questions about the concentration-profit relationship encouraged scholars to examine the impact of concentration and market share on prices rather than profits.

Concentration-Price Studies

In response to the many questions raised about concentration-profit studies, more research focused on within industry, across market studies of structure-price relationships. These studies avoided most of the criticisms of structure-profit studies and across industry studies. They represented cleaner and more direct studies of the structure-performance linkage. Leonard Weiss, one of the nation’s most respected empirical I.O.

\(^3\) Mueller and Sial (1993) conclude that 1974-1976 were so atypical that the long-term relationship between profits and concentration was distorted.
economists, took on the task of summarizing the 100+ studies of concentration and price. His 1989 edited volume was compelling in the evidence presented. Weiss comments, “I believe that our evidence that concentration is correlated with price is overwhelming” (p.283).

For many devotees of the traditional I.O. view, Weiss’ review answered many of the criticisms levied by the revisionists. Concentration and firm market share clearly affected market power and performance.

The research of the 1980s and Michael Porter’s seminal piece (1979) on strategic groups also made it clear that understanding the organization and strategies within industries was important to understand the complexity of factors affecting competition. At least for non-durable consumer goods like food, branded products and private labels differed greatly in their profit margins, entry barriers, and product differentiation. Since then, the interest in differentiated product markets has increased. Today—in large part because of the availability of scanner data—modeling competitive behavior in differentiated product industries is one of the hot areas of I.O. research.

I must confess to some envy at the feasibility of doing demand analysis at the brand level, based upon scanner data, to determine the degree of substitution of brands and hence to define relevant markets. Scanner data coupled with more powerful computers and more sophisticated econometric models has opened up an exciting new world of I.O. research.¹ I believe market power and the dynamics of competition can be better understood at the brand and strategic group level. Before scanner date, finer levels of analysis were often only possible through data obtained in antitrust cases.

¹ One of the first studies to examine market power at the brand level was done at Wisconsin. See Robert Wills, 1983.
Joint Economic Committee Study of Food Retailing

The foregoing provides my perspective of the major factors affecting industrial organization economics in the 1970s and 1980s. Research of the Food System Research Group and NC117, the regional research effort of which we were part from 1974 to 1986, were mindful of these broader debates in the field, even as we examined competition and control issues in the U.S. food system.

Our first major splash has become known as the Joint Economic Committee Study because it was a report done in collaboration with that committee. The study findings, The Profit and Price Performance of Leading Food Chains, 1970-1974, were presented at hearings held by the committee in the spring of 1977 (see Marion et al, 1979). Because of the unusually good data made available to us from data subpoenaed by the committee from 17 of the nation’s largest food chains, the study was able to examine the relationship of local market concentration and firm market share to both firm profits and prices. Because it was a within industry, across market study and analyzed prices and profits, the study provided an important contribution to the broader debate about the relevance of market structure. The study avoided or answered directly many of the criticisms of the revisionist school.

The JEC study found that both relative firm market share and local market concentration were significantly and positively related to supermarket prices. The study had a strong influence on antitrust action to challenge retail mergers during the remainder of the 20th century.
This was the first of the large scale studies done by our group. Large scale studies of this type are only possible with substantial resources and are one of the justifications for the continued existence of UW’s Food System Research Group and Connecticut’s Food Marketing Policy Center.

**Studies of Competition in Food Processing/Manufacturing Industries**

Another major focus of our group during 1975 to 1985 was the food manufacturing industries. Several of the efforts were collaborations with the Economic Research Service of the USDA. Russell Parker, economist with the Federal Trade Commission, also spent four years with our group and made significant contributions.

The end result was the book, The Food Manufacturing Industries: Structure, Strategies, Performance, and Policies (J. Connor et al 1985). This may be the best piece that has come out of our group. Professor John Sutton, who used the book extensively in the research for his book, *Sunk Costs and Market Structure*, comments on the Connor et al book: “This book draws on a decade of research and remains the key point of departure for Industrial Organization economists beginning research in this area.”

Mueller, in his 1983 Fellows address to the American Agricultural Economics Association, indicated one of the bottom lines of the food manufacturing research:

> The evidence shows that high market concentration accompanied by significant entry barriers enhances both prices and profits. Because their prices are elevated more than their profits, the most powerful firms in an industry appear to have higher costs as well. The resulting monopoly profits and consumer overcharge measure only part of the fruits of market power. There is evidence that this market power contributes to inflation, results in disparity in wages, causes an excessive proliferation of products and enormous outlays for advertising and promotion, distorts consumer buying preferences among brands, and defines consumers’ nutritional habits.
What then determines firm shares and market concentration? In some industries scale economies dictate large relative firm size and concentrated markets. Not so in food manufacturing. Prior to the merger wave of the 1980s—allowed by near abandonment of the merger antitrust statutes under Reagan—the food manufacturing industries exhibited contrasting trends. In industries selling undifferentiated food products, concentration was low and remained steady or declined. However, industries with highly differentiated products experienced high concentration that was persistent and increasing. The major causal force propelling increasing concentration during the 60s, 70s, and early 80s was the large scale advertising and promotion of products lending themselves to product differentiation (Mueller and Rogers, 1984). Economies of plant size and capital requirements were not major causes of centralization.

Two other areas of research warrant brief mention. Both received some attention from our group during 1974-97.

- The organization and coordination of commodity subsectors, including pricing and thin markets
- Vertical relationships and restraints in the food system

Organization and Coordination of Commodity Subsectors

Agricultural economists have had an on-going interest in the vertical organization of agricultural commodities, especially as it impacts farmers. Contracts and vertical integration in broilers and processed fruits and vegetables were of concern 50 years ago. These vertical arrangements threatened the independence of farmers, their access to markets, their bargaining power, and created “thin markets.”

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5 Space prevents my lifting up a third area, agricultural cooperatives and their role in the food system. The antitrust treatment of cooperatives under the Capper Volstead Act was the focus of a 1983 monograph (Jesse et al, 1983) and an award winning book (Mueller, Helmberger and Paterson).
But – there has also been considerable interest in the extent to which contracts and vertical integration lead to improved vertical coordination in commodity subsectors. Ray Goldberg of the Harvard Business School has been one of the leading advocates of this perspective.

A major effort of NC117 was in studying vertical commodity subsectors and the instruments of coordination. Comprehensive studies of the organization and coordination of five subsectors were published as monographs. In the book summarizing the findings of NC117 (B.W. Marion and NC117 Committee, 1986), we commented:

> Contract coordination is often seen as the antithesis of market price coordination when it may more properly be viewed as an intermediate state on the open market to integration continuum. A contract with a firm price entered into at the time of production commitment may serve very well as a coordination device. It is the unpriced contract that provides an incentive to manipulate the market that will determine the final contract price…The problem of contracts is the way in which they are negotiated…and the use of formula pricing against a spot market thinned as a result of contracting (p.109).

Because “thin markets” emerged as a topic in which there was considerable interest, a conference in 1978 examined pricing problems in the food industry with an emphasis on thin markets. This was one of the first attempts to determine what was known about thin markets and under what circumstances they might cause problems.

In many ways, the thin market conference laid the base for our four year study of the National Cheese Exchange 15 years later. My colleague, Fritz Mueller, came out of retirement to direct that study.

For those of you who aren’t familiar with the study, the National Cheese Exchange (NCE) was an auction market in Green Bay, Wisconsin. Cheese manufacturers and marketers met there weekly for about 30 minutes to buy and sell car lots of bulk
cheddar cheese to each other in 40 pound blocks or 500 pound barrels. Although only 0.2 percent of all cheese made in the U.S. was sold on the NCE, it was used to formula-price 90-95 percent of the bulk cheese in the U.S.

Each year about five sellers and five buyers made virtually all trades on the NCE. Kraft General Foods, the largest buyer of cheese in the U.S., was the dominant seller on the NCE during 1988-1993, accounting for 75 percent of sales. The NCE had several characteristics of a thin market: relatively few transactions, few traders, and low absolute trading volumes. Although cheese manufacturing and marketing are only moderately concentrated, NCE trading was highly concentrated in both buying and selling. It was a bilateral oligopoly with a dominant seller. Our study concluded that the NCE facilitated market manipulation, with Kraft and other seller-traders with similar interests being the main beneficiaries. Following its acquisition by Phillip Morris in 1988, Kraft became particularly aggressive, both in selling on the NCE to drive bulk cheese prices lower and by increasing the selling prices and gross profit margins on their finished cheese. The result was significantly higher prices to consumers and lower prices to suppliers of bulk cheese (Mueller, W.F. and B.W. Marion, 2000).

The after-shocks of the study were not what they prepare you for in graduate school. The governor appointed a task force to investigate the topic, the U.S. House Committee on Agriculture held two days of hearings, Kraft threatened us with libel charges on three occasions, the USDA changed its procedures for pricing milk, and in

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6 Before 1985, both the wholesale price of Kraft’s cheese and the price it paid for bulk cheese were tied to the NCE price. Changes in the NCE had no effect on Kraft’s margins. In January 1985, Kraft’s wholesale cheese prices were decoupled from the NCE, allowing them to increase selling prices at the same time their buy prices were declining.

7 Fortunately, the University of Wisconsin protects researchers in such situations if the research was done as part of their university appointment. A lawyer with the Wisconsin Dept. of Justice worked with us on this matter. Fortunately, Kraft chose not to carry out its threats.
May 1997 the NCE closed its doors and was replaced by a spot cheese market on the Chicago Mercantile Exchange.

The NCE study was perhaps the first study to fully document the ways in which thin markets are vulnerable to manipulation. Hopefully the study provides a basis for examining other thin markets of concern in the agricultural commodities.

**Vertical Restraints and Relationships in the Food System**

Vertical restraints and relationships have received less attention over the past 30 years from I.O. economists than horizontal restraints associated with market power. However, vertical conflicts are often the cause of private antitrust cases. And, in the U.S. and Europe, as consolidation has occurred among supermarket chains, concern about retail buying power has increased. Retail buyer power is manifested through such things as slotting allowances, listing fees, exclusive supply obligations and retroactive discounts, as well as in transaction prices and payment terms.

Over time, I believe retail buying power will lead to greater market power among large branded suppliers by weakening smaller suppliers and increasing entry barriers. Kraft, P&G, Unilever and Nestle have no problem paying slotting allowances, listing fees, end-of-year rebates and extended payment terms. For small and start-up companies, these are enormous hurdles. The host of vertical restraints/concessions demanded by large chains are also more difficult for small retailers and their wholesalers to match. With little if any enforcement of the Robinson-Patman Act, large chains have learned how to tilt the playing field in their favor.

This area is ripe for a thorough study, perhaps involving a congressional committee in order to obtain data. Four British economists recently completed a large...
study of retail buying power in Europe (R. Clarke, et al, 2002). Nothing similar has been attempted in the U.S.

We initiated little research on vertical restraints in the food system during 1974-1997. A significant contribution to the literature came as a byproduct of Fritz’s involvement in a private lawsuit challenging the licensing system of Sealy Mattress franchises. This was one of those happy opportunities in which consulting provided both income and invaluable data for academic purposes. Fritz’s analysis indicated that market power was the apparent reason for territorial restraints. The free rider and efficiency hypotheses were rejected (Mueller and Geithman, 1991). Frequently, so-called vertical restraints are actually restraints on horizontal competition at one or more levels.

Conclusions

These are my perceptions of some of the major happenings in industrial organization research in the last 30 years and some of the notable contributions of the Food System Research Group. I have focused particularly on work that has been relevant to antitrust policy. The substantial NEIO literature I have ignored in part because I don’t feel comfortable commenting on it, and because it seems of limited relevance to antitrust policy.

To me – the current emphasis on brand-level demand analysis supplements rather than replaces traditional structural analysis of market power. As a firm expands the number of brands in its portfolio, it also likely expands market share and internalizes cross-price effects for brands of products like cereals. This results in price levels increasing as market share increases. In food manufacturing, unilateral power based
upon advertising, market segmentation and product proliferation is likely more important than tacit or explicit collusion.

Although industrial organization research of the last decade has focused more on market conduct and firm strategic behavior, I hope this does not indicate a decline in interest for the role of market structure. Public policies that influence the structure of markets, such as the recent FCC decision to permit greater consolidation of the radio, T.V. and newspaper industries, have enormous long-run consequences. Although the bulk of antitrust laws are directed at anticompetitive conduct, the statutes dealing with structure are potentially the most powerful policies. We need solid economic research to guide the use of those policies.

A Postscript

As I was finishing this paper last week, I read the Science Times section of Tuesday’s (June 17) New York Times. One of the great pleasures of retirement is having the time to read my beloved N.Y. Times. An article, “Brain Experts Now Follow the Money,” described the new field, neuroeconomics, in which researchers scan the brains of people as they make economic and strategic decisions in games designed by experimental economists.

For now, neuroeconomic experiments tell more about individuality and small groups than about markets and economies. But – perhaps, in time, this research will help explain how individuals respond to a lack of tough competition vs. the pressure of tough competition.

In my opinion, we have had many market “experiments” in the last 30 years that indicate a lack of competition negatively affects most dimensions of market performance.
State-run firms, regulated public utilities, cartels, firms with exclusive geographic
territories, and tight oligopolies or dominant firm industries have one thing in common: a
lack of tough competition. And there are similarities in the performance characteristics
of these markets and firms: poor technical efficiency; bloated costs; high prices relative
to costs; slowness in adopting new technology and developing new products; slow
responsiveness to customer desires; and managers that are bureaucratic, unimaginative
and risk averse.

There are no redeeming market virtues from the quiet life. Perhaps this is simply
the way human beings respond to an environment of pressure versus one of no pressure.
Neuroeconomics may help us understand the behavior of managers in different market
settings. For instance, in athletics, there is considerable research that indicates athletes
show the most improvement when their competitors are strong. In universities, the most
productive period of faculty is often prior to tenure. As individuals, we often grow the
most during period of great pain and suffering such as coming to terms with death,
disease or divorce.

Are people in their business roles any different? Is the “crucible of pain and
pressure” important there also for good performance? The evidence from the above
“experiments” supports Michael Porter’s conclusions: industries that experience “tough
competition” because of demanding customers and intense competitive rivalry in their
home markets are more likely to be efficient, at the cutting edge in their products, and
therefore able to compete well in global markets. Porter contends that tough antitrust
policy enhances the global performance of a country’s firms. Protecting one’s firms from
competition does the reverse.
A variety of things can influence the degree of pain and pressure on management. Leveraged buy-outs and “lean and mean” cost-cutting certainly create pressure and frequently improve efficiency temporarily. In the long run, however, the discipline of the market environment may be the most important determinant of tough versus soft competition. The degree of industry concentration and leading firm dominance, the level of entry barriers, the degree of product differentiation, and international trade policies largely determine whether firms and managers experience “the quiet life” or the crucible of “pain and pressure.” The market environment represents a force external to firms and is not easily controlled. Competition policies that encourage highly competitive markets are likely to result in a higher level of performance in the long run than policies that encourage consolidation, protection from foreign competition and cooperative behavior.

These are some of my conclusions from roughly 40 years of observations. Perhaps in the future, neuroeconomists will shed more light on the nexus between the market environment and the performance of individual managers in that market.


Predatory accommodation in vertical contracting with externalities

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June 2003

Abstract

The goal of this paper is to analyze vertical contracts between manufacturers and retailers in a channel including the upstream input market. Using a Nash bargaining framework, we study the contract negotiations between manufacturers and the common retailer, both in a simultaneous and sequential game. The oligopsonistic behavior of manufacturers on the upstream market provides a new explanation for predatory accommodation. With two-parts tariff, we show that joint profit of the industry is not maximised at simultaneous bilateral bargaining equilibria and that below marginal cost pricing in the intermediate goods market arises, when final products are substitutes, and may be welfare improving. When negotiations occurs sequentially, we show, in the two-manufacturers case, that the first manufacturer which enters into negotiations and the retailer may jointly prefer above marginal cost pricing or not, depending on the distribution of bargaining power in the channel. However, the second manufacturer equilibrium wholesale price is set below marginal cost.

**JEL :** L13, L42

**Key-words:** bargaining, vertical relationships, contracts, oligopsony, market power, predatory pricing.

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1 Introduction

It is widely acknowledged that predatory pricing may cause injury to competition and this practice generally constitutes a violation of competition laws, especially when it drives out rivals or impedes entry of new firms. In particular, this is the case when predatory pricing occurs in intermediate goods markets (section 2(a) of the Robinson-Patman Act). Predatory pricing can be established when there is below-cost pricing still with possible recoupment of losses after the predator has driven its rivals out of the market. However, recent economic analysis offer a contrasted view on the impact of predatory pricing on the industry structure as well as on the welfare. Marx and Shaffer (1999) show that below cost pricing without exclusion of rivals may occur in intermediate goods market and may be welfare improving. They coined the term “predatory accommodation” for this kind of situation. They focus on pricing when a monopolist retailer negotiates two-parts tariffs sequentially with two suppliers of imperfect substitutes. It is shown that the retailer and the first manufacturer which negotiates jointly find profitable to establish the wholesale price under (constant) marginal cost in order to extract surplus from the second manufacturer. \(^1\) Intuitively, when the retailer negotiates with the second manufacturer, the retailer’s disagreement payoff is decreasing in the price at which it can buy additional units from the first manufacturer. So, by decreasing this price, the retailer and the first manufacturer jointly increase the size of concessions the second manufacturer must make. However, below-cost pricing does not drive the second manufacturer out of the market. On the contrary, both the retailer and the first manufacturer benefit from its presence by jointly extracting partly its surplus through below-cost pricing as a rent-shifting mechanism.

However, it is clear that their result relies heavily on the sequential nature of the timing and thus the observability of contracts, as acknowledged by the authors. Indeed, Shaffer (2001) shows that when bilateral bargaining are simultaneous then overall joint profit is

\(^1\)The contracts depends only on the quantity purchased from a single supplier, so that exclusive dealing provisions such as in Aghion and Bolton’s (1987) analysis are excluded.
maximized in any bargaining equilibrium and that marginal cost pricing prevails with two-
parts tariffs. Thus, predatory accommodation is valid only for sequential timings.

In this paper, we provide a new explanation for predatory accommodation but in a frame-
work with simultaneous bilateral bargaining. Our point relies on incorporating into the analy-
sis the strategic interactions between manufacturers on the upstream market which provides
the necessary inputs for production. More precisely, we consider a channel structure in which
an upstream sector sells a homogenous raw product to a processing industry composed of
\( n \geq 2 \) manufacturers. The manufacturers subsequently process and sell a final differentiated
commodity to a downstream retailer acting as a monopoly. We assume a perfectly compet-
itive upstream sector while market power is present at both the manufacturers and retail
levels. Thus, manufacturers act both as an oligopsony when buying raw material and as an
oligopoly when selling their products to the retailer. Similarly, the multi-products retailer
acts both as a monopsony when negotiating with manufacturers and as a monopoly with re-
spect to final consumers. The assumption of a monopolist retailer allows for a simple analysis
while enabling to introduce market power at the retail level.

It is worth noting that empirically this framework is broadly consistent with available
studies of market structure in the food industry sector both in the US and in Europe. Food
processing industries often comprise few processors who purchase a raw farm product from
many producers and process it into final products, possibly differentiated (Sexton and Lavoie
(2002)). The literature posits an oligopsonistic relationship in markets where farm product
producers meet with food processors and emphasizes that such an industry structure may
result in imperfect competition on both the buying and selling sides of the market, which
affects the surplus of both farmers and consumers (see e.g. Chen and Lent (1992), Wann and
Sexton (1992), Alston, Sexton and Zhang (1997), Hamilton and Sunding (1998) and Hamilton
(2002)). However, this literature has relatively neglected the existence and the importance
of market power at the retail level. One key feature of our paper is to focus on market power
both at the processing and retail levels.
We show that the presence of the oligopsonistic behavior on the upstream market induces a negative cost externality between manufacturers through quantities exchanged. We then characterize the optimal two-parts tariff for each bilateral bargaining between a manufacturer and the retailer. We show that wholesale price differs from the marginal processing cost depending on final demand characteristics and the intensity of oligopsonistic behavior on the upstream farm market. In particular, in the important case of imperfect substitution between final differentiated products, we find that wholesale price is always below marginal cost. We even prove that below average cost pricing may occur when the degree of products differentiation is sufficiently small. Intuitively, in presence of cost externalities and imperfect substitutes, each negotiated contract takes partially into account the negative effect of the quantities sold by the rival manufacturers’ on the procurement cost. Indeed, for a given manufacturer, decreasing the wholesale price amounts to decrease the rivals’ quantities sold by the retailer, which in turn lowers its own procurement cost by reducing cost externalities. Thus, the perceived marginal cost is lower than marginal cost. This strategic “reducing its own cost” effect is more compelling when final products are less differentiated, ceteris paribus. On the contrary, in the particular case where final demands for both products are independent, cost externalities are irrelevant for the wholesale pricing rule and marginal cost pricing occurs. Of course, the motivation for having below marginal cost pricing is very different from the “rent-shifting” motivation that occurs in Marx and Shaffer’s analysis. Nevertheless, in our context, the properties of the equilibrium are similar: below cost pricing without exclusion of rivals.

We also characterize the optimal fees or slotting allowances paid by manufacturers to the retailer and we show that the sign of these transfers is generally ambiguous and depends on the gap between wholesale price and average cost, on the bargaining power of the manufacturer under scrutiny and on a scale effect that we identify. Moreover, we show that the presence of cost externalities impedes the maximization of joint profit in the simultaneous bargaining process in the channel. Thus, our finding indicates that the form of contracts plays a role in
the degree of inefficiency in the channel.

Welfare analysis surprisingly shows that below cost pricing may be welfare improving as it causes consumer surplus and upstream producers surplus to increase. This increase can outweigh the reduction in joint profit of the industry (manufacturers and the retailer) due to the downward distortion on wholesale prices.

We then turn to the sequential case, restricting the analysis to two manufacturers interacting with the retailer. We show how Marx and Shaffer’s results should be altered. We state that the wholesale price for the first manufacturer which enters into negotiation may be or not under marginal cost, contrary to the case under simultaneous bilateral bargaining. Actually, the gap between wholesale price and marginal cost can be decomposed into three components. One corresponds to the strategic “rent-shifting” effect identified by Marx and Shaffer (1999). A second one corresponds to the “reducing its own cost” strategy identified when bilateral bargaining are simultaneous. Both work in the same direction, that is below marginal cost pricing as a rule in case of substitutes.

However, there is a third effect which works in the opposite direction. Indeed, in sequential bargaining, the joint profit of the retailer and the first manufacturer takes into account the surplus extracted from the relationship between the retailer and the second manufacturer. This provides the retailer with incentives to partially internalize the negative externality of the quantity exchanged with the first supplier on this surplus. This consideration tends to produce above marginal cost pricing as long as the retailer retains some surplus in its negotiation with the second manufacturer. For instance, if products are independent and if the second manufacturer has no bargaining power then above marginal cost pricing is the rule. On the contrary, if the retailer has no bargaining power within its relationship with the second manufacturer, then below marginal cost pricing is the rule.

The paper is organized as follows. Section 2 is devoted first to assumptions and notations and second to establish the profit sharing in bargaining equilibria. Section 3 is devoted to the analysis of optimal two-parts tariffs in simultaneous bargaining. In section 4, we analyze
the negotiations when they occur sequentially. Section 5 provides the welfare analysis and finally Section 6 concludes.

2 The model

2.1 Assumptions and notations

Consider a channel structure in which an upstream producer sector sells a (homogenous) raw product to a processing industry composed of \( n \geq 2 \) manufacturers, denoted \( M_i, \forall i = 1, \ldots, n \). The manufacturers subsequently process and sell a final differentiated commodity to a downstream retailer \( R \) acting as a monopoly. We assume a perfectly competitive upstream sector while market power is present at both the manufacturers’ level and retail level. Thus, manufacturers act both as an oligopsony when buying raw material and as an oligopoly when selling their products to the retailer. Similarly, the retailer acts both as a monopsony when negotiating with manufacturers and as a monopoly with respect to final consumers.

Upstream producers sell a quantity \( x_i \) of the raw product to any manufacturer \( M_i, \forall i = 1, \ldots, n \), at a price \( p_x \) given by the inverse supply function \( p_x = P_x(\sum x_i) \), where \( P'_x > 0 \). Each manufacturer \( M_i \) produces a single product \( q_i \) given the processing technology \( q_i = f_i(x_i) \) with \( f'_i(x_i) > 0, \forall i = 1, \ldots, n \). Equivalently, we define \( C_i(q) \) as the cost function for \( M_i \), where \( q = (q_1, \ldots q_i, \ldots q_n) \) is the vector of quantities:

\[
C_i(q) = \left[ P_x\left(\sum_i f_i^{-1}(q_i)\right)\right] f_i^{-1}(q_i).
\]

Obviously, given our assumption on \( P_x \), upstream competition for raw material entails negative externalities between manufacturers because each production cost is increasing in other manufacturers’ purchases \( (\partial C_i(q)/\partial q_j = x_iP'_x/f'_j(x_j) > 0, \forall i \neq j) \). The quantity \( q_i \) is sold to the retail monopolist \( R \) in exchange of a monetary transfer \( T_i \). Then manufacturer \( M_i \)’s profit is \( \pi^i = T_i - P_x(\sum x_i)x_i \) or equivalently \( \pi^i = T_i - C_i(q) \).

Let \( R(q) \) denote the revenue function of the retail monopolist.\(^2\) Then the retailer’s profit

\(^2\) Alternatively, the retailer may be the final consumer and \( R(q) \) can be interpreted as the indirect utility from consuming the bundle \( q \).
is $\pi^R = R(q) - \sum_i T_i$ if the retailer has an agreement with each manufacturer. For simplicity, we assume that the retailer does not face any distribution cost and if $P_i(q)$ denotes the retail price for commodity $i$, then we have:

$$R(q) = \sum_i P_i(q)q_i.$$ 

Throughout the analysis, we make the following assumptions:

\begin{itemize}
  \item \textbf{A1:} $R(q)$ is continuous, twice differentiable and concave,
  \item \textbf{A2:} $C_i(q)$ is continuous, twice differentiable and convex, $\forall i = 1, \ldots, n,$
  \item \textbf{A3:} There are gains from trading all goods, i.e. $\exists q \in \mathbb{R}_+^n$ such that $R(q) - \sum_i C_i(q) > 0$.
\end{itemize}

In particular, assumption A3 ensures that we can consider equilibria where all products are sold. In addition, we assume that manufacturers are precluded from entering the downstream market so that each manufacturer has to induce the retailer to carry its product in order to obtain positive profits. Thus, the monopoly advantage for the retailer implies that any manufacturer’s profit is non positive if it does not reach an agreement with the retailer (it can be negative if the relationship with the retailer entails specific investment costs before entering into negotiations).

\subsection{2.2 Negotiating contracts}

We consider the following two-stages game between $n$ manufacturers and their common retailer. In the first stage, the retailer negotiates a contract $T_i(q_i)$ simultaneously with each manufacturer. In the second stage, the retailer chooses how much to buy of each product $q_i$ and order these quantities from manufacturers. Then, manufacturers compete to buy the raw product from the upstream sector and process the goods. Finally, the retailer resells these quantities to final consumers, exerting its monopoly power. We are only interested in considering equilibria where all products are sold through the retailer.

As emphasized by Marx and Shaffer (1999) and Shaffer (2001), the main difficulty comes from the linkage across negotiations which raises arduous questions. In particular, what
does each manufacturer know about their rivals’ contract terms? Indeed, when negotiating, each manufacturer must conjecture the set of terms its rivals have or have been offered. In equilibrium, this conjecture must be correct but out-of-equilibrium beliefs may be important in determining the bargaining outcome. In the cooperative bargaining approach, this problem is resolved by assuming that any bargaining outcome must be bilaterally renegotiation proof, i.e. no processor-retailer can deviate from the bargaining outcome in a way that increases their joint profit, taking as given all other contracts. Following Marx and Shaffer (1999) and Shaffer (2001), we thus assume that bargaining between the retailer and any manufacturer $M_i$ maximizes the two players’ joint profit, taking as given all other negotiated contracts. Moreover, we assume that each player earns its disagreement payoff (i.e. what it would earn if an agreement is not reached) plus a share of the incremental gains from trade, defined as the difference between the joint profit of the retailer and $M_i$ when they trade and their joint profit when they do not trade), with proportion $\lambda_i \in [0,1]$ going to manufacturer $M_i$.

In fact, it can be proven that the asymmetric Nash product, which is maximized by the Nash bargaining solution, is maximized if and only if the above assumptions are satisfied (see Proposition 2 in Shaffer (2001)). However, it can easily be shown that the equilibrium contract is not unique. We thus focus in the following on the particular case of two-parts tariffs.

## 3 Simultaneous bargaining with two-parts tariffs

In order to provide a precise characterization of bargaining equilibria, we specialize the model by restricting the set of possible contracts to the set of two-parts tariffs. Denote $T_i(q_i)$ the agreement reached by the retailer with manufacturer $M_i$, $\forall i = 1,...,n$. $T_i$ is defined as the net payment from the retailer to manufacturer $M_i$:

$$
T_i(q_i) = \begin{cases} 
    w_i q_i - F_i, & q_i > 0, \\
    0, & q_i = 0, \forall i = 1...n.
\end{cases}
$$
where \( F_i \), is a fee or slotting allowance paid by \( M_i \) to the retailer, in order to access to the final demand. Of course, the sign of the fee \( F_i \) is not restricted \textit{a priori} in the analysis.

If the retailer buys all the manufacturers’ products, his profit is given by:

\[
\pi^R = \sum_i [P_i(q_i)q_i - T_i] = \sum_i [(P_i(q) - w_i)q_i + F_i].
\]

where \( P_i(q) \) is the (final) inverse demand function for product \( i \). If manufacturer \( M_i \) sells a positive quantity, his profit is:

\[
\pi^i = w_iq_i - C_i(q) - F_i = T_i - C_i(q), \forall i.
\]

As emphasized in the preceding section, we assume that bargaining between the retailer and each manufacturer \( M_i \) results in the maximization of the two players’ joint profit denoted \( \Pi^i \), taking as given the retailer’s contract with all others manufacturers \( M_j, j \neq i \) with:

\[
\Pi^i = \sum_i [P_i(q_i)q_i] - C_i(q) - \sum_{j \neq i} T_j
\]

Then, each manufacturer earns a share of the incremental gains from trade, that is the joint profit with the retailer and manufacturer \( M_i \) when they trade minus their joint profit when they do not trade, with an exogenous proportion \( \lambda_i \in [0, 1] \) going to manufacturer \( M_i \). The proportion \( \lambda_i \) measures the bargaining power of \( M_i \). A value of \( \lambda_i \) close to one means a large bargaining power and a value close to zero means that the manufacturer has low bargaining power.

Denote \( T_{-i} \) as the set of all contracts except for manufacturer \( M_i \), i.e. \( T_{-i} = \{T_1, ..., T_n\} \setminus \{T_i\} \).

If the retailer does not buy manufacturer \( i \)'s product, his profit is given by:

\[
\pi^R_{-i}(T_{-i}) = \sum_{j \neq i} [P_j(q_{-i})q_j - T_j]
\]

where \( q_{-i} = (q_1, q_{i-1}, 0, q_{i+1}, ..., q_n) \) is the vector of production when \( M_i \) does not sell through the retailer.

In the second stage, the retailer takes the contracts \( T_i \) with each manufacturer as given and conditional on the bargaining outcome he chooses \( q \) that maximizes his profit given the
wholesale prices vector $\mathbf{w}$. We denote the equilibrium quantities $q_i(\mathbf{w})$, $\forall i$ when the retailer contracts with all manufacturers. Then:

$$q(\mathbf{w}) \in \arg \max_{q_1,\ldots,q_n} \pi^R = \sum_i [(P_i(\mathbf{q}) - w_i)q_i + F_i]. \quad (2)$$

As the retailer is a monopolist, the retail equilibrium quantities defined by program (2) are given by the following first-order conditions:

$$P_i(q(\mathbf{w})) - w_i + \sum_j \frac{\partial P_j(q(\mathbf{w}))}{\partial q_i} q_j(\mathbf{w}) = 0, \forall i \quad (3)$$

If an agreement does not occur with manufacturer $i$ because negotiation fails in the first stage, then the retailer chooses:

$$\hat{q}_{-i}(\mathbf{w}) \in \arg \max_{(q_j)_{j\neq i}} \pi^R_{-i}(T_{-i}) = \sum_{j \neq i} [(P_j(\mathbf{q}_{-i}) - w_j)q_j + F_j], \quad \forall i$$

and we denote $\hat{\pi}^R_{-i}(T_{-i})$ the resulting profit. We also denote

$$\Pi_{-i} = \sum_{j \neq i} [(P_j(\hat{q}_{-i}(\mathbf{w}))\hat{q}_j(\mathbf{w}) - C_j(\hat{q}_{-i}(\mathbf{w}))[\ldots)$$

as the joint profit of all players (for a given $\mathbf{w}$) when $M_i$ does not participate.

In the first stage (bargaining game), negotiations occur between the retailer and each manufacturer simultaneously. When negotiating with $M_i$, the retailer and $M_i$ take $T_j \forall j \neq i$ as given. The equilibrium wholesale price is given by the maximization of the joint profit:

$$\max_{w_i} \Pi^i = P_i(q(\mathbf{w}))q_i(\mathbf{w}) - C_i(q(\mathbf{w})) + \sum_{j \neq i} [(P_j(q(\mathbf{w})) - w_j)q_j(\mathbf{w}) + F_j]. \quad (4)$$

Solving this maximization program, we state the following proposition.

**Proposition 1** In a simultaneous bilateral bargaining equilibrium with two-parts tariffs, wholesale prices are given implicitly by

$$w_i - \frac{\partial C_i}{\partial q_i} = \sum_{j \neq i} \gamma_{ji} \frac{\partial C_i}{\partial q_j}, \quad \forall i = 1,\ldots,n. \quad (5)$$

where $\gamma_{ji} = \frac{\partial q_j}{\partial w_i} / \frac{\partial q_i}{\partial w_i}$ with $|\gamma_{ji}| \in [0,1]$. Moreover, if products are imperfect substitutes (complements), then wholesale price is below (above) marginal cost ($w_i - \frac{\partial C_i}{\partial q_i} < (>)0, \forall i$).
**Proof:** The first order condition associated to (4) is:

\[ P_i \frac{\partial q_i}{\partial w_i} + \sum_{j=1}^{n} \left[ \frac{\partial P_j}{\partial q_j} \frac{\partial q_i}{\partial w_i} \right] + \sum_{j \neq i} q_j \sum_{k=1}^{n} \left[ \frac{\partial P_j}{\partial q_j} \frac{\partial q_k}{\partial w_i} \right] + \sum_{j \neq i} (P_j - w_j) \frac{\partial q_j}{\partial w_i} \]

\[-\sum_{j=1}^{n} \frac{\partial C_i}{\partial q_j} \frac{\partial q_i}{\partial w_i} = 0, \forall i.\]

Using equation (3) and rearranging terms, we get:

\[
\left( w_i - \frac{\partial C_i}{\partial q_i} \right) \frac{\partial q_i}{\partial w_i} = \sum_j \left[ \frac{\partial P_j}{\partial q_j} \frac{\partial q_i}{\partial w_i} \right] - \sum_{j=1}^{n} \left[ \frac{\partial P_j}{\partial q_j} \frac{\partial q_k}{\partial w_i} \right] - \sum_{j \neq i} q_j \sum_{k=1}^{n} \left[ \frac{\partial P_j}{\partial q_j} \frac{\partial q_k}{\partial w_i} \right] + \sum_{j \neq i} \left[ \sum_{k=1}^{n} \frac{\partial P_j}{\partial q_j} \frac{\partial q_k}{\partial w_i} \right] + \sum_j \frac{\partial C_i}{\partial q_j} \frac{\partial q_j}{\partial w_i} \]

Simplifying this expression, we get the result. Furthermore, we have \( \frac{\partial q_i}{\partial w_i} < 0 \). Moreover, if commodities are imperfect substitutes (complements), then \( \frac{\partial q_j}{\partial w_i} > (\leq) 0 \) and \( \gamma_{ji} < (\geq) 0 \). Finally, because of the Cournot competition setting in the upstream sector, \( \frac{\partial C_i}{\partial q_j} > 0 \), we get a negative (positive) gap between wholesale price and marginal cost if products are substitutes (complements).

Proposition 1 indicates that the equilibrium wholesale pricing differs from the marginal cost of production because of the presence of externalities both at the upstream and downstream levels. In the important case of substitutes, below marginal cost pricing occurs at the equilibrium. Without cost externalities (i.e. when \( \partial C_i / \partial q_j = 0, \forall j \neq i \)), proposition 1 also states that marginal cost pricing prevails as in Shaffer’s (2001) model. In presence of cost externalities and imperfect substitutes, each negotiated contract takes partially into account the negative effect of the quantities sold by the rival manufacturers’ on the procurement cost. Indeed, decreasing the wholesale price amounts to decrease the rivals’ quantities sold by the retailer, which in turn lowers its own procurement cost by reducing cost externalities. Thus, the **perceived** marginal cost \( \frac{\partial C_i}{\partial q_i} + \sum_{j \neq i} \gamma_{ji} \frac{\partial C_i}{\partial q_j} \) is lower than marginal cost. This strategic effect is more compelling when final products are less differentiated, ceteris paribus. On the contrary, in the particular case where final demands for both products are independent (i.e. \( \partial q_j / \partial w_i = 0, \forall j \neq i \)), cost externalities are irrelevant for the wholesale pricing rule and
Proposition 1 does not allow to state that operating profits (i.e. excluding the fee or slotting allowance $F_i$) for manufacturers are positive in the case of imperfect substitutes (i.e. when $\gamma_{ji} < 0$). In theory, it may be the case that the distortions due to cost externalities are so strong that wholesale prices are below average cost for some manufacturers. Indeed, assuming symmetry in cost and demand functions, it is possible to prove that a necessary and sufficient condition to have below average cost pricing at the equilibrium is that $1 + \sum_{j \neq i} \gamma_{ji} < 0$, which means that final commodities are few differentiated ceteris paribus (see Appendix A).

We now show that the presence of externalities does not allow to maximize overall joint profit.

**Proposition 2** In a simultaneous bilateral bargaining equilibrium with two-parts tariffs, joint profit of all manufacturers and the retailer is not maximized.

**Proof:** Maximizing the profit $\Pi^{IVS} = \sum_i [P_i(q_i)q_i - C_i(q_i)]$ of the corresponding integrated vertical structure would lead to the following first order condition for the quantity $q_i$:

$$\sum_j \frac{\partial P_j(q^m)}{\partial q_i} q_j^m + P_i(q^m) - \sum_j \frac{\partial C_j(q^m)}{\partial q_i} = 0, \forall i.$$  \hspace{1cm} (6)

In the non integrated vertical structure, the retailer maximization program implies the following first-order condition (see (3)):

$$P_i(q) - w_i + \sum_j \frac{\partial P_j(q)}{\partial q_i} q_j = 0, \forall i.$$  \hspace{1cm} (7)

Replacing $w_i$ by its value given by (5), equation (7) becomes

$$\sum_j \frac{\partial P_j(q)}{\partial q_i} q_j + P_i(q) - \sum_j \frac{\partial C_j(q)}{\partial q_j} = 0, \forall i.$$  \hspace{1cm} (8)

Comparing expressions (6) and (8), we obtain that the non integrated vertical structure outcome does not maximize the joint profit of the integrated vertical structure. Indeed, in general, we have

$$\sum_j \frac{\partial q_i}{\partial w_i} \frac{\partial C_i}{\partial q_j} \neq \sum_j \frac{\partial C_j}{\partial q_i}, \forall i.$$
Even assuming symmetry of the cost functions (i.e. $\frac{\partial C_i}{\partial q_j} = \frac{\partial C_j}{\partial q_i}$), we still have $\frac{\partial q_j}{\partial w_i} \neq \frac{\partial q_i}{\partial w_i}$ because products are imperfect substitutes.

Thus, the externality induced by the upstream competition induces an efficiency loss in the vertical structure that depends on the final demand assumptions and on the intensity of upstream competition. Indeed, a way to implement the optimum for an integrated (both horizontally and vertically) structure is to set the (internal) wholesale price at $w_i = \sum_j \frac{\partial C_j}{\partial q_i}$, as indicated by (6). This result indicates that the perceived marginal cost is then the sum of all marginal effects of quantity $q_i$ on all manufacturers’ costs and thereby all upstream externalities are internalized at the equilibrium. By contrast, in the non integrated vertical structure, only the negative externalities of others’ quantities on its own cost are partially taken into account in each bilateral bargaining.

Finally, the fee $F_i$ is chosen to divide the incremental gains from trade so that each party earns as profit as it would earn if negotiations have failed. Let $\Pi_{-i}$ denote the equilibrium joint profit of all players when $M_i$ does not participate and let $\Pi$ denote the equilibrium joint profit when all parties are active. We have:

$$\Pi_{-i} = \sum_{k \neq i} [(P_k(\hat{q}_{-i}))\hat{q}_k - C_k(\hat{q}_{-i})] \quad \text{and} \quad \Pi = \sum_i [P_i(q_i)q_i - C_i(q_i)]$$

where $q = q(w)$ and $\hat{q}_{-i} = \hat{q}_{-i}(w)$. Then, the following proposition states the equilibrium fees and payoffs to the retailer and to the manufacturers.

**Proposition 3** In a simultaneous bilateral bargaining equilibrium with two-parts tariffs, the equilibrium payoff to manufacturer $M_i$, for any $i$, is:

$$\pi^i = \lambda_i [\Pi - \Pi_{-i} - \Delta_{-i}]$$

while the equilibrium payoff to the retailer is:

$$\pi^R = \left( 1 - \sum_i \lambda_i \right) \Pi + \sum_i \lambda_i \Pi_{-i} + \sum_i \lambda_i \Delta_{-i}$$

where $\Delta_{-i} = \sum_{j \neq i} \left[ w_j q_j - C_j(q_j) \right] - \sum_{j \neq i} \left[ w_j \hat{q}_j - C_j(\hat{q}_{-i}) \right]$.  

201
**Proof:** Given that the disagreement payoff of any manufacturer is zero because there is only one retailer (actually what is really important is that these payoffs must be constant), we can express the equilibrium payoff for manufacturer $M_i$ as follows:

$$\pi_i = \lambda_i \left[ \Pi - \hat{\pi}_R(T_{-i}) \right]$$

(9)

or equivalently,

$$\pi_i = \lambda_i \left[ P_i(q_i) - C_i(q) + \sum_{j \neq i} [(P_j(q) - w_j)q_j + F_j] - \sum_{j \neq i} [(P_j(q_{-i}) - w_j)\hat{q}_j + F_j] \right]$$

$$= \lambda_i \left[ P_i(q_i) - C_i(q) + \sum_{j \neq i} [(P_j(q) - w_j)q_j - C_j(q)] - \sum_{j \neq i} [(P_j(q_{-i}) - w_j)\hat{q}_j] \right]$$

$$= \lambda_i \left[ \Pi + \sum_{j \neq i} [C_j(q) - w_jq_j] - \sum_{j \neq i} [(P_j(q_{-i}) - w_j)\hat{q}_j + C_j(q_{-i}) - C_j(q_{-i})] \right].$$

Finally, we obtain

$$\pi_i = \lambda_i \left[ \Pi - \Pi_{-i} + \sum_{j \neq i} [C_j(q) - w_jq_j] - \sum_{j \neq i} [C_j(q_{-i}) - w_j\hat{q}_j] \right].$$

Consequently, the equilibrium profit for the retailer is:

$$\pi_R = \Pi - \sum_i \pi_i.$$

Substituting, we obtain that:

$$\pi_R = \left(1 - \sum_i \lambda_i\right) \Pi + \sum_i \lambda_i \Pi_{-i} - \sum_i \lambda_i \left[ \sum_{j \neq i} [C_j(q) - w_jq_j] - \sum_{j \neq i} [C_j(q_{-i}) - w_j\hat{q}_j] \right].$$

This concludes the proof.  

Proposition 3 indicates that the equilibrium payoff of any manufacturer is proportional to the incremental gain of its product ($\Pi - \Pi_{-i}$) diminished by a scale effect $\Delta_{-i}$. When products are substitutes, we have $q_j < \hat{q}_j$. Rewriting the scale effect, we get:

$$\Delta_{-i} = \sum_{j \neq i} [w_jq_j - C_j(q)] - \sum_{j \neq i} [w_j\hat{q}_j - C_j(q_{-i})]$$

$$= \sum_{j \neq i} \left[ \left( \frac{C_j(q) - C_j(q_{-i})}{q_j - \hat{q}_j} - w_j \right) (q_j - \hat{q}_j) \right]$$
Similarly, we can decompose the equilibrium payoff of the retailer $\pi^R$ into three components. The first one is proportional to joint profit and can be negative if the manufacturers possess a sufficiently high bargaining power ($\sum_i \lambda_i > 1$). The second one is a weighted sum of joint profit when one manufacturer does not participate ($\sum_i \lambda_i \Pi_{-i}$). Finally, the third one is a weighted sum of scale effects ($\sum_i \lambda_i \Delta_{-i}$).

Finally, using the definition of $M_i$'s profit and result from Proposition 3 gives the equilibrium fee paid by the manufacturer $M_i$ to the retailer:

$$F_i = \left[ w_i - \frac{C_i(q_i)}{q_i} \right] q_i - \lambda_i [\Pi - \Pi_{-i} - \Delta_{-i}] .$$

We have $\lambda_i [\Pi - \Pi_{-i} - \Delta_{-i}] \geq 0$ by definition (equilibrium payoff for $M_i$). Moreover, the sign of the first term between brackets is positive as long as the wholesale price is higher than average cost at the equilibrium output level. Overall, the sign of $F_i$ is undetermined and depends on the magnitude of the margin. When the retailer has all the bargaining power ($\lambda_i = 0$), then $F_i > 0$ if wholesale price is between marginal cost and average cost.

4 Sequential bargaining

This section is devoted to the analysis of sequential negotiations between manufacturers and the retailer. Following Marx and Shaffer (1999), we restrict for simplicity the study to the case of two manufacturers of imperfect substitutes. We let manufacturer $M_1$ be the first supplier to negotiate with the retailer. The game has now three stages. In stage one, the retailer negotiates a contract $T_1$ with $M_1$ for the purchase of $q_1$. In stage two, the retailer negotiates a contract $T_2$ with $M_2$ for the purchase of $q_2$. In stage three, the retailer chooses quantities $q_1$ and $q_2$ to purchase and resells them in the final goods market. We thus solve for the equilibrium strategies of the retailer and manufacturers using backward induction. Our solution concept is subgame perfection.

In stage three, the retailer takes as given the contracts with the two manufacturers as in the case of simultaneous bargaining (section 3), and chooses $q_1$ and $q_2$ as stated in (2),
whenever an agreement is reached with both suppliers:

\[
\max_{q_1, q_2} \pi^R = R(q_1, q_2) - \sum_{i=1}^{2} (w_i q_i - F_i). \tag{10}
\]

Denote \(q^*_1\) and \(q^*_2\) the maximizers in (10), which are assumed to be uniquely defined.

In stage two, the manufacturer \(M_2\) and the retailer negotiates a contract \(T_2\), taking as given the contract \(T_1\). The optimal two-parts tariff maximizes the joint profit \(\Pi^2\) which is given by:

\[
\Pi^2 = R(q_1^*, q_2^*) - T_1(q_1^*) - C_2(q_1^*, q_2^*).
\]

Proposition 1 obviously applies here and yields to:

\[
w_2^* = \frac{\partial C_2}{\partial q_2} + \gamma_{12} \frac{\partial C_2}{\partial q_1}.
\]

Now, given \(T_1\), if there is no agreement between the retailer and \(M_2\), then the retailer chooses \(q_1\) to solve:

\[
\max_{q_1} \pi^R = R(q_1, 0) - w_1 q_1 + F_1.
\]

which maximizer is denoted \(\hat{q}_1\).

Overall, both players divide the gains from trade so that each receives its disagreement payoff plus a share of the incremental gains, with proportion \(\lambda_2\) accruing to \(M_2\). Consequently, the optimal fee \(F_2^*\) is given by:

\[
F_2^* = \left( w_2^* - \frac{C_2}{q_2^*} \right) q_2^* - \lambda_2 \left( \Pi^2 - \pi^R \right) \tag{11}
\]

where \(\pi^R = R(\hat{q}_1, 0) - T_1(\hat{q}_1)\).

In stage one, the manufacturer \(M_1\) and the retailer negotiates a contract \(T_1\), taking as given the equilibrium strategies in stage two and three. The optimal two-parts tariff maximizes the joint profit \(\Pi^1\) which is given by:

\[
\Pi^1 = R(q_1^*, q_2^*) - T_2(q_2^*) - C_1(q_1^*, q_2^*)
= R(q_1^*, q_2^*) - w_2^* q_2^* + F_2^*(w_1) - C_1(q_1^*, q_2^*).
\]
For M At the equilibrium with sequential bilateral negotiations, the wholesale price Proposition 4 products is e where γ recalling that the result.

Rearranging terms, we obtain the following expression for joint profit:

\[ \Pi^1 = (1 - \lambda_2) (R(q_1^*, q_2^*) - C_2(q_1^*, q_2^*)) - C_1(q_1, q_2) + \lambda_2 w_1 (q_1^* - \hat{q}_1) + \lambda_2 R(\hat{q}_1, 0). \] (12)

This allows us to state the following proposition, assuming that the production of both products is efficient (from the viewpoint of the integrated vertical structure).

**Proposition 4** At the equilibrium with sequential bilateral negotiations, the wholesale price for M1 is given by:

\[ w_1^* - \frac{\partial C_1}{\partial q_1} = (1 - \lambda_2)(1 - \eta) \left( \frac{\partial C_2}{\partial q_1} + \frac{\partial C_1}{\partial q_2} \right) + \gamma_1 \left( \frac{\partial C_1}{\partial q_1} \right) \] (13)

where \( \gamma_{ji} = \frac{\partial q_j}{\partial w_1} \) and \( \eta = \gamma_{21} \gamma_{12} \).

**Proof:** Differentiating (12) with respect to \( w_1 \), we get:

\[ \frac{\partial \Pi^1}{\partial w_1} = (1 - \lambda_2) \left( \frac{\partial R}{\partial q_1} \frac{\partial q_1^*}{\partial w_1} + \frac{\partial R}{\partial q_2} \frac{\partial q_2^*}{\partial w_1} - \frac{\partial C_2}{\partial q_1} \frac{\partial q_1^*}{\partial w_1} - \frac{\partial C_2}{\partial q_2} \frac{\partial q_2^*}{\partial w_1} \right) - \frac{\partial C_1}{\partial q_1} \frac{\partial q_1^*}{\partial w_1} - \frac{\partial C_1}{\partial q_2} \frac{\partial q_2^*}{\partial w_1} + \lambda_2 (q_1^* - \hat{q}_1) + \lambda_2 w_1 \frac{\partial W_1}{\partial w_1} \]

recalling that \( \frac{\partial R(\hat{q}, 0)}{\partial q_1} = w_1 \). Furthermore, recall that at the optimum, we also have: \( \frac{\partial R(q_1^*, q_2^*)}{\partial q_1} = w_1 \) and \( \frac{\partial R(q_1^*, q_2^*)}{\partial q_2} = w_2 \). Replacing and rearranging terms, we then obtain:

\[ \frac{\partial q_1^*}{\partial w_1} \left[ w_1 - \frac{\partial C_1}{\partial q_1} - (1 - \lambda_2) \frac{\partial C_2}{\partial q_1} \right] + \frac{\partial q_2^*}{\partial w_1} \left[ (1 - \lambda_2) \left( \frac{\partial q_1^*}{\partial q_1} \frac{\partial C_2}{\partial q_2} \right) - \frac{\partial C_1}{\partial q_2} \right] + \lambda_2 (q_1^* - \hat{q}_1) = 0. \]

using the result concerning the optimal wholesale price \( w_2 \). Further manipulations yields to the result.

As indicated by Proposition 4, the gap between wholesale price and marginal cost can be decomposed into three terms. The last one \((-\lambda_2 / \partial w_1)(q_1^* - \hat{q}_1))\) corresponds to the “rent
"shifting" strategic effect identified by Marx and Shaffer (1999). This term is non positive when products are imperfect substitutes because $q_1^* < \hat{q}_1$. Intuitively, given the common procurement cost $w_1$, the quantity $q_1^*$ sold when the substitute is also on the market is lower than the quantity $\hat{q}_1$ sold when the other product is not on the shelf. As suggested by Marx and Shaffer, a lower wholesale price has two sub-effects. On one hand, it allows to increase the retailer’s disagreement payoff in proportion to $\hat{q}_1$ at the margin. This provides the retailer with an incentive for below marginal cost pricing with $M_1$. On the other hand, a lower wholesale price also increases the retailer’s joint profit with manufacturer $M_2$ (in proportion to $q_1^*$ at the margin), giving the retailer a weaker bargaining position in its negotiations with $M_2$. This provides the retailer with an incentive for above marginal cost pricing with $M_1$. As long as there are surplus to extract from $M_2$ i.e. $\lambda_2 > 0$ then the first consideration dominates the second one.

The second term ($\gamma_{21} \frac{\partial C_2}{\partial q_1}$) corresponds to the “reducing its own cost” strategy identified in Proposition 1 when bilateral bargaining are simultaneous. Both the first and the second terms work in the same direction, that is below marginal cost pricing as a rule in case of substitutes.

However, there is the first term $((1 - \lambda_2)(1 - \eta)\frac{\partial C_2}{\partial q_1})$ which is non negative because $|\gamma_{ji}| < 1$ and thus $1 - \eta > 0$, $\frac{\partial C_2}{\partial q_1} > 0$ and $0 \leq \lambda_2 \leq 1$. As indicated by (12), the joint profit of the retailer and $M_1$ takes into account the incremental gain coming from the relationship between the retailer and the second manufacturer $M_2$ (i.e. $(1 - \lambda_2)(R - C_2)$). This provides the retailer with incentives to partially internalize the negative externality of the quantity exchanged $q_1^*$ on this surplus and in particular the cost $C_2$ of the second manufacturer. This “internalization effect” tends to above marginal cost pricing as long as the retailer retains some surplus in its negotiation with $M_2$ ($\lambda_2 < 1$).

Overall, Proposition 4 indicates that wholesale price may be or not under marginal cost, contrary to the case under simultaneous bilateral bargaining (see Proposition 1). For example, if products are independent (i.e. $\eta = \gamma_{21} = 0$) and if manufacturer $M_2$ has no bargaining
power ($\lambda_2 = 0$) then only the first positive term remains and above marginal cost pricing is the rule. On the contrary, if the retailer has no bargaining power within its relationship with the second manufacturer ($\lambda_2 = 1$), then the first term disappears and below marginal cost pricing is the rule.

Finally, once again, both players divide the incremental gains from trade so that each receives its disagreement payoff plus a share of the gains, with proportion $\lambda_1$ accruing to $M_1$. Consequently, the optimal fee $F^*_1$ is given by:

$$F^*_1 = \left( w^*_1 - \frac{C_1}{q^*_1} \right) q^*_1 - \lambda_1 (\Pi^1 - \pi^R_{-1})$$

where $\pi^R_{-1} = (1 - \lambda_2) (R(0, \hat{q}_2) - C_2(0, \hat{q}_2))$ and where $\hat{q}_2$ is the maximizer of $R(0, q_2) - C_2(0, q_2)$.

5 Surplus analysis

5.1 Simultaneous bargaining

When bargainings occur simultaneously, we have shown that the equilibrium contracts imply below marginal cost pricing (hereafter BMCP) but that this does not mean that some manufacturers are driven out of the market. Because this practice is often considered as injury to competition, we analyze in this section whether below marginal cost pricing is welfare reducing compared to pricing at marginal cost (hereafter MCP). We define welfare as the non weighted sum of the surplus of the raw product producers ($PS$), of the industry channel ($IS$) (that is the manufacturers and the retailer) and of consumers ($CS$).

The equilibrium surplus of the raw product producers can be written as follows:

$$PS = P_x \left( \sum_i x_i \right) \sum_i x_i - \int_0^{\sum_i x_i} P_x(u)du$$

$$= \sum_i C_i(q) - \int_0^{\sum_i f_i^{-1}(q)} P_x(u)du.$$  

Denote $V(q) = \sum \int_0^{q_i} P_i(u, q_{-i})du$ the utility of a representative consumer buying quantities
$q_i$ of each commodity. Then, the equilibrium consumer surplus is:

$$CS = V(q) - \sum_i P_i(q)q_i.$$ 

Finally, the total equilibrium welfare reduces to:

$$W = V(q) - \int_0^{\sum f_i^{-1}(q_i)} P_x(u)du.$$ 

Intuitively, we conjecture that BMCP may often induce a rise in quantities sold at the equilibrium, and is thereby beneficial for consumers but also for the raw product producers. On the other hand, this increase in quantities may be detrimental for the industry surplus. Overall, the total effect is unclear. We thus specialize the model and we state the following proposition.

**Proposition 5** Assume that $n = 2$. Consider (symmetric) linear demand functions, $P_i(q_i, q_j) = \alpha - q_i - \nu q_j$ where $0 \leq \nu \leq 1$ as well as a linear supply function $P_x = \delta + \phi(x_i + x_j)$. In addition, consider a Leontief (constant return to scale) technology where $q_i = kx_i$. Then, below marginal cost pricing is always welfare improving compared to marginal cost pricing.

**Proof:** see Appendix B. ■

Intuitively, the pro-competitive effect of below marginal cost pricing overcomes the loss in industry surplus. In Table 1, we simulate the impact on welfare for given values of the demand and supply parameters ($\alpha = 1$, $\nu = 0.5$, $\delta = 1$, $\phi = 2$ and $k = 3$).

**TABLE 1:** Comparisons between below-cost pricing, marginal cost pricing and integrated vertical structure

<table>
<thead>
<tr>
<th></th>
<th>MCP</th>
<th>BMCP*</th>
<th>IVSP*</th>
</tr>
</thead>
<tbody>
<tr>
<td>$PS$</td>
<td>0.0147</td>
<td>+6.35%</td>
<td>-11.10%</td>
</tr>
<tr>
<td>$IS$</td>
<td>0.1139</td>
<td>-0.51%</td>
<td>+0.36%</td>
</tr>
<tr>
<td>$CS$</td>
<td>0.0330</td>
<td>+8.16%</td>
<td>-11.10%</td>
</tr>
<tr>
<td>$W$</td>
<td>0.1616</td>
<td>+1.5%</td>
<td>-3.02%</td>
</tr>
<tr>
<td>$(w_i - \frac{\partial C}{\partial q_i})/\frac{\partial C}{\partial q_i}$</td>
<td>0.00%*</td>
<td>-4.54%**</td>
<td>+8.51%**</td>
</tr>
<tr>
<td>Average cost</td>
<td>0.4141</td>
<td>+0.61%</td>
<td>-1.11%</td>
</tr>
<tr>
<td>$w_i$</td>
<td>0.4545</td>
<td>-3.74%</td>
<td>+6.86%</td>
</tr>
<tr>
<td>$P_i$</td>
<td>0.7273</td>
<td>-1.18%</td>
<td>+2.13%</td>
</tr>
</tbody>
</table>

*: These values are in percentage of MCP. **: These percentages indicate the value of ratios.
Below marginal cost pricing amounts to higher quantities sold on the final market. Final prices decrease by 1.18%. This benefits to consumers. On the other hand, these additional quantities induce a larger use of raw product that raises its price. Consequently, the surplus of raw product producers increases. However, the manufacturers and the retailer would jointly benefit from committing to marginal cost pricing. Indeed, strategic interactions at work leads each manufacturer to overproduce in order to reduce rival’s quantity, which in turn lowers the procurement cost. This strategic effect induces losses in industry surplus (IS).

Now, in the benchmark case of integrated vertical structure pricing (IVSP), Table 1 indicates that above marginal cost pricing occurs as it is clear from Proposition 2 and leads to improvement in industry surplus. Actually, quantities decreases as a consequence of high wholesale prices. This in turns reduces both producer and consumer surplus. Overall, welfare decreases because the gain in industry surplus does not compensate the loss for upstream producers and consumers.

It is also interesting to analyze the impact of commodity substitutability on our results. We present the case where the degree of differentiation between the two products is increased. The demand functions are now: \[ P_i(q_i, q_j) = 1 - 0.75q_i - 0.25q_j. \]

\[ \text{TABLE 2: Impact of commodity substitutability on welfare.} \]

<table>
<thead>
<tr>
<th></th>
<th>MCP</th>
<th>BMCP*</th>
<th>IVSP*</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS</td>
<td>0.0278</td>
<td>+5.80%</td>
<td>-14.8%</td>
</tr>
<tr>
<td>IS</td>
<td>0.1528</td>
<td>-0.65%</td>
<td>+0.65%</td>
</tr>
<tr>
<td>CS</td>
<td>0.0469</td>
<td>+5.76%</td>
<td>-14.9%</td>
</tr>
<tr>
<td>W</td>
<td>0.2274</td>
<td>+1.49%</td>
<td>-4.35%</td>
</tr>
<tr>
<td>((w_i - \frac{\partial w_i}{\partial q_i})/\frac{\partial w_i}{\partial q_i})</td>
<td>0.00%*</td>
<td>-3.92%**</td>
<td>+10.53%**</td>
</tr>
<tr>
<td>Average cost</td>
<td>0.4444</td>
<td>+0.72%</td>
<td>-1.69%</td>
</tr>
<tr>
<td>(w_i)</td>
<td>0.5</td>
<td>-2.86%</td>
<td>+7.7%</td>
</tr>
<tr>
<td>(P_i)</td>
<td>0.75</td>
<td>-0.95%</td>
<td>+2.56%</td>
</tr>
</tbody>
</table>

*: These values are in percentage of MCP. **: These percentages indicate the value of ratios.

A decrease in the substitutability of the product tends to increase welfare (40% in the

---

\(^3\) It is worth noting that a change only in \( \nu \) induces also a change in total demand and can yield to unwanted results, as emphasized by Irmen (1997). This is why we choose to decrease the coefficient of both \( q_i \) and \( q_j \) as indicated in the text. Actually, this is equivalent to divide by 2 the cross-price sensitivity (i.e. coefficient \( b \) in: \( q_i = a - dp_i + b(p_j - p_i) \)). For more on this, see Irmen (1997).
considered example). However, the gain in welfare due to BMCP is slightly reduced when products are less substitute. Intuitively, when products are more differentiated, the impact of externalities on the wholesale pricing rule is reduced ceteris paribus (see equation (5)). The pro-competitive effect of below marginal cost pricing is thus attenuated.

5.2 Comparison between sequential and simultaneous bargaining

In this section, we perform simulations regarding the sequential bargaining game using the same set of assumptions and parameters as in Proposition 5 and Table 1. We first consider a symmetric situation where both manufacturers have the same bargaining power ($\lambda_1 = \lambda_2 = \lambda$).

Figure 1 depicts the wholesale prices both in the simultaneous and the sequential bargaining game and the marginal costs for the sequential timing. For the sequential case, as shown in proposition 4, when $\lambda$ increases, the negative “rent shifting” effect identified by Marx and Shaffer (1999) is more important and tends to decrease the wholesale price for the first manufacturer. Also, the incentives to price above marginal cost (“internalization effect”) are reduced. Overall, the wholesale price for the first manufacturer to negotiate decreases in his bargaining power and is always lower than the marginal cost.

These effects do not exist for $w_2$ pricing which is always below marginal cost. However, the level of the bargaining power has an indirect effect on $w_2$ which increases with $\lambda$. It is worth noting that for low values of bargaining power, $w_1$ is higher than $w_2$, because the internalization effect overcomes the rent shifting effect. On the contrary, for higher values of bargaining power, the rent shifting effect becomes predominant and consequently incentives for BMCP are higher for $w_1$ than for $w_2$.

In the simultaneous bargaining game, wholesale prices do not depend on the bargaining power. As can be seen from Figure 1, the main difference between sequential and simultaneous bargaining is on the path behavior of the wholesale price $w_1$ for the first manufacturer to negotiate.
Figure 1: Wholesale prices in the simultaneous and in the sequential bargaining games.
Figure 2: Transfers from the manufacturers to the retailer in the simultaneous and the sequential bargaining games.

When manufacturers have low bargaining power, the fee paid to the retailer is positive. However, this fee decreases with their bargaining power and for a given bargaining power ($\lambda = 0.18$ in figure 2), the retailer pays them a fee. Moreover, the fee compensates for the decrease in wholesale price of the first manufacturer. The fees corresponding to the sequential bargaining game decrease more sharply than in the simultaneous case.

Figure 3 depicts the manufacturers and retailer’s profits as well as input provider, industry and consumer surpluses and total welfare, as a function of $\lambda$, in the sequential game. When the bargaining power of manufacturers increases, we confirm that their profits increase but the retailer’s surplus is reduced. When they have no bargaining power, all the rent is captured by the retailer. However, when manufacturers have all the bargaining power, the retailer profit is still positive even if it is very small because he still has a monopoly power at the
retailing level and can choose not to sell either product. Overall, the total industry surplus decreases because the decrease in the retailer surplus overcomes the increase in manufacturers surpluses. It thus appears that a stronger retailer bargaining position corresponds to a higher size of the pie to be shared in the industry. Intuitively, this reflects a better coordination of pricing decisions in the industry. On the contrary, consumers and upstream producers benefit from large bargaining power. On one hand, the decrease in wholesale price $w_1$ is larger than the increase in $w_2$ and consequently the total input used in the channel increases with $\lambda$, which tends to raise input price. On the other hand, consumers benefit from a lower final price for $q_1$ which overcomes the slight increase in the final price for $q_2$. It is worth noting that surprisingly the surplus of manufacturer $M_2$ is equal or higher than the surplus of $M_1$. Here, being the second to negotiate is preferred by both manufacturers. This feature of the equilibrium also holds when no cost externalities occur ($\phi = 0$, i.e. the Marx and Shaffer's case). To conclude, the increased competition effect which occurs when manufacturers have increasing bargaining power entails an increase in total welfare.

Figure 4 allows to compare the surplus of manufacturers and retailers both in the simultaneous and the sequential bargaining game. For $\lambda \leq 0.221$, the retailer would prefer a sequential bargaining to a simultaneous bargaining as he can better make use of his bargaining position to extract rents from the manufacturers. On the contrary, manufacturers would prefer the simultaneous bargaining game. For these values of $\lambda$, it may seem reasonable to assume that the retailer is able to impose the timing of the game given his strong bargaining position, so that a sequential bargaining occurs. For $\lambda > 0.221$, we obtain a different situation where the retailer would prefer the simultaneous bargaining game. There exists values of $\lambda$ for which both the retailer and the manufacturers agree on the timing. In particular, for $\lambda \in [0.221, 0.225]$, they all agree on a simultaneous bargaining game. Then, when $\lambda > 0.225$, manufacturer $M_2$ prefers sequential bargaining (and this is so for manufacturer $M_1$ from values of $\lambda$ greater than 0.229) . We can then infer that for large value of $\lambda$ ($\lambda > 0.229$), if manufacturers can impose the timing, they will implement a sequential bargaining game that
Figure 3: Profits and surplus in the sequential bargaining game
would lead to larger rent extraction from the retailer.

Finally, consider the following unbalanced case, where one manufacturer, say $M_1$, possesses all the bargaining power and the other one ($M_2$) does not have any bargaining power. Simulations show that a retailer that can impose the timing of the game would prefer to negotiate first with $M_1$. However, negotiating first with $M_2$ improves the surplus of the consumers and the upstream sector as well as the total welfare: Negotiating first with $M_2$ implies that $M_2$ sells at a lower wholesale price than in the converse situation. Indeed, when negotiating $w_2$, it appears that the internalization effect disappears while the rent shifting effect is at its maximum, because $M_1$ has all the bargaining power. Using symmetry, this indicates that there is more competition in the industry when $M_2$ negotiates first than in the

Figure 4: Comparamion between sequential and simultaneous bargaining
converse situation. Of course, both manufacturers have to be compensated by the retailer for these low wholesale prices, through a positive transfer from the retailer.

6 Conclusion

The goal of this paper has been to analyze vertical contracts between manufacturers and retailers in a channel including the upstream input market. Using a Nash bargaining framework, we have studied the contract negotiations between manufacturers and the common retailer, both in a simultaneous and sequential game. The oligopsonistic behavior of manufacturers on the upstream market provides a new explanation for predatory accommodation. With two-parts tariff, we have shown that joint profit of the industry is not maximised at simultaneous bilateral bargaining equilibria and that below marginal cost pricing in the intermediate goods market arises, when final products are substitutes, and may be welfare improving. When negotiations occurs sequentially, we have shown, in the two-manufacturers case, that the first manufacturer which enters into negotiations and the retailer may jointly prefer above marginal cost pricing or not, depending on the distribution of bargaining power in the channel. However, the second manufacturer equilibrium wholesale price is set below marginal cost.

In both sequential and simultaneous bargaining, it is important to extend these results by considering more general form of contract (non linear pricing with discount, market share contracts). Finally, in a companion paper (Bontems and Bouamra-Mechemache, 2003), we perform comparative statics related to shocks on raw product supply and final demand. We show how these shocks affect pricing, prices transmission along the channel, surplus sharing in the channel and welfare.
References


Appendix

A Below average cost pricing

Recalling that \( C_i = [P_x (\sum_i f_i^{-1}(q_i))] f_i^{-1}(q_i) \) with \( q_i = f_i(x_i) \) and assuming symmetry, we have:

\[
\frac{\partial C_i}{\partial q_i} = \frac{\partial C_i}{\partial q_j} + \frac{P_x}{f_i'(x_i)}.
\]

Thus, we can write, using (5):

\[
w_i - \frac{C_i}{q_i} = \frac{\partial C_i}{\partial q_i} + \sum_{j \neq i} \gamma_{ji} \frac{\partial C_i}{\partial q_j} - \frac{C_i}{q_i}
= \left(1 + \sum_{j \neq i} \gamma_{ji}\right) \frac{\partial C_i}{\partial q_i} - \sum_{j \neq i} \left[\gamma_{ji} \frac{P_x}{f_i'(x_i)} - \frac{C_i}{f_i(x_i)}\right]
= \left(1 + \sum_{j \neq i} \gamma_{ji}\right) \frac{\partial C_i}{\partial q_i} - \left(1 + \frac{f_i(x_i)}{x_i f_i'(x_i)} \sum_{j \neq i} \gamma_{ji}\right) \frac{C_i}{q_i}
\]

Because \( f_i \) is concave, we have \( \frac{f_i(x_i)}{x_i f_i'(x_i)} \sum_{j \neq i} \gamma_{ji} > 1 \) and consequently with \( \gamma_{ji} < 0 \): 

\[
1 + \sum_{j \neq i} \gamma_{ji} > 1 + \frac{f_i(x_i)}{x_i f_i'(x_i)} \sum_{j \neq i} \gamma_{ji}.
\]

Thus, as marginal cost is always greater than average cost, we obtain:

\[
w_i - \frac{C_i}{q_i} < (>)0 \iff 1 + \sum_{j \neq i} \gamma_{ji} < (>)0,
\]

and the conclusion follows.

B BMCP is welfare improving

Using the specification in the text, we obtain at the optimum, after straightforward but cumbersome computations, the following expressions:

\[
PS = \frac{2\phi(\delta - k\alpha)^2}{[\phi(\nu - 3) - 2k^2(1 + \nu)]^2}
\]
\[ IS = \frac{2(\delta - k\alpha)^2 (k^2 (1 + \nu) - \phi - \nu\phi)}{[\phi(\nu - 3) - 2k^2 (1 + \nu)]^2} \]

\[ CS = \frac{k^2 (\delta - k\alpha)^2}{[\phi(\nu - 3) - 2k^2 (1 + \nu)]^2} \]

and consequently,

\[ W^{BMCP} = \frac{(\delta - k\alpha)^2 \left[ k^2 (3 + 2\nu) + 2\phi (2 - \nu) \right]}{[\phi(3 - \nu) + 2k^2 (1 + \nu)]^2} > 0 \]

When marginal cost pricing is imposed, we obtain the following expression for welfare:

\[ W^{MCP} = \frac{(\delta - k\alpha)^2 \left[ k^2 (3 + 2\nu) + 4\phi \right]}{[3\phi + 2k^2 (1 + \nu)]^2} > 0 \]

Note that when \( \phi = 0 \), then \( W^{BMCP} = W^{MCP} > 0 \). Denote \( \Gamma = k^2 (3 + 2\nu) + 2\phi (2 - \nu) \) and \( \Delta = \phi(3 - \nu) + 2k^2 (1 + \nu) \). Thus, \( W^{BMCP} = (\delta - k\alpha)^2 \frac{\Gamma}{\Delta^2} \). Similarly, denote \( \Psi = k^2 (3 + 2\nu) + 4\phi \) and \( \Omega = 3\phi + 2k^2 (1 + \nu) \) so that \( W^{MCP} = (\delta - k\alpha)^2 \frac{\Psi}{\Omega^2} \). We have \( \Omega = \Delta + \nu\phi \) and \( \Gamma = \Psi - 2\nu\phi \). Then, we obtain:

\[ W^{BMCP} - W^{MCP} = \frac{(\delta - k\alpha)^2 \left[ \Gamma \frac{\Delta^2}{\Omega^2} - \Psi \right]}{\Delta^2\Omega^2} \]

\[ = \frac{2(\delta - k\alpha)^2}{\Delta^2\Omega^2} \left[ \Gamma (\Delta + \nu\phi)^2 - (\Gamma + 2\nu\phi) \Delta^2 \right] \]

\[ = \frac{2(\delta - k\alpha)^2}{\Delta^2\Omega^2} \left[ \Gamma\nu^2\phi^2 + 2\nu\phi (\Gamma - \Delta) \right] \]

\[ = \frac{2(\delta - k\alpha)^2}{\Delta^2\Omega^2} \left[ \Gamma\nu^2\phi^2 + 2\nu\phi \Delta (k^2 + (1 - \nu)\phi) \right] \geq 0 \]

with equality for \( \phi = 0 \), which states the conclusion.
Advertising in Differentiated Markets

By

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Abstract: This paper considers the role of promotional expenditures by firms in a differentiated product oligopoly model. Advertising is informative and has two types of effects on demand, accommodating effects, which increase total demand in the product class, and predatory effects, which serve only to redistribute consumers among brands in the product class. Depending on the relative importance of each type of effect, advertising can make the demand facing individual brands more elastic or less elastic. This has important implications for whether or not the market-determined levels of advertising are excessive from the welfare perspective. We compare oligopoly outcomes under multi-brand promotion by a monopolist, as well as under both quantity-setting and price-setting forms of oligopoly to the social optimum and identify the linkage between the nature of oligopoly interaction and the predominance of certain forms of advertising effects.

Key words: Oligopoly; product differentiation; informative advertising

*I am happy to acknowledge financial support from the Food System Research Group at the University of Wisconsin, and from the US Department of Agriculture. Correspondence to: S. Hamilton, Department of Economics, P.O. Box 161400, University of Central Florida, Orlando, FL 32816-1400. Voice: (407) 823-4728. FAX: (407) 823-3269. Email: shamilton@bus.ucf.edu
1. Introduction

Promotional competition is important in differentiated product markets. In 2001, total per capita advertising in measured media was $388 in the United States and per capita advertising in measured and unmeasured media (including direct mail and local spot radio and cable) was estimated to be $820 in the U.S. (Advertising Age). Advertising is an important industry in the U.S., in and of itself, and represented a 2.3 percent share of GNP in 2001. Major advertisers include Proctor & Gamble, General Motors, and Unilever, who spent more than $3 billion each on advertising in 2001. In the product categories of restaurants, pharmaceuticals, and soft drinks, moreover, advertising as a percent of sales is traditionally very high. In 2001, the four leading national advertisers in the restaurant category (McDonalds, Wendy’s International, Yum Brands, and Diageo) maintained advertising budgets between 12.8 percent and 22.1 percent of U.S. sales, and, in the soft drink industry, Coca Cola and Pepsi Co. spent 11.9 and 12.1 percent of U.S. sales revenue on advertising. Advertising expenses are large and increasing as a percent of sales in consumer goods industries, such as detergents, cigarettes, and beer, where products are highly substitutable and competition among brands is intense.

The role of advertising in differentiated markets is not well understood. While it has long been recognized that advertising can have two types of effects on demand, either increasing general demand for the product or altering the distribution of consumers between brands within the product category, the relative importance of these two effects remains a subject of considerable debate. In the empirical literature, the relative importance of these two types of effects seems to depend on the particular industries studied. Kelton and Kelton (1982) find that advertising in the brewing industry primarily alters market share between brands and Sass and Saurman (1995) show that advertising bans in the malt beverage industry significantly impact concentration, whereas Roberts and Samuelson (1988) find that cigarette advertising increases
the level of total market demand, but does not influence the distribution of market shares.¹ In the theoretical literature, these forms of advertising effects have been largely handled separately. In the informative advertising literature following Butters (1977) and Grossman and Shapiro (1984), the central role of advertising is to inform consumers of the existence of products. Informative advertising improves the matching between consumers and brands, which makes advertising a predatory activity from the standpoint of firms, as facilitating better matches between existing consumers and existing brands serves only to redistribute market share. In models of persuasive advertising following Stigler and Becker (1977) and Dixit and Norman (1978), the role of advertising is to improve consumer’s perceptions of the attributes in traded commodities, which makes brands within a product category appear more differentiated to consumers, increasing total demand.

This paper develops a model of informative advertising that encompasses both types of effects. The basic insight of the paper is that informative advertising has the potential to have effects both on individual market shares among brands and on total market demand for the product category that comprises the brands. Advertising that informs consumers of the existence of a brand clearly stimulate new consumption in a product category that otherwise would not take place. However, the focus to date in models of informative advertising has been on models that fix total demand for the product category to examine market equilibrium in models based on Chamberlin (1933) that employ the “large-group” assumption of Dixit and Stiglitz (1977).² This eliminates entirely the effect of advertising on expanding total demand in the product category.

By combining both effects of advertising in the model, the model sheds some light on the relationship between advertising and demand elasticities. A higher level of informative advertising tends to make demand more elastic (see, e.g., Grossman and Shapiro (1984)), whereas a higher level of persuasive advertising may increase perceived product differentiation.

¹ For a survey of the empirical literature, see Scherer and Ross (1990).
² Exceptions include Shapiro (1980), who considers a monopoly model, and Grossman and Shapiro (1984), who simulate the effects of advertising in an oligopoly equilibrium with small numbers of firms. Nonetheless, all analytical results in the latter paper are derived under the large group assumption.
and make demand less elastic. Here, purely informative advertising is capable of producing either outcome, and the type of outcome that emerges in equilibrium depends fundamentally on the relative strength of these two influences.

The relative magnitude of each type of effect also has important welfare implications. When advertising results in a shift in product demand, the familiar welfare result is that advertising is excessive (see, e.g., Dixit and Norman (1978)). In informative advertising models, where advertising has purely distributive effects, informative advertising levels tend to be too low under monopoly (Shapiro (1980)), but excessive under monopolistic competition and large numbers oligopoly models (Grossman and Shapiro (1984)). Firms advertise too little under monopoly, because a monopolist considers only the implication of advertising for profits, and not the benefits consumers receive from improved information. Firms advertise too much under large numbers oligopoly, because the positive effect of informative advertising on consumers is swamped by the negative effect on rival brands when only market share is at stake. The aim of this paper is to examine the connections between informative advertising and welfare in a duopoly model that permits a role for advertising both in increasing total product demand and in redistributing market share.

The paper considers advertising in differentiated product markets. To date, very little research has considered advertising in differentiated product markets, and has focused instead on homogeneous products, both in models of informative advertising (Butters (1977), Stegman (1991), Gary-Bobo and Michel (1991), and Stahl (1994)) and in models of persuasive advertising (Stigler and Becker (1977), Nichols (1985)). This is surprising given that a tremendous volume of advertising occurs in differentiated markets.

The paper also compares the outcome of informative advertising under both price-setting and quantity-setting forms of oligopoly. Familiar differences exist between price- and quantity-setting models in other contexts (e.g., levels of capital investment); however, the implications for advertising remain largely unexplored. Gary-Bobo and Michel (1991) consider informative advertising under quantity competition, but their model is quite unlike ours in the sense that they
consider neither heterogeneous product markets nor compare outcomes under price and quantity forms of competition. This seems to be an important link. It is a stylized fact that advertising-intensity is positively-related to industry-average profitability (Schmalensee (1986)), and this result has generally been corroborated in the theoretical literature (see, e.g., Dixit and Norman (1978), Grossman and Shapiro (1984), Gary-Bobo and Michel (1991)), but the linkages to market structure and product differentiation remain somewhat less clear. For a given set of market conditions, it is well known that equilibrium prices and profits are always higher under quantity competition than under price competition, yet it is not at all understood whether this implies systematic differences in advertising levels.

The model considers promotional activities in differentiated product markets where oligopoly firms face competition from competing brands within a product category. Consumers have stable preferences both for consumption within the product category and for the individual characteristics that define the particular brands, but are uncertain about the characteristics contained in individual brands (and about whether brands even exist at all that offer a desired mix of characteristics), unless they receive advertising messages to inform them. Advertising thus affects demand by providing information about the location of the advertising brand in product space. The technology that links advertising to consumer demand is the “shotgun”-type process first considered by Butters (1977) and elaborated by Grossman and Shapiro (1984). Consumers have heterogeneous tastes. Each consumer has tastes for the characteristics that define the product category, but is unaware of the characteristics offered by individual brands unless she is “hit” by an advertising message. Advertising messages, should firms choose to send them, randomly strike customers, and the ads inform consumers by providing what amounts to a brand “address” in characteristic space. The technology for dispersing ads does so only randomly (hence the term “shotgun”), as advertisers are assumed to be unable to target messages towards only those consumers who find the brand most attractive.

We consider the case of two, differentiated brands that are sold in a common marketplace. Prices are posted in the marketplace, so that consumers have full information on
the relative prices of goods. However, without receiving an advertising message about each particular brand, consumers are aware of neither its characteristics nor its “address” within the central market. This stylized representation of the central market can be understood as follows. Imagine standing in a supermarket in which products randomly disappear off the shelves and the only goods that remain through this process are the particular brands an individual consumer has seen advertised. The product space of the supermarket for an individual consumer ultimately depends on the particular set of ads to which she has been exposed, and, to the extent that consumers differ in their tendency to view ads, each consumer therefore perceives the product space in the market differently according to her particular set of advertising messages.

In the next section we derive demand curves for duopoly firms and describe the effects of informative advertising on demand. In Section 3 we compute the monopoly and oligopoly equilibria under conditions of both price and quantity competition. We then turn to the welfare analysis in Section 4.

2. Informative Advertising and Consumer Demand

In this section, we detail the effect of advertising on consumer demand for heterogeneous products. Advertising is the only source of information in the model and consumers rely on information received from ads to locate specific brands in the product space. Each consumer is passive in the sense that she does not search for a brand that best suits her taste, nor does she engage in any activities designed to acquire information, other than viewing ads. Thus, we implicitly assume that the cost of search is high relative to the surplus offered by brands in the product category.

The model contains two substitute brands, each of which is promoted by a firm who exerts advertising effort. We choose a familiar type of product differentiation, based on the characteristics approach associated with Lancaster (1975), and focus on the role of advertising in matching heterogeneous consumers to the products that suit their tastes. The basic demand structure is represented by a Hotelling (1927) “linear city”, in which each brand is located at the
endpoint of a unit segment that connects the characteristic space, and each consumer is identified by a point on the line segment between them that corresponds to her most preferred brand.

Suppose each consumer consumes at most one unit in the product category and receives a value of $v$ from consuming a unit of her most preferred brand. Consumers must bear transportation costs of $t$ per unit of distance to travel to either brand. Given a price for each firm, $p_i, i = 0,1$, a consumer located at a distance of $x \in [0,1]$ enjoys surplus of:

$$U = \begin{cases} 
  v - p_0 - tx & \text{if purchase made at firm 0} \\
  v - p_1 - t(1-x) & \text{if purchase made at firm 1} \\
  0 & \text{otherwise}
\end{cases}$$

Consumers are distributed uniformly on the unit interval and have a common (gross) valuation of the product, $v$, although the net valuation of a particular brand to consumers depends on their location in characteristic space.

The role of advertising in the model is to convey information about a firm’s product to consumers. Consumers purchase a unit in the product class only if they are aware of the existence of a brand that offers positive surplus. If the consumer is aware of both brands, then she selects the brand that offers the greatest surplus; if a consumer is aware of only one brand, then she either chooses to consume the brand or to consume nothing at all in the product category. From the perspective of each firm, there are thus three types of consumers: (i) those who are unaware of any brand in the category (i.e., consumers who do not receive the advertising message of any firms); (ii) those who are aware of the brand but are unaware of the rival brand; and (iii) those who are aware of both brands.

In full information duopoly models, it is typically assumed that the market is fully covered between the two firms in the sense all consumers on the line segment make a purchase at the equilibrium prices. Indeed, full coverage of the market is a necessary condition for oligopoly equilibrium, as strategic interaction cannot otherwise take place between firms. This assumption of full coverage has been retained in the literature on informative advertising.
Our departure point from existing models of informative advertising begins by describing several ways in which a differentiated market can be fully covered. The central idea is that the market can be covered for some consumer types, yet left uncovered for others, while preserving standard notions of oligopoly equilibria. For consumers who receive no advertising messages, the market is clearly uncovered: These consumers fail to purchase regardless of location and price. For the remaining consumers who receive at least one advertising message, we define the market to be completely covered, incompletely covered, or not covered at all as follows.

**Definition 1. Complete coverage.** The market is completely covered if all consumers who receive at least one advertising message purchase a brand at prevailing prices: \( t \leq (v - p_i) \), for \( i = 0, 1 \).

**Definition 2. Incomplete coverage.** The market is incompletely covered if some consumers who receive only one advertising message do not purchase the brand at the prevailing prices, but all consumers who receive both advertising messages do purchase: \( t/2 \leq (v - p_i) < t \), for \( i = 0, 1 \).

In the case of complete coverage, the equilibrium prices are such that a consumer located at the far endpoint of the line segment finds it worthwhile to travel the entire unit distance to consume the more distant brand. In the case of incomplete coverage, a consumer located at the far endpoint of the line segment finds it prohibitively costly to travel the entire unit distance to consume the more distant brand. Nonetheless, consumers in both cases find it worthwhile to travel half the unit distance to consume their favored brand. Under either definition, the market is fully covered among consumers who receive both advertising messages, but only in the case of complete coverage is the market also fully covered among those receiving only one.

Figure 1 depicts the case of incomplete coverage. Let \( x_i \) denote the location of the consumer who is indifferent between the two brands given that she is fully informed of both brands. \( x_i \) is depicted in Figure 1, and is given by
\[ x_i = \frac{t + p_i - p_0}{2t}. \]  

(1)

All fully informed consumers with a location \( x \leq x_i \) find brand 0 to be their first choice at the posted prices. If the density of consumers is given by \( n \), then the total number of fully informed consumers served by brand 0 is \( X_i^0 = nx_i \).

Under incomplete coverage, some consumers who receive only one advertising message do not buy the advertised brand. For a consumer who is informed only about brand 0, let \( x_U \) denote the location of the consumer who is indifferent between purchasing brand 0 or purchasing nothing at all within the product category. By the definition of incomplete coverage, this consumer resides on the unit interval at all permissible prices. The indifferent consumer who receives only a brand 0 message is labeled \( x_U \) in Figure 1, and satisfies

\[ x_U = \frac{v - p_0}{t}. \]  

(2)

Those consumers located between \( x_I \) and \( x_U \) would prefer brand 1 to brand 0 with complete information. The total number of partially informed consumers served by brand 0 is \( X_U^0 = nx_U \).

In the case of complete coverage, the location of the fully informed consumer who is indifferent between the two brands is again given by (1). As in the case of incomplete coverage, all fully informed consumers make a purchase and select between the two brands according to their tastes. By the definition of complete coverage, all consumers who receive only one advertising message also purchase the good. Thus, the total number of fully informed consumers served by brand 0 is \( \tilde{X}_I^0 = X_I^0 = nx_I \) and the total number of partially informed consumers served by brand 0 is \( \tilde{X}_U^0 = n \), the entire consumer population receiving only the advert of brand 0.

The remaining case to consider is that of no coverage at all, \((v - p_i) < t/2\), for \( i = 0,1 \). This is the case of local monopoly power. Among fully informed consumers, a consumer arbitrarily close to the midpoint of the segment prefers to buy nothing at all at prevailing prices than to buy her favored brand. Under local monopoly, it makes no difference to either firm if a consumer if fully informed or only partially informed, as consumers do not switch between
brands based on relative prices. The reaction functions fail to intersect. The total number of consumers served by brand 0 under local monopoly is given by $\hat{X}_i^0 = X_U^0 = nx_U$ in (1) and (2).

Firms use advertising as a vehicle to inform consumers. Following Butters (1977), we assume that firms have no ability to target advertising towards consumers located at a particular point on the line segment. Advertising is of the “shotgun-type” and is non-discriminatory in the sense that a consumer at a given location in characteristic space has an identical likelihood of being hit by an ad as a consumer at some other location in characteristic space.

Let $\phi_i, i = 0,1$, denote the advertising intensity of firm $i$. Advertising intensity is measured in terms of the reach of the ad campaign, so that $\phi_i$ is interpreted as the fraction of the consumer population that is exposed, at least once, to the advertising message of firm $i$. This divides consumers at each location in the product space into four types: With probability $\phi_0\phi_1$ a consumer simultaneously receives advertising messages for each brand, with probability $\phi_0(1-\phi_1)$ a consumer receives the brand 0 message but not that for brand 1, with probability $(1-\phi_0)\phi_1$ a consumer does not receive the brand 0 message but does for brand 1, and with probability $(1-\phi_0)(1-\phi_1)$ a consumer receives advertising messages from neither brand.

The demand facing the oligopolists depends on the equilibrium outcomes for advertising and for the market prices. For the remainder of this section, we describe demand facing a representative firm under three possible scenarios for the endogenous market prices: (i) local monopoly power $(v - p < t/2)$; (ii) incomplete coverage $(t/2 \leq v - p < t)$; and (iii) complete coverage $(t \leq v - p)$. In subsequent sections, we identify the range of parameter values consistent with oligopoly equilibrium in each case and compare the private and social outcomes.

2A. Local Monopoly Power

Consider the case in which firms with local monopoly power engage in advertising. Under local monopoly, the gross value of the product relates to the equilibrium price as $v - p < t/2$, so that a consumer located at the midpoint of the line segment does not purchase the brand, even when fully informed. Local monopolists strategically interact neither in prices, nor in advertising
levels. Thus, demand facing the representative firm depends only on the number of consumers in the monopoly region that receive his advertising message. Although an advertising message is just as likely to be received by a consumer located at some other point in the characteristic space, the message has no impact on behavior outside the monopoly region of the firm.

Demand for the representative firm under local monopoly is

\[ \hat{X}_i^0 = nx_v = \left( n\hat{\phi} / t \right)(v - \hat{p}) , \]  

where \( \hat{\phi} \) is the probability that a consumer, residing somewhere on the line segment, receives the advertising message, and \((v - \hat{p})/t\) is the conditional probability that, given the message is received, the consumer then buys the product. That is, consumers who receive an advertising message only from brand 0 and subsequently choose to buy brand 0 are located uniformly on the interval \([0, (v - \hat{p})/t]\) and those who choose not to buy brand 0 are located on the interval \(((v - \hat{p})/t, 1] \).

Notice that the demand function (3) is linear in the monopoly advertising level. The marginal product of advertising therefore equals its average product: Letting 

\[ \hat{\epsilon}_\phi = \left( \frac{\partial X(.)}{\partial \phi} \right)(\hat{\phi}/X(.)) \]

denote the elasticity of demand with respect to advertising, \( \hat{\epsilon}_\phi = 1 \) for the local monopolist. Notice also that the price elasticity of demand, \( \hat{\epsilon}_p = \hat{p} / (v - \hat{p}) \), is not a function of the advertising level under local monopoly.

The essential feature of this model is that it relies solely on a form of advertising that shifts total demand in the product category. The behavior of the local monopolist is not conditioned by the goal of acquiring market share of existing product customers through inter-brand rivalry. Both prices and advertising serve to attract new customers to the product category that otherwise would not consume either brand at all.

2B. Complete Coverage

The next case to consider is that of complete coverage \((t \leq v - p)\). Since the seminal work of Butters (1977) and Grossman and Shapiro (1984), this is the case considered by virtually all studies of informative advertising. Here, firms strategically interact at every location on the line.
segment. Indeed, a firm can sell to a consumer with preferences aligned perfectly with the characteristics of the rival brand under complete coverage if his advertising message is the only one received by the consumer.

The demand for brand 0 is given by
\[ X^0(\tilde{\phi},\tilde{\phi}) = \tilde{\phi}_0 \tilde{\phi}_1 X^0_U + \tilde{\phi}_0 (1 - \tilde{\phi}_1) X^0_X, \]
and similarly for brand 1, where \( \tilde{\phi} = (\tilde{\phi}_0, \tilde{\phi}_1) \) is the vector of advertising intensities. Among those consumers who receive an advertising message for brand 0, the total demand for brand 0 sums the demand of fully informed and partially informed consumers. All consumers who do not receive an advertising message for brand 0 do not buy brand 0, and those consumers who do receive the brand 0 message are divided between those who also receive the advertising message for brand 1, and who are therefore sensitive to the relative prices of brands in (1), and those who do not receive the brand 1 message, and who are accordingly not price sensitive.

Substituting the number of consumers of each type served by brand 0 into this expression, the demand for brand 0 under complete coverage is
\[ \tilde{X}^0(\tilde{p},\tilde{\phi}) = n \tilde{\phi}_0 \left( \frac{t + \tilde{p}_1 - \tilde{p}_0}{2t} \right) + (1 - \tilde{\phi}_1) \]
and similarly for brand 1. Notice that the brands in demand expression (4) are gross substitutes, \( \partial \tilde{X}^i / \partial \tilde{p}_j = n \tilde{\phi}_0 \tilde{\phi}_1 / 2t \) for all \( i \neq j, i = 0,1. \)

The demand function (4) satisfies the standard and intuitive property that improved consumer information (through large advertising levels in \( \tilde{\phi} \)) increases demand elasticities under oligopoly. In the symmetric case, the price elasticity of demand facing the representative firm, \( \tilde{\varepsilon}_i = \left( \partial \tilde{X}^i / \partial \tilde{p}_i \right) \tilde{p}_i / \tilde{x}_i, \) evaluated at \( \tilde{p}_i = \tilde{p}, \, \tilde{X}^i = \tilde{X}, \) and \( \tilde{\phi}_i = \tilde{\phi} \) for \( i = 0,1, \) is given by
\[ \tilde{\varepsilon} = \frac{\tilde{p} \tilde{\phi}}{t(2 - \tilde{\phi})} \]

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3 Throughout the paper, we denote variables with subscripts and functions with superscripts.
which is an increasing function of $\hat{\phi}$. Improved information increases the demand elasticities (and thus reduces prices). The intuition for this is straightforward. The elasticity of demand in (5) can be decomposed into a weighted share of the demand elasticities of fully informed and partially informed subgroups of consumers. For the subgroup of fully informed consumers, the elasticity of demand is given by (1) as $\varepsilon_i = p/t$, whereas, for the subgroup of partially informed consumers, demand is infinitely inelastic (up to the reservation level). Because the share of fully informed consumers in the demand function (4) increases as the equilibrium advertising levels increase, informative advertising always makes demand more elastic.

The essential feature of the complete coverage outcome is that pricing behavior is influenced solely by competition to acquire market share. All consumers who receive at least one advertising message purchase a brand within the product class, so that price competition between firms is a zero sum game for market share. This is precisely the opposite motivation as arises under local monopoly, where both increases in advertising and decreases in price always increase total product demand.

2C. Incomplete Coverage

Under incomplete coverage ($t/2 \leq v - p < t$), at least one consumer is unwilling to travel the entire length of the line segment to consume the more distant brand. The distinguishing feature between this case and the case of complete coverage is that the number of partially informed consumers who purchase the brand is now endogenous. Among fully informed consumers, a price reduction by one brand predates consumers of the rival brand, as in the case of complete coverage. This coincides with the standard oligopoly outcome in a variety of contexts under full information and price setting behavior. However, a price reduction among partially informed consumers now has a total demand shifting effect. A reduced price now increases total demand in the product category by inducing more distant consumers to purchase a product they otherwise would not buy at higher prices.
The case of incomplete coverage is conceptually important for two reasons. First, it extends the literature on informative advertising in differentiated oligopoly markets to consider environments where price reductions enhance total demand for the product class. This bridges existing models of advertising by encompassing the wide range of cases in which pricing behavior (for a given level of advertising) is neither fully predatory, nor fully accommodating from the perspective of the rival firm. Second, as we demonstrate below, when the level of sales to partially informed consumers is endogenously determined, the demand functions have well defined inverse functions. This allows advertising behavior to be examined under both price and quantity competition in differentiated oligopoly markets.

The demand for brand 0 is given by

\[ X^0(p, \phi) = \phi_0 \phi_0 X^0_i + \phi_i (1 - \phi_i) X^0_u \]

and similarly for brand 1, where \( p = (p_0, p_1) \) is the vector of brand prices and \( \phi = (\phi_0, \phi_1) \) is the vector of advertising intensities. Using the definitions in (1) and (2), the demands are

\[ X^0(p, \phi) = \frac{n \phi_0}{2t} (\phi t + 2(1 - \phi_i) \nu - (2 - \phi_i) p_0 + \phi_i p_1), \quad (6a) \]

and

\[ X^1(p, \phi) = \frac{n \phi_1}{2t} (\phi_0 t + 2(1 - \phi_i) \nu + \phi_o p_0 - (2 - \phi_o) p_1), \quad (6b) \]

As in the case of complete coverage, the brands are gross substitutes, \( \partial X^i(.) / \partial p_j = n \phi_i \phi_j / 2t \) for all \( i \neq j, i = 0,1 \). Each demand function (6a) and (6b) is weighted average of consumers who receive one ad and those who receive two.

In the literature on informative advertising, a standard result is that improved information increases the demand elasticities. Indeed, we found this to be the case above under the assumption of complete coverage. Because the act of providing information, itself, benefits consumers and enhances market efficiency through improved matching between consumers and brands, informative advertising has been viewed as fundamental to this result. Not so. In the symmetric case, the price elasticity of demand facing firm \( i \), \( \varepsilon_i = (\partial X^i / \partial p_i) p_i / x_i \), evaluated at \( p_i = p \), \( X^i = X \), and \( \phi_i = \phi \) for \( i = 0,1 \), is given by
\[ e_b = \frac{(2 - \phi)p}{2(v - p)(1 - \phi) + \phi t} \]

where the subscript refers to the demand elasticity in the incomplete coverage oligopoly equilibrium characterized by Bertrand (price) competition. This satisfies

\[ \frac{\partial e_b}{\partial \phi} = \frac{2p(v - p - t)}{[2(v - p)(1 - \phi) + \phi t]^2}, \]

which is negative by the definition of incomplete coverage.

Improved information in the incomplete coverage equilibrium reduces the demand elasticities (and thus increases prices). The intuition for this is as follows. Decomposing the elasticity of demand (7) into a weighted share of the demand elasticities of the informed and partially informed subgroups of consumers, the elasticity of demand for the subgroup of fully informed consumers is given, as before, by \( e_I = p/t \), but the elasticity of demand for the subgroup of partially informed consumers is now given by \( e_U = p/(v - p) \) in (3). By the definition of incomplete coverage, it follows that \( e_I < e_U \). As the equilibrium advertising levels increase, therefore, the demand facing each firm is comprised of a greater share of fully informed consumers, and hence becomes more inelastic.

An important property of the demands (6a) and (6b) is that the quantity demanded is influenced differentially by own and rival prices. Specifically, the own-price effect is larger in magnitude than the cross-price effect, \( |\partial X^i(\cdot)/\partial p_i| > |\partial X^i(\cdot)/\partial p_j| \). Unlike the outcome of a standard Hotelling model with full information, and also unlike the outcome of a model with complete coverage, this implies that the demands are invertible. Letting \( X = (X_0, X_1) \) denote the vector of output levels, the inverse demands are

\[ p^0(X, \phi) = \alpha_0 - \beta_0 X_0 - \gamma X_1, \quad (8a) \]
\[ p^1(X, \phi) = \alpha_1 - \gamma X_0 - \beta_1 X_1, \quad (8b) \]

where, \( \alpha_0 = \frac{v(2 - \phi_0 - \phi_1) + \phi_1 t}{2 - \phi_0 - \phi_1} \), \( \beta_0 = \frac{(2 - \phi_0)t}{n\phi_0(2 - \phi_0 - \phi_1)} \), and \( \gamma = \frac{t}{n(2 - \phi_0 - \phi_1)} \), and where \( \alpha_1 \) and \( \beta_1 \) are similarly defined.
It is well known that when firms compete in quantities residual demand is less elastic than when firms compete in prices. That is, firm behavior under quantity competition is less competitive, for a given set of demand conditions, than firm behavior under price competition.\(^4\) For a given level of advertising, this is true here as well. Under symmetric market conditions, the demand elasticity facing quantity-setting firm \(i\) is \(\varepsilon_i = p_i / (\beta_i x_i)\). Evaluating this elasticity at \(p_i = p, \quad \beta_i = \beta\) for \(i = 0, 1\), and converting into terms of the equilibrium prices gives

\[
\varepsilon_c = \left(\frac{4(1-\phi)}{(2-\phi)^2}\right)\varepsilon_p, \tag{9}
\]

where the expression in brackets is strictly less than unit value at all permissible advertising levels \(\phi \in [0,1]\), which implies \(\varepsilon_p > \varepsilon_c\). Thus, equilibrium prices are higher (for a given level of advertising) when firms compete in quantities than when firms compete in prices.\(^5\)

3. Monopoly Outcomes

Consider the outcome under monopoly ownership of both brands. There are three possibilities, which coincide with the three types of demand conditions outlined above. In each case, we consider a monopolist who faces symmetric production costs per brand and incurs independent advertising costs for each brand.\(^6\)

3A. Local Monopoly

Under local monopoly conditions \((v-p < t/2)\), demand for each brand is given by (3). Monopoly profit per brand is

\[
\hat{\pi}^m(\hat{p}_m, \hat{\phi}_m) = (\hat{p}_m - c)(n\hat{\phi}_m / t)(v-\hat{p}_m) - nA(\hat{\phi}_m) - F,
\]

where \(F\) is fixed cost, which is assumed to be sunk, \(c\) is the constant unit cost of production, and \(A(\phi)\) is the private cost of sending an advertising message through a unit population density.

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\(^5\) As in the case of price competition, it is easy to verify that advertising that improves information also reduces the demand elasticities (and increases equilibrium prices) under quantity competition.

\(^6\) Multi-product firms often have separate advertising budgets for each product. For example, soft drink producers run simultaneous ad campaigns for cola, cherry, and lemon-lime flavored beverages without “cross-advertising” by promoting multiple brands in the product line at a time.
We assume throughout that $A'(\phi) > 0$ and $A''(\phi) > 0$. The latter assumption reflects the idea that it becomes increasingly expensive for advertising to reach higher fractions of the population, either because the advertising media become saturated, or because consumers differ in their tendency to view ads. A useful specialization of the advertising cost function, which we employ in various places below, is $A(\phi) = -z \ln(1-\phi)$, where $z < 0$ is a constant. This is the form of advertising technology considered by Butters (1977) and Grossman and Shapiro (1984).  

The first-order necessary conditions for the local monopoly equilibrium are

\[
\hat{\pi}_p^m(\hat{p}_m, \hat{\phi}_m) = (n\hat{\phi}_m / t)(v - 2\hat{p}_m + c) = 0
\]

and

\[
\hat{\pi}_\phi^m(\hat{p}_m, \hat{\phi}_m) = (n / t)(\hat{p}_m - c)(v - \hat{p}_m) - nA'(\hat{\phi}_m) = 0.
\]

In (10), the monopoly sets the price above marginal cost according to the reciprocal of the demand elasticity, and in (11), the marginal product of advertising, which is the parallel shift in demand, is set equal to its marginal cost.

The implicit solution to (10) and (11) is $\hat{p}_m^* = (v+c)/2$ and $(v-c)^2 / 4t = A'(\hat{\phi}_m^*)$ in the general case. Notice that the optimal price is not a function of the advertising level. This is because advertising does not affect the extent of the market served by each brand.

Under the advertising cost specialization $A(\phi) = -z \ln(1-\phi)$, the optimal level of advertising is given by $\hat{\phi}_m^* = 1 - \frac{4tz}{(v-c)^2}$. Notice that when $t$ increases, which means consumers are more sensitive to brand characteristics, the monopolist advertises his brands less. Put differently, the result that a monopolist advertises more when the brands are relatively homogeneous is rather striking.

Substituting $\hat{p}_m^*$ into the condition for a local monopoly, the local monopoly outcome occurs for combinations of consumer reservation values, production costs, and transportation costs that satisfy $v-c < t$. With linear demand, a local monopolist fails to cover half the market.

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7 This form of advertising cost can be interpreted as selecting to run ads in a number of magazines with identical and independent readerships. For details, see Grossman and Shapiro (1984).
with each brand at monopoly prices only when a single brand priced at marginal cost cannot cover the entire market.

Substituting the optimal price for a local monopolist into the profit expression gives profit per brand as a function of the advertising level

$$\hat{\pi}^m(\phi^*) = \frac{n\phi^*(v-c)^2}{4t} - nA(\phi^*) - F.$$  

(12)

For the advertising cost specialization $A(\phi) = -z \ln(1 - \phi)$, this reduces to

$$\hat{\pi}^m(\phi^*) = n\left[\frac{(v-c)^2}{4tz} + \ln\left(\frac{4tz}{(v-c)^2}\right) - 1\right] - F.$$

3B. Complete Coverage

Under complete coverage ($t \leq v - p$), the monopolist sells each brand to all consumers who receive an advertising message for that brand. The monopolist, by definition, sets his price sufficiently low that even the most distant consumer from the brand is induced to purchase, which implies that the equilibrium prices must be set below the reservation value of a consumer at a unit distance away from the brand. On the other hand, decreasing prices any further from this position has no consequence on the total quantity sold, so that any lower price than this cannot be optimal. Hence, the optimal monopoly price under complete coverage is $\hat{p}^*_m = v - t$.

The monopolist also has the choice of whether to promote both brands or to promote only one. That is, the monopolist may choose to advertise only a single brand and make no attempt at all to sell the second brand. Doing so would not harm the monopolist’s sales—we have assumed complete coverage by each brand—but doing so would save on advertising costs. Advertising two brands is wasteful from the perspective of a monopolist with complete coverage, because some consumers receive two advertising messages that would purchase anyway having received only one. Specifically, a consumer is hit by advertisements for both brands with probability $\phi^2$ when only one ad is sufficient to induce a purchase.
To see that the monopolist only chooses to advertise one brand under complete coverage, consider the monopoly profit level (per brand) in each case. If only a single brand is promoted, monopoly profit is

$$\pi^m(\tilde{\phi}_m) = n\tilde{\phi}_m(v-c-t) - nA(\tilde{\phi}_m) - F,$$

(13)

where \((v-c-t)\) is the (constant) markup of price over marginal cost, and \(\tilde{\phi}_m\) is the probability that the representative consumer purchases the brand, which is simply equal to the fraction of the population exposed to the (single) ad.

Letting \(\tilde{\phi}_m = \phi_0 = \tilde{\phi}_1\) denote the optimal level of advertising in the symmetric case when both brands are promoted, monopoly profit per brand is

$$\pi^m(\phi_m) = \phi_m n(v-c-t) \left(1 - \frac{\phi_m}{2}\right) - nA(\phi_m) - F.$$

(14)

For later reference, the first order condition associated with promotion of both brands in (14) is

$$\phi_m = \phi_A - \phi_m.$$

(14a)

Notice that total cost per brand is identical in (13) and (14) for a given level of advertising, \(\phi_m = \tilde{\phi}_m\), but that total revenue differs. This is because the probability that a consumer who receives an ad will subsequently buy the advertised brand depends both on whether the consumer, when fully informed, prefers the brand to the alternative brand offered by the monopolist, and on whether the consumer receives advertising messages from one or from both brands. Consumers receive advertising messages from both brands with probability \(\phi_m^2\) and a fully informed consumer (on average) buys the advertised brand half the time and buys the alternative brand the remaining half the time. Consumers receive an advertising message from the representative brand and no other advertising messages with probability \(\phi_m(1-\phi_m)\), and these partially informed consumers buy the advertised brand all the time. Thus, for a representative brand advertised by the monopolist, the probability of making a successful sale to a consumer is \(\phi_m \left(1 - \frac{\phi_m}{2}\right)\).

At this point, it is straightforward to verify that a monopolist always promotes only a single brand when conditions support complete coverage. To see this, suppose the monopolist selected a level of advertising to maximize profits in (14), and let \(\phi_m^*\) denote this level. By
inspection of (13), monopoly profit would be greater at \( \phi_m^* \) if the monopolist chose, instead, to promote only the single brand. Formally, \( \pi^m(\phi_m^* ) - \pi^m(\phi_m^* ) = (n/2)\phi_m (v - c - t) > 0 \). The monopolist could do still better, of course, under single brand promotion at some other level of advertising, \( \phi_m^* \). It follows by revealed preference that a monopolist always chooses to promote only one brand under complete coverage.

The first order condition associated with (13) is

\[
\tilde{\pi}^m_\phi (\phi_m^* ) = n(v - c - t) - nA'(\phi_m^* ) = 0.
\]

(15)

The optimal level of advertising, \( \phi_m^* \), is identified by (15). For the advertising cost specialization \( A(\phi) = -z \ln(1 - \phi) \), the equilibrium advertising level is \( \phi_m^* = 1 - \frac{z}{v - c - t} \) and equilibrium profit is

\[
\tilde{\pi}^m(\phi_m^* ) = n \left[ v - c - t - z \left( 1 - \ln \left( \frac{z}{v - c - t} \right) \right) \right] - F.
\]

Under complete coverage, the monopolist only produces one brand. It remains to identify parameter values that support the monopoly equilibrium (15) under complete coverage. We return to this issue after discussing the remaining case of incomplete coverage in the following section.

3C. Incomplete Coverage

Under incomplete coverage \( (t/2 \leq v - p < t) \), the monopolist considers three types of solutions. First, the monopolist may choose to promote only a single brand, even though doing so incompletely covers the market. Second, the monopolist may choose to promote both brands, but price them each at \( p = v - t/2 \) to preserve a local monopoly market for each brand with independent demands.\(^8\) Third, the monopolist may choose to promote both brands and price them at \( p < v - t/2 \). All fully informed consumers receive positive surplus from consuming their preferred brand at such prices, so that the demand for each brand is given by (6a) and (6b).\(^9\)

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\(^8\) The local monopoly regions would actually intersect at the midpoint of the line segment, but a fully informed consumer at this point receives zero net surplus from either brand so that the demands are independent.

\(^9\) Equivalently, one could use the inverse demands (8a) and (8b).
If the monopolist promotes only one of the two brands, the equilibrium profit level for the promoted brand is identical to that under local monopoly conditions in (12). Substituting the optimal price for the single brand, \( \hat{p}_m^* = (v + c)/2 \), into the conditions for incomplete coverage, the net value of the product, \( v - c \), that supports this outcome is in the range \( t \leq v - c < 2t \). For values of \( v - c \) below this range, a local monopoly is optimal, but both brands are promoted as in Section 3A, whereas for values of \( v - c \) above this range, coverage is complete and the outcome is as in Section 3B.

If the monopolist promotes both brands but prices in a manner to maintain independent demands in two local monopoly markets, then \( \hat{p}_m' = v - t/2 \) in the symmetric case, and total sales per brand are \( \hat{X}(\hat{p}_m',\hat{\phi}_m) = n\hat{\phi}_m / 2 \). Profit per brand is

\[
\hat{\pi}(\hat{p}_m',\hat{\phi}_m) = n\hat{\phi}_m \left( 2(v - c) - t \right) / 4 - nA(\hat{\phi}_m) - F, 
\]

which has the first order condition,

\[
\hat{\pi}_\phi(\hat{p}_m',\hat{\phi}_m) = n\left( 2(v - c) - t \right) / 4 - nA'(\hat{\phi}) = 0. 
\]

Let \( \hat{\phi}_m' \) denote the solution to (17). For the advertising cost specialization \( A(\phi) = -\kappa \ln(1 - \phi) \),

\[
\hat{\phi}_m' = 1 - \frac{4z}{2(v - c) - t}.
\]

Finally, the monopolist can choose to promote both brands, but price them sufficiently low that the demands are independent, as in (6a) and (6b). Pricing the brands below \( \hat{p}_m' \) reduces the profit that the monopolist earns on fully informed consumers, because all informed consumers purchase in either case, but do so now at lower prices. But pricing the brands below \( \hat{p}_m' \) also increases sales to partially informed consumers, who are now willing to travel farther to consume the lower priced brand. Given that two brands are promoted, the decision of how to price them depends on the relative magnitude of these two effects.

If the monopolist promotes both brands but prices them below demand \( \hat{p}_m' \), the demand for each brand is given by (6a) and (6b). Monopoly profit per brand in the symmetric case, \( p_m = p_0 = p_1 \) and \( \phi_m = \phi_0 = \phi_1 \) is

\[
\pi''(p_m,\phi_m) = (p_m - c)\frac{n\phi_m}{2t} \left( 2(v - p_m)(1 - \phi_m) + \phi_m t \right) - nA(\phi_m) - F.
\]
The first order conditions are
\[
\pi_p'(p_m, \phi_m) = \frac{n\phi_m}{2t} (2(v - p_m)(1 - \phi_m) + \phi_m t - 2(1 - \phi_m)(p_m - c)) = 0
\] (19)
and
\[
\pi_\phi'(p_m, \phi_m) = \frac{n(p_m - c)}{t} ((v - p_m)(1 - 2\phi_m) + \phi_m t) - nA'(\phi_m) = 0.
\] (20)
Equation (18) gives the familiar pricing condition under monopoly, \((p-c)/p = 1/\varepsilon_m\), where
\[
\varepsilon_m = \frac{2(1 - \phi_m)p_m}{2(v - p_m)(1 - \phi_m) + \phi_m t}
\] (21)
is the demand elasticity. Equation (20) can be written
\[(p_m - c)\left(\phi_m + (1 - 2\phi_m)(v - p_m)/t\right) = A'(\phi_m),\]
which has the following interpretation. Because \(n\phi_m\) consumers receive the advertising message for each brand, a small increase in \(\phi_m\) of \(d\phi_m = 1/n\) informs (on average) one more consumer. With probability \(\phi_m^2\), this consumer is fully informed, in which case she buys each brand exactly half the time. Thus, the marginal probability that a fully informed consumer purchases the brand is \(\phi_m\). With probability \(\phi_m(1 - \phi_m)\), this consumer is only partially informed, in which case she buys the brand with frequency \((v - p_m)/t\), which is the length of the segment served by the monopolist under incomplete coverage. The marginal probability that a partially informed consumer purchases the brand is \((1 - 2\phi_m)(v - p_m)/t\). A small increase in \(\phi_m\) therefore generates \(\phi_m + (1 - 2\phi_m)(v - p_m)/t\) sales and raises profits by \((p_m - c)\left(\phi_m + (1 - 2\phi_m)(v - p_m)/t\right)\). The monopolist equates this marginal gain to the marginal cost of informing a consumer, \(A'(\ddot{\phi}^m)\).

Unlike the outcomes under local monopoly and complete coverage, notice that the elasticity of demand with respect to advertising is no longer unit valued. For a monopolist who promotes brands with intersecting demands, this elasticity is
\[
\varepsilon_\phi = \frac{2[(v - p)(1 - 2\phi) + \phi t]}{2(v - p)(1 - \phi) + \phi t}.
\]
Advertising has a smaller direct impact on demand, \(\varepsilon_\phi < 1\), than in the other cases, because a higher level of advertising for one brand now has a negative effect on demand for the other. Increased advertising for one brand reallocates a portion of fully informed consumers between
brands that otherwise would have purchased the alternative brand, so that the average product of advertising now exceeds its marginal product.

The optimal prices and advertising levels per brand for the monopolist who produces two brands solve (19) and (20) simultaneously. Let \( (p_m^*, \phi_m^*) \) denote this solution.

To see whether profit is greater for a monopolist who promotes one brand or promotes two brands with intersecting demands, we compare profits in each case for a given level of advertising. For a monopolist who chooses to promote both brands at \( p_m^* < \hat{p}_m^* \), the equilibrium price, as a function of \( \phi_m^* \), is given by (19) to be

\[
p_m(\phi_m) = \frac{v + c}{2} + \frac{t\phi_m}{4(1 - \phi_m)}.
\]

Profit per brand, as a function of the advertising level, is found by substituting (22) into (18), which gives

\[
\pi^m(\phi_m) = \frac{n\phi_m(1 - \phi_m)}{4t} \left( v - c + \frac{\phi_m t}{2(1 - \phi_m)} \right)^2 - nA(\phi_m) - F.
\]

Total monopoly profit is \( 2\pi^m(\phi_m) \). Evaluating total profit at the optimal level of single brand promotion, \( \hat{\phi}_m^* \), and comparing this expression with (12) yields

\[
2\pi^m(\phi_m^*) - \pi^m(\hat{\phi}_m^*) = \frac{n\phi_m^*(1 - \phi_m^*)}{4t} \left( (1 - 2\hat{\phi}_m^*)(v - c)^2 + 2t\hat{\phi}_m^*(v - c) + \frac{(t\phi_m^*)^2}{2(1 - \phi_m^*)} \right).
\]

If the term in square brackets is positive, then promoting two brands at the advertising level \( \hat{\phi}_m^* \) leads to greater profit than promoting only one. Rearranging this term,

\[
2\pi^m(\phi_m^*) > \pi^m(\hat{\phi}_m^*)
\]

when

\[
(1 - \hat{\phi}_m^*)(v - c)^2 - \hat{\phi}_m^*(v - c)(v - c - 2t) + \frac{(t\phi_m^*)^2}{2(1 - \hat{\phi}_m^*)} > 0.
\]

This inequality always holds, because single brand promotion is only feasible under incomplete coverage when \( v - c < 2t \). If a monopolist who promotes both brands advertises each brand at the level \( \hat{\phi}_m^* \), then profit is greater than the maximum profit level obtainable from promoting a single brand. It follows by revealed preference that \( 2\pi^m(\phi_m^*) > 2\pi^m(\hat{\phi}_m^*) > \pi^m(\phi_m^*) \). Accordingly, a monopolist always chooses to promote both brands.
The remaining case to consider is a monopolist who promotes both brands, but prices them at \( \hat{p}_m' \) to maintain local monopoly markets. To assess this case, we proceed similarly as above. Profits per brand (evaluated at \( \hat{\phi}_m' \)) compare in (16) and (23) as

\[
\pi^m(\hat{\phi}_m') - \hat{\pi}^m(\hat{\phi}_m') = \frac{n\hat{\phi}_m'}{4t} \left[ (1-\hat{\phi}_m')(v-c)^2 - t(v-c)(2-\hat{\phi}_m') + \frac{t^2(2-\hat{\phi}_m')^2}{4(1-\hat{\phi}_m')} \right]
\]

The critical value that determines the sign of this expression is

\[
\frac{v-c}{t} = \frac{2-\hat{\phi}_m'}{2(1-\hat{\phi}_m')}
\]

For smaller values of \( (v-c)/t \), \( \pi^m(\hat{\phi}_m') < \hat{\pi}^m(\hat{\phi}_m') \), while the opposite result holds for larger values.

The range of parameter values that support an outcome of incomplete coverage is found by substituting (22) into the two conditions on price, \( p_m \leq v-t/2 \) and \( p_m > v-t \). In terms of the equilibrium advertising levels, this range is defined by

\[
\frac{2-\hat{\phi}_m}{2(1-\hat{\phi}_m)} < \frac{v-c}{t} \leq \frac{4-3\hat{\phi}_m}{2(1-\hat{\phi}_m)}
\]

Notice that outcome under monopoly depends importantly on the term \( (v-c)/t \). This term has two components: \( v-c \) is the social benefit of consumption (gross of transportation costs) and \( t \) is the transportation cost per unit of distance. The interpretation of \( (v-c)/t \) is the ratio of the social benefit of consumption to its opportunity cost for the most distant consumer in product space. In There is a sense in which this measures the intrinsic value of the product space. The product space is more valuable when the reservation price of consumers greatly exceeds the production cost of firms, and for products in which this value is not greatly eroded by the transportation cost necessary to acquire it. This term depends critically on the degree of product differentiation. When product differentiation is more important, this value decreases.

The range of outcomes is depicted in Figure 2. For a product class with a relatively small net value, \( (v-c)/t < 1 \), the outcome is a local monopoly with promotion of both brands at interior prices. The equilibrium prices are such that consumers on the mid-point of the segment do not consume, and the remaining consumers purchase their closest brand when fully informed and consume either their closest brand or no brand at all when partially informed. For a product
category with a relatively larger net value of

\[ 1 < \frac{v - c}{t} < \frac{2 - \phi_m^*}{2(1 - \phi_m^*)} \],

where \( \phi_m^* \) is determined by (19) and (20), the outcome is a local monopoly with a corner solution for the prices at \( \hat{p}_m' \). For a product category that satisfies

\[ \frac{2 - \phi_m^*}{2(1 - \phi_m^*)} < \frac{v - c}{t} \leq \frac{4 - 3 \phi_m^*}{2(1 - \phi_m^*)} \],

the equilibrium is characterized by incomplete coverage with interdependent demands. And finally, for a product category that satisfies

\[ \frac{v - c}{t} > \frac{4 - 3 \phi_m^*}{2(1 - \phi_m^*)} \],

the monopolist provides complete coverage with a single brand and does not promote the other.

For the advertising cost specialization \( A(\phi) = -z \ln(1 - \phi) \), these boundary values are given by

\[ \frac{2 - \phi_m^*}{2(1 - \phi_m^*)} = \frac{4z + 2(v - c) - t}{8z} \quad \text{and} \quad \frac{4 - 3 \phi_m^*}{2(1 - \phi_m^*)} = \frac{3z + v - c - t}{2z} \).

Notice that the value of each boundary point decreases with decreases \( z \), which is the (standardized) marginal cost of advertising. This implies that pricing behavior under monopoly may change over time with the introduction of new media (e.g., the internet) that reduces the cost of exposing the consumer population to ads.

In subsequent sections, we compare the outcome under monopoly to that under oligopoly and to the social optimum. We next turn to the outcomes under oligopoly.

4. Outcomes Under Oligopoly

Under oligopoly, firms choose two strategic variables simultaneously: advertising levels, and either prices or quantities. As in the monopoly case, several outcomes can occur under oligopoly. First, values of the parameters can be such that each firm has local monopoly power \( (v - c < t) \). The outcome in this case coincides with that in Section 3A. Second, the values of the parameters can be such that the demand functions of the oligopoly firms intersect. In this case, depending on the value of the model parameters, the equilibrium is either in pure strategies or in mixed strategies.
In this section, we consider non-cooperative Nash equilibrium in pure strategies under both price and quantity competition. To facilitate the comparison of outcomes, we center attention on the case of incomplete coverage \((t/2 \leq v - p < t)\).\(^{10}\) Throughout, we consider the problem from the perspective of a representative firm and, without loss of generality, label this firm as the producer of brand 0.

4A. Price competition

Under price competition, the profit of the representative firm who produces brand 0 is given by

\[
\pi^b(p, \phi) = (p_b - c)X^0(p, \phi) - nA(\phi_b) - F,
\]

where \(p\) and \(\phi\) are the price and advertising vectors, and demand is given by (6a). The essential difference between profit under price-setting oligopoly and profit under (incomplete coverage) monopoly is that each firm now views the price and advertising level set by its rival as constant, and this fails to internalize the full effects of both pricing and advertising on joint profitability.

The first-order conditions, evaluated in the symmetric case, \(p_b = p_o = p_1\) and \(\phi_b = \phi_o = \phi_1\) are

\[
\pi_{p}^b(p, \phi) = \frac{n\phi_b}{2t}[2(v - p_b)(1 - \phi_b) + \phi_b t - (p_b - c)(2 - \phi_b)] = 0, \tag{24}
\]

and

\[
\pi_{\phi}^b(p, \phi) = \frac{n}{2t}(p_b - c)(2(v - p_b)(1 - \phi_b) + \phi_b t) - nA'(\phi_b) = 0. \tag{25}
\]

In (24), each firm marks up price over marginal cost according to the reciprocal of the demand elasticity, \((p_b - c)/p_b = 1/\varepsilon_b\), where \(\varepsilon_b\) is defined in (7). Notice that \(\varepsilon_b > \varepsilon_m\) in (21) for a fixed advertising level. For an equivalent level of advertising, oligopoly prices are lower than those under monopoly. In (25), the representative firm equates the marginal product of advertising to its marginal cost. Because demand facing the representative firm in (6a) is linear in his own advertising level, the marginal product of advertising equals its average product. It follows that,

\(^{10}\) For the case of complete coverage, the demands are not invertible.
for equivalent prices, the advertising levels under oligopoly are higher than those which occur under monopoly (i.e., $\varepsilon_\phi < 1$ under monopoly).

The oligopoly equilibrium under price-setting behavior is given by the simultaneous solution to (24) and (25). It is possible to eliminate $p_b$ from these two equations. In terms of the equilibrium advertising level, the optimal price that satisfies (24) is

$$ p(\phi_b) = \frac{2v(1-\phi_b) + c(2-\phi_b) + t\phi_b}{4 - 3\phi_b}. $$

Substituting (26) into (25), the effect of advertising on oligopoly profit is

$$ \left(\frac{2 - \phi_b}{2t(4 - 3\phi_b)^2}\left(2(v-c)(1-\phi_b) + \phi_b t\right)^2\right) = A'(\phi_b). $$

In equilibrium, symmetric price-setting firms set $\phi_b^*$ so that $\pi^b_\phi(\phi_b^*) = 0$ in (27). Substitution of $\phi_b^*$ into (26) recovers the oligopoly price, $p_b^* = p_b(\phi_b^*)$. Let $B = (p_b^*, \phi_b^*)$ denote this solution.

The range of parameter values that support an oligopoly outcome under incomplete coverage is found by substituting (26) into the two pricing conditions, $p_b \leq v - t / 2$ and $p_b > v - t$. In terms of the equilibrium advertising levels, this range is defined by

$$ \frac{4 - \phi_b^*}{2(2 - \phi_b^*)} < \frac{v - c}{t} \leq 2. $$

In the remaining case of complete coverage, profit of the representative brand is

$$ \pi^c(p, \phi) = (p_o - c)\bar{X}^0(p, \phi) - nA(\phi_b) - F. $$

In the symmetric case, the first order condition for price implies

$$ \tilde{\phi}_b(\tilde{p}_b - c) = t(2 - \tilde{\phi}_b). $$

(24a)

and the first order condition for advertising implies

$$ (\tilde{p}_b - c)(2 - \tilde{\phi}_b) = 2A'(\tilde{\phi}_b). $$

(25a)

Under complete coverage, the range of parameter values that support an oligopoly outcome is found by substituting (26) into the pricing condition $p_b \leq v - t$. In terms of the equilibrium advertising levels, this range is defined by

$$ \frac{2}{\phi_b} \leq \frac{v - c}{t}. $$

247
The range of outcomes under price competition is depicted in Figure 3. For the range of values \( (v - c)/t < 1 \), the outcome is a local monopoly. For values between one and \( 1 < \frac{4 - \phi_c^*}{2(2 - \phi_c^*)} \), and between 2 and \( 2/\phi_c^* \), the oligopoly equilibrium is in mixed strategies. Behavior in the regions of mixed strategy equilibria may be characterized by sporadic advertising campaigns or by random sales events, none of which is considered in the present focus on pure strategy equilibria.

**B. Quantity competition**

Under quantity competition, the profit of the representative firm who produces brand 0 is

\[
\pi^c(X, \phi) = p^0(X, \phi)X_0 - cX_0 - nA(\phi_0),
\]

where inverse demand is given by (8a).

The first order conditions in the symmetric case, \( X_c = X_0 = X_1 \) and \( \phi_c = \phi_0 = \phi_1 \), are

\[
\pi^c(X, \phi) = v - c + \frac{\phi_c t}{2(1 - \phi_c)} - \frac{(4 - \phi_c) tX_c}{2n\phi_c(1 - \phi_c)} = 0,
\]

and

\[
\pi^p(X, \phi) = \frac{tX_c (n\phi_c^3 + 2(2 - 3\phi_c)X_c)}{4n\phi_c^2(1 - \phi_c^2)} - nA'(\phi_c) = 0.
\]

It is helpful to convert these expressions into terms of market prices by substituting in for the demand function (6) under symmetry, \( X(p, \phi) = \left(\phi n / 2t\right)(2(v - p)(1 - \phi) + \phi t) \). This gives

\[
\pi^c(p, \phi) = p_c - c - \frac{(2 - \phi_c)(2(v - p_c)(1 - \phi_c) + \phi_c t)}{4(1 - \phi_c)} = 0 \quad (28)
\]

and

\[
\pi^p(p, \phi) = \frac{n(p_c - c)((2 - 3\phi_c)(v - p_c) + \phi_c t)}{t(2 - \phi_c)} - nA'(\phi_c) = 0 \quad (29)
\]

Each firm marks up price over marginal cost in (28) according to the reciprocal of the demand elasticity, \( (p_c - c) / p_c = 1/\varepsilon_c \), as in the case of both price-setting oligopoly and monopoly. For a given level of advertising, \( \varepsilon_b > \varepsilon_c > \varepsilon_m \), and it follows that the price of the representative brand under quantity competition is lower than that which emerges under monopoly in (22), but higher than that which emerges under price competition in (24). The interpretation of equation (29) is
that the marginal benefit of an additional unit of advertising, which is the value of the increased quantity evaluated at constant prices, should be set equal to its marginal cost.

Unlike the case of price competition, notice that the marginal product of advertising does not equal its average product under quantity competition. This is because own brand advertising enters equation (6a) linearly, but own brand advertising affects both the intercept and the slope in equation (8a). Oligopoly firms perceive the effect of advertising differently when viewing the price of the rival brand to be fixed than when perceiving his quantity to be fixed. Comparing (25) and (29) for equal prices, the advertising levels are higher under price competition than they are under quantity competition when $t \leq 2(v - p)$, and this always holds by the definition of incomplete coverage. For given prices, firms advertise more under Bertrand than under Cournot.

In terms of the equilibrium advertising level, the optimal price that satisfies (28) is

$$p_c(\phi_c) = \frac{2v(1-\phi_c)(2-\phi_c) + 4(1-\phi_c)c - \phi_c^2(2-\phi_c)t}{2(1-\phi_c)(4-\phi_c)}$$

(30)

Substituting (30) into (29), the optimal level of advertising is

$$\frac{(2 - 3\phi_c)(2(v - c)(1 - \phi_c) + \phi_c t)}{2t(1 - \phi_c)^2(4 - \phi_c)^2} + \frac{\phi_c^2(2(v - c)(1 - \phi_c) + \phi_c t)}{4(1 - \phi_c)^2(4 - \phi_c)} = A'(\phi)$$

(31)

In equilibrium, symmetric firms set $\phi_c^*$ so that $\pi_c^*(\phi_c^*) = 0$ in this expression. Substitution of $\phi_c^*$ into (30) would then recover the equilibrium output level, $p_c^* = p_c(\phi_c^*)$. Let $C = (p_c^*, \phi_c^*)$ denote this solution.

The range of parameter values that support a quantity-setting oligopoly outcome under incomplete coverage is shown in Figure 3. These values satisfy

$$\frac{4 - 3\phi_c^*}{4(1-\phi_c^*)} < \frac{v - c}{t} \leq \frac{8(1-\phi_c^*) + (\phi_c^*)^2}{4(1-\phi_c^*)}.$$

For equivalent advertising levels, a larger range of parameter values supports incomplete coverage under quantity competition than under price competition. This is because prices are higher under quantity competition than under price competition (advertising given), which precludes consumer purchases at more distant locations, and thereby extends the range of outcomes that support the incomplete coverage equilibrium.
5. Welfare Analysis

In this section, we first detail the socially optimal level of advertising, then compare the privately and socially optimal levels under monopoly, and both forms of oligopoly. In all cases, we consider the optimal advertising level of a social planner who takes market structure and prices as given. This is the standard approach. Implicitly, we are assuming that the planner can control each externality in the oligopoly market with independent instruments on production and advertising.

From a normative policy perspective, it is well known that an output subsidy can be used to “correct” the pricing distortion under oligopoly.\(^{11}\) The focus here is on policies that correct the advertising distortion under oligopoly with a subsidy (or a tax) on advertising. In each case, we ignore second-best policy issues that arise when attempting to correct multiple distortions with a single instrument. This is done by suppressing the influence of advertising policy on the equilibrium prices and by assuming that government revenue to support the optimal policy is generated from taxes on an inelastic factor in the economy.

It is somewhat unusual to ask the question of whether advertising is socially inefficient or excessive in explicit terms of whether or not an advertising subsidy would improve welfare. Nonetheless, these questions are equivalent. Indeed, from a social cost perspective, it is useful to note that a portion of advertising expenses is often passed on to consumers; for example, advertisements represent much of the printing cost of a Sunday paper, and this is passed along to consumers through a higher delivery price.\(^{12}\)

Let the social cost of advertising to be \(A_s(\phi)\). The social cost relates to private costs as \(A(\phi) = A_s(\phi) + \tau \phi\), where \(\tau\) is a unit tax (subsidy) now introduced on advertising. For each

\(^{11}\) It is straightforward to show that the social optimum always involves price equal to marginal cost for each brand. To see this, consider the group of consumers who receive only an advertising message from brand 0 and suppose the price of brand zero is set above marginal cost, \(p_0 > c\). There would then exist a consumer in this group at some location, \(z\), who would not consume brand 0 \((v - p_0 - zt < 0)\), even though total social surplus would increase by doing so \((v - c - zt < 0)\).

\(^{12}\) Becker and Murphy (1993) consider an interesting model in which consumers pay (at least implicitly) a market price for advertising, which enters demand as a complement to advertised goods.
outcome of the model, we identify whether the optimal policy for each market structure involves
a tax, $\tau_j > 0$ for $j = m, b, c$, or a subsidy, $\tau_j < 0$ for $j = m, b, c$.

5A. Local Monopoly

The socially optimal allocation depends on industry profits and the surplus consumers receive
from purchasing a brand, which is influenced by total transportation costs in the market. Under
local monopoly conditions, a consumer receives an advertising message from the representative
brand with probability $\hat{\phi}$. At a price of $\hat{p}$, some consumers purchase the brand and some do
not. The conditional probability that a consumer buys the product after receiving the advertising
message is $(v - \hat{p})/t$. The average consumer who purchases the brand travels $(v - \hat{p})/2t$ to
consume the brand and incurs travel cost of $T = (v - \hat{p})/2$, so that consumer surplus per brand
for the average consumer is $v - \hat{p} - T = (v - \hat{p})/2$.

Aggregate welfare is given by
$$\hat{W} = \frac{2n\hat{\phi}(v - \hat{p})}{t} \left( \frac{v - \hat{p}}{2} + \hat{p} - c \right) - 2nA_s(\hat{\phi}) - 2F,$$
where the first term in $\hat{W}$ represents benefits net of variable production costs and transportation
costs. The fraction of the population that consumes the product is $2n\hat{\phi}((v - \hat{p})/t)$ and, for each
unit of consumption, the return to consumers (on average) is $(v - \hat{p})/2$ and the return to
producers is $\hat{p} - c$. The remaining two terms are social advertising costs and fixed costs,
respectively.

The socially optimal $\hat{\phi}$ is defined by the first order condition for the maximization of $\hat{W}$,
$$\frac{(v - \hat{p})^2}{2t} + \frac{(\hat{p} - c)(v - \hat{p})}{t} = A_s'(\hat{\phi}). \quad (32)$$
A small increase in $\hat{\phi}$ that informs one more consumer induces a purchase with frequency
$(v - \hat{p})/t$, and this contributes $(v - \hat{p})/2$ in surplus to consumers and $\hat{p} - c$ to producers.
Equation (32) sets this marginal gain equal to the marginal social cost of advertising.
At the social optimum, \( \tau \) is set to equate the socially and privately optimal levels of advertising. Noting that \( A'(\hat{\phi}) = A_s'(\hat{\phi}) + \hat{r} \), the optimal tax on advertising is recovered by substitution of (11) into (32) to get

\[
\hat{\tau}^* = \frac{(v - \hat{p})^2}{2t} < 0. \tag{33}
\]

Under local monopoly, firms advertise too little from the social perspective. A monopolist fully internalizes the effect of advertising on industry profit, but fails to account for the marginal contribution of advertising to the welfare of consumers. Because the social benefits of advertising for each consumer \( (v - c - tx) \) exceed the private benefits \( (p - c) \), a monopolist always underprovides purely informative advertising, as proven by Shapiro (1980).

If an independent instrument exists to control price, then the optimal subsidy under local monopoly in (33) is evaluated at \( \hat{p}^* = c_s \), where \( c_s \) is the social marginal cost of production. Firms, in this case, would receive subsidies on both advertising \( \hat{\tau}^* = -(v - c)^2 / 2t \) and on output, \( \hat{s}^* = \hat{p}^* - c_s \).

5B. Complete Coverage

Under complete coverage, both brands are always promoted at the social optimum. To see this, recall that the reason a monopolist prefers to promote only one brand under complete coverage is that the monopolist captures no additional rents from fully informing consumers, but incurs additional advertising costs. With probability \( \hat{\phi}^2 \), a consumer receives an advertising message for both brands, when only one ad is sufficient to induce a purchase, and this makes advertising both brands wasteful from the perspective of the monopolist. From the perspective of the social planner, the outcome is just the opposite: Fully informing consumers conserves transportation costs. It is straightforward to show that this makes advertising both brands socially beneficial.

Under complete coverage, all consumers that receive at least one advertising message purchase the product. With probability \( \hat{\phi}^2 \), a consumer receives both advertising messages. The average consumer who receives both advertising messages incurs transportation cost of \( t/4 \) to
obtain her desired brand, so that consumer net benefit for the fraction of the population hit by both ads is \( v - \tilde{p} - (t/4) \). With probability \( 2\tilde{\phi}(1-\tilde{\phi}) \), a consumer receives exactly one advertising message. The advertising message is equally likely to be received from the nearest brand as from the farthest brand, so that a partially informed consumer (on average) incurs transportation cost of \( t/2 \) to obtain her desired brand, and receives net benefit of \( v - \tilde{p} - t/2 \).

Aggregate welfare is given by
\[
\bar{W} = n\phi \left( \phi (v - \tilde{p} - t/4) + 2(1-\phi)(v - \tilde{p} - t/2) + (2-\phi)(\tilde{p} - c) \right) - 2nA_s(\phi) - 2F,
\]
where the first term in \( \bar{W} \) represents benefits net of variable production costs and transportation costs. As in the case of local monopoly, this term is divided into consumer surplus and producer surplus components.

The socially optimal \( \tilde{\phi} \) is defined by the first order condition for the maximization of \( \bar{W} \),
\[
\phi \left( v - \tilde{p} - t/4 \right) + (1-2\phi)(v - \tilde{p} - t/2) + (\tilde{p} - c)(1-\phi) = A_s'(\phi).
\]
A small increase in \( \tilde{\phi} \) that informs one more consumer does one of two things under complete coverage. With probability \( \tilde{\phi} \), the consumer becomes fully informed, which creates value in the economy of \( v - \tilde{p} - (t/4) \), whereas, with probability \( (1-\tilde{\phi}) \), the consumer becomes partially informed. The new consumption by the partially informed consumer contributes to industry profits by \( \tilde{p} - c \). The new consumption also reduces the likelihood that advertising by the rival brand will inform a new consumer, so that, in the symmetric equilibrium, the probability of generating a new consumer with a simultaneous small increase in \( \tilde{\phi} \) for each brand is \( (1-2\tilde{\phi}) \). This consumption creates value in the economy of \( v - \tilde{p} - t/2 \), and the sum of these marginal gains is set equal to the marginal social cost of advertising in (34).

We first compare the outcome in (34) to that under monopoly provision. To do so, note that the selection of \( \tilde{\tau}_m \) by the regulator aligns social and private incentives for advertising and therefore induces the monopolist to promote both brands. Substituting \( A'(\phi) = A_s'(\phi) + \tilde{\tau}_m \) and (14a) into (34) yields
\[
\tilde{\tau}_m^* = -\left( \phi (v - \tilde{p} - t/4) + (1-2\phi)(v - \tilde{p} - t/2) \right) < 0.
\]
Notice that the subsidy in (35), as in the case of local monopoly, internalizes the marginal contribution of advertising to consumer welfare. A monopolist with complete coverage does not sufficiently advertise brands from the social perspective.

If an independent instrument exists to control price, then the optimal subsidy under local monopoly in (35) can be evaluated at $\tilde{p}^* = c$. $^{13}$ A monopoly firm would receive subsidies on both advertising (35) and output, $\tilde{s}^* = \tilde{p}^*_m - c$.

Under oligopoly provision, the outcome differs from that under monopoly in the sense that individual firms do not account for the effect of advertising on reducing the profit of rival firms. Under price-setting oligopoly, firms advertise according to the average product of advertising on demand, and this exceeds the marginal product. Relative to the social level, there are thus two offsetting incentives under oligopoly. The effect of advertising on consumers is not internalized, which reduces advertising levels, and the effect of advertising on industry profits in (34) is not fully internalized, which increases advertising levels.

Substituting $A'(\tilde{\phi}) = A',(\tilde{\phi}) + \tilde{\tau}_b$ and (25a) into (34) gives the implicit equation for the optimal advertising policy under price-setting oligopoly,

$$\tilde{\phi}(v - \tilde{p} - t/4) + (1 - 2\tilde{\phi})(v - \tilde{p} - t/2) - \tilde{\phi}(\tilde{p} - c)/2 + \tilde{\tau}_b^* = 0$$  \hspace{1cm} (36)

The sum of the first two terms is the effect of advertising on consumer surplus. Under monopoly provision, the subsidy on advertising is set to exactly offset this effect in (35). Under oligopoly, the optimal subsidy on advertising is less than that under monopoly (and perhaps it is even a tax), because the third term is negative. Under price-setting oligopoly price, firms advertise excessively relative to the level that maximizes joint industry profit. For a unit density of consumers, the marginal product of advertising on industry profits is $(\tilde{p} - c)(1 - \tilde{\phi}_b)$ and its average product is $(\tilde{p} - c)(2 - \tilde{\phi}_b)/2$. The third term in (36) reflects this difference.

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$^{13}$ Under complete coverage, it should be noted that the socially optimal price is not unique. Among consumers who receive advertising messages, demand is perfectly inelastic, so that any equilibrium price below this level serves only to distribute rents between producers and consumers.
Whether the optimal policy involves an advertising subsidy or an advertising tax under price-setting oligopoly depends on the sum of these two effects. To see which effect dominates, substitute $\tilde{p} - c = (2 - \tilde{\phi})t / \tilde{\phi}$ from (24a) in (36) and evaluate this expression at $\tilde{p}^* = c_e$. Rearranging terms gives

$$\tilde{\tau}_b^* = -\frac{(1 - \tilde{\phi}_b^*)^2}{2 - \tilde{\phi}_b^*} 2(v - c_e - t) + \frac{(1 - \tilde{\phi}_b^*)^2 t}{2 - \tilde{\phi}_b^*} \left( \frac{\tilde{\phi}_b^*}{2(1 - \tilde{\phi}_b^*)} \right)^2 - 1,$$

Notice that the first term is negative by the definition of complete coverage at the social price $v - c_e \geq t$. The second term is negative when $\tilde{\phi}_b^* < 2/3$ and positive otherwise. Hence, the sum of these terms depends on the socially optimal level of advertising, on the social value of consumption (gross of transportation costs), and on the degree of product differentiation. When the term $v - c_e - t$ is arbitrarily small, advertising is excessive under price-setting oligopoly whenever the socially optimal advertising level exceeds $\tilde{\phi}_b^* > 2/3$. This is a noteworthy result in light of the fact that advertising costs change over time with the introduction of new media (e.g., the internet), which may permit advertisers to send messages to consumers at lower cost.

5C. Incomplete Coverage

Under incomplete coverage, all fully informed consumers purchase the product. With probability $\phi^*$, a consumer receives both advertising messages and a fully informed consumer receives (on average) net surplus of $v - p - (t/4)$. With probability $2\phi(1 - \phi)$, a consumer receives an advertising message from only one of the two brands. For this fraction of the population, these consumers are further divided into those who buy the advertised brand and those who do not, as each brand has incomplete coverage of the market segment. The conditional probability of a purchase, given a single advertising message is the fraction of the population who buy the brand at a unit price of $p$, which is $(v - p) / t$. Among those consumers who chose to buy the brand, the average consumer is located at $(v - p) / 2t$ the unit distance from the brand. Thus, consumer benefits net of variable production costs and transportation costs for the fraction of the population that receive a single ad is $(v - p)/2$. 

255
Aggregate welfare is given by

\[ W = n\phi\left[ \phi\left( v - p - \frac{t}{4} \right) + \frac{(1 - \phi)(v - p)^2}{t} \right] + \frac{n\phi(p - c)}{t} \left[ 2(v - p)(1 - \phi) + \phi t \right] - 2nA_1(\phi) - 2F, \]

The first term in \( W \) represents consumer benefits for the fraction of the population that consumes the good. The interpretation is straightforward. With probability \((1 - \phi)^2\), a consumer does not receive an advertisement for either brand and neither consumption nor transportation cost takes place. With probability \(\phi^2\), a consumer receives both ads and travels to the nearest firm, which is on average \(\frac{1}{4}\) the unit distance. And, with probability \(2\phi(1 - \phi)(v - p)/t\) a consumer receives only a single ad and finds it worthwhile to travel there and consume it, which is on average \((v - p)/2t\) the unit distance. The second term is industry profit net of advertising costs.

The first-order necessary for \( \phi^* \) is

\[ \phi\left( v - p - \frac{t}{4} \right) + (1 - 2\phi)\left( \frac{(v - p)^2}{2t} \right) + \frac{(p - c)}{t} \left( (1 - 2\phi)(v - p) + \phi t \right) = A_1(\phi^*). \]  \hspace{1cm} (37)

The first two terms in (37) capture the marginal change in consumer surplus from an additional unit of advertising and the third term is the marginal change in industry profit. As in the previous two cases, the latter effect is completely internalized by the monopolist, so that the optimal policy under monopoly is an advertising subsidy.

Under price-setting oligopoly, substituting \( A'(\phi) = A_1(\phi) + \tau_b \) and (25) into (37) gives the implicit equation for the optimal advertising tax as

\[ \phi\left( v - p - \frac{t}{4} \right) + (1 - 2\phi)\left( \frac{(v - p)^2}{2t} \right) - \frac{\phi(p - c)}{t} \left( v - p - \frac{t}{2} \right) + \tau_b = 0 \]  \hspace{1cm} (38)

The sum of the first two terms is the effect of advertising on consumer surplus. The third term reflects the difference between the marginal product and the average product of advertising on industry profits.

It is possible that firms advertise excessively from the social perspective under price-setting oligopoly. As in the case of complete coverage, this outcome depends on the gross value of the product \((v - c)\), on the degree of product differentiation \((t)\), and on the marginal cost of
advertising. The range of parameters for which advertising is socially excessive under price-setting oligopoly can be determined by numerical simulation.

Proceeding similarly as above, substituting $A'(\phi) = A'_c(\phi) + \tau_c$ and (29) into (37) gives the implicit equation for the optimal advertising tax under quantity competition,

$$\phi \left( v - p - \frac{t}{4} \right) + (1 - 2\phi) \left( \frac{(v - p)^2}{2t} \right) - \frac{2\phi(1 - \phi)(p - c)}{(2 - \phi)t} \left( v - p - \frac{t}{2} \right) + \tau_c = 0 \quad (39)$$

As before, the sum of the first two terms is the effect of advertising on consumer surplus, while the third term reflects the difference between the marginal product and the average product of advertising on industry profits. Comparing (38) and (39),

$$\tau^*_p - \tau^*_c = \frac{\phi^*(p - c)(2(v - p) - t)}{2(2 - \phi^*)} > 0,$$

where the inequality holds by the definition of incomplete coverage. The optimal advertising tax under price setting oligopoly always exceeds that under quantity setting oligopoly.

Under quantity competition, firms advertise less than under price competition for given prices. Hence, there may exist a range of parameter values for which price setting firms over-advertise from the social perspective, but quantity-setting firms under-advertise.

6. Concluding Remarks

We have considered a model of purely informative advertising with differentiated products. Advertising in the model informs consumers about the characteristics of brands and improves the matching of consumers and products. Nevertheless, we show that informative advertising does not necessarily make the demand for individual brands more elastic. Depending on the degree to which the market prices enable consumers to consume brands at distant locations, advertising can make demand more elastic, less elastic, or create parallel shifts.

Relative to the social optimum, advertising levels under oligopoly can be either inefficiently low or excessive. For equivalent prices, firms advertise more under price-setting oligopoly than under quantity-setting oligopoly. In either case, whether advertising is
inefficiently high or inefficiently low depends on the net value of the product (the difference between the reservation price of consumers and the production cost of firms), the degree of product differentiation, and the marginal cost of sending ads. When sending ads is less costly, oligopoly firms tend to excessively advertise products relative to the level which maximizes aggregate welfare in the economy.
References


FIGURE 1. Surplus offered by firms 0 and 1 under incomplete coverage.

\[ v - p_0 \quad \text{surplus at 0} \]

\[ v - p_0 - tx \quad v - p_1 - t(1-x) \]

\[ x_I \quad x_U \]

\[ v - p_1 \quad \text{surplus at 1} \]
FIGURE 2. The range of outcomes under monopoly for different net product values, \((v - c)/t\).

<table>
<thead>
<tr>
<th>Local monopoly (both brands)</th>
<th>Incomplete coverage (both brands)</th>
<th>Local monopoly (single brand)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>( \frac{2 - \phi_m^<em>}{2(1 - \phi_m^</em>)} )</td>
<td>( \frac{4 - 3\phi_m^<em>}{2(1 - \phi_m^</em>)} )</td>
</tr>
<tr>
<td>1</td>
<td>( \frac{v - c}{t} )</td>
<td></td>
</tr>
</tbody>
</table>

FIGURE 3. The range of outcomes under oligopoly for different net product values \((v - c)/t\).

<table>
<thead>
<tr>
<th>Local Monopoly</th>
<th>Incomplete Coverage</th>
<th>Complete Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed strategies</td>
<td>Mixed strategies</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>B</td>
<td>C</td>
<td>( \frac{2}{\phi} )</td>
</tr>
</tbody>
</table>

262
Economic impact of the development of private labels

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1st Biennial Conference of the Food System Research Group

University of Wisconsin, Madison, June, 26-27, 2003
Economic impact of the development of private labels

Introduction

What is a private label (hereafter PL)? The PLMA (Private Label Manufacturers’ Association) defines a PL as follows: “PL products encompass all merchandise sold under a retailer’s brand. That brand can be the retailer’s own name or a name created exclusively by that retailer. In some cases, a retailer may belong to a wholesale group that owns the brands that are available only to the members of the group.” According to Nielsen, PLs are brands that belong to a retailer or a grocery firm and that are distributed exclusively by that retailer. The French law (2001 May 15th) that deals with new economic regulations provides the following definition: a PL “is considered to be a product sold within a retailer brand, whose characteristics are defined by the firm (or the group of firms) that sells the product and is the owner of the brand”.

These definitions bring out two main ideas. First, it is the retailer who owns and controls the brand whereas this was traditionally the role of the producer. Second, the retailer has exclusive rights to the product. This means that different retailers do not sell identical PLs, which is not the case when retailers sell name-brands. Thus the development of PLs does not only change the relations between producers and retailers (because of the retailer’s new role), but also affects competition between retailers, because PLs are an additional way of differentiating between retailers.

Different approaches to the economics of PL are possible. One is the analysis of retailers without taking upstream firms and their relationships with retailers into account. With this approach, the reports published in the literature about oligopoly or optimal choice of a range of products by oligopolists apply. How firms choose their optimal range of products is influenced by two opposite effects (Champsaur and Rochet, 1989). On the one hand, the range of products needs to be as wide as possible in order to discriminate among consumers. On the other hand, each firm’s products need to be differentiated in order to reduce the impact of price competition. Gilbert and Matutes (1993), assuming differentiation between products is due to brands’ name, showed that two firms will compete on a wide range of products because the differentiation due to the brand name weakens competition between products.

Nevertheless, the former analysis fails to reveal the stakes related to procurement as well as to surplus distribution on a vertical structure. A number of reports are devoted to the analysis of vertical relationships and specially the impact of contracts and vertical restraints between producers and retailers. According to these authors, the brand is almost always defined by the upstream producer and there is equivalence between the brand and the upstream manufacturer. Moreover these studies generally focus on the vertical structure made up of a producer and his retailer(s), and deal with, first,
coordination within the structure and, second, the competition between vertical structures (for a survey, see Rey, 1994). Coordination problems in a vertical structure mainly concern price setting, optimal level of services and risk sharing. The authors generally showed that vertical restraints allow better coordination within the vertical structure. Consumers generally benefit from these vertical restraints but this depends on the intensity of competition downstream. The more intense the competition downstream, the more likely it is that consumers will benefit from restraints. The second point dealt with in the studies is the impact of vertical restraints on competition between vertical structures. As in the first case, the impact of vertical restraints is ambiguous when competition between vertical structures is weak. In this case, restraints may have a strongly negative impact on consumers that is not fully compensated for by the positive impact on the vertical structures themselves.

As emphasised by Comanor and Rey (1996), published reports mainly deal with the case of one producer and several retailers. The case of large retailers who wish to profit from their position in order to deter the entry of new retailers has been analysed less frequently. Moreover, as Rey pointed out with reference to these reports (1994), as vertical restraints on the brand are generally designed by the upstream producer there is a limit to the use of their results in the economic analysis of PLs.

In the first section of this paper we provide some statistics about the development of private labels for different products in different countries. Using the results from econometric studies, we also analyse the empirical factors that favour the development of private labels. In the second section, we discuss the reasons retailers introduce private labels i.e. to increase their bargaining power, and to discriminate demand. In the third section we deal with the empirical consequences of the development of private labels on producers and retailers. In the fourth section we review questions that are less frequently discussed. Finally in section five we draw some conclusions about the impact of the development of PLs on welfare.

1. Market share of private labels and factors that favour the introduction and the penetration of private labels

1.1 Background
In Europe the penetration of PLs varies from country to country. However, in all countries the market share in volume is higher than the market share in value. Thus, these products are generally sold at a lower price than the average price. Nevertheless, it is difficult to compare the situation in different European countries because the definition of a PL varies. In particular, it is important to know if discount products are included or not.4

1994.

4
Table 1: Market share of private labels in some European countries (%)

<table>
<thead>
<tr>
<th></th>
<th>Volume (1)</th>
<th>Value (2)</th>
<th>(1) / (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>33,2</td>
<td>27,4</td>
<td>121</td>
</tr>
<tr>
<td>Belgium</td>
<td>34,7</td>
<td>26,0</td>
<td>133</td>
</tr>
<tr>
<td>Spain</td>
<td>20,5</td>
<td>14,8</td>
<td>139</td>
</tr>
<tr>
<td>France</td>
<td>22,1</td>
<td>19,1</td>
<td>116</td>
</tr>
<tr>
<td>Italy</td>
<td>17,1</td>
<td>15,5</td>
<td>110</td>
</tr>
<tr>
<td>Netherlands</td>
<td>20,6</td>
<td>18,4</td>
<td>112</td>
</tr>
<tr>
<td>United-Kingdom</td>
<td>45,4</td>
<td>43,5</td>
<td>104</td>
</tr>
</tbody>
</table>

Source: Linéaires (www.lineaires.com) according to PLMA 2000/AC Nielsen

As illustrated in the graph below, the more concentrated the retail sector, the bigger the market share of private labels.

![Private label penetration and retail concentration](image)

Within a given country, the PL market share varies with the product category and, within a given category, the PL market share varies with the product. Different factors can influence the penetration of PLs. Some are related to the supply (structure of supply, ease of entry, innovation policy, etc) and others to the characteristics of demand. For example, the goods that require a high level of consumer confidence (baby food, health and beauty products, etc.) generally exhibit low rates of PL penetration. (Tables 2 and 3).
Table 2: Market share of private labels in European countries in 1998.

<table>
<thead>
<tr>
<th>Country</th>
<th>Food (13 categories)</th>
<th>Drinks (7 categories)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Value</td>
<td>Volume</td>
</tr>
<tr>
<td>Germany *</td>
<td>12.2</td>
<td>18.5</td>
</tr>
<tr>
<td>Belgium</td>
<td>23.9</td>
<td>34.5</td>
</tr>
<tr>
<td>Spain</td>
<td>17.6</td>
<td>24.1</td>
</tr>
<tr>
<td>Finland</td>
<td>8</td>
<td>9.7</td>
</tr>
<tr>
<td>France</td>
<td>16.5</td>
<td>20</td>
</tr>
<tr>
<td>Netherlands</td>
<td>20.9</td>
<td>25.3</td>
</tr>
<tr>
<td>United-Kingdom</td>
<td>34</td>
<td>42</td>
</tr>
<tr>
<td>Switzerland</td>
<td>50.7</td>
<td>59.6</td>
</tr>
</tbody>
</table>

* Excluding Aldi, which sells almost exclusively private labels. If Aldi is included, the market share of private labels is 10 points higher.


As shown in Table 3, penetration of PLs has increased in recent years in almost all categories.

Table 3: Penetration of PLs by product category in France (%)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Groceries</td>
<td>21.8</td>
<td>21.1</td>
<td>19.9</td>
<td>18.7</td>
<td>117</td>
</tr>
<tr>
<td>Drinks</td>
<td>19.9</td>
<td>19.1</td>
<td>18.9</td>
<td>18.6</td>
<td>107</td>
</tr>
<tr>
<td>Cleaning products</td>
<td>24.8</td>
<td>22.9</td>
<td>20.7</td>
<td>20.0</td>
<td>124</td>
</tr>
<tr>
<td>Health and beauty products</td>
<td>7.3</td>
<td>7.1</td>
<td>6.6</td>
<td>5.9</td>
<td>124</td>
</tr>
<tr>
<td>Frozen products</td>
<td>33.8</td>
<td>31.7</td>
<td>29.7</td>
<td>29.0</td>
<td>117</td>
</tr>
<tr>
<td>Tobacco products</td>
<td>32.9</td>
<td>33.3</td>
<td>28.9</td>
<td>28.6</td>
<td>115</td>
</tr>
<tr>
<td>Dairy products</td>
<td>26.4</td>
<td>26.1</td>
<td>25.7</td>
<td>24.2</td>
<td>109</td>
</tr>
<tr>
<td>Cheese</td>
<td>21.5</td>
<td>20.0</td>
<td>19.4</td>
<td>18.8</td>
<td>114</td>
</tr>
<tr>
<td>Cooked pork meats</td>
<td>37.7</td>
<td>35.2</td>
<td>32.5</td>
<td>24.2</td>
<td>156</td>
</tr>
<tr>
<td>Delicatessen</td>
<td>26.4</td>
<td>23.1</td>
<td>19.2</td>
<td>17.2</td>
<td>153</td>
</tr>
</tbody>
</table>

Source: Linéaires (www.lineaires.com).

According to PLMA, manufacturers of PL products can be classified in three general categories:

- Large-scale manufacturers who produce both their own brands and PL products;
- Medium and small manufacturers who specialise in particular product lines and concentrate almost exclusively on producing PLs;
- Major retailers and wholesalers who operate their own manufacturing plants and provide PL products for their own stores.
In the French dairy sector for example, examples can be found in each of the above categories. Thus almost all large dairy firms produce both their own brands and PLs (Besnier, Bongrain, Nestlé, SODIAAL, Entremont). Medium and small manufacturers have been specialising (at least for some years), in PL production (for example, Senoble, which began with PL production, has now developed its own brand). Finally at least one retailer has its own production line for dairy products (Intermarché owns a production unit in St Père, France).

1.2 Factors that favour the introduction and the development of private labels

We have shown that PL penetration varies across products as well as across retailers. Several researchers have tried to explain why this is the case. Raju, Sethuraman and Dhar (1995) showed that the introduction of PLs is more likely when the product market consists of a large number of national brands (hereafter NB). They also found a positive impact (on the probability of the introduction of PLs) on the amount of sales in the category. In a recent study, Scott-Morton and Zettelmeyer (2000) showed that the introduction of PLs is more likely when the leading NB has a large market share. Their results confirm the positive impact of the total value of category sales. Moreover, their results suggest that the advertising / total sales ratio has a positive impact on the probability of the introduction of private labels. Finally, they found that a large number of producers also favour the introduction of PLs. However, since they controlled for the market share of the leader, this may be the consequence of a greater ability on the part of the retailer to find a firm able to produce his PL.

In a study on the market share of PLs in the U.S. for 34 categories of products in 106 different locations, Dhar and Hoch (1997) showed that 40% of the variance of their sample (variance of the market share of PLs across products, retailers and locations) was explained by differences across categories of products, and that 17% of variance originated from retailers. This study (Dhar and Hoch, 1997, p; 211), showed the main factors that favour a large market share for private labels were the following:

- High quality relative to the NB.
- Low variability of quality of PLs.
- High product category sales (this finding is not confirmed by other studies; Raju and al. (1995) did not find a significant impact of this variable on the market share of PLs).
- High gross margins (in %)
- A small number of national manufacturers operating in the category (this result is the same as that of Raju and al. (1995), who showed that the market share of a PL increases when the number of NB decreases).
- Low national advertising expenditures

The six above factors explained 70% of the variance of the market share of PLs in a sample of 185 products.
The main factors that influence the market share of PLs sold by a given retailer are the following:

- The number of NBs actually sold by the retailer has a negative impact. The lower the number of NBs, the larger the market share of the PLs. This could be due to the competition between products in a context of fixed retail capacity. The larger the number of products (on a specific market), the lower the market share of each ‘variety’.

- The heterogeneity of the market share of NBs (for each retailer) has a positive impact. This could be due to prices. A heterogeneous market share among NBs could be linked to higher prices which would facilitate the penetration of PLs.

- Promotions on PLs and the differences in price between PLs and NBs have a positive impact. Conversely, promotions on NBs have a negative impact even if the impact is lower than that of promotions on PLs.

- Overall strategy of retailers (for example: commitment to quality, use of own name for a PL, a premium brand offering) has a positive impact.

- Wealthier consumers buy fewer PLs.

Finally, according to a survey by LSA/Fournier, the main reasons retailers develop PLs are to increase customer loyalty (16%), to improve their positioning (18%), to improve margins (25%), and to lower prices (33%). These motives are related to two main economic effects i.e. competition between retailers and vertical coordination between producers and retailers.

In the first case, PLs are viewed as an additional way of enabling consumers to differentiate between retailers. Since PLs are specific to each retailer, the supply of products will no longer be identical. In the food sector, where exclusive sales agreements are infrequent, in the absence of PLs, retailers often sell the same products. From this point of view, retailers are consequently not differentiated (although they are obviously differentiated for other reasons such as location, services, etc). As PLs are specific to each retailer, their introduction thus enhances differentiation between retailers. And finally, this is also a way to lessen price competition.

In the second case, by introducing a PL, a retailer becomes a competitor of his supplier. Thus, the retailer reinforces his bargaining position with regard to his supplier.

These two elements are not independent because the level of competition in the final market strongly influences profit sharing within vertical structures. According to Steiner (1985), the relative power between producers and retailers is directly linked to the loyalty of consumers for brands or stores: ‘If consumers are more disposed to switch brands within store than stores within brand, retailers dominate manufacturers. Retail margins will be relatively high and those of manufacturers relatively low. When consumers are more disposed to switch stores within brand than brands within store, the above market power and margin are reversed.’ (Steiner, 1985, 157-158). Consequently the development of a label that incites consumers not to change stores to find their ‘preferred’ product elsewhere can reinforce the bargaining power of retailers.
2. Why should retailers sell private labels?

Even if the intensity of downstream competition is not independent of upstream bargaining power, the majority of economic studies have mainly focused on bargaining power with regard to upstream firms.

2.1. Private Labels increase retailers’ bargaining power

Many of the theoretical models that analyse the development of PLs have mainly focused on the impact of PLs in a vertical structure. Generally speaking, PL products are a tool for retailers to discriminate demand (by supplying a new product) and to enhance their share of profits on the vertical structure. We will see that these two are opposing forces and that the resulting choice of PL characteristics is a compromise between these two objectives.

The usual framework is a vertical structure composed of a manufacturer and a retailer, both being in a position of monopoly. The manufacturer makes a high-quality good at a constant marginal cost. He sells this good to the retailer at a wholesale price \( w \) (we assume linear tariff contracts for the moment).

Excluding distribution costs (in order to keep the analysis simple) the retailer sells this good to consumers at a price \( p \).\(^7\) Within this framework, the consumer price results from a double-marginalization process. Indeed, every firm prices above its marginal cost in order to benefit from its market power. This situation, though profitable for each firm, is detrimental for the social welfare. If the retailer supplies a new product that competes with an existing one, the retailer’s profit can increase to the detriment of the manufacturer’s and this can lead to a reduction in the double-marginalization effect. The competition due to the new sold good limits the market power of the manufacturer, who consequently lowers his wholesale price and this leads to a decrease in the double-marginalization. Unless the supply cost of the PL is too high, the consumer’s surplus rises due to the decrease in double-marginalization.

In the economic reports on private labels, the new good introduced by the retailer is assumed to be of lower quality than the existing one. This is mostly true as it seems that consumers generally perceive private labels as being of lower quality, or at least no higher than the manufacturers’ brands.\(^8\) In a survey carried out for INSEE (French National Statistical Institute), Chardon and Dumartin (1998) show that consumers who frequently buy PLs consider the quality-price ratio as being the main advantage of these products.

Reports in the literature also assume that the PL is bought by the retailer at its marginal production cost. This may be the case when the PL is produced by a competitive fringe composed of small firms, which is quite frequent in the food industry due to the relative absence of barriers to entry. It may also
be the case when the production firm is vertically integrated with the retailer and the internal wholesale price is thus the marginal cost.

Assuming this to be the case, an upstream manufacturer proposes a wholesale price for a NB. The retailer can then choose whether he will sell the NB or not, as well as whether he will sell the PL or not. Finally, the retailer sets the consumers’ price(s) for the NB and/or the PL. The manufacturer can react in three ways with respect to the wholesale price of the NB:

- Propose a monopoly wholesale price, just as if there were no PL;
- Propose a wholesale price sufficiently low in order to deter the retailer from introducing the PL;
- Propose a wholesale price taking into account the presence of the PL (the manufacturer accommodates the entry).

Two opposite hypotheses relative to PL production cost have been reported in the literature. They do not lead to exactly the same conclusions. Mills (1995) analysed the case where the production variable costs for the PL and the NB are the same. The production costs of the two goods only differ in the fixed costs. This can be interpreted as advertising expenses: NBs are (subjectively) considered by consumers as high-quality goods because they are extensively advertised. Advertising expenses are independent of volume sales and can therefore be considered as fixed costs. Conversely, the objective characteristics of the two goods are identical, but the qualities perceived by consumers are not: this is usually referred as subjective quality.

Based on such assumptions, Mills showed that:

- If PL quality is too low (relative to the quality of the NB), the retailer does not introduce the PL because it is considered as a too low quality substitute for the NB product. The NB manufacturer remains in a position of monopoly and sets the wholesale price to the same level as the monopoly wholesale price.
- When the PL quality is above a certain threshold, the retailer facing a monopoly wholesale price might introduce his PL. The NB manufacturer then has an incentive to lower his wholesale price in order to deter the retailer from selling his PL. The manufacturer thus sets a limit wholesale price. The threat of a PL consequently leads to a decrease in the NB wholesale price. The higher the quality of the PL with respect to the NB, the greater the decrease.
- Finally, above a specific quality threshold, PL quality is too high for the NB manufacturer to deter its introduction. The NB manufacturer consequently finds it profitable to set a wholesale price that accommodates the entry of the PL. Both products are thus sold on the market. The higher the quality of the PL, the lower the NB wholesale price. When the
perceived qualities are identical, the NB wholesale price is set to marginal cost and the upstream manufacturer makes zero profit.\textsuperscript{9}

The most important result is that the threat of a PL entry or its actual introduction leads to a decrease in the NB wholesale price. This decrease increases with an increase in PL quality. The vertical structure’s profits increase (due to the decrease in the double-marginalization effect) and the retailer’s profits increase more than the manufacturer’s profit decreases.\textsuperscript{10} Consumers also benefit from the supply of the PL (or from the threat of supplying a PL) since the final price of the NB decreases and market coverage increases.

Taking into account fixed costs does not allow any systematic conclusions to be drawn about the benefit to social welfare of the introduction of a PL. However, as long as the fixed costs are low, social welfare is improved by the sale of a PL.

Contrary to Mills (1995) who assumed that marginal costs were identical for both products, Bontems, Monier and Réquillart (1999) supposed that PL and NB differ in their production marginal costs (marginal production costs?). In their model, the production marginal cost increases with quality. The mechanisms at play remain the same (double marginalization), but the results are different.

Indeed, if the PL possesses a cost-disadvantage (at identical quality, manufacturing the PL is more costly than the NB), thus:

- If the PL quality is low, the NB manufacturer cannot impede the entry of the competing product at a low cost. The retailer therefore sells both products. The price of the NB first decreases as a reaction to PL quality, then, under some conditions, it can increase. Indeed, the higher the PL quality, the more competitive the PL is with respect to the NB. This leads to a decrease in the NB wholesale price. However, the increase in PL quality induces a cost increase which goes in the opposite direction. The resulting summed effect can be an increase in the price of the NB. In this case, it should be noted that the NB will disappear from the store if the cost of the PL is low enough and when the consumers’ willingness to pay for quality is low (the NB quality was too high).

- For intermediate values of PL quality, the NB manufacturer sets a limit wholesale price and deters sales of the PL. In this case, the NB price increases with PL quality. The increasing cost of the PL makes the limit price strategy easier. Above a certain quality threshold, the NB recovers its natural monopoly position because the PL is not competitive. The NB manufacturer fixes a monopoly price and the retailer only sells the NB in his store.

When the NB has no cost-advantage (this means at the same quality, the cost of the PL is the same as that of the NB), the PL is always introduced and the NB final price decreases as a function of PL quality. The actual introduction of a PL (or the threat of introduction) improves social welfare because it lessens or avoids the double-marginalization problem.
This model, which also relies on the assumption of linear tariffs between the manufacturer and the retailer, emphasizes the importance of the role played by the cost structure of the production process in the decision to introduce a PL introduction. One conclusion is however that the development of PLs is beneficial for social welfare.

The two models presented so far also conclude that the introduction of PLs (or the threat of introduction) leads to an increase in the retailer’s bargaining power with respect to the sharing of the vertical structure profits.

Caprice (2000, Chapter 2) also pointed to the increase in the retailer’s bargaining power. Using a two-part tariff between an upstream manufacturer and a retailer (the double marginalization effect vanishes because of the two-part tariff contract: the upstream firm sells at the marginal cost and the franchise fee splits the surplus). He showed that the fact that the possibility exists for a retailer to sell a PL enables him to make a higher profit. In this model, because the retailer assumes the upstream firm will make a take-it or leave-it offer, his profit is defined by his reservation profit. Without a PL, the retailer makes zero profit. If the retailer has the opportunity to sell a PL, this creates a reservation profit and the upstream manufacturer is consequently obliged to leave a rent for the retailer. The amount of this rent is equal to the profit the retailer would make by selling his PL only (i.e. his new reservation profit). The retailer thus increases his bargaining power by increasing the profit he can get in case of a disagreement with the upstream manufacturer.

Some empirical studies (see below) tend to prove that the PL invasion has resulted in an increase in NB prices in some sectors. The models presented so far do not explain such a phenomenon and rely on a Mussa-Rosen formatted demand where goods are assumed to be vertically differentiated. It is clear that the price reaction of the NB depends on the form of the final demand. Some researchers consequently tried to develop models where the increase in NB prices happens after the introduction of PLs, at least in some cases. Gabrielsen and Sørgard (2000) analysed the impact of the introduction of a PL in a vertical structure where contracts are in linear prices. The form the demand takes, which influences the final result, depends on the distinction between two kinds of consumers. Some consumers are loyal to the NB, and as long as the NB product is sold under a certain reservation price (identical for all these consumers), they will only buy the NB. The NB demand is thus inelastic. A second group of consumers is opportunist. They are characterized by a positive switching cost distributed as a function of density. They buy the NB as long as its price is not too high compared to the PL (when the PL is sold). In addition, when they buy a good, the reservation utility is not the same for all consumers. The demand for the PL is thus price-elastic. As a consequence, when only the NB is available, demand for it will increase with a decrease in the NB price. When the relative number of
loyal consumers varies, the authors show that the introduction of PLs can have different effects on NB prices:

- When the number of loyal consumers is low, the final and wholesale prices of the NB decrease. The PL is not introduced by the retailer. The upstream manufacturer consequently only needs a limit price strategy to deter the introduction of the PL. This strategy forces him to lower his wholesale price in order to leave the retailer enough profit from selling only the NB.

- When the number of loyal consumers increases, this limit price policy becomes too costly. The wholesale and final price of the NB increase in response to the actual introduction of the PL. The NB manufacturer then only focuses on loyal consumers. As their demand is inelastic, wholesale price and final price are equal to their willingness to pay for the NB.

- Finally, when the number of loyal consumers is very high, introduction of the PL has no impact on the NB price. Indeed, before the introduction of the PL, only loyal consumers were supplied. The wholesale and retail prices were already equal to the loyal consumers’ willingness to pay.

Such results are in contradiction with the previous models presented, but the results rely on a very particular demand form from two different groups of consumers. Some (we refer to customers) are identical and have infinite switching cost for the PL. Others, on the contrary, have switching costs distributed across a specific law of probability, and their willingness to pay varies. The results are directly due to this dichotomy. However the Gabrielsen and Sorgard’s study shows that the form of the final demand is a key factor in forecasting the impact of the introduction PLs on NB prices.

The main economic effects due to the actual introduction of a PL are summarized in Table 6. The introduction of the PL always increases the retailer’s profit (otherwise he would not sell it) and decreases the NB manufacturer’s profit (except in cases where the profit remains constant). Regarding profit sharing in the vertical structure, the retailer is able to increase his share. The vertical structure surplus increases for two reasons: first, because the double-marginalization effect is less severe (as in Mills and Bontems et al.) and second, because of the demand discrimination the PL provides (all models). Consumers also benefit from the introduction of PLs for the same reasons (weakened double-marginalization and increased variety).
Table 6. Economic effects of the actual introduction of a PL.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Authors</th>
<th>Mills</th>
<th>BMR</th>
<th>Caprice</th>
<th>Gabrielsen and Sørgard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>NB wholesale price</td>
<td>-</td>
<td>-</td>
<td>=</td>
<td>+</td>
<td>=</td>
</tr>
<tr>
<td>Manufacturer’s fixed fee</td>
<td>nr</td>
<td>nr</td>
<td>-</td>
<td>nr</td>
<td>nr</td>
</tr>
<tr>
<td>retail price of NB</td>
<td>-</td>
<td>-</td>
<td>=</td>
<td>+</td>
<td>=</td>
</tr>
<tr>
<td>manufacturer’s profit on NB</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>=</td>
</tr>
<tr>
<td>Retailer’s profit</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Vertical structure’s profit</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Consumers’ surplus</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

BMR: Bontems, Monier and Réquillart (1999)

Nr: not relevant in this model
A: Proportion of loyal customers neither too low neither too high
B: Proportion of loyal consumers high

Thus, retailers use PLs to increase their bargaining power. It should be stressed that whether or not the PL is actually introduced does not modify alter this result. The absence of PLs in certain sectors does not necessarily mean that the retailer has not used the threat of developing PL in order to increase his profits.

2.2. How do retailers choose the characteristics of private labels?

Up to now we have considered PLs as new products whose quality is lower than national brands and which are purchased at marginal cost by retailers. Under this assumption, PLs appear to be very similar to low quality products sold by small brands or brands that are not widely known. However, an essential feature of PLs is that their characteristics are fixed by retailers and not by manufacturers. Moreover, these decisions are taken strategically to enable the retailer to increase his profits. In the models presented above, this choice is driven by trading off price discrimination of final demand and willingness to increase the retailer’s bargaining power in the channel.

For instance, when marginal cost increases with quality, Bontems et al. showed that the quality of the low quality product depends on the market structure and the identity of the player who makes the
decision. The following five situations are classified as a function of an increasing level of quality for a low quality product:

1. Upstream multi-product monopoly that chooses quality.
2. Upstream duopoly where one firm chooses low quality.
3. Integrated vertical structure.
4. Upstream high quality monopoly with a competitive fringe producing low quality which is chosen by the retailer.
5. Upstream duopoly, where the retailer chooses low quality.

Thus, given the same upstream market structure (first compare cases 1 and 4, and second cases 2 and 5), it appears that the retailer chooses higher quality for a low quality product than any upstream firm would chose. This is easily understood when considering the trade-off between price discrimination and the decrease in wholesale price for branded products. Price discrimination of the final demand allows a sufficient degree of product differentiation between both goods to be maintained, whereas the biggest decrease in wholesale price is obtained when product differentiation is low. Thus, the choice by the retailer of PL characteristics takes into account these two opposing effects. Conversely, upstream producers will only consider price discrimination when choosing quality. To sum up, the retailer gains by choosing a low quality product that is close to the branded product.

Caprice (2000) has also studied the optimal private label quality when two-part tariffs are allowed. In section 2.1, we showed that selling private labels enables the retailer to capture a bigger share of the channel’s profit. Thus the possibility of commitment by the upstream producer is crucial for the choice of the level of quality of the PL by the retailer.

If the producer can commit to a contract before the level of quality is chosen by the retailer, then the latter chooses the optimal quality level from the channel’s point of view. Indeed, two-part tariffs allow the parties to exchange the goods at marginal cost and this gives the right incentives to the retailer to maximize joint profit when considering quality choice.

On the other hand, if quality choice is irreversible or if the upstream producer cannot commit to a contract before the retailer’s choice of quality, then the retailer does not maximize joint profit and chooses higher quality. Indeed in this case, the retailer chooses the level of quality that will maximise disagreement payoff, which is obtained when the producer’s product is not sold.

Note that in this model, for the retailer there is clearly no difference between the two situations, because his profit is always equal to his reservation profit, which is the profit he would obtain when selling only PLs. However, the upstream producer strictly prefers to commit to a contract before the retailer chooses low quality, because then the degree of product differentiation is the optimal one from the point of view of the channel’s joint profit.

According to these models, the retailers would strategically choose higher quality for PLs than that that would be chosen by manufacturers. This result seems to be consistent with the marked
development of ‘me too’ products that are replicates of NB products. In a recent study, Hoch and Raju (2002) showed that when PLs are targeted towards NB products, this concerns primarily the strongest NB products.

Scott Morton and Zettelmeyer (2000) consider a model where a monopolist retailer bargains with several upstream producers. One of the manufacturers offers to sell a leading NB product. The retailer has a limited capacity to sell multi-products and can only offer two products on the shelf. The choice is whether to distribute either a second NB produced by a second manufacturer or a PL. The channel’s profit is divided between producers and the retailer. Each producer earns a given share of the incremental profit, that is proportional to his bargaining power. The incremental profit is determined by comparing the channel’s profit when the two products are on the shelf and the profit when only the competing product is sold.

Let us assume that three producers, including the PL manufacturer, compete on the market and have identical bargaining power. Available goods are differentiated along two attributes, one corresponding to vertical differentiation and the other to horizontal differentiation. Thus, branded products are assumed to be of higher (exogenous) quality than the PL. Moreover, the horizontal characteristic of PLs may be set in order to meet consumers’ requirements, which can be of two types. A private label designed for market segment 1 will procure less utility for type 2 consumers than type 1 consumers. Assuming that the leading brand is designed for type 1 consumers; the problem for the retailer is to decide whether to sell a second NB, designed for type 2 consumers, or to sell a PL whose horizontal characteristic has to be chosen. The authors showed in this framework that the introduction of a PL always diminishes the joint profit of the channel, compared to selling the second national brand. But selling a PL also leads to a decrease in the incremental contribution to profits of the leading brand. This enables the retailer to capture an increasing share of the total surplus. Overall the retailer’s choice is driven by his bargaining power. When his bargaining power is low, the retailer strictly prefers to sell a PL and conversely, when his bargaining power is high, a second national brand is chosen instead. Indeed, with an increase in his bargaining power, the retailer pays more attention to total surplus. The authors also showed that if introduced, the second NB would be designed for type 2 consumers (in order to lessen competition with the leading brand). Conversely, the PL would be introduced on the same segment as the leading brand because its main purpose is to decrease the incremental gain of the leading brand.

Once again, it appears that product positioning depends to a large extent on whether it is decided by upstream producers or by retailers. While manufacturers and retailers may both have an interest in price discrimination of the final demand, product positioning by retailers through the design of PLs allows them to capture a bigger share of the channel’s surplus. As a consequence, this model shows that PLs will compete more aggressively with a leading brand than would other NBs.
One important feature of Scott-Morton and Zettelmeyer’s analysis is to explicitly introduce a bargaining procedure in vertical contracting in the channel. However, the modelling of final demand could be improved in order to test the robustness of their conclusions. Moreover, the assumption of equal bargaining power for all the upstream producers should be removed in order to better represent asymmetric situations.

3. Empirical analysis of the development of private labels

Empirical studies dealing with the impact of the development of PLs can be classified according to the type of data used:

- Analysis based on cross-section data
- Analysis based on time-series data

The first group of empirical analyses (Putsis, 1997; Cotterill, Putsis and Dhar, 2000) on the impact of the development of PLs used cross-section data relating to many different food products and many local markets. The authors showed that price reaction functions have positive slopes. A decrease in the NB (PL) price is accompanied by a decrease in the PL (NB) price. According to Putsis (1997), these price function reactions are asymmetric. The PL price would react more to a variation in NB price than the NB price to a change in PL price. However, Cotterill, Putsis and Dhar (2000) did not confirm these results on asymmetric price reaction functions.

Putsis’s results suggest that a larger PL market share is correlated with a decrease in the NB price and an increase in the PL price. This negative relation between the PL market share and the difference in price between the NB and the PL is rather counter-intuitive. However, if the competition between the NB and the PL is strongly influenced by the quality of both goods, this could be the result of the role of this unobserved characteristic (Mills, 1995). A larger PL market share would result from a higher level of PL quality (compared with NB quality). In table 7, we show the impact of an increase in PL quality on price and surpluses according to the two models previously described.

When PL quality increases, the NB price decreases because of the decrease in differentiation between the two products. Moreover the PL price increases in response to the increase in consumer utility (in the vertical differentiation model, the utility of every consumer increases with the quality of product). Finally, the NB market share decreases because the decrease in NB price does not compensate for the negative impact on demand for an increase in PL quality. Thus, in a cross-section analysis, the PL market share is larger when the difference between NB and PL prices is smaller, because a limited difference in price is associated with a small difference in quality between the NB and PL products.

Moreover, according to Mills and ‘BMR’ models, the retailer’s margin for PL is greater than the margin for NB. This prediction is in accordance with empirical facts.
Table 7: Impact of an increase in PL quality

<table>
<thead>
<tr>
<th></th>
<th>Mills</th>
<th></th>
<th>BMR</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Wholesale price of NB</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Retail price of NB</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Market share of NB (%)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Retail price of PL</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Market share of PL(%)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Average PL NB price</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>NB producer’s profit</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Retailer’s profit</td>
<td>+</td>
<td>+ then -</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Vertical structure profit</td>
<td>+</td>
<td>+ then -</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Consumers’ surplus</td>
<td>+</td>
<td>+ then -</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

A: low level of heterogeneity between consumers
B: high level of heterogeneity between consumers

A second group of empirical analyses (Ward, Shimshack, Perloff et Harris, 2002; Gabrielsen, Steen et Sorgard, 2002) used time-series data, thus eliminating the effects of structure. Ward et al. studied the impact of the development of PL in the US. They used monthly data on prices, market shares, and advertising expenses for 34 product categories. For each category, they analysed how NBs react to the development of PLs. They showed that an increase in the PL market share is accompanied by:

- An increase in the price of NBs (or no impact)
- A decrease in the price of PLs (or no impact)
- A negative impact or no impact on average prices
- A decrease in advertising activity for NBs

Gabrielsen, Steen and Sorgard (2002) studied the impact of the introduction of PLs in Norway. They used weekly data on the prices and market shares of 83 products. For each product, they studied changes in NB prices over time and distinguished the period before the entry of PLs from the period after entry. When the impact of the introduction of PLs is significant (17 cases and 83 products) the impact is positive (15 cases). Thus, the introduction of PL induces an increase in NB prices. The increase in NB prices is larger when the PL market share is small. Finally their results suggest that the increase in NB prices is larger for leading and nationally distributed brands.
Finally, some empirical analyses deal with the interactions between manufacturers and retailers and the measurement of profit-sharing in vertical structures. Thus Kadialy, Chintagunta and Vilcassim (2000) studied the share of profits between manufacturers and retailers on fruit juice and tuna markets in the US. They used a model based on conjectural variations. According to their results, manufacturers who produce high quality products (or perceived as such by consumers) gain a larger share of the profit of their vertical structure than other manufacturers. However, these estimates are based on wholesale and retail prices and do not take fixed fees into account. Chintagunta, Bonfrer and Song (2001), using data on sales from different stores of a large supermarket chain, studied the impact of the introduction of PLs in the breakfast oats market. They showed that the introduction of PLs generates a decrease in the price of the leading NB, a decrease in promotion activities of the NB and no change in the margin the retailer earns on the NB.

4. Less frequently analysed topics

We have just shown that empirical findings do not systematically support the theoretical mechanisms involved in the previous models. An inadequate treatment of product quality in the analysis could explain some gaps. The divergences could also originate in other mechanisms that were not integrated in the previous models. We discuss some of these in the following section.

4.1. Private labels, capacity constraints and competition between retailers

According to Allain and Flochel (2000) restricting the supply of shelf space (as done by the Raffarin law in France) could slow down the development of PLs. This result is obtained with a model similar to the one developed by Bontems, Monier and Réquillart. In such a framework, restricting the availability of shelf space favours NBs to the detriment of PLs because absolute margins at the retail level are larger on NBs than PLs. However, Allain and Flochel (2000) also showed that the restriction of shelf space is detrimental to upstream producers because it induces an overall decrease in the quantity of NBs sold by the retailer (this is due to the increase in price). The latter result is true only if the downstream structure does not change. With free-entry at the retail level, restriction of shelf space per retailer is not incompatible with an increase in the profit of upstream firms. Thus, the negative impact on profits of restrictions on shelf space is now lower due to the entry of new retailers. The positive impact on profit of a price increase now outweighs the negative impact of the decrease in sales.

Generally, studies on the development of PLs consider a downstream monopoly. This allows the analysis to focus on strategic interactions within a vertical structure (i.e. between retailers and producers). However, such a framework neglects interactions between retailers. Caprice (2000)
investigated the strategic choice of a producer with respect to two retailers who are considering developing their own PL. He showed that for a given quality gap between a NB and a PL, the strategic choice of the upstream producer depends on the difference in production costs between the NB and the PL. When the upstream producer has only a small cost advantage (w.r.t. the producer of PL) then the NB is not sold by retailers. When the cost advantage increases, then it is better for the NB producer to offer his product to only one retailer. Finally, if the cost advantage is big enough, the producer sells his products to both retailers. The optimal choice of the upstream producer results from a trade-off between the size of his share of the cake (the share is bigger when his product is distributed by the two retailers) and the size of the cake to share (competition between retailers decrease the overall surplus).18

4.2. Can the Private Labels be profitable to National Brand manufacturers?

As the PLs compete directly with the NB products, a priori, NB manufacturers loose profits when a retailer introduces a new PL. However it is more complicated that it seems. Private labels do indeed compete with NBs on the product market, but the question of PL production and its associated profits remains. From this point of view, NB manufacturers may find it profitable to manufacture the PL for the retailer.

One argument given by the leading NB manufacturers about producing PLs is that the production of such a good allows them to use excess production capacity. They will in fact produce a good that will compete with their own, but if they refuse to produce it, others will do so. The extra revenues from the production of the PL will then go to other firms, whoever these may be: big competing manufacturers or small companies.

This reasoning nevertheless has the following caveat: it implicitly assumes that firms that may be chosen to manufacture the PL are able to make a product whose characteristics are close to those of the NB. If this is not the case, a leading NB manufacturer may see no advantage in producing the PL because there is no credible alternative for the retailer to find a “serious” competitor. Coca-Cola falls into this category: its brand is so well known that no competing PL is a threat. Consequently Coca-Cola does not manufacture PLs.

When a close alternative NB to the PL exists, the manufacturer may find it profitable to produce its own competing good. But in fact it is the retailer who chooses who will produce his PL.

When taking the decision about who is going to produce his PL, the retailer trades-off between gains in efficiency and shares in rents. On the one hand, if the manufacturer of the NB also manufactures the PL, he may pay some costs such as packaging costs, or he may help the retailer in the definition of the
PL manufacturing process and characteristics. This will allow the NB manufacturer to offer a good at a lower cost than an isolated firm from the competitive fringe could. On the other hand, by having his PL produced by the manufacturer of the equivalent NB, the retailer entrusts both the goods and his profits to the same agent, i.e. the manufacturer of the NB. This will have some implications for the NB tariff proposed by the upstream manufacturer.

As shown in Bergès-Sennou (2002), when the retailer’s bargaining power is low, he will prefer to entrust the production of his PL to an independent firm, because if the retailer entrusts his PL to the NB manufacturer, he has also to share the profits from the PL with the NB manufacturer. But if the retailer’s bargaining power is limited, then he will get less of the profit from the PL in the negotiation than he would if the PL were produced by an independent firm. The second result is that the higher consumer loyalty to the NB, the more likely the PL is to be entrusted to the NB manufacturer. High consumer loyalty to the NB means that the PL is really not a credible alternative to the NB. In this case the retailer finds it more profitable to only benefit from the cost-advantage of the NB manufacturer. The model also predicts that the merger of buying units belonging to different retailers favours isolated firms for PL production.

5. Concluding remarks

Most of the models agree on the positive impact on welfare of the development of PLs in the short term. In these models, PLs are frequently considered as additional goods that allow the retailer to increase his profit to the detriment of the upstream producer, either by decreasing the wholesale price or by capturing a larger share of the surplus of the industry. In these models, consumers benefit from the increase in the number of goods available and from the positive impact of the reduction in double marginalization. In practice in the shop, a PL generally replaces another product, for example a regional brand. In this case the positive impact linked to the increase in the number of goods available for the consumer in a shop disappears. However we have shown that the strategic choice of product quality by a retailer or a producer is not identical. For a given quality of the NB, the retailer designs a less differentiated good than an upstream producer would. Thus the consumer will benefit from an increase in competition between the two products but could be penalised by the lower degree of differentiation between products. Thus, in a more realistic framework, it is not certain that the introduction and development of PLs lead to an increase in consumer surplus and to an increase in welfare. For example, Caprice (2000), using a framework of non-linear pricing, showed that when the choice of characteristics of the PL is strongly irreversible, the introduction of PL decreases welfare as compared to a case where the characteristics are chosen by the integrated vertical structure.
In a longer term analysis, even if no specific work has been done on this topic, the impact of PL could well be less positive. The argument is the following: the development of PLs leads to a different share of profits within vertical structures. A decrease in the profits of the upstream producers could lead to less innovation and thus reduce the variety of goods available to consumers. This mechanism is reinforced by the strategy of retailers who develop ‘me-too’ products. This strategy is nothing else than free-riding on research and development of new products. This free-riding will discourage the efforts devoted to the development of new products in the long term. Moreover, the development of PLs can modify competition between retailers in the long term. For example, PLs enable greater differentiation between retailers and thus lower price competition among retailers which is detrimental to welfare (for a discussion on long-term effects, see Dobson, 1998).

A lot of questions remain to be answered. While most of the theoretical models agree on a decrease in the price of NBs in response to the development of PLs, some recent empirical works conclude exactly the opposite. If these results are confirmed by other studies (for example, in other countries) it will be vital to develop alternative models in order to explain the mechanisms involved. First, it is important to consider non-linear pricing rather than linear pricing between manufacturers and retailers. Among other reasons, the existence of fixed fees justifies doing so. Second, a PL should be considered as a good which is a substitute for an existing good rather than an additional one. Third, we should take into account that in many cases the manufacturer of the NB is also the producer of the PL. Thus the producer will try to keep his products differentiated in order to better discriminate the demand. Fourth, the impact of PLs on competition between retailers remains an unexplored question.

On the empirical agenda, it is important to extend studies to a larger number of cases in order to confirm or invalidate existing results, for example, to distinguish between different NBs. It is possible that the impact of a PL on the leading NB is different from the impact of a PL on less well-known brands. Finally, taking into account the ‘quality’ of PLs with respect to NBs is important in empirical studies but difficult to achieve due to lack of available information.
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PLMA, [www.plmainternational.com](http://www.plmainternational.com)
F. Bergès-Sennou is a researcher at the University of Toulouse (INRA). P. Bontems and V. Réquillart are researchers at the University of Toulouse (INRA and IDEI). The authors thank Stéphane Caprice as well as participants at the seminar at INRA, Dijon for helpful comments. All errors are ours.

By discount products, we refer to products sold at very low price, generally in specific retail outlets.

By National Brands we refer to brands that are designed by and belong to upstream manufacturers and that are distributed at a national scale.

Thus, according to the results of Raju and al. (1995), the factors that favour the probability of the introduction of a private label and those that favour their development are not identical.

Results are still valid when assuming that the retailer faces a distribution cost.

This may now be less pronounced thanks to the introduction of “High-quality” private labels such as Reflets de France, Saveurs étrangères. Nevertheless the majority of private labels are perceived to be of inferior or equal quality to NB products.

If the PL possesses a cost-advantage over the NB, for high quality values of the PL, only the PL is present on the product market and the NB is not listed any longer (see Allain and Flochel, 2001).

This does not take into account the fixed costs linked with the production of the good (not modelled).

In this framework, the quality of branded products is exogenous and not strategically determined.

With linear pricing, only one instrument (i.e. the quality of the PL) is available both to reduce double marginalisation and to discriminate final demand as a function of quality. Conversely, two-part tariffs allow the franchise fee to be used as a second instrument.

Note that the incomplete nature of the agreements can justify the impossibility for the producer to commit to a contract.

For example, Putsis (1997) analysed competition between PLs and NBs over 135 food products sold in 59 geographical areas in 1991 and 1992. Cotteril, Putsis and Dhar (2000) used data from 125 food products in 54 geographical areas.

According to Cotterill, Putsis and Dhar (2000), these results could originate in an inappropriate econometric treatment that does not deal with the simultaneity of demand and competitive interactions between agents in the market. Using the same kind of data and dealing with the problem of simultaneity, they found a positive link between the PL market share and the difference in price between the NB and the PL.

They estimate a price equation for NB (AR(1) model) which includes a dummy variable indicating if a PL product is present or not. The coefficient of this variable indicates the impact of the existence of PL.

The framework of the analysis assumes two-part tariffs. Thus an increase in competition between retailers generates a decrease in the surplus of the industry as there is now a double marginalisation problem (as shown previously, with linear pricing the decrease in double marginalisation generates an increase in the surplus of the industry).


This latter effect is only relevant in a framework of linear pricing.

In a study on strategic interactions between manufactures and retailers, Villas-Boas (2002) rejects the assumption of linear pricing.
Private Label Entry as a Competitive Force?*

An analysis of price responses in the Norwegian food sector

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June 2001
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Abstract:
According to existing theory, the introduction of a private label has an ambiguous effect on the prices of competing national brands. We undertake an empirical analysis of the effects of private label entry on national brand prices in the Norwegian food sector. We first estimate a set of 83 dynamic price regressions. The results suggest that introduction of a private label typically leads to higher prices on national brands. However, we observe a large heterogeneity in price responses. When we apply a dynamic panel data approach, the same picture emerges. We find heterogeneity with both negative and positive significant price responses. However, we also establish that highly distributed and ranked products are typically more influenced by private label entry than less distributed and ranked products (“weaker” national brands). We also find some support in our data that more successful PL entry – as measured by the PL market share – have typically a larger impact on the national brand prices.

* The authors are particularly grateful to Turid Marie Espeseth for her research assistance and to ACNielsen, Norway, for providing the dataset. We would also like to thank Øyvind Anti Nilsen and seminar participants at ACNielsen, NHH and the University of Bergen for valuable comments and suggestions. This research is partly financed by the Norwegian Research Council through SNF (The Foundation for Research in Economics and Business Administration).
1. Introduction

Retailer-owned brands, often denoted by private labels (or simply store-brands), have had an enormous growth in the last decades in many countries and many product categories (Dobson, 1998; Connor et al., 1996). Most of the academic literature on private labels, a rather new literature, is primarily empirical studies trying to explain the variation in private labels penetration across product categories (e.g. Sethuraman, 1992; Hoch and Banerji, 1993; Dhar and Hoch, 1997). Others are concerned about whether introduction might shift the relative channel power from the national brand manufacturer to the retailer (Chintagunta et al., 2000; Kadiyali et al., 2000; Messinger and Narasimhan, 1995). Although the predominant public opinion seems to be that the growth of private labels have had a pro-competitive effect (see Harris et al., 2000), there are rather few theoretical as well as empirical studies actually investigating the competitive effect from private label introduction. The purpose of this article is to test empirically what effect private label introduction has on the prices of competing national brands in the Norwegian grocery sector.

According to existing theory, private labels have an ambiguous effect on prices on national brands. On the one hand, it is argued that the introduction of a private label may lead to lower retail prices of the competing national brands. The argument is simply that the introduction of a private label would lead to intense price rivalry between the national brand and the private label (see Mills, 1995). On the other hand, if consumers’ demand elasticity is heterogeneous, private label introduction may result in higher retail prices on the national brands. One reason is that the introduction of a private label leads to intense rivalry for the price sensitive consumers. The national brand producer may then give up fighting for the price sensitive consumers and instead concentrate on consumers with low demand elasticity, and then at a higher price than before entry of a private label (see Perloff et al., 1996). Another reason to expect a price increase on national labels following private label introduction is that the private label producer may shift to a higher price to take advantage of the increased channel power vis-à-vis the national brand manufacturer. Yet another reason is that the national brand producer may have to increase prices on national labels to offset the lower retail prices of the private label and maintain profit margins.
introduction is that the national brand producer may initially have met the challenge of private labels by offering the retailer an exclusivity contract. In this contract the retailer is offered a low wholesale price contingent on that no private label is introduced in the relevant product category. However, if the retailer at some point in time refuses such a contract, and introduces a private label, the response from the national brand may be to increase his price (see Gabrielsen and Sørgard, 2000).

As discussed above the theoretical predictions of the price effects of private label introduction are mixed, and so are also the results from the empirical literature. Putsis (1997) analyse the price response from national brands on private label introduction, and finds that private label introduction on average lowers the prices of national brands. Cotterill et al (2000) investigate the effect from private label market coverage (distribution) on the price of the national brand. These authors find that in some product categories an increase in private label market coverage will increase the prices of national brands, while the opposite is true in other product categories. Finally, Harris et al (2000) find that increases in the market share of private labels leads to a rise in the price of national brands in some product categories, whereas the opposite is true in other product categories.

We argue that according to theory it is important to focus on the price effect of the private label introduction. The reason is that private label introduction at a particular point of time may identify a termination of an exclusive dealing relationship with the national brand producer, and may as such be a genuine reason for a price increase on the national brand. We have therefore, in contrast to Cotterill et al (2000) and Harris et al (2000), chosen to focus on the price response from national brands to the introduction of a private label. Putsis (1997) also looks at price responses to private label introduction, but that study reports the average price effect of a private label introduction. According to theory, the price of national brands may increase in some product categories and fall in other product categories. It is therefore
natural to focus on individual product categories. In addition it is of interest to trace any systematic regularities between product categories. In accordance with this, we report the price effect on national brands of individual private label introduction and whether there are some characteristics across product categories that explains why the prices of some national brands go up and others go down.

The dataset is provided by ACNielsen Norway. It consists of 83 private label entries over a period of 4 years. We estimate a set of 83 dynamic price regressions. We find that an introduction of a private label typically leads to higher prices on national brands. However, a large heterogeneity in price responses is observed. A closer examination indicates that the degree of product differentiation and the number of loyal customers might matter for the results. Therefore, we extend the model and apply a dynamic panel data approach using the full dataset. The same picture as before emerges. We find heterogeneity with both negative and positive significant price responses. However, we also establish that highly distributed and ranked products are typically more influenced by private label entry than less distributed and ranked products (“weaker” national brands). We also find some support in our data that more successful PL entry – as measured by the PL market share – have a larger impact on the national brand prices.

One important lesson from our study is that it is too simple to argue that more private label products leads to more intense price rivalry. The main result is that product “strength” matters. That is, the prices of the largest national brand products in terms of ranking or distribution are more influenced by private label entry than number 2 and 3 products, or less distributed products.
2. Theory

Recent theoretical work on private labels include Mills (1995), Narasimhan and Wilcox (1998), Raju et al (1995), Perloff et al (1996) and Gabrielsen and Sørgard (2000). All these authors focus on the effects on wholesale and retail prices on national brands from private label introduction. In Mills (1995) private label introduction is always beneficial for the retailer as national brand producers are forced to price concessions. Private label introduction is also beneficial to society because their introduction alleviates problems due to double marginalization and therefore excessively high consumer prices. Much in the same vein is Narasimhan and Wilcox (1998). In their model some consumers incur switching costs when starting to buy the private label. Again private label introduction triggers a battle over market shares which leads to price concessions from the national brand producer. Due to a rectangular demand assumption, consumer prices are unaffected by private label introduction, but introduction is always beneficial for the retailer due to lower wholesale prices from the national brand producer.

In Raju et al (1995) the main focus is on how the introduction of a private label affects a retailer's profits and which factors determine the private label's market share. Comparative statics concerning how the introduction of a private label affects prices on national brands is not reported. Perloff et al (1996) apply a Hotelling model and find that the introduction of a private label may even increase the price of the national brand. After entry of a private label each producer of a national brand may find it attractive to sell only to the consumers located close to its product in the characteristic space. This may lead to an increase in the price of the national brand, since it before entry sets a low price to attract consumers located far away from its location.

Finally, Gabrielsen and Sørgard (2000) add to the strategy set of national brand producers by allowing them to react to a threat of private label introduction not only by
lowering wholesale prices, but to do so in exchange for national brand exclusivity. This option implies that the mere threat of private label introduction may affect the equilibrium outcome. The model distinguishes between loyal and switching consumers. Loyal consumers never consider buying a private label, switching consumers may switch if the price differential is sufficiently large. When private label entry is feasible, one of three situations may emerge. First, national brand exclusivity (no introduction of a private label) may still arise as an equilibrium outcome. If so, the price of the national brand will go down compared to a situation without private labels (the monopoly outcome). The reason is that the producer of the national brand may lower its exclusive dealing wholesale price so as to make it unattractive for the retailer to introduce a private label. Second, if the private label is introduced the producer of the national brand may increase its wholesale price compared to monopoly and thereby induce an increase in the retail price of the national brand as well. The reason is that the competition for the switching consumers is harsh after private label introduction, and the national brand producer chooses to concentrate on his loyal consumers and increases his price. Third, the private label may be introduced leaving the price of the national brand unaffected. This happens when the national producer serves only the loyal consumers before entry, and thus sets a high wholesale price both before and after the introduction of a private label.

In addition to these theories there are also more general theories that can explain why national brand producer may respond to private label introduction by increasing their prices. One strategy that national brand producers may use when faced with private label entry is to increase the quality of the goods they produce, or alternatively intensify advertising. These strategies will increase costs and may also increase brand loyalty, which both will tend to increase prices. Second, Salop (1977) have shown that a firm can be better able to exploit ignorant consumers by increasing consumer uncertainty. A national brand producer can
create noise by selling the same product under different labels (brand proliferation). It is well known that many national brand producers also supply a virtually identical product to grocery stores under a private label. Provided that the cost of brand proliferation is small it may be profitable to sell the branded product at a high price and the private label at a low price compared to selling only the branded product at an intermediate price.

3. Empirical predictions

It should be clear from the previous sections that the predictions on how prices on national brands respond to private label introduction are ambiguous. If private label introduction alleviates problems due to double marginalisation on branded products, we should expect lower prices on national brands. However, two other effects may overturn this effect. First, if the national and private labels are differentiated one might observe a price increase or no price change at all. Second, if a brand has loyal consumers in the sense that these consumers will never consider purchasing the private label, the number of loyal consumers may be important. The more loyal customers, the more likely one is to observe price increases on national brand. For more homogenous products with few loyal consumers a price increase is less likely, and with few loyal consumers prices on national brands might depreciate after entry of a private label (henceforth PL entry). Finally, we do expect that the price change of the national brand is more significant in product categories where the private label has a high market share than in product categories where it has a limited market share. The intuition is simply that a large market share by the private label triggers a large price response by the national brand.

The discussion can be summarised in three central predictions:

**Prediction 1:** We expect price increases in some product categories, and price reduction in others after PL entry. Heterogeneity should be present.
Prediction 2: “Strong” national brands should on average increase their prices more often than “weak” products after PL entry.

Prediction 3: If PL entry is successful in terms of market shares, we expect a larger impact on the national brand price than when PL entry is less successful.

Note, though, that we should be careful with the last prediction. This prediction does not follow directly from the models discussed above. In particular, also alternative interpretations apply. For instance, a private label with a large market share has a large impact on a national brand price, suggesting a causality from private label market share to the price of national brands. However, we could have the opposite causality. A large price increase on the national brand can result in a large market share for the private label. Moreover, we could have a substantial price reduction on a national brand to prevent a private label from capturing a large market share. If so, we could observe that a significant price reduction on the private label in a product category where the private label did not succeed. That would not be in line with prediction 3.

4. The market in question

We analyse the Norwegian food market. During the last ten years we have seen a structural change at the retail level, where four large chains; “Hakon gruppen (HG)”, “Reitan gruppen (RG)”, “Forbukersamvirket (FS)” and “Norges gruppen (NG)” have increased from representing less than 50% of the market to nearly 100%. Table 1 shows the development in market shares in the Norwegian food sector.

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1 FS was renamed in October 2000, and its name is now CooP.
However, most of the takeovers and mergers took place before 1995. The last five years the chains have had relatively stable market shares. We use a data set from ACNielsen Norway. The dataset is a weekly panel with 197 weeks of information on prices, market shares, distribution on both private labels and national brands for the period January 1997 to October 2000. The dataset is described in more detail in Appendix A.

Table 1: The development in market shares of the Norwegian food chains.

<table>
<thead>
<tr>
<th>År</th>
<th>HG</th>
<th>RG</th>
<th>FS</th>
<th>NG</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>10.2</td>
<td>5.7</td>
<td>22.8</td>
<td>7.1</td>
<td>54.2</td>
</tr>
<tr>
<td>1992</td>
<td>16.8</td>
<td>11.0</td>
<td>23.0</td>
<td>16.5</td>
<td>32.7</td>
</tr>
<tr>
<td>1994</td>
<td>24.0</td>
<td>11.3</td>
<td>24.4</td>
<td>37.1</td>
<td>3.2</td>
</tr>
<tr>
<td>1995</td>
<td>27.7</td>
<td>11.8</td>
<td>24.9</td>
<td>32.7</td>
<td>2.9</td>
</tr>
<tr>
<td>1996</td>
<td>28.6</td>
<td>11.8</td>
<td>25.2</td>
<td>32.1</td>
<td>2.3</td>
</tr>
<tr>
<td>1997</td>
<td>28.3</td>
<td>12.5</td>
<td>25.2</td>
<td>32.6</td>
<td>1.4</td>
</tr>
<tr>
<td>1998</td>
<td>28.0</td>
<td>13.2</td>
<td>24.9</td>
<td>32.7</td>
<td>1.0</td>
</tr>
<tr>
<td>1999</td>
<td>27.7</td>
<td>13.7</td>
<td>25.2</td>
<td>33.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Source: Notes from the Norwegian competition authority 1/2000

This market may serve as a particular good case, since the private label “invasion” still is relatively “new”, but at the same time increases rapidly. The national brands have been exposed to the threat from PL entry for only a relatively short time period, and have during our data period been forced to react to the private label “invasion”.

Figure 1 The development in private label shares from January 1995 to January 1999, Source: ACNielsen 1999 (excluding RG).
In Figure 1 the development in market shares of private labels are shown; in less than four years the market share is nearly doubled. Newer figures including also the RG-chain suggest a private label market share above 10% by the end of 2000. We expect that this trend will continue. The increase in private label share has been a common strategy for all chains. In Figure 2 we decompose the private label shares for each of the chains, and as we see the same growth pattern is present for all four chains.

To be able to obtain a tractable dataset we have restricted our analysis to 83 private label introductions. These introductions are chosen according to several criteria. First, we have only

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2 The chains have a declared strategy to increase the number of private labels. An FS chain representative said in March 2000: "All unprofitable products will be removed from our shelves" (source: Dagens Næringsliv 01.03.2000). One month later the HG-Chain representative Svante Nilsson said: "We will make more room for our own private labels in our stores. Private labels are more profitable to the chain than national brands, and
considered private labels introduced in the period January 1998 to January 2000 and that reached a national market share within its product group above 2% by May 2000. This is to obtain a long enough pre- and post entry period, and to include only “significant” entrants. Second, product groups where a lot of noise is anticipated due to other factors as seasonal products (e.g., “Easter soft drinks”), “price signal products”, “structural changes” etc. were excluded. Finally, we excluded groups where it was difficult to identify who the rival or rivals were. The remaining group is both representative for the Norwegian food sector, includes 41 different market segments, and covers the most important private label introductions in our data period.3

As discussed in the previous section, theory suggests some heterogeneity with regards to price responses to PL entry. By looking at our data we can get a first impression of this heterogeneity.

In figures 3 and 4 we show the price development for some of the analysed products. In Figure 3 the prices of ready-made frozen French fries are shown. We observe an upward shift in the price of the national brand after PL entry. FRIONOR is a large producer with relatively strong products in a differentiated product segment. This suggests that a possible explanation for the increase can be loyal consumers, increased quality or spatial competition. The market share of the private label was 23.5% in May 2000.

In Figure 4 the prices of a more typical homogenous product are shown – spaghetti. The price effect of the PL entry differs from one national brand to another. One national brand (Sopps) seems to increase its price, the other national brand (Maretti) reduces its price after entry. The two national brands have each approximately 30% of the market in this chain, but in the aggregated Norwegian spaghetti market, Sopps (47%) is nearly twice as big as Maretti

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3 The data period is restricted to four years since this is the longest period ACNielsen was able to provide data for directly from their database. Furthermore, earlier data is of a lower quality.
(27%). Hence, the market leader increases its price and the closest rival reduces its price. The PL entry was quite successful in this chain, usurping a market share of 30% by May 2000.

Finally, in Figure 5 we have shown the price development for a very homogenous product – flour. Here the entry leads to a large price decrease of the national brand (Møllerens). Still, the entry was extremely successful. The private label dominates this segment by May 2000, with a market share of 73%.

The three Figures suggest that we will find both price increases and reductions following PL entry. More interesting though, is to see whether we can detect systematic patterns in the national brand price shifts. This is what we turn to next.

5. Econometric model

To our knowledge, our study is the first to use micro data to test directly the price response of the introduction of private labels. However, within a very parallel literature on generics in the market for pharmaceuticals, several price response studies have been conducted. Grabowski and Vernon (1992) studied the effect of generic entry on prices for 18 high sales volume pharmaceutical products that were first exposed to generics during the years 1983 to 1987. For each drug the authors examined prices prior to entry and prices one year subsequent to generic entry. Using a relatively simple regression model they estimated the impact of the number of generic suppliers in a market on the ratio of the generic price to the name brand price. Their result suggested that name brand prices rose relative to generic prices subsequent to generic entry.

\[ \text{Figure 3 to 5 approximately here} \]

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4 The model included two covariates along with the number of generics; the total dollar sales in a market in a given year and a time dummy.
Caves et al (1991) suggest that simple pre-entry versus post-entry brand name price comparisons or regressions of price on numbers of generic entrants may understate negative entry effects on prices because other omitted factors have caused brand-name prices to rise over time. One such variable is producer price index for pharmaceuticals. They argue that empirical price regression models must be specified so as to minimize bias from these unobservable time-varying factors. Caves et al (1991) include fifty different intercepts to represent category-year groups average changes, in addition to several other time related dummy-variables, linear time trends and quadratic time trends. They found evidence that suggested that entry led to reductions in name brand prices.

In this paper, we pursue two econometric test strategies. First, we formulate a basic dynamic price model that will be used to undertake an exploratory analysis of our dataset. This will enable us to uncover heterogeneity in the outcome for the different product types, and get a first grip on possible systematic patterns. Second, Section 5.2 extends our dynamic price model to take advantage of the panel properties in our dataset. Here we are able to test statistically some of the more suggestive results from the exploratory tests in the first subsection. The models will be in line with those of Caves et al (1991). However, we include a dynamic element by explicitly modelling the autoregressive element of the price process as an AR(1) model.

5.1 The basic dynamic price model

The most commonly used statistical model to describe price development is the autoregressive first order model (AR(1)). Last period’s price is the main predictor for this period’s price. We assume that the development in a price series \( x_t \) is described by;

\[
x_t = \rho \cdot x_{t-1} + \epsilon_t, \quad \text{where} \quad \epsilon_t \sim iid \ (0, \sigma)
\]

This model has been widely applied within the
literature on market integration and efficient markets, and offers several advantages. First-order serial correlation is captured within the model, and when extended with more variables it allows us to distinguish between short and long run effects. The AR(1) model is therefore a better statistical price model than the ones used in the earlier empirical studies discussed above. It has a sound statistical foundation, and has also been widely used as a common way of describing price processes in the economic literature. In our case we would like to include other factors as well. In particular, prices may rise over time due to a general price increase on food. To account for this, a linear trend \((t)\) and the consumer price index \((\text{CPI})\) are included (see Caves et al, 1991). Furthermore, the different product prices will have different means which is accounted for with a constant term \((\alpha)\):

\[
(1) \quad p_t^{NB} = \alpha + \rho \cdot p_{t-1}^{NB} + \lambda_t + \gamma \cdot \text{CPI}_t + \epsilon_t.
\]

where \(p_t^{NB}\) is the national brand price. To measure any possible shift in the national brand price after PL entry we also include a dummy variable \((D_{\text{int}^{PL}})\). This variable takes the value “1” if entry of a private label in the same market segment as the national brand.

\[
(2) \quad p_t^{NB} = \alpha + \rho \cdot p_{t-1}^{NB} + \lambda_t + \gamma \cdot \text{CPI}_t + \beta D_{\text{int}^{PL}} + \epsilon_t.
\]

---

5 See e.g., Isard, (1977); Richardson, (1978); Beck, (1994); Ardeni (1989); Goodwin and Schroeder (1991); Doane and Spulber (1994), Sauer, (1994); Schwarz and Szakmary, (1996); Asche, Salvanes and Steen (1997); Asche, Bremnes and Wessels (1999).

6 Caves et al (1991) apply a GLS model that accounts for first order serial correlation. However, our AR(1) specification is a better way of dealing with serial correlation, since instead of “removing” the autoregressive component (as in GLS) we use it to obtain a better price model.

7 For all the coffee products we also include an international coffee price, expressed in NOK. This is to prevent any noise from fluctuating international coffee prices.
Equation (2) is our basic price model, which we will use throughout the analysis. A \( \beta \) significantly different from zero will indicate that the national brand price is significantly influenced by the PL-entry. A positive \( \beta \) suggests a price increase, and a negative \( \beta \) indicates a price reduction. The price variable \( P_{i}^{NB} \), and the CPI index are measured in logarithm.

We estimate (2) for the 83 product matches we have in our dataset, providing us with 83 OLS regressions. This will give us a first idea about the effect of PL entries; have the PL entries any significant price effects on the national brands, and if so, which products experience a price increase and for which products has the price gone down? For most of the 83 product matches we have 197 weeks of price observations, for some of them we have fewer observations. The key results from these 83 regressions are presented in Table 2.

Several things can be learned from these results. First, prediction 1 is confirmed; we observe a large heterogeneity, with both significantly positive and negative \( \beta \)s. Second, most of our \( \beta \)s are positive, 51 of 83 estimated parameters (or more than 60%) are positive. This pattern is even stronger when we consider the significant parameters. Using a two-tailed test, 15 parameters are significantly positive on a 5% level, whereas only two is found to be significantly negative. This is in line with the findings in Harris et al (2000).\(^8\) Hence, it seems that the introduction of a private label typically leads to higher prices on national brands.

Third, looking at the product categories we get the impression that the degree of product differentiation and the number of loyal customers might matter. The most significant and largest price reduction for national brands was found for flour, probably one of the most homogeneous product group in our sample (see Figure 5). When looking at product groups with positive shifts in national brand prices, we find several “strong” products. For instance,
for the six product matches of coffee in our sample, four PL entries are found to increase national brand prices significantly. We also find several soft drink matches where the same thing applies. Also Frionor significantly increased its price on French fries in response to PL entry (see Figure 3). This supports prediction no. 2.

Turning to market shares, Table 2 reports the private label market share in each product group and chain. The average private label market share for all 83 products is 33.7%. For the 15 significant positive $\beta$s the average is considerably higher, 41.7%. For the two negative $\beta$s the market share is above 73% for both products.

Note also that no significantly negative $\beta$s is found for products with small market shares; private labels need to be large to induce a decrease in national brand prices. The average PL market share in Table 2 over all negative $\beta$s is 40%, whereas the average PL market share for the positive $\beta$s is 30%. Finally, none of the PL entries that lead to a significant price increase had less then 7% PL market share. In the group of non-significant $\beta$s we have as many as 15 products with PL market shares less than 7% (28%), and as many as 10 below 3%.

To sum up, if PL market share can be interpreted as a success criterion, our findings give support to prediction 3; significant changes in national brand prices are typically observed in product categories with successful entry of a private label. Moreover, no national brands reduce their price as a response to an unsuccessful (small) introduction, whereas some increase their price. The latter result is important, since the alternative to prediction 3 – significant price reduction on a national brand in a product category where a private label is not successful – found no support. In such a case an unsuccessful entry should be linked to a reduced national brand price. We would anticipate negative significant $\beta$s in these cases.

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8 These authors state: “We have a remarkable result. Despite the large number of estimated coefficients (288) every statistically significant coefficient is positive.” Actually they found one fourth of their coefficients to be positive on a 5% level, in our case the number is close to this; one fifth.
since a significant reduction in the national brand price would reduce the room for potential private label success. However, this is not what we can observe in the regression results.

So far we have found some support for our predictions. However, we need to go a step further to statistically validate our conclusions. In order to try to single out what is a strong product we might condition our test on variables that can serve as instruments for the “strength” of a product, alternatively, the number of “loyal” customers. In addition to market shares we therefore use two more variables, the actual distribution ratio of each product in all Norwegian stores, and a ranking of the products according to size. The distribution ratio is a number between 0 and 100, where 100 means that the product is distributed in all stores. The only national brand in our dataset that covers 100% of the stores is Coca-Cola. The rank variable tells whether the national brand is a number 1, a number 2, or a number 3 product in terms of market share. Table 3 presents correlation between the estimated $\beta$s, distribution ratio, rank and market shares, and may give us a first impression of relationships.

Several interesting things can be seen from these simple correlations. The higher the PL market share, the more likely we are to observe reduced national brand price; the higher the national brand market share, the more likely we are to observe a price increase. Rank and distribution ratios are, however, variables that seem nearly uncorrelated with the $\beta$s. When we consider only the “significant” product matches, we find a negative correlation between rank and $\beta$ at -.22. However, the correlation is insignificant. The sign suggests that a number 3 national brand is more likely to reduce its price than a number 1 ranked national brand. The most interesting result in Table 3 is that for the “significant” product matches, all correlations are substantially stronger and significant.
The next section extends model (2) to take advantages of the panel properties to see whether these “suggestions” also are valid in an econometric model based on the full data set of 15,761 observations.

5.2. A dynamic panel price model

We now extend the dynamic price model to exploit the panel properties of our dataset. Furthermore, we condition our dummy variable \( D_{\text{PL}} \) on our information on market shares, distribution and rank. Our basic panel model is:

\[
\begin{align*}
    P_{i,t}^{\text{PL}} &= M_r + \rho \cdot P_{i,t-1}^{\text{PL}} + \lambda t + \gamma CPI_t + \beta D_{\text{PL}} + \epsilon_{i,t} \\
    (3)
\end{align*}
\]

where \( M_r \) is a set of dummy variables that vary according to market segment. For example, market segment number 14 is coffee and includes three different coffee-product matches within one chain. There are a total of 41 different market segments with 1 to 7 product matches; \( r=1-41 \). The market segment dummies are included to account for different price levels in each market segment. Hence, the model we use includes both a dynamic AR(1) component for each product match, and a “fixed effects” element through the 41 market segment dummies.\(^9\)

Now we extend the dynamic panel model in two levels. First, we estimate three models where we condition \( D_{\text{PL}} \) on private label market share, and the national brands’ rank and distribution level:

\(^9\) Since we here include a lagged endogenous variable problems might arise since the lagged endogenous variable can be correlate with the error term in a dynamic fixed effect model (Anderson and Hsiao, 1982; Nickell, 1981). However, this problem is present if (as is most common) the cross section element dominates the time dimensional element, i.e., the number of cross sectional observations exceeds usually by far the number of
The distribution, rank and PL-market share variables are all dummies and have the same structure; “1” denotes high (distribution, rank or PL-market share), “2” medium and “3” low. For instance, $PLMS_{3}$ refers to a low private label market share and will accordingly take the value ‘one’ when this is the case, and ‘zero’ otherwise. $RANK_{2}^{NB}$ represents a national brand that is ranked as number two etc. The exact definitions of these variables are given in Appendix A. By estimating these three models we will be able to uncover whether differences in distribution, rank or PL-market share are important for the price response of the national brands.

Finally, we extend the model even further. The third step is to look at two combinations of models 4.1 to 4.3, where we condition $Dint^{PL}$ on rank and PL-market share, and distribution and PL-market share. The model that combines distribution and private label market share is:
\[
\begin{align*}
\;P_{i,t}^{NB} &= M_r + \rho \cdot P_{i,t-1}^{NB} + \lambda t + \gamma CPI_t + \\
&\quad \sum_{j=1}^{3} \sum_{k=1}^{3} \beta_{jk} D_{int}^{PL} \cdot DISTR_{j}^{NB} \cdot MS_k^{PL} + \varepsilon_{i,t}
\end{align*}
\]

(5.1)

where \(j\) refers to distribution level and \(k\) to PL market share size. Hence, the parameter \(\beta_{11}\) measures the price response of the national brand for those national products that have a large distribution and where the private label has acquired a large market share. Correspondingly, \(\beta_{33}\) measures the price response for those products that have a relatively small distribution and where the private label only has gained a small market share. In the next model, we condition on rank rather than distribution:

\[
\begin{align*}
\;P_{i,t}^{NB} &= M_r + \rho \cdot P_{i,t-1}^{NB} + \lambda t + \gamma CPI_t + \\
&\quad \sum_{j=1}^{3} \sum_{k=1}^{3} \beta_{jk} D_{int}^{PL} \cdot RANK_{j}^{NB} \cdot MS_k^{PL} + \varepsilon_{i,t}
\end{align*}
\]

(5.2)

Now the parameter \(\beta_{11}\) measures the price response of the national brand for those national products that are ranked as number 1 and where the private label has acquired a large market share, etc.

These five extended models allow us to test whether differences in rank, distribution or the private label market share, or combinations of these can explain the heterogeneity in price responses uncovered in the previous section. In particular, this panel data framework which is considerably more than the 83 product matches.
allows us to use all information simultaneously, and also permits various statistical tests of the validity of our results.

The models 3 to 5 are presented in Table 4. The statistical properties are good, with a high explanation power, and a clearly significant AR(1) parameter; $\rho$ is estimated close to 0.80 in all six models, suggesting a stationary process.\(^{10}\) The trend and CPI variables are both non-significant and have different signs. However, these two variables are strongly positive correlated (with correlation $> 0.90$), and therefore multicollinearity applies with large standard errors. The trend parameter picks up the positive price trend, and the CPI variable any possible negative deviation from this trend. The coffee price variable is significant and positive in all models.

[Table 4 here]

Turning now to the parameter $\beta$, several interesting things can be observed. In model 3, $\beta$ is non-significant, suggesting no change in national brand price. This result, which is more like an average effect, disregards the underlying heterogeneity. In the extended models, we try to decompose the heterogeneity. The first extension – model 4 – suggests some more action. In models 4.1 to 4.3 one of the $\beta$s is significant, indicating a negative shift in national brand price for products that is ranked as number one – but only at a 10% level. A joint F-test (bottom Table 3) of the effect of conditioning the price response on rank, distribution and PL-market share; \(H^0: \beta_1 = \beta_2 = \beta_3 = 0\), cannot be rejected for distribution and PL market share, but is clearly rejected for rank. Hence, rank seems to pick up some of the observed heterogeneity. We extend the model even further in models 5.1 and 5.2. It is evident that more of the heterogeneity is then accounted for. Out of 18 different $\beta$s, 9 are significant. The majority of these suggest a positive price response. On a 5% level, all significant $\beta$s are
positive in the distribution vs. PL market share model (5.1). The results are summarised with signs in Table 5.

When we look at the significant $\beta$s, we observe some regularities. In particular, $\beta_{11}$, $\beta_{12}$ and $\beta_{13}$ are significant in all models. The products that either are ranked as number one or have the highest distribution are thus most influenced by private label entry. These are those products where we would anticipate most loyal customers and “strong” products (see prediction 2). Furthermore, $\beta_{11}$ in both models are significant on a 1% level and positive.

Hence, a large PL market share, or a successful entry, leads to a price increase on the highest ranked and distributed products. Correspondingly, $\beta_{13}$ is significant and negative in both models, suggesting that the national brands are more likely to reduce price after less successful PL entry (low PL market share).

Of the remaining 12 parameters (medium and low rank or distribution) only 3 parameters are significant. $\beta_{21}$ is negative, suggesting that number 2 products are more likely to compete with successful PL entrants, whereas number 2 products that face “smaller” PL entrants increase their price ($\beta_{23} > 0$). The last significant parameter $\beta_{33}$ in model 5.1 is harder to interpret at first glance. It suggests that the national brands that have the lowest distribution increase their prices when faced with a “small” PL entrant. However, within this group we typical find “niche” products that might have very loyal customers within more narrowly defined market segment.

We perform different joint F-test in models 5.1 and 5.2. First, we jointly test the importance of the degree of distribution and rank. We impose a joint zero restriction on the

---

10 Even though we know that the AR(1) parameter will have a negative biased variance, a test of $\rho = 1$ is
three parameters that correspond to each distribution/rank level. For instance, $H^1_0 : \beta_{11} = \beta_{12} = \beta_{13} = 0$ implies that there is no national brand price response in the high distribution or number one product group. The different hypotheses are summarised and test statistics provided in Table 5 and 6. The same pattern as was seen in the individual parameters can be traced also here. The null of no price response in the high distribution/rank one group ($H^1_0$) is clearer rejected than the medium and low hypotheses ($H^2_0$ and $H^3_0$). When we test whether differences in PL market share have different effects in terms of price response, we find that the null hypothesis of no national brand price response is rejected in five out of six tests. Most clearly for the high PL market share group ($H^4_0 : \beta_{11} = \beta_{21} = \beta_{31} = 0$), and the low PL market share group ($H^6_0 : \beta_{13} = \beta_{23} = \beta_{33} = 0$). In the distribution/PL market share model (5.1) all three PL market share hypotheses were rejected. The PL market share test results are interesting, since these give support to our third empirical prediction: the degree of success of the PL entry – the size of the PL market share - matters for the national brand price response.

Our predictions from theory thus seem to have found statistical support. We do find heterogeneity also in the panel data models, with both negative and positive significant price responses; prediction 1. There is also a pattern where highly distributed and ranked products are more influenced by PL entry than less distributed and ranked products (“weaker” national brands); prediction 2. This is seen in both the individual parameters and the joint tests. Finally, prediction 3 that more successful PL entry – as measured by the PL market share – rejected with t-values in the range of 39 to 49, clearly indicating a stationary process.
should have a larger impact on the national brands find some support. The joint null of no price response of national brands on the most successful PL entrants \( (H_0: \beta_{11} = \beta_{21} = \beta_{31} = 0) \) is most clearly rejected in Table 5. However, as opposed to what we concluded in the previous section, we find some weak support for the alternative to prediction 3. We now find two out of six cases where national brand prices are reduced significantly in market segments where the PL market share is low. The empirical evidence is mixed, though, since out of the remaining four cases we find two significant positive estimates.

6. Some concluding remarks

In our single regression approach we observed a large heterogeneity, with both significantly positive and negative \( \beta \)'s. Most of our \( \beta \)'s were positive: out of 83 estimated parameters, more than 60%. This tendency is even stronger when we consider the significant parameters. 15 parameters are significantly positive on a 5% level, whereas only two is found to be significantly negative. Hence, it seems that an introduction of a private label typically leads to higher prices on national brands. A closer examination indicates that the degree of product differentiation and the number of loyal customers might matter in each product category. The most significant and largest price reduction found for national brands was in the product category flour, probably the most homogenous product group in our sample. When we looked at the product groups where we found positive shifts in national brand prices, we found several “strong” products.

In the dynamic panel data approach the same picture emerged. We found heterogeneity with both negative and positive significant price responses supporting our first empirical prediction. We also found that highly distributed and ranked products are typically more influenced by PL entry than less distributed and ranked products (“weaker” national...
brands), supporting our second prediction. Finally, even though we are more careful here, we also find some support in our data for prediction 3. More successful PL entry – as measured by the PL market share – have typically a larger impact on the national brands.

We have thus to a large extent been able to condition the heterogeneity observed in section 5.1 on differences in distribution, rank and PL market share. However, there is still some heterogeneity that is not accounted for. One candidate is marketing activity by the national brands, and another candidate could be product quality characteristics.

One important lesson from our study is that it is too simple to argue that more private label products leads to more intense price rivalry. What we have found, though, is that product “strength” matters. That is, the prices of the largest national brand products in terms of ranking or distribution are more influenced by PL entry than number 2 and 3 products, or less distributed products. We also found that the prices of national brands typically increase after an introduction of a private label.
References


Appendix A – Data and variable description

The data set is from ACNielsen Norway, and contains weekly prices on national brands and private labels for the period 01.01.1997 to 01.10.2000. In addition we have data on market shares, distribution level of the national brands and the ranking of these in May 2000. Totally we have 83 product matches in 41 different market segments. Totally this give us a panel of 15761 observations. The consumer price index is from the Statistics Norway (SSB).

The dummy variables used in models 4 and 5 are defined as:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS\textsuperscript{PL}_1</td>
<td>1 if the PL market share is \geq 20%</td>
</tr>
<tr>
<td>MS\textsuperscript{PL}_2</td>
<td>1 if the PL market share is between 8% and 20%</td>
</tr>
<tr>
<td>MS\textsuperscript{PL}_3</td>
<td>1 if the PL market share is \leq 8%</td>
</tr>
<tr>
<td>Rank\textsuperscript{NB}_1</td>
<td>1 if the national brand is ranked as number 1</td>
</tr>
<tr>
<td>Rank\textsuperscript{NB}_2</td>
<td>1 if the national brand is ranked as number 2</td>
</tr>
<tr>
<td>Rank\textsuperscript{NB}_3</td>
<td>1 if the national brand is ranked as number 3</td>
</tr>
<tr>
<td>Distr\textsuperscript{NB}_1</td>
<td>1 if the national brand has a distribution level \geq 70%</td>
</tr>
<tr>
<td>Distr\textsuperscript{NB}_2</td>
<td>1 if the national brand has a distribution level between 30% and 70%</td>
</tr>
<tr>
<td>Distr\textsuperscript{NB}_3</td>
<td>1 if the national brand has a distribution level \leq 30%</td>
</tr>
</tbody>
</table>
Figures and Tables

Figure 3 Price development French fries

Figure 4 Price development Spaghetti
Figure 5 Price development flour
Table 2  Econometric results equation (2) for all 83 product matches

<table>
<thead>
<tr>
<th>Market Segm. Number</th>
<th>Market segment Product</th>
<th>Matched National brand</th>
<th>matched National</th>
<th>Market share</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Frozen vegetables</td>
<td>Nora Blomkålblanding 800</td>
<td>0.020*</td>
<td>0.003</td>
<td>76.2 %</td>
</tr>
<tr>
<td>10</td>
<td>Frozen vegetables</td>
<td>Nora Amerikansk Blanding</td>
<td>0.022*</td>
<td>0.004</td>
<td>76.2 %</td>
</tr>
<tr>
<td>5</td>
<td>Soft drink lemon</td>
<td>Seven Up Prb 1.5 L</td>
<td>0.035*</td>
<td>0.009</td>
<td>32.8 %</td>
</tr>
<tr>
<td>18</td>
<td>Spaghetti</td>
<td>Marett Spaghetti 12 Min</td>
<td>0.070*</td>
<td>0.019</td>
<td>32.6 %</td>
</tr>
<tr>
<td>9</td>
<td>French fries</td>
<td>Frionor Pommes Frites 600</td>
<td>0.025*</td>
<td>0.007</td>
<td>75.5 %</td>
</tr>
<tr>
<td>26</td>
<td>Rice</td>
<td>Uncle Ben's Jasminris 2 K</td>
<td>0.058*</td>
<td>0.017</td>
<td>46.2 %</td>
</tr>
<tr>
<td>4</td>
<td>Soft drink lemon</td>
<td>Seven Up Prb 1.5 L</td>
<td>0.134*</td>
<td>0.040</td>
<td>32.1 %</td>
</tr>
<tr>
<td>35</td>
<td>White cheese</td>
<td>Norwegia F45 Skf Ppk. 500</td>
<td>0.026*</td>
<td>0.008</td>
<td>12.0 %</td>
</tr>
<tr>
<td>13</td>
<td>Nectar Apple</td>
<td>Nora Eplenectar 1 L</td>
<td>0.043*</td>
<td>0.017</td>
<td>76.5 %</td>
</tr>
<tr>
<td>15</td>
<td>Coffee</td>
<td>Evergood Filtermalt 250 G</td>
<td>0.068*</td>
<td>0.029</td>
<td>12.6 %</td>
</tr>
<tr>
<td>11</td>
<td>Orange Juice</td>
<td>Nora Appelsin Juice 1 L</td>
<td>0.042*</td>
<td>0.018</td>
<td>44.9 %</td>
</tr>
<tr>
<td>9</td>
<td>French Fries</td>
<td>Frionor Pommes Strips 600</td>
<td>0.016*</td>
<td>0.007</td>
<td>75.5 %</td>
</tr>
<tr>
<td>15</td>
<td>Coffee</td>
<td>Krone Gull Filtermalt 250</td>
<td>0.075*</td>
<td>0.035</td>
<td>12.6 %</td>
</tr>
<tr>
<td>32</td>
<td>Chips</td>
<td>Maarud Potetgull Lett Sal</td>
<td>0.028*</td>
<td>0.014</td>
<td>13.1 %</td>
</tr>
<tr>
<td>10</td>
<td>Frozen vegetables</td>
<td>Frionor Erter/Gulrotter 8</td>
<td>0.020*</td>
<td>0.010</td>
<td>76.2 %</td>
</tr>
<tr>
<td>16</td>
<td>Instant Coffee</td>
<td>Nescafe Gull 200 Gr</td>
<td>0.008**</td>
<td>0.004</td>
<td>5.5 %</td>
</tr>
<tr>
<td>29</td>
<td>Rice for porridge</td>
<td>Ming Grorris Blå 750 Gr</td>
<td>0.010**</td>
<td>0.005</td>
<td>7.0 %</td>
</tr>
<tr>
<td>14</td>
<td>Coffee</td>
<td>Coop Rod Filtermalt 250 G</td>
<td>0.107**</td>
<td>0.061</td>
<td>7.1 %</td>
</tr>
<tr>
<td>19</td>
<td>Spaghetti</td>
<td>Sopps Spaghetti 500 Gr</td>
<td>0.014**</td>
<td>0.009</td>
<td>17.2 %</td>
</tr>
<tr>
<td>1</td>
<td>Coca Cola</td>
<td>Pepsi Max Prb 1.5 L</td>
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<td>0.035</td>
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</tr>
<tr>
<td>21</td>
<td>Macaroni</td>
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<td>0.020</td>
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</tr>
<tr>
<td>22</td>
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<tr>
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<td>Macaroni</td>
<td>Marett Makaroni 5 Min 50</td>
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<td>13.6 %</td>
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<td>Sopps Spaghetti 500 Gr</td>
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<td>0.014</td>
<td>32.6 %</td>
</tr>
<tr>
<td>21</td>
<td>Macaroni</td>
<td>Sopps Makaroni Snarkokt 5</td>
<td>0.018</td>
<td>0.012</td>
<td>26.2 %</td>
</tr>
<tr>
<td>22</td>
<td>Macaroni</td>
<td>Sopps Makaroni Snarkokt 5</td>
<td>0.018</td>
<td>0.012</td>
<td>0.7 %</td>
</tr>
<tr>
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<td>Macaroni</td>
<td>Sopps Makaroni Snarkokt 5</td>
<td>0.018</td>
<td>0.012</td>
<td>13.6 %</td>
</tr>
<tr>
<td>39</td>
<td>Baguettes</td>
<td>Wasa Kuvertbaguetter Fine</td>
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<td>0.005</td>
<td>48.9 %</td>
</tr>
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<td>0.040</td>
<td>0.028</td>
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<tr>
<td>31</td>
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<tr>
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<td>Ciabatta</td>
<td>Bakers Ciabatta Halvstek</td>
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<tr>
<td>41</td>
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<tr>
<td>37</td>
<td>Baguettes</td>
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<tr>
<td>4</td>
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</tr>
<tr>
<td>7</td>
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<td>0.034</td>
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<td>76.2 %</td>
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<td>0.016</td>
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</tr>
<tr>
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<td>Sprite Prb 1.5 L</td>
<td>0.007</td>
<td>0.011</td>
<td>32.8 %</td>
</tr>
<tr>
<td>Market segm. Number (r)</td>
<td>Market segment Product</td>
<td>Matched National brand</td>
<td>$\beta$</td>
<td>SE($\beta$)</td>
<td>Market share PL</td>
</tr>
<tr>
<td>------------------------</td>
<td>------------------------</td>
<td>------------------------</td>
<td>--------</td>
<td>------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>24</td>
<td>Pasta.</td>
<td>Buitoni Penne Rigate 500</td>
<td>0.018</td>
<td>0.029</td>
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<tr>
<td>30</td>
<td>Pizza</td>
<td>Stubburet Pizza Big One C</td>
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<td>0.032</td>
<td>0.3 %</td>
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<tr>
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<td>Pasta.</td>
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<td>0.029</td>
<td>2.9 %</td>
</tr>
<tr>
<td>24</td>
<td>Pasta.</td>
<td>Buitoni Penne Rigate 500</td>
<td>0.016</td>
<td>0.029</td>
<td>2.9 %</td>
</tr>
<tr>
<td>16</td>
<td>Instant coffee</td>
<td>Nescafe Gull 200 Gr</td>
<td>0.002</td>
<td>0.005</td>
<td>1.9 %</td>
</tr>
<tr>
<td>6</td>
<td>Cider</td>
<td>Mozell Drue &amp; Eple Prb 1.</td>
<td>0.017</td>
<td>0.038</td>
<td>48.1 %</td>
</tr>
<tr>
<td>20</td>
<td>Spaghetti</td>
<td>Sopps Spaghetti 500 Gr</td>
<td>0.001</td>
<td>0.004</td>
<td>18.2 %</td>
</tr>
<tr>
<td>1</td>
<td>Coca Cola</td>
<td>Coca-Cola Prb 1.5 L</td>
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<td>0.031</td>
<td>11.2 %</td>
</tr>
<tr>
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</tr>
<tr>
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<td>0.030</td>
<td>0.1 %</td>
</tr>
<tr>
<td>32</td>
<td>Chips</td>
<td>Kims Chips Salt 250 Gr</td>
<td>-0.001</td>
<td>0.024</td>
<td>13.1 %</td>
</tr>
<tr>
<td>8</td>
<td>Soft drink Champagne</td>
<td>Villa Champagne 1.5 L</td>
<td>-0.005</td>
<td>0.007</td>
<td>76.2 %</td>
</tr>
<tr>
<td>28</td>
<td>Rice</td>
<td>Uncle Ben's Jasminris 2 K</td>
<td>-0.0002</td>
<td>0.003</td>
<td>43.8 %</td>
</tr>
<tr>
<td>28</td>
<td>Rice</td>
<td>Uncle Ben's Jasminris 2 K</td>
<td>-0.0002</td>
<td>0.003</td>
<td>43.8 %</td>
</tr>
<tr>
<td>35</td>
<td>White Cheese</td>
<td>Synnove Gulost Ca 500 Gr</td>
<td>-0.008</td>
<td>0.060</td>
<td>12.0 %</td>
</tr>
<tr>
<td>24</td>
<td>Pasta.</td>
<td>Buitoni Eliche 500 Gr</td>
<td>-0.006</td>
<td>0.029</td>
<td>50.5 %</td>
</tr>
<tr>
<td>2</td>
<td>Soft drink Orange</td>
<td>Fanta Appelsin 1.5 L</td>
<td>-0.008</td>
<td>0.037</td>
<td>30.3 %</td>
</tr>
<tr>
<td>12</td>
<td>Orange Juice</td>
<td>Meierienes Appelsinjuice</td>
<td>-0.001</td>
<td>0.005</td>
<td>35.5 %</td>
</tr>
<tr>
<td>35</td>
<td>White Cheese</td>
<td>Jarlsberg F45 Skf 500 Gr</td>
<td>-0.005</td>
<td>0.019</td>
<td>12.0 %</td>
</tr>
<tr>
<td>30</td>
<td>Pizza</td>
<td>Stubburet Pizza Grandiosa</td>
<td>-0.006</td>
<td>0.019</td>
<td>4.5 %</td>
</tr>
<tr>
<td>25</td>
<td>Pasta.</td>
<td>Buitoni Penne Rigate 500</td>
<td>-0.006</td>
<td>0.017</td>
<td>28.8 %</td>
</tr>
<tr>
<td>25</td>
<td>Pasta.</td>
<td>Buitoni Penne Rigate 500</td>
<td>-0.006</td>
<td>0.017</td>
<td>28.8 %</td>
</tr>
<tr>
<td>25</td>
<td>Pasta.</td>
<td>Buitoni Penne Rigate 500</td>
<td>-0.006</td>
<td>0.017</td>
<td>28.8 %</td>
</tr>
<tr>
<td>3</td>
<td>Soft drink Orange</td>
<td>Fanta Appelsin 1.5 L</td>
<td>-0.006</td>
<td>0.017</td>
<td>30.9 %</td>
</tr>
<tr>
<td>27</td>
<td>Rice</td>
<td>Uncle Ben's Jasminris 2 K</td>
<td>-0.002</td>
<td>0.005</td>
<td>14.3 %</td>
</tr>
<tr>
<td>2</td>
<td>Soft drink Orange</td>
<td>Solo Prb 1.5 L</td>
<td>-0.014</td>
<td>0.036</td>
<td>30.3 %</td>
</tr>
<tr>
<td>33</td>
<td>Nuts</td>
<td>Kims Cashewnotter 100 Gr</td>
<td>-0.006</td>
<td>0.014</td>
<td>8.0 %</td>
</tr>
<tr>
<td>36</td>
<td>Baguettes</td>
<td>Wasa Baguetter Fine 2-Pk</td>
<td>-0.013</td>
<td>0.019</td>
<td>74.5 %</td>
</tr>
<tr>
<td>31</td>
<td>Pizza</td>
<td>Stubburet Pizza Big One C</td>
<td>-0.017</td>
<td>0.026</td>
<td>0.5 %</td>
</tr>
<tr>
<td>3</td>
<td>Soft drink Orange</td>
<td>Solo Prb 1.5 L</td>
<td>-0.016</td>
<td>0.019</td>
<td>30.9 %</td>
</tr>
<tr>
<td>38</td>
<td>Ciabatta</td>
<td>Bakers Ciabatta Halvstekt</td>
<td>-0.034</td>
<td>0.039</td>
<td>41.0 %</td>
</tr>
<tr>
<td>10</td>
<td>Frozen vegetables</td>
<td>Frionor Fransk Blanding</td>
<td>-0.007</td>
<td>0.007</td>
<td>76.2 %</td>
</tr>
<tr>
<td>37</td>
<td>Baguettes</td>
<td>Wasa Baguetter Fine 2-Pk</td>
<td>-0.005</td>
<td>0.005</td>
<td>46.3 %</td>
</tr>
<tr>
<td>10</td>
<td>Frozen vegetables</td>
<td>Frionor Blomkålbling</td>
<td>-0.007</td>
<td>0.006</td>
<td>76.2 %</td>
</tr>
<tr>
<td>32</td>
<td>Chips</td>
<td>Pringles Potetchips Origi</td>
<td>-0.014</td>
<td>0.013</td>
<td>13.1 %</td>
</tr>
<tr>
<td>11</td>
<td>Orange Juice</td>
<td>Meierienes Appelsinjuice</td>
<td>-0.008</td>
<td>0.005</td>
<td>44.9 %</td>
</tr>
<tr>
<td>34</td>
<td>Tomato purée</td>
<td>Heinz Tomatpure 145 Gr</td>
<td>-0.008**</td>
<td>0.005</td>
<td>90.4 %</td>
</tr>
<tr>
<td>41</td>
<td>Olive oil</td>
<td>Ybarra Olivenolje 500 MI</td>
<td>-0.015**</td>
<td>0.009</td>
<td>54.3 %</td>
</tr>
<tr>
<td>12</td>
<td>Orange Juice</td>
<td>Nei Appelsinjuice 1 L</td>
<td>-0.005**</td>
<td>0.003</td>
<td>35.5 %</td>
</tr>
<tr>
<td>40</td>
<td>Olive oil</td>
<td>Ybarra Olivenolje 500 MI</td>
<td>-0.023**</td>
<td>0.012</td>
<td>50.0 %</td>
</tr>
<tr>
<td>10</td>
<td>Frozen vegetables</td>
<td>Frionor Amerikansk Blandi</td>
<td>-0.013*</td>
<td>0.005</td>
<td>76.2 %</td>
</tr>
<tr>
<td>17</td>
<td>Flour</td>
<td>Møllerens Hvetemel Siktet</td>
<td>-0.052*</td>
<td>0.009</td>
<td>73.0 %</td>
</tr>
</tbody>
</table>
Table 3  First order correlation coefficients between the estimated $\beta$ s and market shares, rank and distribution ratio

<table>
<thead>
<tr>
<th></th>
<th>PL market share within market segment within chain</th>
<th>PL market share in market segment in Norway</th>
<th>National brand Market share within chain</th>
<th>National brand Rank</th>
<th>National brand Distribution Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All products</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correlation</td>
<td>-0.175</td>
<td>-0.145</td>
<td>0.131</td>
<td>0.054</td>
<td>-0.068</td>
</tr>
<tr>
<td>(P-value)</td>
<td>(0.115)</td>
<td>(0.191)</td>
<td>(0.240)</td>
<td>(0.625)</td>
<td>(0.54)</td>
</tr>
<tr>
<td><strong>All significant Product matches</strong> (5% two tailed test)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correlation</td>
<td>-0.636</td>
<td>-0.557</td>
<td>0.445</td>
<td>-0.22</td>
<td>0.108</td>
</tr>
<tr>
<td>(P-value)</td>
<td>(0.005)</td>
<td>(0.016)</td>
<td>(0.065)</td>
<td>(0.367)</td>
<td>(0.671)</td>
</tr>
</tbody>
</table>
Table 4  
Empirical results for the dynamic panel data models 3 to 5

<table>
<thead>
<tr>
<th>Model</th>
<th>Model 4.1 (distrib)</th>
<th>Model 4.2 (rank)</th>
<th>Model 4.3 (PLms)</th>
<th>Model 5.1 ( (\beta_{jk}) )</th>
<th>Model 5.2 ( (\beta_{jk}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \rho )</td>
<td>0.804* (0.004)</td>
<td>0.802* (0.005)</td>
<td>0.803* (0.004)</td>
<td>0.797* (0.005)</td>
<td>0.796* (0.005)</td>
</tr>
<tr>
<td>( \lambda )</td>
<td>0.001 (0.0009)</td>
<td>0.001 (0.0009)</td>
<td>0.001 (0.0009)</td>
<td>0.001 (0.0009)</td>
<td>0.001 (0.0009)</td>
</tr>
<tr>
<td>( \gamma )</td>
<td>-0.167 (0.178)</td>
<td>-0.183 (0.178)</td>
<td>-0.165 (0.177)</td>
<td>-0.165 (0.178)</td>
<td>-0.181 (0.178)</td>
</tr>
<tr>
<td>Coffee price</td>
<td>0.039* (0.013)</td>
<td>0.041* (0.013)</td>
<td>0.039* (0.013)</td>
<td>0.048* (0.013)</td>
<td>0.041* (0.013)</td>
</tr>
<tr>
<td>( \beta )</td>
<td>-0.0003 (0.002)</td>
<td>-0.0002 (0.0025)</td>
<td>-0.004*** (0.0025)</td>
<td>0.0019 (0.0037)</td>
<td></td>
</tr>
<tr>
<td>( \beta_1 )</td>
<td>-0.0007 (0.0030)</td>
<td>0.004 (0.0029)</td>
<td>-0.0020 (0.0032)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \beta_2 )</td>
<td>-0.00007 (0.0031)</td>
<td>-0.003 (0.0036)</td>
<td>-0.0001 (0.0028)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \beta_3 )</td>
<td>-0.006 (0.0008)</td>
<td>0.022* (0.006)</td>
<td>0.014* (0.006)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \beta_{11} )</td>
<td>-0.006*** (0.003)</td>
<td>-0.006*** (0.003)</td>
<td>-0.006*** (0.003)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \beta_{12} )</td>
<td>-0.006 (0.006)</td>
<td>-0.039* (0.003)</td>
<td>-0.006 (0.006)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \beta_{13} )</td>
<td>-0.007 (0.005)</td>
<td>5.6e-06 (0.010)</td>
<td>5.6e-06 (0.005)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \beta_{21} )</td>
<td>-0.002 (0.004)</td>
<td>-0.003 (0.003)</td>
<td>-0.002 (0.004)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \beta_{22} )</td>
<td>0.006 (0.004)</td>
<td>0.006** (0.003)</td>
<td>0.006 (0.004)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \beta_{23} )</td>
<td>-0.006 (0.005)</td>
<td>-0.0008 (0.004)</td>
<td>-0.006 (0.005)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \beta_{31} )</td>
<td>0.008** (0.004)</td>
<td>-0.003 (0.003)</td>
<td>0.008** (0.004)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \beta_{32} )</td>
<td>-0.003 (0.003)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \beta_{33} )</td>
<td>0.008** (0.004)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.999</td>
<td>0.999</td>
<td>0.999</td>
<td>0.999</td>
<td>0.999</td>
</tr>
<tr>
<td>( N )</td>
<td>15761</td>
<td>15761</td>
<td>15761</td>
<td>15761</td>
<td>15761</td>
</tr>
</tbody>
</table>

\( H^0 : \beta_1 = \beta_2 = \beta_3 = 0 \)

F-test(3, 15713) | 0.02 | 4.86* | 0.33 |

*/ Significant on a 1% level **/significant at a 5% level, ***/significant on a 10% level
### Table 5 Joint tests of hypotheses the dynamic panel data model 5

<table>
<thead>
<tr>
<th>Model</th>
<th>Model</th>
<th>Joint importance of Distribution or Rank</th>
<th>Joint importance of PL market share</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>5.2</td>
<td>High Distribution or Rank = 0</td>
<td>High PL market share = 0</td>
</tr>
<tr>
<td>$\beta_{jk}$</td>
<td>$\beta_{jk}$</td>
<td>$H_0^1: \beta_{11} = \beta_{12} = \beta_{13} = 0$</td>
<td>$H_0^4: \beta_{11} = \beta_{21} = \beta_{31} = 0$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12.96*</td>
<td>9.95*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medium Distribution or Rank = 0</td>
<td>Medium PL market share = 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$H_0^2: \beta_{21} = \beta_{22} = \beta_{23} = 0$</td>
<td>$H_0^5: \beta_{21} = \beta_{22} = \beta_{23} = 0$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.54</td>
<td>4.28*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low Distribution or Rank = 0</td>
<td>Low PL market share = 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$H_0^3: \beta_{31} = \beta_{32} = \beta_{33} = 0$</td>
<td>$H_0^6: \beta_{13} = \beta_{23} = \beta_{33} = 0$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.53</td>
<td>5.02*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8.99*</td>
</tr>
</tbody>
</table>

*/* Significant on a 1% level **/significant at a 5% level, ***/significant on a 10% level
Table 6 A summary of the results from models 5.1 and 5.2 (βs and joint F-tests)

<table>
<thead>
<tr>
<th></th>
<th>High (K=1)</th>
<th>Medium (K=2)</th>
<th>Low (K=3)</th>
<th>Joint test of “row” (Table 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Distribution</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High J=1</td>
<td>+*</td>
<td>+*</td>
<td>-***</td>
<td>$H^1_0$</td>
</tr>
<tr>
<td>Medium J=2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>$H^2_0$</td>
</tr>
<tr>
<td>Low J=3</td>
<td>0</td>
<td>0</td>
<td>+**</td>
<td>$H^3_0$</td>
</tr>
<tr>
<td><strong>Joint test of “column” (Table 4)</strong></td>
<td>$H^4_0$</td>
<td>$H^5_0$</td>
<td>$H^6_0$</td>
<td></td>
</tr>
<tr>
<td><strong>Rank</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“1” J=1</td>
<td>+*</td>
<td>-***</td>
<td>-*</td>
<td>$H^1_0$</td>
</tr>
<tr>
<td>“2” J=2</td>
<td>-*</td>
<td>0</td>
<td>+**</td>
<td>$H^2_0$</td>
</tr>
<tr>
<td>“3” J=3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>$H^3_0$</td>
</tr>
<tr>
<td><strong>Joint test of “column” (Table 4)</strong></td>
<td>$H^4_0$</td>
<td>$H^5_0$</td>
<td>$H^6_0$</td>
<td></td>
</tr>
</tbody>
</table>

*/ Significant on a 1% level **/significant at a 5% level, ***/significant on a 10% level
Market Conduct in the U.S. Ready-to-Eat Cereal Industry

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Abstract

The “Big Three” case against top breakfast cereal makers was a focus of U.S. antitrust activity during the 1970s, but the case was dismissed in 1981 without satisfactorily resolving the issue of whether firms operate as a “shared monopoly.” We investigate this issue with a differentiated-products oligopoly framework and previously unexamined data from Selling Area Markets, Inc. Price-cost margins are found to average 39%, more than 90% of the level associated with joint-profit maximization. Market power is exercised through tacit collusion, product differentiation, and the holding of multiple brands by individual firms. Implications for antitrust litigation and policy are drawn.

Key words: Shared monopoly, oligopoly pricing, cereal, antitrust law

JEL Classification: D43, L13, L4, L66
I. Introduction

The U.S. Ready-To-Eat (RTE) cereal industry has a number of features that facilitate the exercise of unilateral or cooperative market power. First, the industry is highly concentrated. Although there are approximately 40 companies producing more than 400 brands, more than 90% of output since 1980 has been produced by just four firms.\(^1\) Selling expenses average more than 30% of sales value, with smaller firms tending to advertise more than large firms, and most of the expenditure on mass-media advertising. Another characteristic is product proliferation. New product launches have increased from one to two per year in the 1950s, to more than 100 per year since the 1980s. If one accounts for all variations in sizes and flavors of the 400 brands, there are approximately 1000 RTE cereal products for sale in the U.S. Private label products (on which the supermarket affixes its own company imprint) are an important source of competition in other industries, but have limited effect in the cereal industry. Branded cereals continuously capture more than 90% of the market, despite having a 40% premium over private label cereals (Connor, 1999).

These attributes have led U.S. antitrust authorities to closely scrutinize the cereal industry in the past. The Federal Trade Commission (FTC), in fact, devoted roughly two-thirds of its antitrust resources to investigate the industry during the Ford and Carter administrations. The FTC sued the top three manufacturers – Kellogg’s, General Mills, and Post – for effectively operating as a “shared monopoly.”\(^2\) By the late 1970s events turned against the prosecutors, however. The 1970s period of relative activism by the FTC was poorly received in some circles, and Congress

\(^1\) These numbers are valid for the RTE cereal industry as a whole. If the classification is made by individual product (corn flakes, for example) the concentration is still higher (Connor, 1999).

\(^2\) Another RTE cereal company, Quaker, was a respondent to the 1972 FTC case, but was dropped in 1978 (Scherer and Ross, p. 465). Two other cereal-makers, Ralston and Nabisco, were also mentioned in the original 1972 FTC complaint, but not listed as respondents.
directed some of this negative pressure onto the FTC. The political climate in 1979-1980 was particularly unfavorable to FTC prosecutors: during the U.S. presidential campaign, incumbent Jimmy Carter and challenger Ronald Reagan both came out against the FTC’s side.³ Perhaps not surprisingly, the case was later dismissed in 1981, and appeals by FTC enforcement staff went nowhere.⁴

Since the trial brought much publicity to the cereal industry and its characteristics are found in many other markets, the sector has been of continual interest to economists. The many studies of the industry include Schmalensee (1978), Scherer (1979, 1982), Liang (1989), Stanley and Tschirhart (1991), Cotterill and Haller (1997), Connor (1999), and Nevo (2001). Within this literature there appears to be consensus that firms are highly profitable, and that market power is exercised through a combination of product differentiation and firm management of a portfolio of brands, with barriers to entry created through brand proliferation and extensive advertising.⁵ There is less consensus, however, regarding the FTC’s allegation of “shared monopoly” behavior, in which supracompetitive price levels are achieved through tacit collusion, as if a single agent jointly manages all brands. This rift in the literature is highlighted by comparing the conclusions of Nevo

³ According to Scherer and Ross (p. 466), “during the week before he was elected President of the United States, Ronald Reagan released a letter to the president of Kellogg, observing, ‘It is clear to me that the [cereal] case under consideration has very little basis in fact and that a favorable ruling on behalf of the FTC would have a chilling effect on American industry.’ A similar statement was made by then-President Carter while he was campaigning in Michigan.”

⁴ There was a fair amount of drama surrounding the demise of the case. According to Scherer and Ross (1990, p. 466), “As the trial neared completion, the administrative law judge who had presided over it for four years was disqualified on procedural grounds. A replacement judge heard the final defense witnesses, drew the threads, and ordered that the case be dismissed. Except for rejecting the cereal makers’ ‘all breakfast foods’ proposal and accepting RTE cereals as a relevant market, which he found to be highly concentrated, he resolved virtually every contested issue of fact or theory in favor of the companies. What followed was even more unprecedented. As is common in important FTC proceedings, the … FTC enforcement staff sought to appeal to the commission as a whole. But their superiors … refused to transmit the appeal … Under a cloud of continuing congressional criticism … the commission elected to receive the appeal but dismissed it without addressing its factual merits.”

⁵ Engineering estimates indicate that there are no additional economies of scale to be gained from having a plant (or a firm) larger than 4-6% of total industry output (Scherer, 1982, p. 196).
(2001), for example, with those of an earlier analysis: Scherer and Ross (1990). In his abstract, Nevo concludes that (p. 307):

…prices in the industry are consistent with noncollusive pricing behavior, despite the high price-cost margins. Leading firms are able to maintain a portfolio of differentiated products and influence the perceived product quality. It is these two factors that lead to high price-cost margins.

As such, Nevo concludes that firms do not engage in cooperative pricing, and particularly not at a level approximating joint-profit maximization, which is representative of shared monopoly (p. 336). When set against the conclusions of previous studies, however, this conclusion is somewhat surprising. For example, although Schmalensee (1978) focuses primarily on entry deterrence among leading firms, he characterizes the industry’s pricing as “approximately cooperative” (p. 315). In a more detailed analysis of the industry’s pricing behavior, Scherer and Ross (1990, p. 257) find the industry is characterized by *collusive price leadership*. This conclusion is based on evidence such as the following, which is a passage from Scherer (1982, p. 203-4):\(^6\)

Kellogg normally led list price changes in “rounds” covering many but not all the products in its line. Out of 15 unambiguous price increase rounds between 1965 and 1970, for which the period of documentary evidence is reasonably complete, Kellogg led 12. Kellogg’s price increase was followed nine times by General Mills and ten times by Post; on only one occasion did neither follow.

Such price movements can be described as “consciously parallel,” and MacLeod (1985) shows formally that this may be the result of collusion. This evidence would therefore appear to

---

\(^6\) This evidence of leader-follower behavior was determined using highly detailed data obtained from industry participants via a court-ordered process of discovery.
contradict Nevo’s finding of noncollusive behavior.

One might hypothesize that this discrepancy reflects the different periods of time under study. Scherer, for example, uses 1965-1970 data, while Nevo examines 1988-1992 data. We note that neither study restricts its findings to a particular period of time, however. Each frames the discussion of results within the context of the FTC trial. A more likely explanation is that Scherer (1982) and Scherer and Ross (1990) are describing a “barometric” form of price leadership. As described in Stigler (1947), a “barometric” price leader acts as an industry guide who “commands adherence of rivals to his price only because, and to the extent that, his price reflects market conditions with tolerable promptness” (p. 446). As such, the parallel price movements described by Scherer and Ross could reflect common adjustment to changing outside forces, not collusion. Thus their results might be consistent with those of Nevo.

The goal of this paper is to resolve this paradox bringing new data and methodology to bear on the issue. We employ heretofore unexploited data on the RTE cereal industry from Selling-Area Markets, Inc. (SAMI). These data encompasses the period from January 1975 to December 1990, permitting us to examine the period during and after the trial. In Section II we describe these data and offer an initial investigation regarding the form of market power exercised by the industry. From this we form an explicit hypothesis concerning industry conduct that can be tested econometrically. In Section III we develop alternative models of a price-setting, differentiated-products oligopoly for estimation with the SAMI data. Section IV describes our estimation scheme, the results, and the implications for antitrust law and litigation. Summary and conclusions are provided in Section V.

II. A First Look at the Data

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7 Ono (1982) provides a formalization and clarification of this concept.
SAMI data are at the brand-level, and in dollars and pounds for the U.S. market as a whole. There are 13 observations per year corresponding to four-week intervals. According to their documentation, the geographical coverage of the SAMI data is extensive and accounts for nearly 95% of the U.S. cereal sales (data on individual markets is not given). Brand-level unit values or “prices” are found by dividing sales in dollars by sales in pounds. To account for general inflation over time, unit values are deflated with the Bureau of Labor Statistics’ Food and Beverage Consumer Price Index. This is centered on 1982-84 and is an average for U.S. cities, as are the SAMI data.8

Our analysis begins with Figure 1, which displays average cereal prices for the four largest cereal manufacturers as well as private label price over the sample period.9 A number of observations can be made from this figure. First of all, the prices associated with all five cereals are stable or slightly trending downward during the second half of the 1970s. The year 1980, however, marks an noticeable shift. After this point the prices of branded cereals begin a strong upward trend. With the exception of Quaker cereals, this rise continues on into the 1990s. In contrast, private label prices, which may be a reasonable proxy for marginal costs in this industry (Barsky et al., 2003), are very stable throughout the 1980s. Another observation is that branded cereal prices tend to move closely together. This brings to mind the “consciously parallel” pricing described in Scherer (1982), and formalized in MacLeod (1985). One also notes there are frequent, small dips and rises in the price series, particularly among branded cereals. For example, in 1985

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8 In the present draft of this paper we focus on the Kids segment of the cereal market. Kids cereals are distinguished by a combination of high sugar content and marketing targeted at kids, in which the image of a colorful cartoon character is typically emphasized as opposed to family imagery or nutritive properties. Twenty-one kids cereals are tracked by the SAMI data over the duration of the sample period. In terms of pounds of cereal, we examine seven of these, which account for an average 41% share of the kids segment. The cereals are Kelloggs Froot Loops, Kellogg Corn Pops, Quaker Cap N Crunch, Quaker Life, General Mills Lucky Charms, General Mills Trix, and General Mills Kix. SAMI data also provide information on an aggregate Private Label category which encompasses all of the segments.

9 These unit values were calculated by dividing total sales in 1982-84 US$ of all brands together, by total sales in pounds.
there is a small spike in the prices of the four branded manufacturers. This does not occur in the private label price series.

These observations are quite striking, and lead to the following questions: Why did prices decline slightly in the 1970s? Why do branded prices rise so markedly in the 1980s? Why do branded prices move closely together? Why are there occasional dips and rises? The parallel nature of the brand price movements is consistent with the story told by Scherer (1982), although as noted before, this might occur even without collusion, since firms producing similar products are likely to respond to outside market forces in the same way, at about the same time. As for the price declines in the 1970s and the rises in the 1980s, there are a number of possible explanations. On the demand side, this could have been caused by stagnating consumer demand for RTE cereals in the 1970s, followed by booming demand in the 1980s. There is, however, little evidence to support this case. According to the SAMI quantity data, during the 1980s sales of private label cereals were increasing slightly relative to branded cereals. Additionally, the 1980s witnessed a proliferation of convenience-oriented breakfast alternatives such as toaster pastries, cereal bars, and breakfast items at fast food restaurants. The emergence of these competitors would, if anything, have lessened the overall demand for branded cereals, not increased it. Yet in the SAMI data, consumption of branded cereals almost precisely mirrors the growth of the U.S. population over the sample period.

More plausible explanations for the 1970s price decreases and 1980s price increases arise on the supply side. These could reflect macro-level changes in the prices of raw materials and other inputs, including mass-media selling expenses and energy costs. In this sense, the parallel price shifts among branded cereals may have been “barometric” in nature, reflecting effects on the industry as a whole. However, this theory is weakened by the fact that private label prices did not experience the steep rise that branded cereal prices did. If overall market forces were affecting the cereal industry, it seems they would have changed the price of private labels as well. Moreover,
historically there is very little evidence of barometric price leadership. Indeed, Scherer and Ross (1990) argue that many of the criteria for this phenomenon are not found in this industry. For example, switching of the price leader occurs rarely, and rejection of the leader’s price initiatives is uncommon. In particular, in examining the data obtained by FTC prosecutors, Scherer (1982, p. 204) finds that “the price leader did not rescind its price increases when others failed to follow; instead it relied upon its product differentiation to prevent a sudden loss of business and waited until parity was restored in a subsequent round.”

However, it would appear that many of the criteria for collusive price leadership are met, including: (a) the industry is tightly oligopolistic, (b) sellers’ products are close substitutes, (c) cost curves are similar, (d) there are barriers of entry to new rivals, and (e) demand for the industry’s products is relatively inelastic (Scherer and Ross, p. 249). Another rule-of-thumb for distinguishing between barometric and collusive behavior is identified in MacLeod (1985). He observes that “the only time one may have reasonably conclusive evidence of tacit collusion is through the observation of price wars” (p. 41). In other words, if firms are behaving non-cooperatively, one would not expect there to be sudden dips in prices soon followed by reversion back to a higher level. This does appear to happen in Figure 1, however, particularly among branded cereals. These patterns could reflect periodic breakdowns in collusive behavior. The existence of price wars may also explain the late 1970s fall in cereal prices (Figure 1). However, a striking feature of this decline is that it coincides perfectly with the demise of the FTC case against the cereal industry. The lowering of prices may have been a conscious attempt by the cereal companies to deflect criticism of supracompetitive pricing during the trial.

In the next section we will begin sorting through these possibilities by specifying a differentiated products oligopoly model that can be empirically estimated with the SAMI data. Our running hypothesis is that the parallel price movements exhibited in Figure 1 reflect a conscious effort by cereal companies to monopolize the cereal company and increase their profitability.
Although the limitations of data and model do not permit an explicit test of collusive price leadership as described in Scherer and Ross (1990), the analysis allows us to gauge the extent to which firms operate as a “shared monopoly.”

III. Theoretical and Empirical Framework

General strategy

One of the defining characteristics of oligopoly is that firms recognize their mutual interdependence. In modeling oligopoly it is thus unrealistic to restrict firms to operate in isolation, making decisions as if rivals’ behavior is fixed. A number of approaches to estimating the nature and extent of these interactions is offered in the empirical industrial organization literature (Cotterill, Putsis, and Dhar, 2000). One is the “menu approach,” in which a number of stylized strategic games are specified, estimated, and evaluated via non-nested hypothesis tests to determine which game is most consistent with the data (e.g., Gasmi, Laffont, and Vuong, 1992; Dhar et al., 2002). In an alternative approach, instead of specifying strategic interactions a priori, the game played by firms is identified through estimation of conjectural variation parameters (e.g., Roberts, 1984; Liang, 1989). A third alternative, the approach used in this paper, involves estimating the reaction functions associated with particular brands, and in particular, the price reaction elasticities (e.g., Cotterill, Putsis, and Dhar, 2000; Cotterill and Samson, 2002). These parameters represent the observed tendency of a brand’s price to change in response to the price changes in other firms’ brands. This differs from the conjectural variations approach in that actual price responses are estimated instead of anticipated price responses. The two approaches yield equivalent estimates of competitive interaction if conjectures are consistent. However, tests for consistency generally find little support (e.g., Liang, 1989; Dhar et al., 2002). Given the discrepancy between conjectured and actual responses, the latter would seem a better representation of actual pricing and profitability.

A weakness of reaction curve oligopoly models is that they are static and cannot account
for the inherently dynamic process of reaching an equilibrium. Some studies have made progress in relating observed price reactions to more advanced, dynamic models of price conjectures. For example, Müller and Normann (2002) study evolutionary games and find support for a reaction curve approach. Some careful empirical studies have as well (e.g., Genesove and Mullin, 1998). In any case, observed price reaction elasticities are a useful and tractable approach for measuring competitive interactions and departures from competitive behavior in oligopolies.

Our general approach involves setting up an oligopolistic, brand-level profit maximization framework that can be estimated and used to calculate actual, observed Price-Cost Margins (PCMs). While these PCMs will provide information about the extent of market power that is exhibited in the industry, we are interested in the form of market conduct exhibited. A benefit of our framework is that it is quite general and nests additional modes of industry conduct for which corresponding brand-level PCMs can be calculated. These special cases are not intended to represent actual behavior, but serve as benchmarks for putting the actual, observed PCMs in context (a similar approach is employed in Nevo, 2001). In particular, the maximum potential PCMs associated with (i) unilateral market power (i.e., product differentiation), (ii) unilateral market power plus the portfolio effect (i.e., market power associated with a firm managing multiple brands), and (iii) shared monopoly (i.e., a joint profit-maximizing scheme), are calculated for comparison to the observed PCMs.

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10 Müller and Normann (2002) find conjectures that are evolutionary stable and the same as in Bresnahan’s (1981) consistent conjectures equilibrium. Both the outcome implied by the conjectures and the conjectures themselves are justified. Theoretical underpinnings for the conduct parameter approach are also developed in Cabral (1995), Dockner (1992), and Dixit (1986).

11 While Corts (1999) uses simulations of a dynamic oligopoly model to show that conduct parameters can mismeasure market power, Genesove and Mullin (1998) use highly detailed cost data to demonstrate that in practice this bias may be quite small.
Model

The cereal industry is characterized by a small number of firms each selling differentiated brands. In this context it is appropriate to consider the profit-max problem of a multi-brand firm. Our set-up is similar to Nevo (1998). Let $\Theta$ represent the set of brands associated with a certain segment of the cereal industry (e.g., kids cereals). There are $F$ firms, each producing some subset, $\Theta_f$, of this segment’s brands. Let $\Theta_{-f}$ be the subset of this segment’s brands not associated with firm $f$. Therefore, $\Theta = \Theta_f \cup \Theta_{-f}$. There are $J$ brands in $\Theta$, indexed $j = 1, \ldots, J$, or $k = 1, \ldots, J$. Marginal costs are constant. The profits of firm $f$ are:

$$\Pi_f = \sum_{j \in \Theta_f} (p_j - mc_j)q_j - C_f \tag{1}$$

where $p_j$ is the price of brand $j$, $mc_j$ is the (constant) marginal cost of brand $j$, and $C_f$ is the firm’s fixed cost of production. The demand for brand $j$ depends on its own price and that of all competitors in the segment: $q_j = q_j(p_j, \ldots, p_J)$. In other words, the demand for a brand depends on own- and cross-price elasticities of demand. Firms maximize profit by simultaneously choosing the prices of brands within their portfolios, taking into account the average price reactions of brands not part of their portfolio, such that: $p_{j \in \Theta_f} = h(p_{k \in \Theta_{-f}})$ \footnote{Scherer (1982) and Scherer and Ross (1990) find there to be price leadership in the cereal industry, in which case we might have modeled a sequential move game. This is complicated by the fact that the roles of leader and follower periodically changes among the firms. Furthermore, our data are too imprecise to distinguish leader-follower behavior. In contrast, Scherer’s data (which was made available through the FTC trial) indicates the particular day on which price changes were announced by a manufacturer, and also indicates the precise delay in their implementation in retail stores.}. The first order condition of brand $j$ associated with firm $f$ is:

$$q_j + \sum_{r \in \Theta_f} (p_r - mc_r) \left[ \frac{\partial q_r}{\partial p_j} + \sum_{k \in \Theta_{-f}} \frac{\partial q_r}{\partial p_k} \frac{\partial p_k}{\partial p_j} \right] = 0. \tag{2}$$

Multiplying though by $p_j / \sum p_r q_r$, as well as by $(p_r / p_j)$, $(p_k / p_j)$, and $(q_r / q_j)$ in certain terms, yields the following modified first order condition:
The term \( s_j \) is the expenditure share on brand \( j \), \( \text{PCM}_r = (p_r - mc_r) / p_r \) is the price-cost margin, and \( \varepsilon_{rj} = (\partial q_r / \partial p_j)(q_j / q_r) \) is the price elasticity of demand for brand \( r \) with respect to brand \( j \).

The term \( \eta_{kj} = (\partial p_k / \partial p_j)(p_j / p_k) \) is a price reaction elasticity and measures the degree to which brand \( k \) is observed to respond to a change in brand \( j \)'s price. We now solve (3) for brand \( r \)'s price-cost margin (\( \text{PCM}_r \)).

It is useful to rewrite (3) in matrix form. Define the term \( \Psi_{jr} \):

\[
\Psi_{jr} = s_j \left[ \varepsilon_{rj} + \sum_{k \in \Theta_{rj}} \varepsilon_{rk} \eta_{kj} \right].
\]

Following Nevo (1998), let \( \Omega' \) be a \((J \times J)\) matrix, with element \( \Omega'_{jr} \) in row \( j \) and column \( r \) be:

\[
\Omega'_{jr} = \begin{cases} 
1, & \text{if } \exists f : \{r, j\} \subset \Theta_f \\
0, & \text{otherwise}
\end{cases}
\]

In turn, \( \Omega \) is a \((J \times J)\) matrix with typical element \( \Omega_{jr} = \Omega'_{jr} \Psi_{jr} \). \( \text{PCM} \) is a \((J \times 1)\) vector of price-cost margins, and \( \mathbf{s} \) is a \((J \times 1)\) vector of expenditure shares. Then (3) can be re-written in matrix form:

\[
\mathbf{s} + \Omega \Psi = 0.
\]

Solving for the price-cost margins yields:

\[
\text{PCM} = -\Omega^{-1} \mathbf{s}.
\]

To help in understanding (6), consider the following scenario. Suppose there are three firms (General Mills, Quaker, and Kellogg’s) which altogether produce seven kids cereals. General Mills produces brands 1 and 2; Quaker produces brands 3 and 4; and Kellogg’s produces brands 5, 6, and 7. In this case (6) takes the form:

\[
\begin{bmatrix}
\text{PCM}_1 \\
\text{PCM}_2 \\
\text{PCM}_3 \\
\text{PCM}_4 \\
\text{PCM}_5 \\
\text{PCM}_6 \\
\text{PCM}_7
\end{bmatrix}
= 
\begin{bmatrix}
\Psi_{11} & \Psi_{12} & 0 & 0 & 0 & 0 & 0 \\
\Psi_{21} & \Psi_{22} & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & \Psi_{33} & \Psi_{34} & 0 & 0 & 0 \\
0 & 0 & \Psi_{43} & \Psi_{44} & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & \Psi_{55} & \Psi_{56} & \Psi_{57} \\
0 & 0 & 0 & 0 & \Psi_{65} & \Psi_{66} & \Psi_{67} \\
0 & 0 & 0 & 0 & \Psi_{75} & \Psi_{76} & \Psi_{77}
\end{bmatrix}
\begin{bmatrix}
\mathbf{s}_1 \\
\mathbf{s}_2 \\
\mathbf{s}_3 \\
\mathbf{s}_4 \\
\mathbf{s}_5 \\
\mathbf{s}_6 \\
\mathbf{s}_7
\end{bmatrix}
\]

\[
\begin{bmatrix}
\mathbf{s}_1 \\
\mathbf{s}_2 \\
\mathbf{s}_3 \\
\mathbf{s}_4 \\
\mathbf{s}_5 \\
\mathbf{s}_6 \\
\mathbf{s}_7
\end{bmatrix}
= 
\begin{bmatrix}
\Psi_{11} & \Psi_{12} & 0 & 0 & 0 & 0 & 0 \\
\Psi_{21} & \Psi_{22} & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & \Psi_{33} & \Psi_{34} & 0 & 0 & 0 \\
0 & 0 & \Psi_{43} & \Psi_{44} & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & \Psi_{55} & \Psi_{56} & \Psi_{57} \\
0 & 0 & 0 & 0 & \Psi_{65} & \Psi_{66} & \Psi_{67} \\
0 & 0 & 0 & 0 & \Psi_{75} & \Psi_{76} & \Psi_{77}
\end{bmatrix}^{-1}
\begin{bmatrix}
\mathbf{s}_1 \\
\mathbf{s}_2 \\
\mathbf{s}_3 \\
\mathbf{s}_4 \\
\mathbf{s}_5 \\
\mathbf{s}_6 \\
\mathbf{s}_7
\end{bmatrix}
\]
Equation (7) implies that without observing actual costs, brand-level PCMs can be estimated based on inter-firm price reaction elasticities, and on own- and cross-price elasticities of demand.

This information allows us to gauge the extent to which firms exercise market power. To distinguish among the different forms of market power, we obtain benchmarks described earlier. Scenario (i) represents the potential for unilateral market power. It assumes the cereal industry is comprised of single-brand firms deriving market power solely from product differentiation. Firms are assumed to operate in isolation from each other, so price reaction elasticities are set equal to zero (i.e., \( \eta_{ij} = 0 \; \forall \; k,j \in \Theta \)). Scenario (ii) adds to this a portfolio effect. This time the profit maximization problem is set up to let each firm manage multiple brands, thereby internalizing the cross-price effects of demand associated with these brands. In this context, a firm producing two imperfectly substitutable brands will charge a higher price for them than if produced by two rival, single-brand firms. As with the first scenario, firms are assumed to operate in isolation from each other.\(^{13}\) The difference in PCMs between scenarios (i) and (ii) represents the maximum potential increase in PCM associated with the portfolio effect (assuming that firms are operate without error). To these two modes of market power, scenario (iii) incorporates the potential for coordinated market power, and represents perfect collusion or “shared monopoly.” It assumes that a single agent jointly maximizes the profit of all brands. The difference in PCMs between scenario (iii) and (ii) represents the maximum possible benefit from collusion (again, assuming that firms are operate without error).

These three benchmarks are special cases of (7). In all three scenarios equation (4) reduces to: \( \Psi_{jr} = s_j \varepsilon_j \), since price reaction elasticities are zero. In the case of the \( \Omega' \) matrix, in scenario (i) each brand is managed by a single-product firm, so \( \Omega' \) is an identity matrix (\( \text{PCM}_r = -1/\varepsilon_r \)). In scenario (ii) multi-brand firms jointly set the prices for their subset of brands, so \( \Omega' \) contains

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\(^{13}\) This distinguishes scenario (ii) different from the actual, observed scenario, which relies on estimates of the price reaction elasticities.
blocks of ones centered on the diagonal (this is represented above in (7)). In contrast, scenario (iii) implies that $\Omega'$ is comprised entirely of ones.

**Demand elasticities**

A central objective of this study is to quantify the strategic interactions of firms in the cereal industry. Information about the demand side, while important for calculating margins, is of less importance than characterizing inter-firm behavior. As a result, we assume that consumer preferences among brands within a segment are invariant over the period of study.\(^{14}\) The key reason for this simplification is that the demand elasticities of Nevo (2001) can be used. These provide a richer and more accurate characterization of demand than available elsewhere in the literature, or compared to what is possible with the SAMI data.\(^{15}\) Nevo (2001) uses the Berry, Levinsohn, and Pakes (1995) discrete choice approach to estimate an aggregate model of demand for RTE cereals. The use of a random coefficients approach allows 25 brands to be examined simultaneously, although information on how brands are segmented is also taken into account. Substitutability among brands is modeled in terms of the underlying characteristics of cereals, including calories, sweetness, and texture. While the mixed logit model approach is perhaps overly restrictive in some ways (e.g., prices of different brands have a common coefficient in the indirect utility function), the results are state-of-the-art concerning our knowledge of the demand for RTE cereals.

There are 21 brands in common within the Nevo and SAMI data (the former cover 1988-92; the latter cover 1975-90). Although in theory we could examine all these brands as a single

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\(^{14}\) This is not as restrictive as it may seem, since it leaves open the possibility that overall demand for the cereals of given segment changed over the time period.

\(^{15}\) For example, the SAMI data are an aggregate for the U.S. as a whole, whereas Nevo’s data are decomposed into regions. The latter provides a key means of identifying the demand equations. Another limitation of the SAMI data is that other important information about demand was unavailable for this earlier time period.
category, it is standard practice to divide the cereal market into segments. For example, Schmalensee (1978) observes that cereals are “ spatially” differentiated products grouped into different segments, which he describes as “clusters of more directly competitive brands” (p. 309). Nevo also characterizes the market as segmented, and makes use of this information in identifying his model. In turn, Cotterill and Haller (1997) cite the research of A.C. Nielsen, a leading marketing information company, as a reason for their decision to work in terms of segments. Accordingly, we divide the brands common to both the SAMI and Nevo data into two segments that reflect in a general sense the breakdown used by Nielsen: Kids and Adult/Family.

Elasticity estimates are not reported here for space reasons, but are in Table VII and a supplementary table of Nevo (2001). Own price elasticities among Kids cereals range from -2.227 for Cap N Crunch to -3.332 for Frosted Mini-Wheats, and cross-price elasticities range from 0.016 to 0.182. Among Adult/Family cereals, own-price elasticities range from -2.496 to -3.821, and cross-price elasticities range from 0.021 to 0.241. Positive cross-price elasticities indicate that brands are substitutes as opposed to complements, which is realistic given that consumption of one generally does not coincide with consumption of another (in contrast to complementary food items such as milk and cereal, for example).

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16 As an illustration of the widespread acceptance of the fact that the RTE cereal industry is segmented, Cotterill and Haller (p. 2) provide the following quote from Nielsen Marketing Research executives. It describes one segment of the industry, but is applicable to any of them: “The [Taste Enhanced Wholesome] segment consists of brands that possess strong interactions with each other. Including other category segments into the evaluation may ‘dilute’ the switching patterns observed in the data.”

17 Due to collinearity among some brands of the same company, all 21 possible brands were not used in the regression analysis. Those omitted either did not fit into one of the segments considered, or had an extremely low or high market share. The Kids segment includes General Mills Trix, General Mills Lucky Charms, Kellogg’s Frosted Mini Wheats, Kellogg’s Corn Pops, Kellogg’s Froot Loops, Quaker Cap N Crunch, and Quaker Life. No data on a Post Kids cereal was available. The Adult/Family segment includes Post Raisin Bran, Post Grape Nuts, Kellogg’s Rice Krispies, Kellogg’s Special K, Kellogg’s Raisin Bran, General Mills Cheerios, and General Mills Wheaties. Data on Adult/family cereals from Quaker was limited to a single, marginal brand, and thus excluded.
Price reaction elasticities

Although wholesale prices are the strategic variables of cereal manufacturers, the SAMI data provide information on retail prices. One can estimate the strategic behavior of manufacturers using retail prices, however, if retailers are characterized as following a proportional markup rule. This seems reasonable given that the genesis of the FTC case was market power exercised by manufacturers, not retailers, and since this is the approach of related studies.\(^{18}\)

In deriving price reaction functions from the first order conditions (equation 2), they turn out to be particularly complex functions of demand coefficients and conjectures. As a result, a first order Taylor series approximation concerning the price reaction elasticities is estimated, as in Cotterill, Putsis, and Dhar (2000) and Cotterill and Samson (2002). This approximation involves a linear, non-recursive system of simultaneous equations, with one equation per brand of cereal. A three-stage least squares estimation technique is employed as it is likely the most efficient estimation process, at least in an asymptotic sense (Judge et al., 1988, p. 668). In this procedure the endogenous variables are first regressed on the system’s predetermined variables, and the resulting predicted values serve as instruments in subsequent estimation. To help develop appropriate instruments and identify each equation, a one-period lag of the dependent variable (\(\ln p_{jt}, \) where \(t\) indexes time) is included on the right hand side of each equation.

A key goal of the specification is to distinguish price changes that occur for strategic reasons from price changes that are merely barometric in nature. Ideally one would directly observe all exogenous supply and demand forces acting upon the industry. The residual of these

\(^{18}\) This is not to say that the balance of power between food manufacturers and retailers has not shifted towards the latter in recent years (i.e., after the period of this study). There has been increased use of slotting fees, charges for promotions, and performance requirements for manufacturers’ products, made possible through consolidation in the form of mergers and acquisitions, and new information gathering techniques such as electronic scanners (Kaufman, 2000).
effects on price would reflect firms’ competitive interactions. Unfortunately it is a very tall order
to obtain direct measurements, particularly for our sample time period. In terms of the raw
ingredients used to produce cereal, data was obtained on the U.S. Midwestern wholesale price of
refined sugar \( p_{SGR} \), and price of wheat \( p_{WHT} \). These comprise roughly one-sixth of manufacturer
price, and a smaller portion of retail price (Nevo, 2001, Table III). To help account for the
remainder of costs, we draw on the observation of Barsky et al. (2003) that private label prices are
often an excellent proxy for costs. Accordingly, we incorporate the logged price of private labels
(\( \ln p_{PL} \)) as a regressor to further represent the industry’s overall costs.

To account for changes on the demand side, the log of expenditure (\( \ln x_i \)) for a given
cereal segment is also included as an explanatory variable. This would normally be expected to be
positively related to brand level prices, and may help to account for competition from newly
introduced, out-of-segment products such as toaster pastries and granola bars.\(^{19}\)

In initial tests of the model, Breusch-Godfrey tests revealed that serial correlation is a
problem in most equations.\(^{20}\) As a result, all variables are first differenced for final estimation,
signified in (8) by the “d” in front of the corresponding variables. The final empirical form is:

\[
d\ln p_j = \sum_{j=1}^{n} \eta_{jk} d\ln p_{kt} + \beta_{1j} d\ln p_{j, t-1} + \beta_{2j} d p_{SGR_t} + \\
+ \beta_{3j} d p_{WHT_t} + \beta_{4j} d\ln p_{PL_t} + \beta_{5j} d\ln x_t + u_{jt}. \tag{8}
\]

If \( u_t \) is the original disturbance term at time \( t \) in the levels versions, then \( u_{jt} = v_{jt} - v_{jt-1} \) in (8).
Checking of the order conditions indicate the equations are over-identified.\(^{21}\)

\(^{19}\) It may have been desirable to incorporate additional exogenous variables that capture potential variation in marketing
strategies, demographic patterns, consumer preferences, and the number of competing products (new cereal introductions,
as well as competing non-cereal products), but such information was unavailable for the sample period.

\(^{20}\) This test is suitable for situations in which a lagged endogenous variable is used. It is described, for example, in

\(^{21}\) There are six predetermined variables excluded from each equation. The number of endogenous variables (less one) in
an equation is either four or five, depending on the brand.
IV. Econometric Estimation and Results

Price reaction elasticities

In regression equation (8) there is a specific price reaction elasticity ($\eta_{jk}$) associated with each brand $j \in \Theta_f$ of firm $f$, and each outside brand $k \in \Theta_{-f}$. Thus two brands of the same firm are not restricted to have identical price reaction elasticities with all outside brands. Evidence suggests, however, that strategic pricing is done at the firm level as opposed to individual brand level. For example, Scherer’s description of price changes in the industry suggests they are frequently across all products of a firm (p. 203-4). Cotterill, Putsis, and Dhar (2000) also provide evidence that Post, Kellogg’s, and other cereal manufacturers make price changes for all their brands simultaneously (p. 110-111). In examining the cereal “price wars” of the mid-1990s, Solman (1996) characterizes the battles as carried out by firms as a whole, as opposed to waged at the level of individual brands. For instance, Solman observes that “the company with the third largest share took the lead in price cutting.” The implication is that price reaction elasticities are likely to be nearly identical for same-firm brands. This possibility concerning $\eta_{jk}$ was tested as joint hypothesis when estimating (8). Using critical values from $F$ and Wald Chi-square tests, a hypothesis that price reaction elasticities are common across brands of the same firm was not rejected for 70% of the cases. Given this finding, in the remainder of the analysis, brands of the same firm are restricted to have common price reaction elasticities.

Three stage least squares estimates of the Adult/Family and Kids price reaction functions are presented in Tables 1 and 2, respectively. A row gives the estimated coefficients for a particular cereal brand’s version of equation (8). $R$-square values vary from 0.057 to 0.169 among 22 Activities that affect costs, such as dealing with input suppliers and a distribution network, often take place at the firm level as opposed to the level of individual brands. For instance, negotiations over retail shelf space and in-store promotions occurs at the firm level. Furthermore, advertising is often done at the firm level instead of for each brand individually in order to reduce costs.
Adult/Family cereals, and from 0.032 to 0.170 among Kids cereals. While some of these $R^2$ values are very low, this is common among models constructed in first differences. Alternative models formulated in levels generally had higher $R^2$ values, typically in excess of 0.50, but in the end, emphasis was given to designing an appropriate economic specification as opposed to focusing on high coefficients of variation.\textsuperscript{23}

Estimates of price reaction elasticities are in the leftmost ($7 \times 7$) block of cells in Tables 1 and 2. A given entry $(i, j)$ represents the percent by which row $i$’s price is estimated to change when column $j$’s price increases by 1%. The effect of the restrictions mentioned earlier should be readily apparent: brands of the same firm have identical price reaction elasticities with respect to the brands of other firms. Estimator standard errors are in parenthesis below the estimates. One, two, and three asterisks indicate statistical significance at the 10%, 5%, and 1% level, respectively, in a two-sided test.

In both segments, four out of six coefficients are statistically different from zero at one of the aforementioned significance levels. Among Adult/Family cereals, the two cases in which price reaction elasticities are not statistically different from zero involve General Mills and Post (Table 1). If Post raises its prices by 1%, General Mills does not respond in a consistent way, and vice-versa. Among the Kids cereals, it is Quaker and Kelloggs which have weak pricing interaction. If Kelloggs raises its prices by 1%, for example, Quaker does not have a uniform response. This is consistent with Scherer’s (1982) observation that Quaker tends to operate more independently of Kelloggs than other firms (p. 204).

The remaining price reaction elasticities (8 out of 12) are statistically different from zero,\textsuperscript{23} Another approach that was tried left the variables undifferenced, but incorporated the autocorrelation correction method of Pagan (1974). This approach gave rise to high $R^2$ values, but was much more complex and computationally burdensome than first differencing, and both approaches resulted in essentially the same price reaction elasticities. Yielding to Occam’s razor, the simpler first-differencing strategy of (8) was adopted.
generally at the 1% level. This means that even after industry-wide demand and cost forces are taken into account, there is a high level of pricing interaction among branded cereals. The tight coordination in pricing goes well beyond the signaling of market conditions. This eliminates the possibility that firms play a Nash-Bertrand game.

The signs of price reaction elasticities provide further evidence as to what kind of strategy is followed. For both segments, all coefficients that are statistically significant are positive. So when one firm raises prices and restricts output, others follow suit. For example, when Kellogg’s raises its Adult/Family cereal prices by 1%, Post tends to respond by 0.422%, and General Mills responds by 0.264%. As an example from the Kids segment, when General Mills raises its prices by 1%, Kellogg’s tends to respond by 0.419%, and Quaker responds by 0.355%. Even though firms could get a bigger share of the cereal market if they lower or hold their prices constant when a rival raises theirs, this is not the nature of interaction in the industry. This rules out non-cooperative rivalry as the game played by firms. We are left to conclude that the inter-firm coordination in pricing has a good deal of strategic content.

In general very little of the variation in brand price changes is related to the regressors that proxy for exogenous supply and demand forces. For example, in no equation are the coefficients of the cost shift variables ($dp_{SGR}$, $dp_{WHIT}$, and $d \ln p_{PL}$) statistically different from zero at a 5% level of significance. In many ways these results are not highly surprising. Solman (1996), for example, indicates that total raw material costs are only about $1.35 on a $4.00 box of cereal. As a result, even though there are relatively large variations in sugar and wheat price changes over the sample period, this explains very little of the variation in cereal price changes. It might seem that the price changes of private labels, which may closely align with costs, would be related more closely to brand price changes. Yet even if private labels do reflect costs, it is clear in Figure 1 that they bear little relation to the prices of branded cereals, at least after dismissal of the FTC trial in 1981. Throughout the 1980s the price of private label cereals is remarkably stable as the price of branded
cereals rises rapidly. As a result, the coefficients on private label prices are no different from zero in a statistical sense.

With regard to demand forces, the overall demand for a segment ($d \ln x$) had statistical significance in about half of the brands (Tables 1 and 2). For example, the price elasticity of Post Raisin Bran and Post Grape Nuts with respect to overall segment demand was $-0.031$ and $-0.059$ at 5% and 1% levels of significance, respectively. However, in these and other cases the influence of segment demand tends to be quite small in magnitude. As an alternative to $d \ln x$ it may have been desirable to include the number of new cereal brand introductions, and information on competing breakfast products (e.g., cereal bars, toaster pastries, fast food breakfast items), as explanatory variables. However, the introduction of competing products would if anything have suppressed demand for Adult/Family and Kids cereals. This, in turn, would have depressed branded cereal prices, yet there is a robust upward trend throughout the 1980s (Figure 1).

The primary finding of the regressions is that the tight coordination in branded cereal pricing is only marginally related to industry-wide demand and cost forces. As such, barometric price signaling explains only a small fraction of the parallel pricing in Figure 1. On the other hand, the price reaction elasticities range from only 0.247 to 0.422, values that are not particularly large in magnitude. One might expect, in contrast, that prices to move in lockstep if firms truly operate as a shared monopoly. The next section will provide a means of addressing this issue through calculation of price-cost margins.

**Price-cost margins**

The estimates of firm interaction can now be used to assess the extent and type of market power exhibited in the cereal industry. To derive a vector of observed “actual” PCMs, a version of equation (7) was set up to reflect a segment’s actual brand-to-firm correspondences. Estimated price reaction elasticities, demand elasticities, and brand market shares were then plugged into this
system to calculate observed PCMs. These embody all of the possible forms of market power, including product differentiation, the portfolio effect, and inter-firm coordination. While we associate the observed PCMs with “truth,” they are, of course, conditional on the modeling assumptions and data.

Table 3 presents the observed PCMs for individual cereals along with bootstrapped 95% confidence intervals that take estimator standard error into account. The maximum potential PCM associated with three hypothetical scenarios is also presented. As described in Section III, the first scenario reflects product differentiation alone, the second scenario adds to this the portfolio effect, and the third scenario corresponds to joint-profit maximization of all brands.

The average observed PCMs for Adult/Family and Kids cereals are 35.5% and 42.3%, respectively. The observed Kids PCMs are generally higher than those for Adult/Family cereals because demand for the former tends to be more inelastic. In other words, there is typically more sensitivity to price with respect to cereals purchased for adults or the family, as opposed to cereals purchased for kids. Examination of the confidence intervals for observed PCMs suggests there is little uncertainty surrounding the estimates. This reflects the small standard errors of most price reaction elasticity estimators (Table 1 and 2). With the exception of Kellogg’s Special K, the observed PCM of every brand falls between the PCM associated with product differentiation and portfolio effect (scenario ii), and the PCM associated with joint profit maximization (scenario iii).

In the case of Kellogg’s Special K, the observed PCM exceeds the PCM associated with joint-profit maximization. This reflects the fact that a shared monopoly has more brands to manage, and must account for a larger set of own- and cross-price demand interactions. If some of the additional brands under shared monopoly are close substitutes for Special K, higher profits may be obtained by keeping its price lower than in scenario (ii) in order to prevent substitution to the shared monopoly’s other, less profitable brands.

The observed PCMs clearly exceed the level associated with the second benchmark
scenario, in which unilateral and portfolio market power are exercised, but firms otherwise price in a perfectly competitive manner. For Adult/Family and Kids cereals the average gap is 2.6 and 2.5 percentage points, respectively. Using the lower bound of observed PCM confidence intervals, average PCMs are still more than two percentage points higher than the level in the second hypothetical scenario. This suggests that even though firms do not change their prices in lockstep, tacit collusion is an important reason for the high PCMs. The average observed Adult/Family and Kids PCMs are 95.7% and 89.6% of the average PCMs obtainable by a shared monopoly. This lends strong support to the FTC’s 1970s allegation that the industry effectively operates as a shared monopoly, especially in light of the shared monopoly scenario being just an extreme, theoretical maximum.

Comparison to other studies

There are several differences between these results and those of Nevo (2001), for example. For example, consider that Nevo (Table VIII) uses the same three hypothetical cases of industry conduct as benchmarks for decomposing the exercise of market power. Since the two studies use identical demand elasticities, the average PCM for single-brand firms is essentially the same: 35.8% versus 35.0%. However, the potential for market power obtained through the portfolio and joint-profit maximization effects are more pronounced in Nevo’s results. Average PCMs for those scenarios are 42.2% and 72.6% in Nevo, respectively, versus 36.4% and 42.2% in this study. This discrepancy is due to the fact that more brands are considered in Nevo’s study (25 versus 14 here), and since this study further analyzes the 14 cereals separately in two segments. In particular, this study focuses on the top two or three brands of each firm in a segment, while in Nevo’s study a multi-brand firm is modeled as having perhaps eight brands (somewhat closer to reality, if not all the way there). With more brands, the portfolio effect is intensified, since a greater number of demand interactions are internalized within the firm’s profit-maximization problem. As a firm
adds more imperfectly substitutable brands to its portfolio, it charges higher prices for each of them than if they were managed independently. As a result, the measurement of PCMs is sensitive to the number of brands considered. In turn, this framework has the potential to bias the measurement of average PCM if calculations are based on only a subset of a firm’s brands. This is of less concern in this study since we focus on comparing the observed PCM to several hypothetical benchmarks, all of which correspond to exactly the same set of brands. We are thus studying relative differences, and it is of less importance that there is a potential for bias in an absolute sense.

Another difference between this study and Nevo’s is that he finds little evidence of cooperative pricing within the RTE cereal industry. While Nevo acknowledges that his results “do not rule out cooperative pricing between a subset of products … or producers” (p. 336), they ultimately are interpreted as consistent with a Nash-Bertrand pricing game, in which firms set prices with rivals not responding. The salient feature of oligopoly, however, is that there are interdependencies among firms, and most economic theories of oligopoly assume that firms perceive these interdependencies. In this context, it is irrational for firms to not engage in “oligopoly pricing,” and set prices as in Nash-Bertrand. Furthermore, such a pricing game would not appear to explain the steady upward climb in branded cereal prices exhibited in Figure 1.

At the heart of this discrepancy may be Nevo’s reliance on an accounting-based margin as the actual observed PCM. While Nevo acknowledges this measure to be “crude” (p. 336), it is worth highlighting its specific limitations for assessing the form of market power in an industry. First, there are well-known conceptual problems of using accounting measurements to infer monopoly profits (Fisher and McGowan, 1983). A second issue is the sensitivity of the portfolio

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24 The principal value used is 46%. This is from a First Boston Bank report on the Kelloggs company cited in 1996 Congressional testimony by Ronald W. Cotterill.
25 These are described in Fisher and McGowan (1983). They contend that “such a procedure is valid only to the extent that profits are indeed monopoly profits, accounting profits are in fact economic profits, and the accounting rate of return equals the economic rate of return,” and that these criteria are rarely met in practice. Industrial organization economists
effect to the number of brands that a firm is modeled to own (described in the previous paragraph). In particular, the accounting-based PCM used by Nevo corresponds to a particular firm (Kellogg’s), which has a different number of brands than the number used to calculate the benchmark PCMs. These large differences in ownership structure alone would seem to make the accounting-based PCM irrelevant. Additionally, it is unclear what year the accounting-based PCM corresponds to, and whether it is reasonably stable over time. We note that Connor et al. (1985) estimate the average gross margin for the RTE cereal industry to be 30.4% (p. 291). This is a substantial difference from the 46.0% figure used by Nevo, and highlights how such measures are dependent on the year and firm being examined. This is not to discount the major contribution made by Nevo’s study; it only makes us quite hesitant to accept non-collusive Nash-Bertrand pricing as representative of industry behavior.

Implications for antitrust litigation and remedies

This study presents a wealth of evidence that the parallel pricing exhibited in Figure 1, including the period of declining prices during the industry’s antitrust trial, and the period of rising prices after dismissal of the case, is the result of tacit collusion. We saw in the introduction that industry conditions are conducive to collusion. There are few complicating factors, such as dissimilar cost curves or elastic consumer demand. In turn there are many facilitating practices, including high concentration, and barriers to entry obtained through product proliferation and excessive advertising. Figure 1 reveals there is a large and increasing divergence between branded and private label prices after dismissal of the antitrust case. In turn, our econometric evidence finds that pricing responsiveness among firms goes well beyond the level associated with mere signaling of overall demand and cost conditions. Finally, the industry average PCM is roughly 349

appear to often have reservations on using accounting data on profits for empirical research (Aiginger et. al., 2001).
92% of what might be possible through joint profit-maximization, an extreme form of coordination possible only in theory. At a minimum, these characteristics are more likely to have been generated in a collusive than a non-collusive environment, meaning that they pass the “Likelihood Ratio of Collusion” legal criterion described in Milne and Pace (2003).

Even if one accepts this conclusion and deems the current situation as undesirable for consumers and potential entrants to the industry, the above evidence is likely insufficient for pursuit of antitrust litigation. This is the classic “oligopoly problem” (Church and Ware, 1999). As long as there was no explicit agreement, it is not illegal for oligopolists to achieve supracompetitive prices by setting prices according to perceived interdependencies. In other words, tacit collusion is legal even if there is no “meeting of the minds” or “conscious commitment to a common scheme,” and even if the result is enhanced exercise of market power.

It is not difficult to construe some forms of tacit collusion as an agreement (Church and Ware, 1999). For example, when one firm raises its price and others follows its lead, it takes little effort to imagine the behavior as constituting an agreement. The first price increase is an offer; those that follow are acceptances; as each observes the others’ actions, they reach a common understanding (Baker, 1996). In the judicial sense of the word, however, agreement is unnecessary to bring about leader-follower behavior in a concentrated industry.

Absent sufficient evidence of an agreement, successful litigation under Section 1 of the Sherman Act may be possible if evidence of parallel pricing is supplemented by “plus factors.” An example of a plus factor is if a firm acts in a way that is not rational with respect to its unilateral self-interest. Such a plus factor in the RTE cereal industry may be the existence of periodic price wars. This may be why prices trended downward in the late 1970s and then trended upward in the 1980s. On the other hand, this behavior may have been to avoid the appearance of shared monopoly. Either way, this raising then lowering of prices seems inconsistent with firms acting in unilateral self-interest (MacLeod, 1985). In turn, Solman (1996) states that “since 1983, [cereal
prices] have risen at twice the rate of inflation,” and that “after years of rising prices, the major cereal manufacturers have entered in a price war.” Again, if firms were behaving independently, it would not seem in their interest to lower prices followed by reversion to a higher level. Although we cannot determine whether this a legitimate plus factor, such evidence is generally necessary for prosecution of oligopoly pricing / tacit collusion.

Even if antitrust litigation can proceed, the issue of an appropriate remedy arises.\(^{26}\) This is perhaps the most difficult problem, and the heart of the oligopoly problem. In the 1988 case of *Clamp-All Corp. v. Cast Iron Soil Pipe Institute*, the Supreme Court found that oligopoly pricing does not violate Section 1 of the Sherman Act, “not because such pricing is undesirable (it is not), but because it is close to impossible to devise a judicially enforceable remedy for ‘interdependent’ pricing. How does one order a firm to set its prices *without regard* to the likely reactions of its competitors?” (Emphasis in original.) Remedies that have been proposed for the oligopoly problem in the past include direct price regulation, price freezes (Bishop, 1983), introduction of a government-supported maverick to lower prices in the industry (Gal, 2001), and restructuring of the industry.\(^ {27}\) None of these remedies seems capable of creating a long term improvement in economic performance. An appropriate remedy for the oligopoly problem will likely be evasive for many years to come.

V. Summary and Conclusions

Several RTE cereal firms were sued in the 1970s by the FTC for acting as a “shared monopoly,” but the case was dismissed in 1981 before the issue of what conduct leads to the

\(^{26}\) A survey of economists reveals there is little consensus as to whether competition policy should be designate tacit collusion as a legal offense (Aiginger et. al., 2001).

\(^{27}\) The last proposal was advanced by prosecutors in the 1970s FTC trial. The idea was to break the cereal companies into eight evenly sized firms, and to institute compulsory licensing of significant cereal formulas and trademarks (Scherer and Ross, p. 464).
industry’s consistently high profits could be resolved. Since then the industry has been of continuing interest to economic scholars. Several recent studies have muddied the waters, however, particularly with respect to the shared monopoly issue, wherein firms are purported to tacitly collude to achieve joint movement to higher prices. Using heretofore-unemployed SAMI data on the industry, this study uses a differentiated-products oligopoly framework to ascertain the degree and type of market power that is exercised.

The data reveal that branded cereal prices fell slightly during the trial, and underwent a dramatic increase in the years following the case’s dismissal. Econometric estimation of price reaction elasticities indicate that brand-level pricing is strikingly parallel, going well beyond the level necessary to signal industry-wide cost and demand conditions. These results support Scherer’s (1982) finding that market conduct is tacitly collusive. The analysis is also consistent with his hypothesis that the mechanism for collusion is leader-follower behavior, although it does not test for this due to data limitations. Brand-level price-cost margins are estimated to range from 31.8% to 46.8%. Comparison with hypothetical scenarios of industry conduct indicate the exercise of market power is due to product differentiation, the ability of firms to manage a portfolio of brands, and tacit collusion. Average price-cost margins are approximately 92% of those attainable under joint profit-maximization.

As such, the evidence is consistent with the theory of shared monopoly put forward by FTC prosecutors in the 1970s case. The evidence also provides support to studies of repeated games and other theories showing that supracompetitive pricing is possible even if oligopolistic firms do not engage in a process deemed an “agreement” in antitrust law (e.g., Harrington, 2003; Rotemberg and Saloner, 1990; MacLeod, 1985). Due to the apparent lack of an explicit price-fixing agreement among the firms, the RTE cereal industry is likely beyond the reach of current antitrust laws. This underscores the general need for economic and legal scholars to give increased attention to the “oligopoly problem.”
References


Figure 1. Ready-to-eat cereal prices over time

Notes: These are unit values from Selling Area Markets, Inc. (SAMI), normalized on the Bureau of Labor Statistics U.S. average Food and Beverage Consumer Price Index (base period 1982-1984).
<table>
<thead>
<tr>
<th></th>
<th>Post Raisin Bran ((d \ln p))</th>
<th>Post Grape Nuts ((d \ln p))</th>
<th>Kellogg Rice Krispies ((d \ln p))</th>
<th>Kellogg Special K ((d \ln p))</th>
<th>Kellogg Raisin Bran ((d \ln p))</th>
<th>G Mills Cheerios ((d \ln p))</th>
<th>G Mills Wheaties ((d \ln p))</th>
<th>Lagged own price ((d \ln p_{\text{pre}}})</th>
<th>Price of sugar ((dp_{\text{SGR}}))</th>
<th>Price of wheat ((dp_{\text{WHT}}))</th>
<th>Private label price ((d \ln p_{\text{PL}}))</th>
<th>Segment expenditure ((d \ln x))</th>
<th>(R^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post Raisin Bran ((d \ln p))</td>
<td>0.422*** (0.085)</td>
<td>0.422*** (0.085)</td>
<td>0.422*** (0.085)</td>
<td>-0.007 (0.135)</td>
<td>-0.007 (0.135)</td>
<td>0.18 (0.016)</td>
<td>0.08 (0.019)</td>
<td>0.173** (0.080)</td>
<td>-0.031** (0.013)</td>
<td>0.074</td>
<td></td>
<td></td>
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<tr>
<td>Post Grape Nuts ((d \ln p))</td>
<td>0.422*** (0.085)</td>
<td>0.422*** (0.085)</td>
<td>0.422*** (0.085)</td>
<td>-0.007 (0.135)</td>
<td>-0.007 (0.135)</td>
<td>-0.083* (0.050)</td>
<td>0.021 (0.019)</td>
<td>0.032 (0.092)</td>
<td>-0.059*** (0.015)</td>
<td>0.169</td>
<td></td>
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<tr>
<td>Kellogg Rice Krispies ((d \ln p))</td>
<td>0.265*** (0.052)</td>
<td>0.265*** (0.052)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.247*** (0.078)</td>
<td>0.247*** (0.078)</td>
<td>0.096* (0.058)</td>
<td>0.041* (0.022)</td>
<td>0.019 (0.026)</td>
<td>0.004 (0.116)</td>
<td>0.002 (0.022)</td>
<td>0.106</td>
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<tr>
<td>Kellogg Special K ((d \ln p))</td>
<td>0.265*** (0.052)</td>
<td>0.265*** (0.052)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.247*** (0.078)</td>
<td>0.247*** (0.078)</td>
<td>0.013 (0.060)</td>
<td>0.022 (0.020)</td>
<td>0.003 (0.023)</td>
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<td>0.020 (0.022)</td>
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<tr>
<td>Kellogg Raisin Bran ((d \ln p))</td>
<td>0.265*** (0.052)</td>
<td>0.265*** (0.052)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.247*** (0.078)</td>
<td>0.247*** (0.078)</td>
<td>-0.058 (0.050)</td>
<td>-0.017 (0.021)</td>
<td>-0.013 (0.091)</td>
<td>-0.013 (0.016)</td>
<td>0.009 (0.016)</td>
<td>0.111</td>
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<tr>
<td>G Mills Cheerios ((d \ln p))</td>
<td>0.023 (0.084)</td>
<td>-0.023 (0.084)</td>
<td>0.264*** (0.083)</td>
<td>0.264*** (0.083)</td>
<td>0.264*** (0.083)</td>
<td>--</td>
<td>--</td>
<td>-0.001 (0.053)</td>
<td>-0.024 (0.015)</td>
<td>-0.010 (0.017)</td>
<td>-0.078 (0.077)</td>
<td>0.045** (0.014)</td>
<td>0.095</td>
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<tr>
<td>G Mills Wheaties ((d \ln p))</td>
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<td>-0.023 (0.084)</td>
<td>0.264*** (0.083)</td>
<td>0.264*** (0.083)</td>
<td>0.264*** (0.083)</td>
<td>--</td>
<td>--</td>
<td>0.010 (0.056)</td>
<td>0.033* (0.019)</td>
<td>0.009 (0.022)</td>
<td>-0.084 (0.094)</td>
<td>0.033** (0.017)</td>
<td>0.057</td>
</tr>
</tbody>
</table>

Note: Standard error in parenthesis. Coefficients concerning same company are restricted to be equal. One, two, and three asterisks signify statistical significance at the 10%, 5%, and 1% level, respectively, in a two-sided test.
Table 2. Estimation of Price Reaction Functions: Kids cereals

<table>
<thead>
<tr>
<th></th>
<th>G Mills Trix ((d \ln p))</th>
<th>GM Lucky Charms ((d \ln p))</th>
<th>Kellogg Frosted M.W. ((d \ln p))</th>
<th>Kellogg Corn Pops ((d \ln p))</th>
<th>Kellogg Froot Loops ((d \ln p))</th>
<th>Quaker Cap N Crunch ((d \ln p))</th>
<th>Quaker Life ((d \ln p))</th>
<th>Lagged own price ((d \ln p_{p,t-1}))</th>
<th>Price of sugar ((d p_{SGR}))</th>
<th>Price of wheat ((d p_{WHT}))</th>
<th>Private label price ((d \ln p_{PL}))</th>
<th>Segment expenditure ((d \ln x))</th>
<th>(R^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>G Mills Trix ((d \ln p))</td>
<td>--</td>
<td>--</td>
<td>0.280*** (0.071)</td>
<td>0.280*** (0.071)</td>
<td>0.280*** (0.071)</td>
<td>0.231* (0.130)</td>
<td>0.231* (0.130)</td>
<td>-0.002 (0.048)</td>
<td>0.000 (0.016)</td>
<td>-0.009 (0.017)</td>
<td>-0.018 (0.087)</td>
<td>-0.005 (0.011)</td>
<td>0.152</td>
</tr>
<tr>
<td>G Mills Lucky Charms ((d \ln p))</td>
<td>--</td>
<td>--</td>
<td>0.280*** (0.071)</td>
<td>0.280*** (0.071)</td>
<td>0.280*** (0.071)</td>
<td>0.231* (0.130)</td>
<td>0.231* (0.130)</td>
<td>-0.039 (0.051)</td>
<td>0.004 (0.016)</td>
<td>-0.005 (0.018)</td>
<td>0.014 (0.088)</td>
<td>-0.010 (0.011)</td>
<td>0.170</td>
</tr>
<tr>
<td>Kellogg Frosted M.W. ((d \ln p))</td>
<td>0.419*** (0.090)</td>
<td>0.419*** (0.090)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>-0.117 (0.147)</td>
<td>-0.117 (0.147)</td>
<td>-0.001 (0.064)</td>
<td>-0.019 (0.019)</td>
<td>0.015 (0.023)</td>
<td>0.018 (0.106)</td>
<td>-0.021 (0.014)</td>
<td>0.085</td>
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<tr>
<td>Kellogg Corn Pops ((d \ln p))</td>
<td>0.419*** (0.090)</td>
<td>0.419*** (0.090)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>-0.117 (0.147)</td>
<td>-0.117 (0.147)</td>
<td>-0.071 (0.064)</td>
<td>-0.020 (0.017)</td>
<td>0.021 (0.021)</td>
<td>0.130 (0.099)</td>
<td>0.006 (0.013)</td>
<td>0.088</td>
</tr>
<tr>
<td>Kellogg Froot Loops ((d \ln p))</td>
<td>0.419*** (0.090)</td>
<td>0.419*** (0.090)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>-0.117 (0.147)</td>
<td>-0.117 (0.147)</td>
<td>0.050 (0.055)</td>
<td>0.006 (0.019)</td>
<td>0.011 (0.021)</td>
<td>0.099 (0.102)</td>
<td>0.028** (0.013)</td>
<td>0.073</td>
</tr>
<tr>
<td>Quaker Cap N Crunch ((d \ln p))</td>
<td>0.355*** (0.138)</td>
<td>0.355*** (0.138)</td>
<td>-0.071 (0.110)</td>
<td>-0.071 (0.110)</td>
<td>-0.071 (0.110)</td>
<td>--</td>
<td>--</td>
<td>0.043 (0.055)</td>
<td>0.001 (0.018)</td>
<td>0.004 (0.019)</td>
<td>-0.031 (0.096)</td>
<td>0.025** (0.012)</td>
<td>0.032</td>
</tr>
<tr>
<td>Quaker Life ((d \ln p))</td>
<td>0.355*** (0.138)</td>
<td>0.355*** (0.138)</td>
<td>-0.071 (0.110)</td>
<td>-0.071 (0.110)</td>
<td>-0.071 (0.110)</td>
<td>--</td>
<td>--</td>
<td>0.012 (0.058)</td>
<td>0.000 (0.018)</td>
<td>-0.009 (0.019)</td>
<td>-0.025 (0.095)</td>
<td>-0.019* (0.012)</td>
<td>0.065</td>
</tr>
</tbody>
</table>

Note: Standard error in parenthesis. Coefficients concerning same company are restricted to be equal. One, two, and three asterisks signify statistical significance at the 10%, 5%, and 1% level, respectively, in a two-sided test.
Table 3. Price-cost margins (%)

<table>
<thead>
<tr>
<th>Product</th>
<th>Observed PCM based on price reaction elasticities</th>
<th>Maximum potential PCM associated with:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Product differentiation&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Product differentiation plus portfolio effect&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Adult/Family cereals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post Raisin Bran</td>
<td>42.0  (41.8 - 42.1)</td>
<td>40.1</td>
<td>40.5</td>
</tr>
<tr>
<td>Post Grape Nuts</td>
<td>31.2  (31.1 - 31.4)</td>
<td>28.8</td>
<td>29.8</td>
</tr>
<tr>
<td>Kellogg Rice Krispies</td>
<td>35.7  (35.4 - 35.9)</td>
<td>31.0</td>
<td>32.4</td>
</tr>
<tr>
<td>Kellogg Special K</td>
<td>36.7  (36.3 - 37.1)</td>
<td>30.4</td>
<td>31.8</td>
</tr>
<tr>
<td>Kellogg Raisin Bran</td>
<td>44.4  (44.1 - 44.8)</td>
<td>38.8</td>
<td>40.2</td>
</tr>
<tr>
<td>G Mills Cheerios</td>
<td>28.7  (28.6 - 28.8)</td>
<td>27.3</td>
<td>27.9</td>
</tr>
<tr>
<td>G Mills Wheaties</td>
<td>29.7  (29.4 - 30.0)</td>
<td>26.2</td>
<td>27.5</td>
</tr>
<tr>
<td>Average</td>
<td>35.5  (35.4 - 35.6)</td>
<td>31.8</td>
<td>32.9</td>
</tr>
<tr>
<td>Kids cereals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GM Trix</td>
<td>46.8  (46.3 - 47.3)</td>
<td>39.1</td>
<td>40.4</td>
</tr>
<tr>
<td>GM Lucky Charms</td>
<td>46.7  (46.2 - 47.1)</td>
<td>39.4</td>
<td>40.8</td>
</tr>
<tr>
<td>Kellogg Frosted M.W.</td>
<td>33.6  (33.3 - 33.9)</td>
<td>30.0</td>
<td>31.9</td>
</tr>
<tr>
<td>Kellogg Corn Pops</td>
<td>43.8  (43.5 - 44.1)</td>
<td>40.8</td>
<td>42.3</td>
</tr>
<tr>
<td>Kellogg Froot Loops</td>
<td>45.2  (45.0 - 45.4)</td>
<td>42.7</td>
<td>44.0</td>
</tr>
<tr>
<td>Quaker Cap N Crunch</td>
<td>46.5  (46.1 - 46.8)</td>
<td>43.9</td>
<td>46.0</td>
</tr>
<tr>
<td>Quaker Life</td>
<td>33.6  (33.3 - 33.9)</td>
<td>31.7</td>
<td>33.2</td>
</tr>
<tr>
<td>Average</td>
<td>42.3  (42.1 - 42.5)</td>
<td>38.2</td>
<td>39.8</td>
</tr>
</tbody>
</table>

Note: Actual, observed PCMs are based on a multi-brand profit-maximizing firm in which inter-firm interaction is given by the price reaction estimates. Bootstrapped 95% confidence intervals are in parenthesis.

<sup>a</sup> PCM associated with a single-brand profit-maximizing firm operating in isolation.

<sup>b</sup> PCM associated with a multi-brand profit-maximizing firm operating in isolation.

<sup>c</sup> PCM associated with a single agent who jointly maximizes profit of all brands.
Contract Incentives in the Processed Potato Industry

by

Kynda R. Curtis and Jill J. McCluskey*

Key words: agency theory, agricultural contracts, potatoes, ratchet effect.

Abstract: The processed potato industry is highly vertically coordinated though the use of production contracts between growers and processors. Contracts in this industry are primarily used to combat market thinness and potato quality requirements. This study uses a two period principle-agent model to describe the incentives inherent in processing potato production contracts. Actual processor production contracts and delivered potato loads from the Columbia Basin are examined. We conclude that contracts are effective at increasing potato load quality over the spot market alternative. Additionally, processors are able to gauge grower ability levels in at the end of the first contract period, which leads to reductions in grower payments for specific levels of potato quality, also known as ratcheting.

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1. Introduction

The processed potato industry is extensively vertically coordinated through the use of production contracts between growers and processors. Production contracts generally specify prices or pricing mechanisms, stipulate a buyer, and provide for participation of the buyer regarding management decisions over the production process. Today, production contracts are prevalent in processed vegetable production. In fact, 40% of total U.S. fruit and vegetable production is completed under contract (DeVore, 1999). Production contracts provide the contracting parties with an intermediate level of control and risk sharing. Contracts also allow parties to allocate resources with greater confidence and are often used to improve quality and/or performance through incentive structures. Contracts provide processors input supply control, input quality control, improved response to consumer demand, and operational efficiency due to the reduced transaction costs of raw material searches, as well as negotiation and improved coordination of product delivery. Contracts provide growers with market security and income stability, in addition to access to capital and technology through technology transfers and credit facilitation. However, not all contract aspects may be viewed positively by growers. Skully (1998) points out that the loss of independence and control over one’s own farming operation may be viewed negatively by growers, who feel that they have become employees rather than independent business owners.

We analyze production contracts between potato processors and growers in the Columbia Basin area of Washington and Oregon. This area was chosen due to its importance in the U.S. potato processing industry. The potato is Washington State’s third largest crop with an annual
production value of $548 million (Spud Topics, 2001). Processing potatoes make up 87% of Washington's total potato production and the Columbia Basin produces one third of North America's frozen potato products (Tri-City Herald, 2003). Processors primarily produce dehydrated, frozen, and chip potato products. Dehydrated products include dehydrated potato flakes, sliced and diced potatoes, potato granules, shredded potatoes, and potato powder. Frozen products consist of fries, hash browns, and preformed potatoes. These products are sold to quick service restaurants such as McDonald’s and Kentucky Fried Chicken (KFC), as well as food service distributors.

Production contracts are used in the Columbia Basin area to combat two primary issues; market thinness and quality control, as well as secondary issues such as the timing of input availability and capacity issues. There are typically few potato processors available to purchase potatoes from local growers. Thus, growers see contracts as a way of guaranteeing a buyer and a price for his/her crop, which leads to reductions in price risk, especially when there is a large distribution in spot market prices from year to year (Babcock and Carriquiry, 2002). Knoeber and Thurman (1995) show that compared to independent growers, contract production shifts nearly 97% of the market price risk from growers to intermediaries in the broiler industry. Hueth and Ligon (1999b) find that growers are subject to 47% of the market price risk due to contract design in the tomato industry.

Processors require a steady supply of high quality potatoes to ensure their production goals. High quality potatoes allow the processor to reduce costs and increase production, which naturally leads to increased profits. Gould (1999) states that every .005 increase in specific gravity will increase the number of potato chips which can be processed from 100 pounds of raw potatoes by one pound. Contracts allow processors to provide incentives, which lead to higher
potato quality. Contracting is often the result of an effort to control quality. Wolf et al. (2001) conclude that vertical coordination through contracting is “an organizational response to an increased demand for quality among increasingly discerning consumers.” Quality requirements for potatoes differ according to end-use and the market demand for each product category. As an example, potatoes are classified by shape, skin color, and use. Generally, potatoes with higher specific gravity\(^1\) (solid content) will be well formed, smooth, and firm. In addition, potatoes of uniform size will be easier to process and produce uniform cuts for fry products. According to the Washington State Potato Commission, potatoes with low sugar content will uniformly produce light colored fry products, which are currently preferred by consumers. Potatoes which have been overly exposed to light exhibit green tinted skin, which produces a bitter taste, making them unfit for processing.

In the following sections, a complete description of the common processing potato production contracts is given, followed by a brief overview of previous studies aimed at modeling incentives structures in agricultural contracts. A two period model of the potato production contract incentive structures used in the Columbia Basis area is presented. Processor incentives for ratcheting are then examined. Finally, a case study examining actual contracts and spot market prices providing supportive evidence of the model is presented.

2. Potato Production Contracts

The basic processing potato production contract in Washington consists of four main sections: harvest and delivery, farming practices, payments and adjustments, and buyer rights. The contract is negotiated prior to the growing season. The harvest and delivery section

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\(^1\) The specific gravity is the solid content of the potato, measured as the ratio of weight in air to weight in water and
specifies the exact quantity of potatoes (either per/ton or per/cwt. (hundred weight)) that the processor will purchase from the grower, a range of delivery dates, and the type of delivery equipment requested. These provisions help the processor schedule “just in time” resource availability for production.

The farming practices section requires the grower to plant certified seed potatoes in the appropriate season, apply a USDA approved pesticide and adhere to an application schedule, as well as fertilize and irrigate as needed. These farming practices directly affect potato quality and ensure the processor of a minimum level of effort from the grower. The chief attributes that determine quality include tuber weight (normally 4 to 6 ounces), nematodes, hollow heart, specific gravity, internal discoloration (resulting from net necrosis), sugar content, surface scab, and bruising, as well as tare. Bruise free is the percentage of the potato load which is free from any discoloration caused by injury or impact during the harvesting, loading, or hauling process. Normally, the production contract will suggest the appropriate equipment to be used by the grower, especially for hauling, in order to reduce bruising. The tare is the percentage of rock, dirt, and foreign material delivered with each load of potatoes. Normally, a production contract will expect this to be less than 4-6% of the total load weight delivered. If the tare percentage exceeds this amount, the grower will be discounted for each ton delivered.

The quality attributes of a potato load are a function of a combination of factors including day length, light intensity, air temperature, humidity levels, soil temperature, plant density, seed quality, soil type, pests, weeds, and moisture content (Kunkel and Thornton, 1986). Although many of these factors are out of grower control, it is evident that growing practices are extremely important to potato quality outcomes.

greater than 1.000, the specific gravity of water
The payments and adjustments section provides a specific base price for each ton of potatoes delivered, plus an adjustment schedule based on potato quality. Potatoes not meeting size requirements or containing disease are graded as culls. The growers are paid the base price per ton plus or minus any adjustments for usable potatoes (non-culls) based on potato quality measurements. The base price is negotiated with processors by the Potato Growers of Washington (PGW). The payment schedule is based on the grower’s absolute performance. The final section of the contract usually includes details on quality testing procedures, performed by a third party (currently the Washington State Department of Agriculture), to eliminate processor incentives to under report delivered potato load quality, as described in Balbach (1998) with regards to ownership benefits in the sugar beet industry. Normally, the grower and the processor pay half of the testing costs.

The processor outlines in the buyer’s rights section his/her right to inspect the crop at any time during the growing season and his/her right to harvest the crop and charge the cost to the grower if the harvest and delivery is not completed in a certain time interval. Additionally, the grower’s liability for processor losses due to gross negligence is outlined. It should be noted that the production contracts used in the Washington processed potato industry are generally not resource providing, unlike many production contracts in agriculture. Hence, the grower retains ownership of the crop and any resources necessary to produce and deliver the potatoes.

As is obvious from the above contract description, the processor makes every effort to induce the grower into providing an appropriate level of potato load quality. By requiring certain growing practices, the processor may relieve itself from contract obligation, should the grower be grossly negligent. The payment schedule provides grower incentives to produce potatoes
above the minimum quality standards. Additionally, the growers are exposed to a certain degree of price risk for loads not meeting the minimum standards.

3. Previous Studies

As Goodhue (1999) points out, the incentives underlying production contracts in agriculture are not currently well understood. Additionally, empirical study has not kept up with theoretical work in agency theory. Hueth and Ligon (1999b) analyze modes of contracting in the tomato industry to provide an understanding of the variation in grower risk. They suggest that the unobserved action of the grower in producing a quality product creates a rent, which must be paid by the shipper. If these actions can be observed in the downstream price of the product, then conditioning a grower’s compensation on the downstream price may help shippers to monitor grower efforts in production.

Hueth and Ligon (1999a) consider the role of price and production risk in shaping the supply decision of a single risk averse farmer. Production decisions are analyzed under three different "intermediation regimes". The authors argue that in an environment with asymmetric information, a farmer's response to a change in expected price would be less pronounced than in the other two environments. They find that production contracts providing a low risk environment for growers led to increased production over the no contract alternative in the tomato industry.

Goodhue (1999) outlines the various reasons why agricultural contract intermediaries such as shippers, processors, or packers, may wish to control some or all of a grower's non-labor inputs. The reasons include planning, intellectual property preservation, quality control, and the reduction of asymmetric informational rents. Goodhue discusses empirical techniques which
have been used to test principal-agent models as they apply to agricultural contracts. She then identifies techniques which may aid in distinguishing between the appropriate explanation of the incentives found in agricultural contracts.

Goodhue (2000) considers the issue of input control in the case of broiler contracts in which market intermediaries often control some of the grower's inputs. She argues that the choice of a relative compensation measure and a decision to control major inputs by the processor can be explained as a response to grower heterogeneity, grower risk aversion, and systemic uncertainty. Input control is a way to lower information rents paid to highly productive growers.

Levy and Vukina (2002) examine linear contracts in a principal-agent framework where agents are heterogeneous in their abilities. The authors assume the principal either knows the agents' ability or may learn it in a dynamic sequence of contracts by incurring a transaction cost. They show that without transaction costs the optimal contract should be individualized to each agent's ability. However, as individualized contracts are rarely observed, the authors point to transaction costs as the cause, finding that the equilibrium contract depends on the costs of screening relative to the distribution of the agents' abilities. More importantly they find that even if transaction costs are not significant, the dynamic incentives of the agents preclude individualized contracts, when the principals have monopsony power over agents.

Hueth and Ligon (2002) estimate a principle-agent model of contracts for the tomato processing industry in California. The authors jointly estimate the grower's risk aversion and the cost of high effort by minimizing the distance between computed and actual compensation schedules. They find that in the case of perfect competition the growers' measure of constant
absolute risk aversion is 0.08. Also, growers who face higher incentives produce tomatoes with higher soluble solids at a cost of 1.8% over the cost of the lower level of soluble solids.

4. Contracting Model

In the processed potato industry, growers may contract with a processor or sell their crop on the spot market. Spot market prices tend to fluctuate largely from one year to another due to weather and disease issues, and the level of imports (primarily from Canada), all of which determine crop availability, as well as the domestic and export demand for processed potato products (spot market prices for processing potatoes in the Columbia Basin for 1995-2000 are listed in Table 1). Hence, the grower wishing to reduce price risk will contract with a selected processor as long as the expected utility from the contract exceeds that of the spot market. Contracts in this industry primarily extend for only one growing season, but are typically renewed. Hence, the grower and processor are likely to contract repeatedly, which will allow the processor to gain knowledge of the grower's ability. A grower's ability may be attributed to such things as management skills, experience, farm size, soil quality, and access to capital.

As Goodhue (1999) points out, when vertical relationships include asymmetric information, the intermediary is likely to reduce rents paid to growers by collecting relevant information. Contractors may use monitoring, input control, quality measurement, and residual claims as tools to address asymmetric informational issues (Hueth et al., 1999). In the processed potato industry, the processor may gain knowledge of a growers' ability through the use of quality measurement, observation of the growers' initial investment decisions, as well as weather and disease conditions. Hueth and Ligon (1999b) show that in the fresh tomato industry, the intermediary may be able to increase their expected profits by engaging in some sort of quality
measurement and by using this measurement to modify payments to the growers. Also, when this quality measurement is highly correlated with the actual quality, then the processor may offer a contract for a given quality, satisfying the grower's participation constraint, while imposing a severe consequence for a different quality outcome.

The large initial investment in land and machinery that the grower must make to enter the industry requires a long-term relationship with a processor to ensure initial investment recovery. However, due to the short-term nature of contracting in this industry, the grower must show that he/she is able to produce a high quality product in order to ensure future contracts. The grower's initial investment decisions, per the revelation principle, could be considered a signal of ability and a commitment to an implicit long-term contract with the processor (Goodhue, 2000). Knoeber (1989) views the growers' provision of initial productive assets as a signal of agent ability under asymmetric information.

Weather conditions, which alter moisture and temperature levels, are random inputs to the grower's production. Allen and Lueck (1999) find that when a random input from one time period is positively correlated with a random input from the second period, the processor may use observed performance in the first period to estimate the grower's actual effort in the second period. Wolf et al. (2001) conclude that moral hazard continues to exist in the second contract period and further, because the grower has an incentive to shirk and blame decreases in performance on random events. However, the authors assume that the intermediary has no way of verifying the random event occurred, which is not practical in the processed potato industry due to field monitoring. Processors monitor growers through on-site visits from field personnel. Field personnel provide growers with important information concerning expected yields and technical processes. Key and McBride (2003) conclude that the majority of the productivity
gains of contracted growers in the hog industry were due to knowledge transfers from processors to growers. Hence, these field personnel are generally not regarded as spies, but rather interventionists should the grower need assistance in preventing crop damage. However, if the field representative feels the grower is not being sufficiently diligent, he/she may discuss non-renewal or breech of contract implications with the grower (Wolf *et al.*, 2001).

Levy and Vukina (2002), state that in a market where growers have heterogeneous abilities, assuming the utility functions of all growers exhibit constant absolute risk aversion, contracts for growers with differing abilities will have different base payments, but equal marginal or variable payments. As the authors point out, these ability specific contracts create a hybrid market. This type of market has been observed in the processed potato industry in the Columbia Basin. An examination of processing potato contracts, as well as actual delivered potato loads, shows that processors paid substantially different base payments, but rather equal marginal or variable payments for specific quality improvements above the base payment quality level. A complete description is given in the case study section.

The market for processing potatoes in the State of Washington appears to be an oligopsony, as there are currently only five major processors. Richards *et al.* (2001), provide evidence of collusive regimes in the Washington processed potato industry, leading to significant welfare losses. However, the authors point out that oligopsony buying power is conducive to markets which exhibit high transportation costs, large investment (grower) into specialized equipment, and specialized needs of processors, which is the case in the processed potato industry.

We consider a model based on the principal-agent framework with two processors and many growers contracting over two time periods to produce a single commodity, namely
processing potatoes. The growers and the two processors are both heterogeneous. The growers have heterogeneous ability types denoted by $a = l, h$, where $l$ is the low ability type and $h$ is the high ability type. The two processors types are classified by the base payment they provide in their contracts, where processor $L$ offers a low base payment and processor $H$ offers a high base payment. Each processor has a different isoprofit curve based on his/her technology, which is highly firm specific, human capital, and respective product lines (see Figure 1 for an illustration). For example, one processor may concentrate on producing French fry products which require high quality usable (non-cull) potatoes. Another processor may concentrate on producing dehydrated products, or products which use smaller potatoes such as hash browns or chips. These products can be produced with processing culls, which do not require high quality usable potatoes. Hence, these differences across processors provide for differing profit maximizing potato quality levels.

The output quality level produced by a grower at time $t$ is equal to

$$y_\text{it} = d(e_t, a) \text{ for } i \in \{1, 4\}$$

(1)

where the growers' effort level at time $t$ is $e_t = 0$, and $i$ is an increasing quality index. The possible output qualities at time $t$ for this model are restricted to a minimum quality for processing potatoes $y_{1t}$, a medium quality of $y_{2t}$, and a high quality of $y_{3t}$, where $y_{1t} < y_{2t} < y_{3t}$. The low-ability growers are capable of producing quality levels less than or equal to $y_{2t}$, but the high-ability growers are capable of producing all quality levels.

The grower's payment under contract is a function of measured output quality, denoted $r_t$, a random variable governed by the conditional density $h(r_t|y\text{it})$ (Hueth and Ligon, 1999b). For our purposes we assume that $r_t$ is perfectly correlated with $y_{it}$. Hence, the grower's total compensation schedule per potato load under contract is given by
\[ p_t(y_{it}) = (B_t + b_t(y_{it}))(q_t - l_t(y_{it}, q_t)) + C_t(l_t(y_{it}, q_t)) \]  \hspace{1cm} (2)

where \( B_t \) is the base payment for a specified quality level of usable potatoes. The bonus or penalty (variable payment) \( b_t(y_{it}) \) is a piecewise linear schedule dependent on potato load quality. The total potato load quantity is specified by \( q_t \), where \( l_t(y_{it}, q_t) \) is the number of culls and \( C_t \) is the cull payment. Since the potato load payment is a non-decreasing function of \( y_{it} \), this implies that under contract the grower is provided with a payment quality pair \((p_t(y_{it}), y_{it})\), for each quality level actualized at the end of the growing season. The contract specified payment schedule for realized quality levels alleviates any uncertainty associated with the potato load payment.

Each grower has a von Neumann-Morganstern utility function \( U_{at}(p_t(y_{it}), y_{it}) \) at time \( t \), which is increasing, convex, and continuously differentiable, where \( U_{at}'(p_t(y_{it})) \geq 0 \), and \( U_{at}'(y_{it}) \leq 0 \). The disutility of each output quality choice per grower type is denoted \( z_a(y_{at}) \), where \( z_a'(y_{it}) \geq 0 \). We use the following notation,

\[ U_{at}(p_t(y_{at}), y_{at}) = v(p_t(y_{at}) - z_a(y_{at})) \]  \hspace{1cm} (3)

where \( v(.) \) is the indirect utility function. We assume here that \( v'(.) > 0 \) and \( v''(.) = 0 \).

Since the grower has the option to either sell his/her crop on the spot market or contract with one of the two processors, we will examine the spot market choice first. We assume that the grower is not able to produce an alternative crop. As contracting in the processed potato industry is often completed after field preparation, this assumption is not restrictive.

**Spot Market**

If the grower chooses to sell his/her crop on the spot market he/she must provide a minimum quality level \( y_{1t} \), such that the crop will be graded for processing. The spot market
price $p_{st}$ at time $t$, is a random variable with a conditional density of $g(p_{st}|\mu_t)$, where $\mu_t$ is aggregate market conditions. Hence, the utility of the grower is simply a function of the price received for the crop minus the cost of producing the crop $U_{at}(p_{st}q_t - z_a(y_{it}))$. In the spot market the grower will choose a level of quality to maximize his/her expected utility.

$$\max_{y_{st}} \int v(p_{st} - z_a(y_{it})) f(p_{st}|\mu_t) dp_{st}$$

subject to

$$y_{st} \geq y_{it}$$

(4)

(5)

As is evident, there is no incentive for the grower to choose higher quality levels and hence will choose $y_{st}$, the minimum quality level. This is similar to the situation described by Boger (2001) in the hog industry, where the spot market is the efficient solution for growers who make no specific investment, which leads to hogs of low quality. For the grower to enter into a contract with the processor, the growers' contract utility must at least be equal to the certainty equivalent of the expected utility from the spot market. Hence, the growers' reservation utility is set by the spot market. The reservation utility for the high-ability grower at time $t$ is equal to

$$\overline{U}_{ht} = U_{ht}(c(f,u)) = \int v(p_{st} - z_h(y_{it})) f(p_{st}|\mu_t) dp_{st}$$

(6)

and the reservation utility for the low-ability grower at time $t$ is equal to

$$\overline{U}_{lt} = U_{lt}(c(f,u)) = \int v(p_{st} - z_l(y_{it})) f(p_{st}|\mu_t) dp_{st}$$

(7)

where $U_{at}(c(f,u))$ is the certainty equivalent which makes the grower indifferent between the certain payment in the contract and the gamble in the spot market. Due to the differences in the cost of quality production for the two ability levels (i.e. $z_h(y_{it}) > z_l(y_{it})$), the reservation utility level of the low-ability grower is less than that of the high-ability grower, i.e. $\overline{U}_{lt} < \overline{U}_{ht}$.

**Contracting in the First Period**
The risk-neutral processor\(^2\) wishes to maximize profits given a market price for processed potato products. We assume the processor is aware of the grower's utility function and the distribution of his/her ability level. We assume the processor selects the number of growers necessary to make his/her processed potato production goals. This provides for a competitive market between growers. We limit the processors choice to potato quality levels and associated compensation schemes to maximize profit. This provides the processor with the following net profit function at time \(t\)

\[
\pi^*_{H,L}(y_a) = s_t * Q_t - p_t(y_{it}) - w_t * x_t(y_a) \tag{8}
\]

where \(s_t\) is the market price for processed potato products, \(Q_t\) is total processed product output, \(p_t(y_{it})\) is the payment made to the grower, \(w_t\) is the price of other inputs, and \(x_t(y_{it})\) is all other (non potato) inputs, a non-increasing function of actual potato quality. We assume the firm's profits are not perfectly observable and that \(\pi^*_{H}(y_{3t}) = \pi^*_{L}(y_{2t})\), or the level of profit maximizing potato quality for each processor, \(H\) and \(L\), is differing.

In the initial contract period there is both a hidden action and a hidden information problem for the processor. Since the processor is unaware of the grower's disutility of quality production (due to lack of information regarding his/her type), processor \(H\) is forced to provide increased payments to all growers under contract to attract the high-ability grower. Processor \(H\) wishes to contract with high-ability growers, because high quality levels, \(y_3\), are consistent with his/her profit maximization goals. Figure 1 provides a graphical description. As Goodhue (2000) notes in the broiler industry, better growers are provided with higher quantities over time, and lesser growers are forced out. This situation is also evident here. Processor \(H\) will renew contracts in the second period with growers who provide the \(y_3\) quality in the first period. Hence,

\(^2\) The processor is larger and more diversified than the grower and hence better able to bear risk (See Wolf et al.,
processor $H$ must solve the following problem in the first period (time subscripts have been dropped due to the current examination of one contract period only)

$$\max_{p(y_1), y_1} \beta (\pi (y_1) - p(y_1)) + (1 - \beta) (\pi (y_2) - p(y_2))$$

subject to the participation constraint (PC),

$$v(p(y_1) - z_a(y_i)) \geq U_a$$

where the grower chooses $y_i$ to solve the incentive compatibility constraint (ICC),

$$v(p(y_i) - z_a(y_i)) \geq v(p(y_j) - z_a(y_j))$$

subject to a minimum quality standard,

$$y_i \geq y_2$$

where $a \in h, i \in 1, 2, j \in 1, 2, j?i, \beta$ is the probability of a high-ability grower and $(1 - \beta)$ is the probability of a low-ability grower, and $\pi (y_i)$ is the gross processor profit before grower payments are made. The quality standard constraint is necessary as the payment structure of a $(p(y_1), y_1)$ payment quality pair, which provides a payment of zero under current contracts, does not satisfy the participation constraint for either ability type grower. Per the revelation principle, at the end of the first period, the grower will reveal his/her type though the choice of $y_i$. As a choice of $y_3$ is the only choice, which makes sense for the high-ability grower under contract, he/she will choose the $y_3$ quality level. The low-ability grower will choose the $y_2$ quality level, because other choices are either not contract rational or out of the range of the grower's ability. Both constraints are binding for the high-ability grower, because the high quality level, $y_3$, is the efficient choice under the contract (Mas-Colell et al., 1995). However, only the participation
constraint is binding for the low-ability grower. The ICC is not binding because it does not hold for the low-ability grower, who has a large disutility of the $y_3$ level of quality production.

Based on processor $H$'s isoprofit curve, net profits, $p^*$, are maximized with the $(p(y_3), y_3)$ potato load payment and quality level combination. However, since the processor received some portion of potatoes at the $y_2$ quality level his/her profits are diminished to the extent that the value of $\beta$ is less than one. This one period profit loss is the cost of determining the agent types in the first period.

Solving processor $H$'s problem for the high-ability worker, $p(y_i)$ must satisfy the following Kuhn-Tucker first order condition

$$ -\beta + \lambda (v'(p(y_3) - z_h(y_3)) + \psi (v'(p(y_1) - z_h(y_1))) - v'(p(y_2) - z_h(y_2))) $$

where $\lambda = 0$ and $\psi = 0$ denote the multipliers on the participation constraint and IC constraint respectively. As both constraints are binding, the high-ability grower's compensation is given by

$$ \frac{1}{v'(p(y_3) - z_h(y_3))} = \frac{\lambda + \psi - \psi (v'(p(y_2) - z_h(y_2)))}{\beta}. $$

Since $\beta$ is either equal to one or a fraction it increases the overall compensation provided in the nominator. For the low-ability grower, $p(y_i)$ must satisfy the following Kuhn-Tucker first order condition

$$ -(1 - \beta) + \lambda (v'(p(y_2) - z_l(y_2))). $$

As only the participation constraint is binding, the low-ability grower's compensation is given by

$$ \frac{1}{v'(p(y_2) - z_l(y_2))} = \frac{\lambda}{(1 - \beta)}. $$

Since $(1 - \beta)$ is a fraction, this compensation is greater than the constant $\psi$.  

377
Since the medium potato quality level, \( y_2 \), is consistent with processor \( L \)'s profit maximization goals, processor \( L \) provides compensation in the participation constraint equal to the low-ability grower's reservation utility. This reservation utility is not high enough to induce the high-ability grower to take the contract (see Figure 1). Hence, processor \( L \) is aware that the growers under his/her contract are low-ability, (i.e. he/she has perfect information) so he/she chooses a contract to induce the highest level of quality for the low-ability grower. Processor \( L \) solves the following problem in the first period

\[
\max_{p(y_1), y_1} \pi(y_2) - p(y_2)
\]

subject to the participation constraint (PC),

\[
v(p(y_i) - z_a(y_i)) \geq U_a
\]

subject to a minimum quality standard,

\[y_i > y_1\]

The IC constraint is not binding because processor \( L \) is aware of the grower types under contract. The low-ability grower will choose \( y_2 \), as choice of \( y_1 \) doesn't satisfy the participation constraint or the quality constraint. Also, the grower has no incentive to hide his/her ability, because a choice of \( y_1 \) will not provide for contract renewal in the second period.

For the low-ability grower, \( p(y_i) \) must satisfy the following Kuhn-Tucker first order condition

\[-1 + \lambda (v'(p(y_2) - z_i(y_2))).\]

As only the participation constraint is binding, the low-ability grower's compensation is given by

\[
\frac{1}{v'(p(y_2) - z_i(y_2))} = \lambda.
\]
Hence, the low-ability grower's compensation with processor \( L \) is equal to the constant \(?\), which is lower than the compensation provided by processor \( H \). Low-ability growers will wish to contract with processor \( H \) in the first period, even though they will have to move to processor \( L \) in the second period, as long as potential mobility costs do not exceed the difference in compensation. Kanemoto and MacLeod (1992), provide an excellent examination of contract arrangements, which include the mobility costs of worker movement between employers.

**Contracting in the Second Period**

In the second period, both processors are aware of the grower ability types under contract, and hence, can restrict growers to their reservation utilities. Since the processor is aware of the grower's ability type, he/she does not face the IC constraint and thus, there is no information cost to eliciting the efficient amount of quality. Processor \( H \) must solve the following problem in the second period (again time subscripts have been dropped)

\[
\max_{p(z_{3i}), y_{i}} \pi(y_{3}) - p(y_{3})
\]  \hspace{1cm} (22)

subject to the participation constraint (PC),

\[
v(p(y_{i}) - z_{h}(y_{i})) \geq U_{h}
\]  \hspace{1cm} (23)

subject to a minimum quality standard,

\[y_{i} > y_{2}\]  \hspace{1cm} (24)

The quality standard constraint in this period removes any incentives, which may have existed in the first period, for the low-ability grower to accept the contract. Hence, processor \( H \), who wishes to contract only with high-ability growers, effectively screens out the low-ability growers,
who must either contract with processor \( L \) in the second period or take his/her chances on the spot market.

Solving processor \( H \)'s problem for the high-ability worker, \( p(y_i) \) must satisfy the following Kuhn-Tucker first order condition

\[
-1 + \lambda (v'(p(y) - z_h(y))) = 0.
\]  

(25)

As only the participation constraint is binding, the high-ability grower's compensation is given by

\[
\frac{1}{v'(p(y) - z_h(y))} = \lambda.
\]  

(26)

Hence, the high-ability grower's compensation with processor \( H \) in the second period is equal to the constant \( ? \). The problem of processor \( L \) in the second period is identical to the first period as grower ability types under contract remain low.

Given the contract for each processor type specifies the growers' quality choice, according to Mas-Colell et al. (1995), the risk-neutral processor should insure the risk-averse grower against any price risk and provide the grower with a fixed payment based on the quality level specified, such that the grower receives his/her exact reservation utility. Hence, we see a fall in the payment for high potato quality, \( y_3 \), from the high-ability grower from the first period to the second period, as a result of the non-binding IC constraint. The problem of processor \( L \) in the second period is identical to the first period as grower ability types under contract remain low.

5. Processor Incentives
The revelation principle and processor monitoring as described in our model, provide incentives for the grower to reveal his/her true ability at the end of the first period. Since the processors are aware of the growers’ ability type after the first period, the processor has the incentive to ratchet up quality standards in later periods. Kanemoto and McCloud (1992) define this behavior, often refereed to as the ratchet effect, as "relationships characterized by relationship specific investments in the absence of long-term contracts, which encourage a firm to use its observation of the worker's output early in the relationship as a guide to setting performance standards in the future." Since the worker, or grower in our case, may anticipate this outcome in advance, he/she may reduce performance in the first period to disguise his/her true ability. However, in order for the worker to effectively use this strategy, the alternatives of the worker in the second period can not depend on the ability of the worker (Freixas et al. 1985). We know from our previous discussion, that the alternatives for the grower in the processed potato industry in the second period, do, in fact, depend on the revelation of his/her true ability in the first period. Hence, the "ability disguise" strategy is not useful to the grower and gives the processor incentives for ratcheting. Additionally, the absence of long-term contracts provides the processor with the ability to change payment structures over time. As Freixas et al. (1985) state, non-commitment on the part of the principal is a crucial element in the ratchet effect.

As seen in the described model, potato payment schedules provided by the processors in the second and following periods provide an expected utility level equal to the grower's expected reservation utility. For the high-ability grower, this creates a loss in compensation over the first period. This situation is similar to the hidden action observable effort case, where the principal offers a fixed wage payment, when there is no problem providing incentives (Mas-Colell, 1995).
In the second period, the IC constraint is not binding for the high-ability grower leading to compensation also equal to a constant, which is lower than in the first period.

If the processor wishes to increase profits by adjusting the payment schedule down for given levels of quality, the processor must at least cover the agents' disutility of quality production at the efficient quality level. However, if payment schemes are currently at reservation levels, how does the processor reduce payments in future periods? The answer lies in the change in the expected reservation level of utility from year to year. Each additional year of known spot market prices creates an additional observation in which to update the variance of the spot market price distribution. The grower will update the expected value of his utility from selling his/her crop on the spot market and then make a decision to contract with the processor or to remain independent. If spot market prices decrease over time, the processor may be able to decrease payments for a given quality and still provide an expected utility at least that of the grower's expected reservation utility.

6. Processed Potato Industry Case Study

Two main assumptions were made in the design of the principal-agent model used in this analysis. First, processors will offer contracts with differing base payment and similar variable payments, according to the grower's ability type, which creates a hybrid market. Second, the potato quality characteristics necessary for profit maximization differ for each processor, based on their end product line. This creates a separation in contracts based on quality incentives and a need for a certain ability grower. Then through the use of the two period principal-agent model we concluded that processors use information gained in early periods to select out certain growers and also lower grower payments to specific quality levels, which increases processor
profit capture. In this section we analyze actual processing potato production contracts to provide evidence of these three issues.

**Hybrid Markets**

Grower storage production contracts for Russet Burbank potatoes from two separate Washington processors, processor #1 (P1) and processor #2 (P2), for the years 1995 and 1996 are analyzed. Ten sample potato loads delivered for processing in 1995 and 1996 were then randomly chosen from a data set. Each sample load is of a different size (tons) and includes tubers of differing quality attributes (Table 1). The Russet Burbank potato variety is used in the analysis because it has a long dormancy and storage has little effect on its post harvest specific gravity (Kunkel and Thornton, 1986).

Ten sample loads from each year of 1995 and 1996 were inserted into the two production contracts for 1995 and 1996. Total load payment, base payment, and variable payment are then analyzed. The quality attributes available for comparison in all loads and all years included the percentage tare for each load, the bruise free percentage for each load, and the specific gravity rating for each load.

Although the incentive for each quality attribute was slightly different among the two processors, the average variable payment in both years was very similar (Tables 2 and 3). The average variable payment per ton for the 1995 loads for P1 was $14.31 and $14.88 for P2. The average variable payment per ton for the 1996 loads was $13.52 for P1 and $13.95 for P2. The incentive for bruise free was much higher in the P2 contracts for both years, but was capped at $10 per ton. The P1 contracts for both years had lower incentives, but were not capped, which provided the ability for some loads to exceed the $10 maximum from the P2 contracts. The tare
deduction for excessive dirt and other foreign material in the potato load was zero for all 1996 loads and $.50 for one load in the 1995 P1 contract. The base load price from each of the two contracts was drastically different at $68.70 and $73.00 per ton of usable potatoes for the P1 1995 and 1995 contracts, and $90.40 and $96.90 per ton of usable potatoes for the P2 1995 and 1996 contracts.

**Profit Maximizing Potato Quality**

As previously mentioned, processors have a varied end product line up. One processor may concentrate on producing French fry products which require high quality usable (non-cull) potatoes, while another processor may concentrate on producing dehydrated products, or products which use smaller potatoes such as hash browns or chips, which can be produced with processing culls and do not require high quality usable potatoes. In our analysis of the potato contracts provided by processors 1 and 2 as described above, we find that processor 1 (P1), who provided a lower base does, in fact, offer an end product, which included potato products which use smaller potatoes or waste materials. P1 has an expanded offering of hash brown and mashed potatoes (dehydrated flakes) with a variety of flavorings, as well as many wedge and skin finger foods. P1 has a much more limited offering of French fry products, than processor 2 (P2). P2 focuses primarily on French fry products with a limited offering of mashed and hash browns. As P2 offers the high base payment contract, this would indicate that they need a higher quality usable potato for their French fry products, which is indeed the case. When 2001 contracts for the P1 processor were examined, it was found that payments for processing culls (small, well
formed, and disease and discoloration free) were increased from $20/ton to $40/ton. Hence, the P2 processor is indeed looking for smaller potatoes which are not large high quality.

**Ratcheting**

We evaluated the production contracts for processor #2 (P2) from 1995 to 2000. This evaluation shows that payments to the high base quality, including base levels of specific gravity, bruise free, sugar content, size, internal discoloration, and USDA grade, did in fact decrease over time. The average per ton price in the first two years was $93.65 and the average per ton price in the last two years was $85.50. Interestingly, spot market prices during the same six years, averaged $94.15 per ton, however, base prices under contract do not reflect the variable payments for quality levels above or below the base level. Variable payments to specific quality attributes also were reduced in the last two years of the P2 contracts examined (Table 2). Per ton payment increases for additional increments in specific gravity decreased from $1.25 to $1.10 and then to $0.80 in 2000. Additionally, the allowable percentage of tare included with the potato load was reduced from 4% to 3%, but penalties for each extra percentage of tare was reduced from $0.50 to $0.10.

**7. Conclusions**

Production contracts in the processed potato industry are effective at increasing quality. Processors provide incentive for growers to provide a level of quality higher than that of the spot market. Babcock and Carriquiry (2002), explain that contracts are the only way to induce a risk-averse farmer to move away from producing a commodity to producing a high-value product. Alexander *et al.* (2000), show that for the no-contract case as well as the late season contract
case, the share of limited use tomatoes with mold, greens, and excess material increases, or, said otherwise, the quality of the tomatoes diminishes.

The repeated nature of contracting in the processed potato industry allows the processor to gain knowledge of the grower's true ability at the end of the first period. The processor may then use this knowledge to ratchet up quality standards in the second and later periods. We show that payments for certain quality levels do fall for high-ability growers in the second period. An examination of current contracts provides evidence of ratcheting over time.

Additionally, an important assumption made is that quality testing achieves a degree of truth in the assessment of potato load quality. However, as only a small sample of each load is tested, there is certainly room for measurement error. If the measurement error is large, it may adversely affect grower incentives in a repeated contract situation. However, as Hueth and Ligon (1999b) point out, the quality testing results must be at least informative or efficiency losses will result. Also, the cost of the quality measurement adversely affects the profits of the processor and hence the payment scheme provided the grower. It may be that grower-owned processor cooperatives may diminish this cost and lead to higher efficiency in the processing potato industry.
References


DeVore, Brian (April/May 1999). Selling the Farm Down Contract Creek. The *Land Stewardship Letter* 17, no. 2.


*Spud Topics* (September 27, 2001). Potatoes Number Three Commodity in Washington State.


Figure 1: Processor and Grower Maximization
Potato quality payment structures and isoprofit curves for the $H$ and $L$ processor. High and low-ability growers are represented by the single crossing indifference curves which indicate their reservation utilities.
Table 1: Spot Market Prices for Processing Potatoes in the Columbia Basin 1995-2000

<table>
<thead>
<tr>
<th></th>
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<th></th>
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</tr>
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<tbody>
<tr>
<td>Per cwt.</td>
<td>$3.75</td>
<td>$8.00</td>
<td>$1.50</td>
<td>$3.25</td>
<td>$5.75</td>
<td>$6.00</td>
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<tr>
<td>Per ton</td>
<td>$75.00</td>
<td>$160.00</td>
<td>$30.00</td>
<td>$65.00</td>
<td>$115.00</td>
<td>$120.00</td>
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</table>

Source: Fraser's Potato Newsletter, January 8, 1998 and January 31, 2001. (Average $94.15)
Table 2: Grower Potato Load Payment Schedules 1995 to 2000

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<td><strong>Base</strong></td>
<td>$90.40</td>
<td>$96.90</td>
<td>$88.65</td>
<td>$84.65</td>
<td>$84.65</td>
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<td><strong>Tare</strong></td>
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<td>4%:(-.50)</td>
<td>4%:(-.50)</td>
<td>4%:(-.50)</td>
<td>4%:(-.50)</td>
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<td><strong>Bruise Free</strong></td>
<td>55%:(+0.50)</td>
<td>55%:(+0.50)</td>
<td>55%:(+0.50)</td>
<td>55%:(+0.50)</td>
<td>55%:(+0.50)</td>
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<td><strong>Specific Gravity</strong></td>
<td>1.0780:(+1.25)</td>
<td>1.0780:(+1.25)</td>
<td>1.0780:(+1.25)</td>
<td>1.0780:(+1.25)</td>
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(+) Specifies a dollar amount for every percentage increase and/or decrease.
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<th>Load Weight in Tons</th>
<th>Total Pounds Examined</th>
<th>Percentage Tare</th>
<th>Percentage Culls</th>
<th>Percentage Processing Culls</th>
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<td></td>
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<td>346.74</td>
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### Table 4: Processor 1 Sample Load Payments

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Market Structure and Consumer Valuation in the rBST-free and Organic Milk Markets

Tirtha Dhar
Jeremy D. Foltz

Abstract
This study uses revealed preferences of consumers to study the consumer valuations of rBST-free and organic milk. The study specifies and estimates a quadratic AIDS model for different milk types using US supermarket scanner data. The introduction of rBST-free and organic milk is used to estimate both competitive and variety effects as measures of consumer valuations. Results show significant consumer valuations for organic milk and to a lesser extent rBST-free milk.

Keywords: Demand Systems, Q-AIDS, Milk markets, Biotechnology, Organics, Food Labeling

JEL Codes: Q130, C300, D120, D400

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1 This project is funded by the Food Systems Research Group, University of Wisconsin-Madison. We are grateful to Professor Kyle Stiegert for providing us the funds and access to the scanner data and Eric Finnin for diligent tracking of organic and rBST-free brands. Any errors and omissions are the sole responsibility of the authors.

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Market Structure and Consumer Valuation in the 
rBST-free and Organic Milk Markets

The U.S. food sector is going through rapid transformations in terms of new product introduction and innovations. Organic and genetically modified food products are leading the way in changing the landscape of available choices to consumers. This rapid expansion of product spaces has taken place concomitantly with an increase in public policy concerns on issues of standardization, labeling, health risks and associated consumer welfare. In this paper we explore these broader issues in the context of a specific product introduction, the introduction of rBST-free and organic milk in the U.S. market. From a policy perspective understanding the market for organics and the various components of that demand (i.e., what portion is for GMO free and what is for other attributes of organics) can help determine the value of creating a national standard and the potential welfare losses to consumers of weakening such a standard. Are consumers willing to pay extra for organic and rBST-free milk? If so, how much are they willing to pay? What is the value or cost of a national labeling policy?

Labeling of genetically modified food products first became an issue for consumers in the U.S. with the introduction of rBST (recombinant bovine somatotropin) into the milk supply in 1994. A number of states, including Wisconsin and Vermont, passed laws allowing processors to label their milk as being rBST-free.\(^4\) As the first widely consumed food product produced with genetic modification technology, rBST has garnered a lot of interest in its adoption process (see e.g., Foltz and Chang, Barham et al.) but relatively little research has been done on the consumer side. In addition to labels specifically on rBST-free milk, there is an increasingly large market for organic milk and milk products. Since organic labeled foods not only do not contain genetically modified products but also have other potentially desirable attributes such as being pesticide and antibiotic free, the differences between rBST-free milk and organic milk can identify some of the different values consumers place on product attributes.

\(^4\) Milk that comes from cows treated with recombinant bovine somatotropin is not genetically modified it is the hormone somatotropin that has been genetically engineered. No studies have shown milk from cows treated with rBST to have somatotropin in it that is recognizable as being genetically engineered. However, most labeling of rBST-free milk implies that such would be the case.
Since the possibility of genetically modified foods entering the market became apparent in the early 1990’s, a large literature has developed investigating consumer valuations for non-genetically modified foods as well as labels about genetic modifications (see e.g., Armand-Balmat, Teisel et al., Huffman et al.). This literature has been based primarily on consumer willingness to pay surveys (by telephone or mail) and experiments conducted with potential consumers of products. Both of these techniques rely on the accuracy of consumers either reached by telephone at home or invited to an artificial laboratory setting to predict their behavior when faced with different products in the supermarket. In addition, due mostly to cost and logistics, many of these efforts are local, often concerning only one or two cities or a single state.

The present study uses revealed preferences of consumers to study the consumer valuations of rBST-free and organic milk, basing its analysis on IRI scanner data of fluid milk purchases in 12 key US metropolitan markets. Of the 12 cities, 4 are in the West census region, 4 in the South census region, 3 in the Midwest, and 1 in the Northeast region. Due to disclosure agreements with IRI we cannot mention the cities or brands included in our analysis. Instead these cities are identified by US census regions as: West census region cities (WT_1,..., WT_4); South census region cities (SO_1,..., SO_4); Midwest region cities (MW_1,..., MW_3); and Northeast region city (NE_1). The database provides detailed brand level information on volume sold, total revenue generated, number of units sold, and the extent of merchandising and price reduction. This data allows a simultaneous exploration of consumer willingness to pay, market structure, and the conduct of firms in these markets. As a result we are able to provide a comprehensive analysis of the U.S. retail fluid milk market by types (i.e., organic, rBST and unlabeled milk).

The revealed preference data used here have a number of obvious advantages over the previous survey and experimental based literature. First and foremost it relies on consumer’s actual behavior rather than their predicted behavior. Second data is available for 12 major metropolitan cities spanning U.S. regions and the different types of cities: old industrial city, mainstream fast-growing city, counterculture fast-growing city, old line blue-blood city, etc. Thus one can make some reasonable inferences about the population as a whole from this data. A third advantage is we observe consumer
responses both at the time they are introduced to a product and their subsequent purchase pattern once they are used to the product in the market. Having this time series avoids potential biases inherent in the experimental and survey literature when consumers are faced with a product they have never seen or tasted before. A final advantage is that rBST-free, organic, and unlabeled milk are all real products that consumers consider buying each time they go to the grocery store.

The goals of this paper are to:
- Identify empirically the extent of market penetration of GMO-free milk products.
- Estimate price premiums and market shares of different milk types in each of the 12 markets and estimate Engle curves for the milk types.
- Analyze the level and determinants of consumer valuation for the different types of milk using a highly flexible quadratic almost ideal demand system (Q-AIDS) framework as in Banks, Blundell and Lewbel (1997). We use full information maximum likelihood estimation techniques to estimate the demand systems for four regionally and geographically representative markets after controlling for price and expenditure endogeneity as in Dhar, Chavas and Gould (2002).
- Based on the estimates of our models we measure compensating variations attributable to rBST-free and organic milk, as a measure of willingness to pay for GMO-free products.

The article is organized as follows. First, we describe the data and present descriptive analysis of the products: rBST-free, organic and unlabeled and the 12 markets. The reduced form analysis of this section provides insights and guidelines for the structural demand analysis in the section that follows. In Section 2 we provide a detailed demand system specification and our estimation methods to generate consistent parameter estimates. In Section 3, we present our empirical specification of the demand, price and expenditure systems. Econometric results and post estimation measures such as price and expenditure elasticities, and welfare impacts of different types of milk are then presented in Section 4. A conclusion drawing policy implication for USDA labeling and regulation policy follows.
1. Data and Descriptive Statistics:

We use retail scanner data from Information Resources Inc. (IRI) to conduct exploratory market analyses and estimate our demand system. Our scanner database, which was collected so as to be representative of the markets in our 12 cities, provides brand level milk prices and sales each week starting from 3/9/1997 to the week ending 2/24/2002. Brands that are labeled as rBST-free or organic were identified through interviews with processors and retailers. We augment this database with milk price data from the Federal Milk Marketing Order and a national organic milk producer. The demographic variables come from the U.S. Census. The descriptive statistics of the variables used in our analysis are described below.

The simplest method for understanding premiums for rBST-free and organic milk is an investigation of retail price differentials. Tables 1 and 2 present the average prices for the three milk types in our study by city of sale and by year, respectively. On average, price differences between organic and unlabeled milk are about $3.00 per gallon and between rBST-free and unlabeled about $1.50 per gallon. This represents more than a 100% mark-up for organic milk and 50% for rBST-free milk. A number of significant differences between milk types and cities, however, become immediately apparent. A western city, WT_4, has the lowest prices for both organic and rBST-free milk, although its price for unlabeled milk is above average. In one of the southern cities, SO_3, and a Midwestern city, MW_2, rBST-free milk is priced at about the same high level as organic milk.

Over the 5 years from 1997 to 2002 prices increased by 24% in organic, 25% in rBST-free, and 13% in unlabeled milk. This asymmetric pattern of price inflation pushed the price differential between organic and unlabeled from $2.68 to $3.64 per gallon (123% of the unlabeled price) and between rBST-free and unlabeled from $1.42 to $2.10 per gallon (70% of the unlabeled price).

Such price differentials show significant willingness-to-pay among certain consumers for the attributes of organic and rBST-free milk. In particular since organic milk represents rBST-free milk with added attributes (e.g., no antibiotics, organic feed given to the cows, and potentially the idea of small-farm production) one can identify the value to consumers of these different components. Thus on average over this period,
avoiding milk from cows treated with a genetically modified hormone was worth $1.50 per gallon, while drinking milk from cows which also received no antibiotics, were fed organic feeds with no-pesticides, and are advertised as coming from small dairy farms was worth an additional $1.50 per gallon. These averages, however, ignore market effects and different demand surface curvatures, which are analyzed in the next section.

Tables 1 and 2 also show market shares by type of milk by city and by year. While unlabeled milk clearly has nearly all the market, ranging from a low of 96% in WT_4 to a high of 99.86% in WT_3, rbst-free and organic milks are making some small in-roads. There is great variability by city, for example in WT_4 1% of the dollar sales of milk are organic and 2.7% are rBST-free, while MW_3 has no rBST-free sales and a paltry quarter of a percentage of its milk sales being organic.

The yearly share data in Table 1 identify two key features: the organic market is growing rapidly, while the rBST-free market seems to have peaked in 1998 and is in decline. Organic market shares increased nearly seven fold over the same period. Figure 1 shows that growth in four key markets. That spectacular growth rate in organic market shares does show signs of slowing since it was 94% between 1997 and 1998 had slowed to 16% between 2001 and 2002. Even so, in the end organic still accounts for less than 1% of the milk market.

In contrast, rBST-free milk has a declining market share, suggesting two possible scenarios. It may be that as consumers learn more about rBST over time their perceptions of the risks associated with the technology go down reducing their desire to buy rBST-free milk. Some studies (see e.g., Tegene et al.) have suggested that information plays a major role in consumer willingness to pay for goods without genetically modified ingredients. Another possibility comes from the literature on product differentiation. From the consumer’s perspective these milk products may be vertically differentiated such that given the same price organic milk is preferred to rBST-free milk and rBST-free milk is preferred to unlabeled milk. In this case rBST-free milk might be a “starter” or “gateway” milk for those who would like to buy organic but cannot afford it. Or, a third related possibility is that consumers move up the “quality ladder” from unlabeled to rBST-free to organic in an incremental process driven by

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5 For detailed discussion on the concept of product differentiation please refer to Tirole (1988).
learning about the products. In such a scenario rBST-free consumers move to organic because the learning that takes place in purchasing rBST-free milk and reading the labels at the breakfast table makes consumers more likely to purchase organic milk. All of these conjectures would require further study, probably using different types of data.

To complete the description of the data we present Engle curves for the three types of milk in Figures 2, 3, and 4. These curves show dollar expenditures of each milk type as a function of total expenditure on milk for a single milk market, WT_4. The Engle curves were estimated non-parametrically using the Lowess smoothing technique in order to allow for non-linearities in the curves. The curves show significant differences as well as major non-linear portions. Both the organic and unlabeled milk Engle curves are mostly increasing with respect to the total milk expenditures. Although organic milk has a concave Engel curve, unlabeled milk has a linear Engel curve. RBST-free milk shares, in contrast, are declining and convex to the origin suggesting that as milk expenditures increase consumers switch out of rBST-free milk. This expenditure declining with total expenditures for rBST-free milk provides some evidence for the quality ladders hypothesis, that as expenditures rise consumers are switching out of rBST-free milk, although the Engle curves do not identify whether they are in fact switching to organic milk.

2. A Consumer Demand System for Multiple Milk Types

In this section we first describe our choice of demand system. Then we derive the analytical form of the post estimation measures: elasticities and welfare effects.

a. Quadratic Almost Ideal Demand System:

To specify demand for different types of milk we use the quadratic almost ideal demand system (Q-AIDS). Our non-parametric analysis of Engel curves suggests that the relationship between per capita expenditure on any milk type and total per capita expenditure on milk is non-linear. Banks, Blundell and Lewbel (1997) have shown that in the presence of such non-linear Engel curves use of a rank 2 demand system such as the standard AIDS model is inappropriate. The Q-AIDS is the best available exactly
aggregable demand system to capture any non-linear impacts of price and expenditure changes on demand. The demand system underlying the Q-AIDS is of rank 3, which, as proved in Gorman (1981), is the maximum possible rank for any demand system that is linear in functions of income. Unlike the AIDS model (Deaton and Muelbauer, 1981) and the exactly aggregable Translog model of Jorgenson et al. (1982) the Q-AIDS model permits goods to be luxuries at some income level and necessities at others.

In order to derive a Q-AIDS demand system let \( e(p, u) \) be the household expenditure function, where \( p \in R^n \) is the \((n\times 1)\) price vector of the \((n\times 1)\) vector of consumption goods \( q \in R^n \). Under the almost ideal class of demand systems, \[
\ln e(p, u) = \ln a(p) + c(p)[d(p) + u^{-1}],
\]
where:
\[
\ln a(p) = \alpha^T \ln p + 0.5(\ln p)^T \Gamma (\ln p), \quad c(p) = \beta^T \ln p, \quad \text{and} \quad d(p) = \tau^T \ln p.
\]
Denoting by \( k_n \) the \((n\times 1)\) vector
\[
\begin{bmatrix}
k \\
\vdots \\
k
\end{bmatrix},
\]
the parameters \((\alpha, \beta, \tau, \Gamma)\) satisfy the restrictions:
\[
\alpha^T 1_n = 1, \quad \beta^T 1_n = 0, \quad \tau^T 1_n = 0, \quad \Gamma 1_n = 0_n \quad \text{(homogeneity/adding up), and} \quad \Gamma^T = \Gamma \quad \text{(symmetry)}.
\]
Letting \( M > 0 \) be household expenditure, the Marshallian demand specification (with \( q_1, \ldots, q_n \) quantity demanded) in terms of expenditures shares \( w = (p_1 q_1^*/x, \ldots, p_n q_n^*/x)^T \) are
\[
(1) \quad w = \alpha + \Gamma \ln p + \beta [\ln x - \ln a(p)] + \tau [\ln x - \ln a(p)]^2/c(p).
\]
In order to facilitate the empirical implementation one can also specify this demand specification in summation notation as:
\[
(2) \quad w_{ilt} = \alpha_i + \sum_{j=1}^N \gamma_{ij} \ln(p_{jlt}) + \beta_i \ln\left(M_{ilt} / P_{lt}\right) + \frac{\tau_i}{\prod_{i=1}^N P_{jlt}^\beta} \left[\ln\left(M_{ilt} / P_{lt}\right)\right]^2
\]
where \( p = (p_1, \ldots, p_N)^T \) is a \((N\times 1)\) vector of prices for \( q \), and \( w_{ilt} = (p_{ilt} x_{ilt}/M_{ilt}) \) is the budget share for the \( i^{th} \) commodity consumed in the \( l^{th} \) city at time \( t \). The term \( P \), the price index can be expressed as:
\[
\ln(P_{lt}) = \delta + \sum_{m=1}^N \alpha_m \ln(p_{mlt}) + 0.5 \sum_{m=1}^N \sum_{j=1}^N \gamma_{mj} \ln(p_{mlt}) \ln(p_{jlt}).
\]
The above Q-AIDS specification (equation 2) can be modified to incorporate the effects of socio-demographic variables \((Z_{1lt}, \ldots, Z_{Klt})\) on consumption behavior, where \(Z_{klt}\) is the \(k\)th socio-demographic variable in the \(l\)th city at time \(t, k = 1, \ldots, K\). This method, demographic translating, allows demographic differences to shift both the intercept and elasticity parameters. Under demographic translating, \(\alpha_i\) is assumed to take the following form: 

\[
\alpha_{ilt} = \alpha_{0i} + \sum_{k=1}^{K} \lambda_{ik} Z_{klt}, \ i = 1, \ldots, N.
\]

**b. Using Q-AIDS to analyze substitution between milk types:**

From estimating a Q-AIDS model, one can recover detailed compensated and uncompensated own and cross price elasticities, expenditure elasticities, and measures of consumer welfare. The own and cross price elasticities allow us to analyze the substitution behavior of consumers between the different types of milk as a way of describing consumer demand for labeled milk. In addition, the literature suggests that labeled milk should be a luxury good, a proposition which can be analyzed with the expenditure elasticity. Together these elasticities describe the patterns of consumer willingness to pay for labeled milk.

Differentiating the demand system (equation 1) with respect to \(\ln p\) and \(\ln M\) gives us price and expenditure elasticity measures. Let 

\[
\mu_i = \frac{\partial w_i}{\partial \ln m} = \beta_i + \frac{2\lambda_i}{b(P)} \left\{ \ln \left[ \frac{m}{a(P)} \right] \right\}
\]

and 

\[
\mu_{ij} = \frac{\partial w_i}{\partial \ln p_j} = \gamma_{ij} - \mu_i \left( \alpha_j + \sum_k \gamma_{jk} \ln p_k \right) - \frac{\lambda_i \beta_j}{b(P)} \left\{ \ln \left[ \frac{m}{a(p)} \right] \right\}^2.
\]

Then the expenditure elasticities are given by: 

\[
e_i = \frac{\mu_i}{w_i} + 1.
\]

The uncompensated price elasticities are given by 

\[
e_{ij}^u = \frac{\mu_{ij}}{w_i} - \delta_{ij}\]

where \(\delta_{ij}\) is the Kronecker delta. We use the Slutsky equation to calculate the set of compensated elasticities such that: 

\[
e_{ij}^C = e_{ij}^u + e_j w_j.
\]

**c. Using Q-AIDS to Measure Benefits from Labeled Milk:**

Since rBST-free and organic milks were just being introduced to the general milk market during this data’s study period, one can think of measuring consumer valuation of
labeled milk as measuring the benefits of a new product introduction. New products have two effects: on the one hand they raise competition, potentially lowering prices of all related goods; on the other they provide increased choice to consumers which according to standard consumer theory should have a non-negative effect on consumer utility. Since we observe markets both with and without each of the labeled milk varieties we can use this variation in the data along with the Q-AIDS model to identify key components of consumer benefits from the product.

The standard approach in the literature on product introductions (see e.g., Hausman (1981) and Hausman and Leonard (2002)) measures the total effect on consumers from the introduction of new products as the difference in the consumers’ expenditure function before and after the introduction, i.e., the compensating variation, \( CV \). Holding utility constant at the post-introduction level, compensating variation can be described as:

\[
CV = e(p_1, p_N, r, u_i) - e(p_1, p_N^*(p_0), r, u_i),
\]

where \( p_1 \) is the vector of post-introduction prices of the competing products, \( p_N \) is the post-introduction price of the new product(s), \( p_0 \) is the pre introduction prices, \( r \) is a price vector for products outside the industry, and \( u_i \) is the post-introduction utility level. The function \( p_N^*(p) \) defines the ‘virtual’ price for the new products, which is the reservation price at which demand for the new product would be zero given the prices of the other products.

This total benefit to consumers can be decomposed into two components:

\[
CV = [e(p_1, p_N, r, u_i) - e(p_1, p_N^*(p_1), r, u_i)] + [e(p_1, p_N^*(p_1), r, u_i) - e(p_1, p_N^*(p_0), r, u_i)],
\]

which can be re-written as:

\[
CV = -(VE + CE).
\]

Here the first term (\( VE \)) represents a variety effect, implying the change in consumer welfare due to the availability of the new products(s), holding the prices of the existing brands constant at the pre-introduction level. The second term is the competitive effect (\( CE \)), which represents the consumer welfare due to the change in the prices of existing brands after the introduction. The impact of the competitive effect can be positive or negative based on the nature of competition between firms producing the products originally on the market and those that have entered the market.
The variety effect can be estimated indirectly out of the parameters of the Q-AIDS demand system as the area under the estimated demand curve between actual price/consumption points and the price that sets consumption equal to zero. The competitive effect can be estimated directly from the milk price series before and after introduction of a labeled milk variety. The empirical techniques for estimating these effects are described below.

3. Estimation Procedures for the Demand System

A number of previous studies have found problems of endogeneity of price and expenditure in estimating demand systems using aggregate scanner data such as those used in this study (see e.g., Dhar, Chavas and Gould, 2003). In order to account for potential price and expenditure endogeneity, our estimation procedure for the Q-AIDS demand system, equation (2), includes an additional set of equations that simultaneously estimate the determinants of milk prices and milk expenditures as functions of strictly exogenous variables. We estimate our demand equations, reduced form price equations, and expenditure equation using a full information maximum likelihood (FIML) estimation method. Due to adding up restrictions of the Q-AIDS demand system we drop one demand equation and estimate a system with 2 demand equations, 3 reduced form price equations, and 1 expenditure equation.

The reduced form price equations used to control for price endogeneity for each milk type (unlabeled, rBST-free, and organic) are specified to capture the supply side of the price formation mechanism. The price equation for the $i^{th}$ commodity in the $l^{th}$ city at time $t$ is:

$$ p_{ilt} = f(\text{supply/demand shifters}). $$

In equation (5) supply/demand shifters would include variables to describe raw material, product manufacturing, and packaging costs. Following Blundell and Robin we specify a

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6 Note that it is also possible to generate indirect estimates of the competitive effect from the Q-AIDS system if one is willing to assume that the milk processors are engaged in a Bertrand competition game. Since part of the purpose of this paper is to evaluate whether or not there is any competition between labeled and unlabeled milk it would be counter productive to assume a specific type of competition.

7 An alternative is the GMM framework developed by Banks, Blundell, and Lewbell.
reduced form expenditure equation where household expenditure in the \( l \)th city at time \( t \) is a function of median household income and a time trend:

\[
M_{lt} = f(\text{time trend, income}).
\]

Given these reduced form specifications for the price and expenditure equations, we estimate jointly (2), (5) and (6) by FIML. The resulting parameter estimates have desirable asymptotic properties (Amemiya).

To control for city specific variations, we modify the Q-AIDS specification with demographic translating variables \((Z_{l1}, ..., Z_{lK})\). Our AIDS model also incorporates a set of four seasonal dummy variables for each city along with socio-demographic variables. In order to maintain theoretical consistency of the AIDS model, the following restrictions are applied to demographic translating parameter \( \alpha_{0i} \):

\[
\alpha_{0i} = \sum_{r=1}^{4} d_{ir} D_{r} , \sum_{r=1}^{4} d_{ir} = 1, i = 1, \ldots, N, \]

where \( d_{ir} \) is the parameter for the \( i \)th brand associated with the seasonal dummy variable \( D_{r} \) for the \( r \)th season. Note that as a result, our demand equations do not have intercept terms.

### 3.1 Empirical Specifications

#### Price Specification

Most recent studies of differentiated products have modeled price as a function of supply and demand shifters, assuming these shifters are exogenous to the price formation mechanism (e.g., Cotterill, Franklin and Ma; Cotterill, Putsis and Dhar; and Kadiyali, Vilkassim and Chintagunta). For milk products, raw milk prices account for 62% of the retail milk price and thus can be used as a reasonable proxy for a large part of the variability in manufacturing costs.\(^8\) Other important retailing and processing costs we include in the price formation equation provide proxies for labor, merchandising, and packaging costs. We therefore specify the retail price functions, equation (5), with raw milk price, marketing and other product characteristics as explanatory variables:

---

\[
\ln(p_{ilt}) = \theta_{i0} + \theta_{il} \ln(C_{ilt}) + \theta_{i2} \left[ \ln(C_{ilt}) \right]^2 + \theta_{i3} \ln(wage_{ilt}) + \theta_{i4} \ln(p_{ilt-1}) + \theta_{i5} PRD_{ilt} + \theta_{i6} UPV_{ilt}
\]

where \(p_{ilt}\) is the retail price of milk type \(i\), in city \(l\) and at time \(t\). As a measure of milk costs, \(C_{ilt}\) is the price of announced cooperative class I milk price in city \(l\) at time \(t\), including adjustments for the added costs of organic milk. Similarly, \(wage_{ilt}\) is the wage rate in city \(l\) at time \(t\) and \(p_{ilt-1}\) is the lagged retail price.\(^9\) As a measure of the average size of purchases \(UPV_{ilt}\) is the unit volume of the \(i^{th}\) product in the \(l^{th}\) city at time \(t\). For example, if a consumer purchases only one gallon bottles of a brand, then unit volume for that brand will be just one. Conversely, if this consumer buys a half-gallon bottle then the unit volume will be 2. This variable is used to capture packaging-related cost variations, as smaller package size per volume implies higher costs to produce, distribute, and shelve. The variable \(PRD_{ilt}\) is the percent price reduction of brand \(i\) and is used to capture any costs associated with specific price reductions such as aisle end displays or freestanding newspaper inserts.

**Expenditure Specification**

Similarly the reduced form expenditure function in (6) is specified as:

\[
\ln(x_{ilt}) = \psi_{0} + \psi_{1} TR_{t} + \psi_{2} \ln(x_{ilt-1}) + \psi_{3} \ln(wage_{ilt}) + \psi_{4} C_{idx_{ilt}},
\]

where \(t = 1, \ldots, 260\) and \(\psi_{0}\) is the intercept term. \(TR_{t}\) is a linear trend, capturing any unobservable time specific effects on consumer milk expenditures. The variable \(wage_{ilt}\) is the average wage rate in city \(l\) and is used as a proxy to capture the effect of income differences on milk purchases. \(x_{ilt-1}\) is lagged expenditure by one period. \(C_{idx_{ilt}}\) is the city level consumer price index; this variable captures any city level overall supply shocks to consumers.

In general the reduced form specifications, equations (8) and (9), are always identified, although the issue of parameter identification is rather complex in such non-linear structural models.\(^{10}\) We checked the order conditions for identification that would

\(^9\) Note that processors pay the same price to farmers for rBST-free and unlabeled milk and this price is governed by the federal milk marketing order (FMMO). On the other hand organic milk farmers tend to a premium price for their price and this price is not regulated by any federal authority.

\(^{10}\) For a detailed discussion please refer to Mittelhammer, Judge and Miller (p.474-475).
apply to a linearized version of the demand equations (2) and found them to be satisfied. Finally, we did not uncover numerical difficulties in implementing the FIML estimation. As pointed out by Mittelhammer, Judge and Miller (p.474-475) we interpret this as evidence that each of the demand equations is identified.\footnote{Due to space limitations, we report only related econometric results. More complete reports of the results are available from the authors on request.}

**Translating**

Our translating specification (e.g. \( \alpha_{ilt} = \alpha_{0i} + \sum_{k=1}^{K} \hat{\lambda}_{ik} Z_{ikt} \)) has four quarterly dummies and two continuous variables. These two variables are: the monthly wage rate in the city and the consumer price index. The seasonal dummies will be able to capture any seasonal variations in a given city. The wage rate variable captures any impact of change in income on milk consumption. And lastly the consumer price index can capture any exogenous shocks in other markets on the consumption of milk.

4. Q-AIDS Model Estimation Results

Table 3 provides parameter estimates for the demand system, reduced form price and expenditure equations. In total we estimate 45 parameters, of them 34 parameters are significant at a 5% level of significance. Both of our estimated \( \beta \) parameters measuring how consumption of milk changes with expenditure are significant at a 5% level of significance. Of the two estimated \( t \) parameters, which describe the quadratic term on expenditure, one of them is significant at the 5% level and the other one is significant the 10% level. The significance of parameters \( (t) \) associated with the quadratic part of the demand system validates the choice of a Q-AIDS formulation for demand.

4.1 Analysis of Elasticity Estimates:

Table 4 presents expenditure elasticity estimates and associated standard errors while Tables 5(a) and 5(b) present uncompensated and compensated price elasticity estimates and associated standard errors. We estimate elasticities at the mean of the variables and find all of them to be significantly different from zero at a 5% level or less. The un-
compensated price elasticities are not significantly different from the compensated ones. Since this implies that the overall impact of per capita expenditure on milk consumption is minimal, the analysis of price elasticities uses un-compensated price elasticities.

All types of milk show, as expected by theory, negative uncompensated own-price elasticities. Of the own price effects rBST-free milk has the highest own price elasticities (-4.40) followed by organic milk (-1.37) and unlabeled milk has the lowest (-1.04). RBST-free and organic milk have negative cross price elasticities, implying they are complements to each other. In contrast the positive cross price elasticities between unlabeled and both rBST-free and organic milks implies that unlabeled milk is a substitute for both of them. This substitution pattern is, however, asymmetric suggesting greater movement to organic and rBST-free milk than back to unlabeled milk. For example, a 1% change in the price of unlabeled milk leads to a large switch from unlabeled to other milk: a 1.51% change in rBST-free milk demand and a 3.15% change in organic milk demand. On the other hand, a 1% price change in rBST-free milk leads to only a 0.05% change in unlabeled demand, and 1% price change in organic milk leads to only a 0.02% change in demand for unlabeled milk. This implies that once consumers switch to higher priced products (i.e. rBST-free and organic) they usually do not switch back to unlabeled milk even for significant price changes. Such stickiness in consumer behavior may suggest that once consumers choose labeled milk they perceive a quality difference in comparison to unlabeled milk as would be the case in a vertically differentiated product market. Consumers in vertically differentiated markets do not tend to switch back to a lower quality product once they switch to a higher quality product.

Among the expenditure elasticities, rBST-free milk has the highest (4.39) and organic milk has the lowest (0.5) elasticity. Unlabeled milk has, as expected, an expenditure elasticity just below unity suggesting a necessity. The low expenditure elasticity for organic milk is perhaps surprising given that the organic milk is commonly perceived to be associated with higher income groups of the population. And the

---

12 Blind taste tests conducted informally by the authors could discern no quality differences in terms of taste between these three types of milk.
13 A classic example of vertically differentiated market is computer chips market. Once consumers switch to Pentium 4 chips they prefer not to switch back to Pentium 3 or lower quality chips.
relationship between income and milk expenditure may not be positively correlated. It is commonly known that large families with children tend to have higher per capita expenditure on milk. In that case our result suggests that smaller families with no children tend to consume more organic milk. In the case of rBST-free milk early work on rBST in milk by Grobe and Douthitt (1995) does suggest that risk perceptions of rBST are negatively correlated with income, which would be consistent with these results. Similar to the arguments made in the case of organic milk, it is probable that large families with children are interested in minimizing the risks associated with artificial hormones but not that interested in other associated benefits of organic milk. Another possible explanation is that we are only estimating a partial demand system and we have not fully accounted for cross expenditure effects.

4.2 Estimating Consumer Willingness to Pay

As demonstrated above, consumer willingness to pay for labeled milks can be estimated by the compensating variation. This compensating variation has two elements a competitive effect and a variety effect. The estimation procedure and results for each of these elements are described below.

4.2.1 Competitive Effects:

The strategy for identifying the competitive effects of specialty milks is to compare prices in markets and times in which they are sold with those where and when they are not offered for sale. The data set includes one city where no rBST-free milk was sold, 6 cities that experienced an introduction of organic milk, and 7 cities that experienced an rBST-free milk introduction. This provides a way to value consumer surplus from rBST-free and organic milk by observing the effects of their introduction on prices of unlabeled milk, which is the competition effect (CE). If the introduction of these specialty milks reduces the price of unlabeled milk, then consumers benefit from the competition even if they do not purchase the specialty milk. This competition effect would be over and above the benefit, utility, gained by those who consume specialty milk described by the variety effect.
Following Hausman and Leonard let the pricing equation for unlabeled (non-specialty) milk be described in the following manner:

\[ p_{it} = W_i + I_{it} \delta_1 + B_{it} \delta_2 + \epsilon_{it}, \]

where \( \epsilon_{it} = \nu_i + \mu_{it} \).

The dependent variable is the price of milk in city \( i \) during week \( t \). The time specific effects in the market are captured by the 0-1 indicator variable \( W_i \). In order to account for fixed effects in each market, the error structure is assumed to include a city specific effect \( \nu_i \) and a mean zero error term \( \mu_{it} \). The indicators \( I_{it} \) capture the effects of an introduction of specialty milks, equaling 1 if it is present in the market and zero otherwise. Thus, the coefficient \( d_1 \) represents the competitive effect (CE), the change in price with the introduction of labeled milk having controlled for city and time specific effects. The variable \( B_{it} \) represents the number of brands in a city during a particular week in order to control for the general effects of brand introduction in the estimation.

The equation is estimated using weekly prices per gallon averaged across brands of unlabeled milk in each of 12 cities as the dependent variable. Results for the key parameters of interest are presented in Table 6. The estimated competition effect is strong with milk prices shown to be decreasing in the total number of brands, as well as the introduction of organic and rBST-free brands. More importantly, the introduction of organic milk or rBST-free milk has an effect of decreasing the price 6 or 7 times lower than the entry of another unlabeled milk brand. This price reduction due to the competitive effect of organic and rBST-free milk combined reduce the price almost 2 cents per gallon. While 2 cents represents less than 1% of the average price paid, when these numbers are aggregated to a national figure they imply a net competitive effect of specialty milk of about $2.5 million per week or $130 million per year. This represents the benefit consumers of unlabeled milk receive from the existence of labeled/specialty milk in the market, even though they do not purchase it.

4.2.2 Variety effect:

As mentioned above we use our demand system parameter estimates to measure variety effects for the introduction of rBST-free and organic milk. Table 7 presents estimates of the virtual prices, which are the prices at which quantity purchased would be driven to
zero, and the variety effects consumers receive from having rBST-free and organic labeled milk in the market. We estimate the virtual price of a milk type by solving our estimated Q-AIDS setting the budget share of the milk type to zero.

The virtual prices show some important differences between how rBST-free milk and organic milk are priced in the market. RBST-free milk has a much lower virtual price and is priced on average and in most markets within $1.50 of its virtual price. This implies that rBST-free brands have relatively little pricing power and that raising rBST-free milk to the price of organic would result in near zero sales. On the other hand the lower estimated price elasticities for organic milk imply much higher virtual prices and significant scope for price increases in the absence of competition. These differences also suggest that most of the consumer benefits from labeled milk come from organic milk rather than from rBST-free milk.

From the virtual prices and the estimated demand surface curvatures one can calculate the average variety effect, which, averaged across the four cities, is 17 cents per capita per gallon per week. This implies a representative consumer across these four cities receives 17 cents worth of benefit per week just for the option of having rBST-free and organic milk in his/her choice set. There are, however, significant variations at the city level. The highest per capita variety effect is in a western city, WT_4, (27 cents per week), and the lowest is in a southern city, SO_1, (12 cents per week). The ranking of these benefits between these cities does not match with the ranking of median household income of the cities, suggesting the common perception that organic and rBST-free milk consumption is positively associated with income may not be correct.

Based on an estimated per capita yearly benefit of $8.84 per person the total variety effect benefit to all 26 million consumers in the four cities combined is $234 million per year. When aggregated to the national level, the variety effect equals $2.5 billion per year in consumer benefits from having rBST-free and organic milk in the market. If the average benefit to any U.S. consumer is equal to the estimated lowest benefit for any given city (i.e., SO_1) then benefit should be equal to $1.7 billion. The variety effect dwarfs the estimated competitive effect and is more than five times the estimated expenditure of U.S. consumers on organic milk.
5. Conclusions and Policy Implications:

This work has investigated consumer willingness to pay for rBST-free and organic milk using retail price differentials and a quadratic version of the almost ideal demand system in a revealed preference analysis. In contrast to most of the literature, these estimates take into account changes in consumer behavior over time and the price effects of competition between processors. This work finds consumers pay significantly more for rBST-free and organic milk but also derive significantly large benefits from having them both in the market. The results show that nationally consumers benefit both from the competition induced by labeled milk and by the benefits of an increased choice set. In addition this work has identified much greater consumer benefits to organic milk than rBST-free milk, which is like organic but may come from cows treated with antibiotics and that eat feed from field potentially treated with herbicides and pesticides.

These results shed some light on USDA labeling policy options for organic and GMO-free goods. It seems clear that consumers derive significant benefits from being able to buy organic milk and rBST-free milk and to the extent a national organic standard is necessary the benefits are quite large. One should note that a less stringent standard would have very little benefit to consumers. This presents a cautionary tale to policy makers considering creating organic standards with low thresholds: these efforts to create weak labels may not be worth the consumer benefits.

A number of productive avenues for future research remain for investigation. The surprising result that higher per capita expenditure is not associated with higher organic milk purchases deserves particular attention. It is possible that organic purchases are being driven by ideology or risk preferences as much as income and future research might benefit from controlling for those effects. Finally it is clear that the market for labeled milk has significant scope for non-competitive behaviors which is a direction we plan to investigate in the future.
References:


Table 1: Average Milk Price and Market Share by City

<table>
<thead>
<tr>
<th>City Code</th>
<th>Price</th>
<th>Organic</th>
<th>rBST</th>
<th>Free</th>
<th>Unlabeled</th>
<th>Price</th>
<th>Market Share</th>
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<tbody>
<tr>
<td>MW_1</td>
<td>6.44</td>
<td>5.32</td>
<td>2.82</td>
<td>0.3735</td>
<td>0.4137</td>
<td>99.2127</td>
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<tr>
<td>MW_2</td>
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<td>0.2345</td>
<td>0.0005</td>
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<tr>
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<td>99.9143</td>
<td></td>
</tr>
<tr>
<td>WT_4</td>
<td>5.28</td>
<td>3.69</td>
<td>3.01</td>
<td>1.0956</td>
<td>2.6918</td>
<td>96.2125</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>5.91</td>
<td>4.85</td>
<td>2.80</td>
<td>0.4116</td>
<td>0.4846</td>
<td>99.1442</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Average Milk Price and Market Share by Year

<table>
<thead>
<tr>
<th>Year</th>
<th>Price</th>
<th>Organic</th>
<th>rBST</th>
<th>Free</th>
<th>Unlabeled</th>
<th>Price</th>
<th>Market Share</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>5.26</td>
<td>3.97</td>
<td>2.57</td>
<td>0.1199</td>
<td>0.3042</td>
<td>99.6012</td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td>5.50</td>
<td>4.38</td>
<td>2.69</td>
<td>0.2310</td>
<td>0.6051</td>
<td>99.2143</td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td>5.72</td>
<td>4.76</td>
<td>2.84</td>
<td>0.3620</td>
<td>0.5649</td>
<td>99.1201</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>6.06</td>
<td>4.97</td>
<td>2.85</td>
<td>0.5420</td>
<td>0.5019</td>
<td>98.9980</td>
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<tr>
<td>2001</td>
<td>6.55</td>
<td>5.53</td>
<td>2.97</td>
<td>0.6901</td>
<td>0.4208</td>
<td>98.9241</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>6.82</td>
<td>5.81</td>
<td>2.95</td>
<td>0.8009</td>
<td>0.4482</td>
<td>98.7882</td>
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Table 3: Regression Results

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Estimates</th>
<th>t-stat</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Q-AIDS Parameters</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quarterly Binary 1 in rBST Milk</td>
<td>0.17</td>
<td>4.39</td>
</tr>
<tr>
<td>Quarterly Binary 2 in rBST Milk</td>
<td>0.17</td>
<td>4.41</td>
</tr>
<tr>
<td>Quarterly Binary 3 in rBST Milk</td>
<td>0.18</td>
<td>4.43</td>
</tr>
<tr>
<td>Quarterly Binary 4 in rBST Milk</td>
<td>0.17</td>
<td>4.40</td>
</tr>
<tr>
<td>Quarterly Binary 1 in Organic Milk</td>
<td>0.00</td>
<td>-0.46</td>
</tr>
<tr>
<td>Quarterly Binary 2 in Organic Milk</td>
<td>-0.02</td>
<td>-1.62</td>
</tr>
<tr>
<td>Quarterly Binary 3 in Organic Milk</td>
<td>-0.26</td>
<td>-18.29</td>
</tr>
<tr>
<td>Quarterly Binary 4 in Organic Milk</td>
<td>-0.26</td>
<td>-18.35</td>
</tr>
<tr>
<td>Wage in rBST Milk</td>
<td>-0.26</td>
<td>-18.33</td>
</tr>
<tr>
<td>CPI in rBST Milk</td>
<td>-0.26</td>
<td>-18.28</td>
</tr>
<tr>
<td>Wage in Organic Milk</td>
<td>-0.02</td>
<td>-12.49</td>
</tr>
<tr>
<td>CPI in Organic Milk</td>
<td>0.07</td>
<td>19.88</td>
</tr>
<tr>
<td>$\beta$ in rBST Milk</td>
<td>0.07</td>
<td>4.02</td>
</tr>
<tr>
<td>$\beta$ in Organic Milk</td>
<td>-0.02</td>
<td>-3.90</td>
</tr>
<tr>
<td>$t$ in rBST Milk</td>
<td>0.02</td>
<td>1.95</td>
</tr>
<tr>
<td>$t$ in Organic Milk</td>
<td>-0.01</td>
<td>-3.35</td>
</tr>
<tr>
<td>$G_{11}$</td>
<td>-0.03</td>
<td>-9.50</td>
</tr>
<tr>
<td>$G_{12}$</td>
<td>-0.02</td>
<td>-13.33</td>
</tr>
<tr>
<td>$G_{22}$</td>
<td>0.00</td>
<td>-1.66</td>
</tr>
<tr>
<td><strong>Price Equations</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept: rBST Milk</td>
<td>-0.25</td>
<td>-3.90</td>
</tr>
<tr>
<td>Intercept: Organic Milk</td>
<td>-0.21</td>
<td>-3.40</td>
</tr>
<tr>
<td>Intercept: Unlabeled Milk</td>
<td>-0.48</td>
<td>-4.94</td>
</tr>
<tr>
<td>Coop Milk Price: rBST-free milk</td>
<td>0.04</td>
<td>0.67</td>
</tr>
<tr>
<td>Coop Milk Price: Organic milk</td>
<td>0.12</td>
<td>1.79</td>
</tr>
<tr>
<td>Coop Milk Price: Unlabeled milk</td>
<td>-0.06</td>
<td>-0.98</td>
</tr>
<tr>
<td>Wage Rate: rBST-free Milk</td>
<td>0.12</td>
<td>6.84</td>
</tr>
<tr>
<td>Wage Rate: Organic Milk</td>
<td>0.03</td>
<td>3.43</td>
</tr>
<tr>
<td>Wage Rate: Unlabeled Milk</td>
<td>0.14</td>
<td>7.44</td>
</tr>
<tr>
<td>1 period lagged Price: rBST-free Milk</td>
<td>0.74</td>
<td>39.75</td>
</tr>
<tr>
<td>1 period lagged Price: Organic Milk</td>
<td>0.88</td>
<td>72.38</td>
</tr>
<tr>
<td>1 period lagged Price: Unlabeled Milk</td>
<td>0.83</td>
<td>44.38</td>
</tr>
<tr>
<td>Percentage Price Reduction: rBST-free milk</td>
<td>-0.01</td>
<td>-6.65</td>
</tr>
<tr>
<td>Percentage Price Reduction: Organic milk</td>
<td>-0.01</td>
<td>-8.97</td>
</tr>
<tr>
<td>Percentage Price Reduction: Unlabeled milk</td>
<td>-0.01</td>
<td>-9.92</td>
</tr>
<tr>
<td>Unit per volume: rBST-free milk</td>
<td>0.05</td>
<td>9.71</td>
</tr>
<tr>
<td>Unit per volume: Organic milk</td>
<td>0.12</td>
<td>4.43</td>
</tr>
<tr>
<td>Unit per volume: Unlabeled milk</td>
<td>0.08</td>
<td>3.32</td>
</tr>
<tr>
<td>Coop Milk Price$^2$: rBST-free milk</td>
<td>0.06</td>
<td>0.77</td>
</tr>
<tr>
<td>Coop Milk Price$^2$: Organic milk</td>
<td>-0.07</td>
<td>-1.44</td>
</tr>
<tr>
<td>Coop Milk Price$^2$: Unlabeled milk</td>
<td>0.08</td>
<td>0.92</td>
</tr>
<tr>
<td><strong>Expenditure Function</strong></td>
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<td></td>
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<tr>
<td>Intercept</td>
<td>-0.28</td>
<td>-1.08</td>
</tr>
<tr>
<td>Time trend</td>
<td>0.01</td>
<td>10.18</td>
</tr>
<tr>
<td>1 period lagged expenditure</td>
<td>0.75</td>
<td>37.23</td>
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<tr>
<td>Wage rate</td>
<td>0.28</td>
<td>9.46</td>
</tr>
<tr>
<td>CPI</td>
<td>-0.18</td>
<td>-3.12</td>
</tr>
</tbody>
</table>
Table 4: Expenditure Elasticities

<table>
<thead>
<tr>
<th>Products</th>
<th>Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>rBST Free</td>
<td>4.39</td>
</tr>
<tr>
<td></td>
<td>14.19</td>
</tr>
<tr>
<td>Organic</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>5.01</td>
</tr>
<tr>
<td>Unlabeled</td>
<td>0.97</td>
</tr>
<tr>
<td></td>
<td>266.65</td>
</tr>
</tbody>
</table>

Table 5a: Price Elasticities (Un-Compensated)

<table>
<thead>
<tr>
<th>Products</th>
<th>rBST Free</th>
<th>Organic</th>
<th>Unlabeled</th>
</tr>
</thead>
<tbody>
<tr>
<td>rBST Free</td>
<td>-4.40</td>
<td>-1.66</td>
<td>1.51</td>
</tr>
<tr>
<td></td>
<td>-12.81</td>
<td>-12.88</td>
<td>2.76</td>
</tr>
<tr>
<td>Organic</td>
<td>-2.51</td>
<td>-1.37</td>
<td>3.15</td>
</tr>
<tr>
<td></td>
<td>-9.97</td>
<td>-6.36</td>
<td>12.36</td>
</tr>
<tr>
<td>Unlabeled</td>
<td>0.05</td>
<td>0.02</td>
<td>-1.04</td>
</tr>
<tr>
<td></td>
<td>12.66</td>
<td>12.61</td>
<td>-152.93</td>
</tr>
</tbody>
</table>

Table 5b: Price Elasticities (Compensated)

<table>
<thead>
<tr>
<th>Products</th>
<th>rBST Free</th>
<th>Organic</th>
<th>Unlabeled</th>
</tr>
</thead>
<tbody>
<tr>
<td>rBST Free</td>
<td>-4.40</td>
<td>-1.66</td>
<td>1.55</td>
</tr>
<tr>
<td></td>
<td>-12.80</td>
<td>-12.88</td>
<td>2.84</td>
</tr>
<tr>
<td>Organic</td>
<td>-2.51</td>
<td>-1.37</td>
<td>3.15</td>
</tr>
<tr>
<td></td>
<td>-9.97</td>
<td>-6.36</td>
<td>12.37</td>
</tr>
<tr>
<td>Unlabeled</td>
<td>0.05</td>
<td>0.02</td>
<td>-1.08</td>
</tr>
<tr>
<td></td>
<td>12.54</td>
<td>12.44</td>
<td>-226.29</td>
</tr>
</tbody>
</table>

Table 6: Reduced Form Price Model - Fixed Effects

<table>
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<tr>
<th>Dependent variable: Price of unlabeled milk</th>
<th>Estimates</th>
<th>t-stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic brand introduction</td>
<td>-0.01</td>
<td>-4.65</td>
</tr>
<tr>
<td>rBST-free brand introduction</td>
<td>-0.01</td>
<td>-5.62</td>
</tr>
<tr>
<td>Total number of brands in market</td>
<td>-0.0012</td>
<td>-8.49</td>
</tr>
<tr>
<td>Constant</td>
<td>0.36</td>
<td>48.03</td>
</tr>
</tbody>
</table>

N=3120, number of groups=12
R-square: within = 0.457; between = 0.097; overall = 0.104
Note: Equation includes 259 weekly dummy variables
Table 7: Virtual Price and Variety Effects

<table>
<thead>
<tr>
<th>City</th>
<th>Indirect Utility</th>
<th>rBST Free</th>
<th>Organic</th>
<th>Variety Effect</th>
<th>City Population</th>
<th>Total Benefit from Variety Effect</th>
</tr>
</thead>
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<tr>
<td></td>
<td>VP</td>
<td>MP</td>
<td>VP</td>
<td>MP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO_1</td>
<td>0.417</td>
<td>5.78</td>
<td>4.92</td>
<td>35.09</td>
<td>5.93</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>0.000</td>
<td>0.001</td>
<td>0.003</td>
<td>0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NE_1</td>
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<td>4.45</td>
<td>4.28</td>
<td>89.34</td>
<td>5.57</td>
<td>0.16</td>
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<tr>
<td></td>
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<td>0.001</td>
<td>0.005</td>
<td>0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WT_1</td>
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<td>55.70</td>
<td>6.02</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td>0.000</td>
<td>0.001</td>
<td>0.004</td>
<td>0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WT_4</td>
<td>0.505</td>
<td>7.56</td>
<td>3.69</td>
<td>382.62</td>
<td>5.28</td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td>0.000</td>
<td>0.003</td>
<td>0.007</td>
<td>0.003</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Four Cities</td>
<td>0.417</td>
<td>5.82</td>
<td>4.36</td>
<td>93.97</td>
<td>5.70</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>0.000</td>
<td>0.001</td>
<td>0.005</td>
<td>0.001</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Total Benefit is estimated on a per week basis

*Italicized numbers are the standard errors

*VP: Virtual Price; MP: Existing Mean Price in the market
Figure 1: Weekly Market Share for the four cities

Lowess smoother, bandwidth = .8

Figure 2: Non-parametric Engel curve: organic milk in WT_4
Figure 3: Non-parametric Engel curve: rBST-free milk in WT_4

Figure 4: Non-parametric Engel curve: Unlabeled milk in WT_4
Strategic Patent Breadth and Entry Deterrence with Drastic Product Innovations

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First Biennial Conference of the Food System Research Group, Madison-Wisconsin,
June 2003

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1. **Introduction**

Innovating firms choose to patent their innovations when patenting allows the appropriation of more rents than do other forms of intellectual property protection (e.g., trade secrecy). The degree of appropriability of innovation rents enabled by a patent is mainly defined by two elements – patent length and patent breadth (Merges and Nelson 1990, Klemperer 1990). While the innovator cannot affect patent length since it is standardized and predetermined by law (i.e., 20 years for most patents) he plays a crucial role in the determination of the breadth of protection granted to the patent. The innovator’s claims in the patent application specify the breadth of protection sought for the innovation and constitute the basis on which the Patent Office decides on the breadth of protection granted to the patent, if any, and the courts rule on patent validity and infringement issues (Merges and Nelson 1990, Miller and Davis 1990, Cornish 1989).

The purpose of this paper is to theoretically examine the innovator’s optimal patent breadth strategy; the patent breadth choice that maximizes the innovator’s ability to appropriate innovation rents. The analysis of the innovator’s patenting behavior in the existing economic literature has primarily focused on the innovator’s decision to patent the innovation or to keep it a secret (Horstmann et al. 1985, Waterson 1990). Lerner (1995) empirically examined some other aspects of the innovator’s patenting behavior, namely, the decision to patent in certain patent subclasses given competitors’ patent subclass choices and legal costs. There is no formal framework of analysis of the innovators’ patent breadth choice once the decision to patent has been made, however. Instead, it has been traditionally assumed that the innovator has an incentive to claim ‘as much as possible’ (Lenz 1988).

Our paper explicitly models the innovator’s patent breadth decision and examines the optimal patent breadth strategy that the innovator should employ when faced with entry by products
of superior quality and the possibility that the breadth of the patent will be legally challenged. Patent breadth is defined in terms of the area in a vertically differentiated product space that the patent protects. The theoretical model developed considers the efficiency of patent breadth as an entry deterrent. As a consequence, the model also explicitly examines the assumption that the innovator has an incentive to claim the broadest scope of patent protection possible.

Analytical results show that in most cases the optimal patent breadth strategy for the innovator is to claim a patent breadth which is less than the maximum possible. The analysis also shows that that it is possible under some conditions for an innovator to use patent breadth to deter entry – when this is possible, the optimal patent strategy is to always deter entry. These conditions occur under certain combinations of the entrant’s R&D effectiveness and trial cost values (i.e., low R&D effectiveness – which results in high R&D costs – and high trial costs). When these specific conditions do not hold, the optimal strategy for the innovator is to allow a new competitor to enter the market. When allowing entry, the innovator chooses patent breadth so that the benefits of increased product differentiation that result from greater patent breadth are traded off with the increased likelihood of patent challenge and invalidation that comes with greater patent breadth.

One of the conclusions of the paper is that the innovator will choose the maximum patent breadth when patent infringement is never an optimal strategy for the entrant. The innovator may also choose maximum patent breadth when entry deterrence is not possible and it is optimal for the innovator to induce patent infringement. This occurs under a very specific set of conditions (i.e., a combination of very low R&D effectiveness values and low monopoly profits).

The rest of the paper is organized as follows. Section two gives a background discussion of the relationship between patent breadth and innovation rents and outlines inefficiencies related to the patent granting process. Section three describes the theoretical development of the strategic patent breadth model; it describes the market conditions, defines patent breadth and models the
choice of patent breadth as a sequential game of complete information. Section four provides the analytical solution of the model. Finally, section five concludes the paper.

2. Background

The innovator’s patent breadth choice is a strategic decision. Patent breadth defines the technological territory claimed and protected by the patent. It plays an important role in the determination of the degree of competition in the market and the effective patent life, which in turn determine the true reward to the innovator. On the one hand, the greater is the breadth of patent protection, the harder it is for potential competitors to enter into the patentee’s market with non-infringing innovations and thus, the longer the patentee can maintain the limited monopoly that the patent grants (Gallini 1992). At the same time, however, a patent that is too broad increases the likelihood of both infringement and patent validity challenges by competitors and/or third parties (Merges and Nelson 1990). Consequently, broad patent protection may reduce the effective patent life, and thus the innovation rents that can be captured with the patent, as patents may be revoked during infringement trials and patent validity challenges (Barton 2000). This concern is especially critical in light of the increase in patent litigation during the last decades, particularly in the field of biotechnology, and the increase in the number of patents that are invalidated after being challenged (Barton 2000, Lanjouw and Schankerman 2001, Harhoff and Reitzig 2000). Thus, a broad patent protection may impede the innovator’s ability to safeguard and/or defend the technological territory protected by his patent.

The assumption that the innovator has an incentive to follow a ‘claim as much as possible’ strategy is mainly based on the premise of an efficiently operating Patent Office that will prune back or reject broad and/or erroneous claims during the patent granting process. If the Patent Office could grant an ‘optimal’ patent then the innovator would be better off claiming broad patent
protection as the patent breadth granted cannot be greater than the patent breadth claimed. Evidence shows, however, that the United States Patent and Trademark Office (USPTO) often grants broad patents that cannot survive a validity attack and patents that appear to overlap leading to disputes that have to be resolved through costly litigation or settlement (Voss 1999, Barton 2000, Lenz 1988, Lerner 1994). Barton (2000) claims that, due to the increase in patent applications over the last decade and resources limitations in the USPTO, patent examiners spend on average only twenty five to thirty hours examining a patent application, time that is not enough to conduct effective searches and evaluate patent claims.

The inefficiencies present in the patent granting process suggest that the innovator cannot always rely on the Patent Office for help in refining his patent claims. This is especially true for pioneering/drastic innovations. According to the Patent Office’s policy, drastic innovations are usually granted broader protection (EPO 2000, USPTO 1999). Merges and Nelson (1990) observe that claims to drastic innovations are often allowed to cover areas beyond the area examined and disclosed by the innovator while the narrowing of the claims of drastic innovations is usually left to the courts.

Existing patent breadth studies have mainly focused on the determination of a socially optimal patent policy and have thus assumed an efficient patent granting process (Gilbert and Shapiro 1990, Klemperer 1990, Gallini 1992, Green and Scotchmer 1995, Chang 1995, Matutes et al 1996, O’ Donughue 1998). In these studies, a regulator (e.g., Patent Office) determines a socially optimal patent breadth; a patent breadth that rewards the innovator/patentee ‘sufficiently’ at the least social costs.

---

1 According to the European Patent Office (EPO) (2000) ‘an invention that opens up a whole new field is entitled to more generality in the claims than an invention that is concerned with advances in a known field of technology’.

2 This is due to the fact that the more drastic is the innovation, the harder it is for an examiner to find support in the prior art to object to broad claims demonstrating that embodiments of the claimed invention would be impossible to make without undue experimentation. Thus, when drastic innovations are concerned, the burden falls on the examiner who must disprove enablement (Merges and Nelson 1990).
This paper follows a different approach. We seek to determine a privately rather than a socially optimal breadth of patent protection. In our analysis the innovator determines the breadth of patent protection claimed that maximizes his ability to appropriate innovation rents given the inefficiencies present in the patent granting process. Our analysis focuses on drastic product innovations; innovations that generate new demand or meet demand not previously met. The focus is on drastic innovations because, the Patent Office’s role in refining the innovator’s patent claims is limited and the innovation rents that are at stake are substantial increasing the probability of a patent challenge (Cornish 1989, Lanjouw and Schankerman 2001). Consequently, the innovator, in our model, does not rely on the Patent Office to structure his claims. He is aware of both the inefficiencies in the determination of patent breadth in the Patent Office and that his effort to safeguard his technological territory does not usually conclude with the granting of the patent.

The section that follows describes the theoretical development of the strategic patent breadth model.

3. **The Strategic Patent Breadth Model**

3.1 **Model Assumptions**

The model is based on a number of assumptions. The optimal patent breadth strategy is determined in a sequential game of complete information. The agents in the game are an incumbent/patentee who, having invented a patentable drastic product innovation and having decided to seek patent protection, decides on the patent breadth claimed and a potential entrant who decides on whether to enter the patentee’s market and, if entry occurs, where to locate in a vertically differentiated product space. Both the incumbent and the entrant are risk neutral and maximize profits. It is assumed that the regulator (e.g., Patent Office) always grants the patent as claimed; thus, the regulator is not explicitly modeled. The assumption that the Patent Office plays no role in refining the patent claims
is a realistic assumption for drastic innovations.

The patentee’s investment decision that led to the development of a new product is not examined – this decision is treated as exogenous to the game. In addition, it is assumed that the patentee and the entrant each produce at most one product and that the entrant does not patent her product since further entry is not anticipated (see footnote 4 below). The production process for the entrant is assumed to be deterministic, so that once the entrant chooses a location she can produce the chosen product with certainty. It is also assumed there is no time lag between making and realizing a decision.

The patentee and the entrant, if she enters, operate in a vertically differentiated product market that can support at most two products. Consumers differ according to some attribute $\lambda$, uniformly distributed with unit density $f(\lambda) = 1$ in the interval $\lambda \in [0,1]$, each buying one unit of either the patentee’s or the entrant’s product but not both. The patentee is assumed to have developed a product that provides consumers with utility $U_p = V + \lambda q_p - p_p$, where $V$ is a base level of utility, $q_p$ is the quality of the patentee’s product $p_p$ is the price of the product produced by the patentee. The entrant’s product has quality $q_e > q_p$, $q_e \in (0,1]$, that provides consumers with utility $U_e = V + \lambda q_e - p_e$, where $p_e$ is the price of the entrant’s product. Without affecting the qualitative nature of the model, the quality of the patentee’s product $q_p$ is set equal to zero (i.e., $q_p = 0$). As a result, the entrant’s quality $q_e$ is interpreted as the difference in quality between her product and that of the patentee, or more generally as the distance the entrant has located away from the patentee.\(^3\)

\(^3\) With $q_p \neq 0$, equation (1) becomes $\lambda' = \frac{(p_e - p_p)}{q_e - q_p}$. Since the quality difference, $q_e - q_p$, in the denominator is the relevant parameter of interest in the subsequent analysis, the assumption that $q_p = 0$ can be made to ease the notation.
Product \( i = (p,e) \) is consumed as long as \( U_i \geq 0 \) and \( U_i > U_j \). It is assumed that \( V \) is large enough so that \( V \geq p_i \forall i = p,e \) and the market is always served by at least one product. The consumer who is indifferent between the two products has a \( \lambda \) denoted by \( \lambda^* \), where \( \lambda^* \) is determined as follows:

\[
V \geq p_i \forall i = p,e
\]

\[
U_p = U_e \Rightarrow \lambda^* = \frac{p_p - p_e}{q_e}
\]

Since each consumer consumes one unit of the product of her choice, the demand for the products produced by the patentee and the entrant are given by \( y_p = \lambda^* \) and \( y_e = 1 - \lambda^* \), respectively.

The patentee has already incurred the development costs associated with the product quality that he has patented. Thus, the R&D costs for the patentee are sunk. For the entrant, however, market entry can only occur if she develops a higher quality product. To do so, she incurs R&D costs \( F_e(q_e) \), where \( F_e = \beta \frac{q_e^2}{2} \) and \( \beta \geq 4 \frac{9}{9} \). The restriction on the parameter \( \beta \) ensures that the quality chosen by the entrant, \( q_e \), is bounded between zero and one. Note that with this formulation, \( F_e'(q_e) > 0 \) and \( F_e''(q_e) > 0 \), thus, it is increasingly costly for the entrant to locate away from the patentee in the one-dimensional product space (i.e., to produce the better quality product). In addition, since \( q_e \) represents the quality difference between the patentee’s and the entrant’s product the filing of a patent by the patentee provides the entrant with knowledge of how to produce the patentee’s product (i.e., \( F_e(q_p) = 0 \) – the assumption of perfect information disclosure by the patent is made). The R&D costs are assumed sunk once they have been incurred and neither the patentee nor the entrant find it optimal to relocate once they have chosen their respective qualities. Once the R&D costs are incurred, production of the products by both the patentee and the entrant occur at

\[
\text{without affecting the qualitative nature of the model.}
\]
zero marginal cost.\textsuperscript{4}

The patent breadth claimed and granted to the patentee’s product is denoted by $b$ and it defines the area in the one-dimensional product space that the patent protects, thus, $b \in (0,1]$. Patent breadth values close to zero indicate protection of the patented innovation only against duplication. It is assumed that when the entrant locates at a distance $q_e < b$ away from $q_p$, a trial always takes place, either because the patentee files an infringement lawsuit or because the entrant directly challenges the validity of the patent. It is further assumed that the filing of an infringement lawsuit is always met with a counterclaim by the accused infringer that the patent is invalid.\textsuperscript{5} The costs incurred during the infringement trial/validity attack by the patentee and the entrant are denoted by $C_p$ and $C_E$, respectively. These costs are assumed to be independent of the breadth of protection and of the entrant’s location. The trial costs will only be incurred if $q_e < b$ and they are assumed to be sunk – once made they cannot be recovered by either party.\textsuperscript{6}

The patent system being modeled is assumed to be that of the fencepost type, in which patent claims define an exact border of protection. Under the fencepost system, infringement will always be found when an entrant locates within the patentee’s claims, unless the entrant proves that the patent is invalid (Cornish 1989).\textsuperscript{7} In the fencepost system the probability that infringement is found does not depend on how close the entrant has located to the patentee. The implication of

\textsuperscript{4} Note that the market conditions outlined above imply that the Finiteness Property introduced by Shaked and Sutton (1982) holds; products are vertically differentiated, the burden of quality improvements falls on fixed rather than on variable costs and the unit variable costs increase in quality slower than the willingness to pay for quality – $\forall \lambda > 0$. Thus, this market will be concentrated irrespective of its size and the level of fixed costs. Moreover, given the assumption that consumer preferences are such that the market can support at most two products this market is a natural duopoly.

\textsuperscript{5} This is a standard defence adopted by accused infringers (Cornish 1989, Merges and Nelson 1990).

\textsuperscript{6} With this assumption we exclude the possibility of the court awarding lawyers’ fees to either party.

\textsuperscript{7} In contrast, a signpost patent system implies that claims provide an indication of protection and the claims are interpreted using the doctrines of equivalents and reverse equivalents. Under a signpost system the closer the entrant locates to the patentee the easier it is to prove infringement using the doctrine of equivalents. In addition, infringement may be found even when the entrant locates outside the patentee’s claims using the doctrine of reverse equivalents.
assuming a fencepost patent system is that the probability that infringement will be found (given that the entrant has located at \( q_e < b \) distance away from \( q_p \)) is equal to the probability that the validity of the patent will be upheld. Thus, the fencepost patent system implies that the events that the patent is found to be infringed and that the patent is found to be invalid can be treated as mutually exclusive and exhaustive.\(^8\)

Patent validity is directly linked to patent breadth. In general, the broader is the patent protection, the harder it is to show novelty, nonobviousness and enablement (Miller and Davis 1990). Thus, the broader is patent protection the harder it is to establish validity. In addition, evidence from the literature shows that courts tend to uphold narrow patents and invalidate broad ones (Waterson 1990, Cornish 1989, Merges and Nelson 1990). To capture this element, the probability that the patent will be found to be valid or equivalently that infringement will be found, denoted by \( \mu(b) \), is assumed to be inversely related to patent breadth, \( \mu'(b) < 0 \).

### 3.2 The Game

The strategic patent breadth game consists of three stages. In the first stage of the game, the patentee applies for a patent, claiming a patent breadth, \( b \). In the second stage of the game, a potential entrant observes the patentee’s product and the breadth of protection granted to it and chooses whether or not to enter the market. If the entrant does not enter she earns zero profits while the patentee operates as a monopolist in the third stage of the game and earns monopoly profits \( \Pi_p^M \). If the entrant enters, she does so by choosing the quality \( q_e \) of her product relative to that of the patentee. This decision determines whether the entrant infringes the patent or not.

If the entrant chooses a quality greater than or equal to the patent breadth claimed by the

---

\(^8\) Note that, our analysis and results are not affected by whether only certain claims are invalidated during the infringement/validity trial or the entire patent; that is, when patent breadth is narrowed rather than the entire patent revoked. This occurs because further entry is not anticipated in our model (see footnote 4).
patentee (i.e., \( q_e \geq b \)), then no infringement occurs, and she and the patentee compete in prices in the third stage of the game and earn duopoly profits \( \Pi_{ne}^{NI} \) and \( \Pi_{np}^{NI} \), respectively. If the entrant locates inside the patent breadth claimed by the patentee (i.e., \( q_e < b \)), the patent is infringed and a trial occurs in which the validity of the patent is examined. With probability \( \mu(b) \), the patent is found to be valid (i.e., infringement is found), the entrant is not allowed to market her product and the patentee operates as a monopolist in the third stage of the game. With probability \( 1 - \mu(b) \), the patent is found to be invalid, and the entrant and the patentee compete in prices. The payoffs for the patentee and the entrant when the entrant chooses \( q_e < b \) are \( E(\Pi_e^I) \) and \( E(\Pi_p^I) \), respectively. Figure 1 illustrates the extensive form of the game outlined above.
The solution to this game is found by backward induction. The third stage of the game in which the patentee and the entrant – when applicable – compete in prices is examined first, followed by the
second stage in which the entrant makes her entry decision, and then the first stage in which the patentee makes his decision regarding patent breadth.

4. **Analytical Solution of the Game**

4.1 **Stage 3 – The Pricing Decisions**

In the third stage of the game, two cases must be considered – the case where the entrant has entered and the case where the entrant has not entered. Considering the last case first, in the absence of entry by the entrant, the patentee will charge \( p_p = V \) and earn monopoly profits \( \Pi_p^H = V - F_p \).

If entry occurs, the problem facing duopolist \( i \) is to choose price \( p_i \) to maximize profit

\[
\pi_i = p_i y_i - F_i \quad (i = p, e),
\]

where \( y_p = \frac{p_e - p_p}{q_e} \) and \( y_e = \frac{q_e + p_p - p_e}{q_e} \). Recall that the R&D costs, \( F_p \) and \( F_e \) for the patentee and the entrant, respectively, are assumed to be sunk at this stage in the game. The Nash equilibrium in prices, as well as the resulting outputs and profits, are given by:

(2) **Patentee:**

\[
p_p^* = \frac{q_e}{3}, \quad y_p^* = \frac{1}{3}, \quad \pi_p^* = \frac{q_e}{9}
\]

(3) **Entrant:**

\[
p_e^* = \frac{2q_e}{3}, \quad y_e^* = \frac{2}{3}, \quad \pi_e^* = \frac{4q_e}{9}
\]

Since the entrant has the higher quality product, she charges the higher price. Profits are increasing in the distance \( q_e \) between the patentee’s and the entrant’s location. The greater is the difference in quality between the two products, the less intense is competition at the final stage of the game and the greater are the profits for both the incumbent and the entrant.\(^9\)

\(^9\) This is a well-established result in the product differentiation literature in simultaneous games. When competitors first simultaneously choose their locations in the product space and then compete in prices they choose maximum differentiation to relax competition in the pricing stage that would curtail their profits (Lane 1980, Motta 1993, Shaked and Sutton 1982).
4.1 Stage 2 – The Location Decision

As outlined above, the entrant must choose one of three options – Not Enter, Enter and Not Infringe the Patent, or Enter and Infringe the Patent. For any given patent breadth, \( b \), the entrant will choose the option that generates the greatest profit.

The outcome of the Not Enter option is straightforward – the entrant earns zero profits. The outcomes of the other two options depend on a number of factors, including patent breadth, R&D costs and trial costs. The benefits and costs associated with the Enter and Not Infringe option are examined below, followed by an examination of the benefits and costs associated with the Enter and Infringe option. Once the net benefits of each option are formulated, the most desirable option for the entrant is determined for any given patent breadth.

- Entry with No Infringement (\( q_e \geq b \))

For the entrant to enter without infringing the patent, the entrant must choose a quality location that is greater than or equal to the patent breadth – i.e., \( q_e \geq b \). Let \( q_e^* \) be the optimal quality the entrant would choose when the patent breadth is not binding, where \( q_e^* \) solves the following problem:

\[
\max_{q_e} \Pi_e = \pi_e - F_e = \frac{4q_e}{9} - \beta \frac{q_e^2}{2}
\]

Optimization of equation (4) yields the optimal quality \( q_e^* \):

\[
q_e^* = \frac{4}{9\beta}
\]

Equation (5) indicates that the less costly it is to produce the better quality product (i.e., the smaller is \( \beta \)), the further away from the incumbent the entrant locates.

As long as \( q_e^* \geq b \), the patent breadth does not affect the location chosen by the entrant, since the entrant can choose her optimal quality without fear of infringement. Thus, patent breadth
will only be binding if \( q_e^* < b \). Since an increase in quality beyond \( q_e^* \) results in a reduction in profits, the entrant’s profit is decreasing in \( q_e \) for all \( q_e > q_e^* \). As a result, the entrant, when faced with a binding patent breadth, will always choose a quality equal to the patent breadth chosen by the patentee (i.e., \( q_e = b \)).

Thus, a profit-maximizing entrant that wishes to not infringe the patent will choose her entry location \( q_{e, NI} \) as follows:

\[
q_{e, NI} = \begin{cases} 
\frac{4}{9\beta} & \text{if } b < \frac{4}{9\beta} \\
 b & \text{if } b \geq \frac{4}{9\beta}
\end{cases}
\]

while the profits earned by the entrant are:

\[
\Pi_{e, NI} = \begin{cases} 
\frac{8}{81\beta} & \text{if } b < \frac{4}{9\beta} \\
 \frac{4}{9}\beta - \frac{\beta}{2}b^2 & \text{if } b \geq \frac{4}{9\beta}
\end{cases}
\]

### Entry with Infringement (\( q_e < b \))

If the entrant enters and infringes the patent filed by the patentee, a trial takes place. If the patent is found to be valid during trial, the entrant cannot enter and the patentee has a monopoly position in the market. If the patent is found to be invalid, the entrant is allowed to market her product and the patentee and the entrant operate as duopolists. The probability that the patent is found to be valid is given by \( \mu(b) \), with \( \mu(b) \) having the functional form \( \mu(b) = 1 - \alpha b \).\(^\text{10}\) Thus, \( 1 - \mu(b) = \alpha b \) is the probability that the patent will be found to be invalid. For an given patent breadth, the greater is the

\(^{10}\) Patent breadth is not the only factor affecting the validity of the patent. A patent may also be invalidated because of unallowable amendments during patent examination and because the innovation is not regarded an invention under the patent law (Cornish 1989). By assuming that the innovator has generated a patentable innovation we have excluded the latter case. To keep the analysis simple we assume that the probability of patent invalidation due to unallowable amendments is negligible.
validity parameter \( \alpha \), the greater is the probability that the patent will be found invalid. With this background, the quality chosen by the entrant is determined by solving:

\[
\text{max}_{q_e} E\left(\Pi_e^I\right) = (1 - \mu) \cdot \pi_e - F_e - C_e = \alpha b \frac{4q_e}{9} - \beta \frac{q_e^2}{2} - C_e
\]

The optimal quality chosen is given by:

\[
q_e^* = \frac{4\alpha b}{9\beta}
\]

Equation (9) shows that when the entrant infringes the patent she finds it optimal to locate at a distance proportional to the breadth of the patent. Because there is uncertainty with respect to whether the entrant will be able to continue in the market, she ‘underlocates’; to reduce the R&D costs, which are incurred with certainty, the entrant locates closer to the patentee than she would have done had infringement not been a possibility.

The expected profits for the entrant are given by equation (10):

\[
E\left(\Pi_e^I\right) = \frac{8\alpha^2 b^2}{81 \beta} - C_e.
\]

When patent breadth is negligible (i.e., \( b \) approaches zero), the expected profits from infringement approach \(-C_e\), since the probability of the patent being found valid approaches one. As patent breadth increases, expected profits from infringement also increase, a reflection of the rising probability that the patent will be found invalid.

**The Entry/Infringement Decision**

The decision made by the entrant whether to enter, and if entry occurs, whether to infringe the patent, depends on patent breadth, \( b \), and three variables that are treated as exogenous in this study – the R&D cost parameter \( \beta \), the trial costs \( C_e \) and the validity parameter \( \alpha \). As shown above, when patent breadth is such that \( b \leq q_e^* \) the entrant always finds it profitable to enter the market.
locating at her most preferred location \( (q_e^*) \) without triggering the trial outcome. For patent breadth values such that \( b > q_e^* \), however, the entrant may be deterred from entering the market or, if entry cannot be deterred, she may always finds it profitable to enter without infringing the patent or she may enter and be induced to either infringe or not infringe the patent. These cases where \( b > q_e^* \) are examined below.

**Case I – Entry Deterrence**

The entrant can be deterred from entering the market when there exists a, \( \hat{b} \), where \( \hat{b} \) ensures that the following conditions are satisfied: \( \Pi_e^N(\hat{b}) \leq 0; E(\Pi_e^I(\hat{b})) \leq 0 \) and \( \hat{b} \in (q_e^*,1] \). In fact, there might be a range of patent breadths that deter entry. Define \( \hat{b}_I \) as the patent breadth that makes the entrant indifferent between entering the market and infringing the patent on the one hand and not entering the market on the other hand. Then \( \hat{b}_I \) must ensure that the following conditions are met:

\[
E(\Pi_e^I(\hat{b}_I))) = 0 \quad \text{and} \quad \hat{b}_I \in (q_e^*,1].
\]

Also, define \( \hat{b}_{NI} \) as the patent breadth that makes the entrant indifferent between entering the market without infringing the patent on the one hand and not entering the market on the other hand. Then \( \hat{b}_{NI} \) must satisfy the following conditions:

\[
\Pi_e^N(\hat{b}_{NI}) = 0 \quad \text{and} \quad \hat{b}_{NI} \in (q_e^*,1].
\]

It is straightforward to show that \( \hat{b}_I = \sqrt{\frac{81\beta C_e}{8\alpha^2}} \) and \( \hat{b}_{NI} = \frac{8}{9\beta} \); since \( \hat{b}_{NI} \in (q_e^*,1] \), \( \hat{b}_{NI} \) exists only for \( \beta \) values such that \( \beta \geq \frac{8}{9} \). Given the above, any \( b \in (q_e^*,1] \) such that \( b \leq \hat{b}_I \) makes entry under infringement unprofitable for the entrant while any \( b \in (q_e^*,1] \) such that \( b \geq \hat{b}_{NI} \) makes entry under no infringement unprofitable for the entrant. Thus, the entrant

\[11 \quad \text{The assumption is made that when the entrant is indifferent she will not enter.}\]
will not find it profitable to enter the market if a \( \hat{b} \in (q_e^*,1] \) such that \( \hat{b}_{NI} \leq \hat{b} \leq \hat{b}_T \) exists. Case I is illustrated in Figure 2, panels (i) and (ii).

**Case II – Entry and No Infringement**

The entrant will always enter and not infringe when the entrant’s trial costs and R&D effectiveness are such that, \( \forall b \in (q_e^*,1], \Pi_e^{NI} > E(\Pi_e^I) \text{ and } \Pi_e^{NI} > 0 \). Case II is illustrated in Figure 2, panel (iii).

**Case III – Entry and Inducement of Infringement/Non Infringement**

Let \( \tilde{b} \) be the patent breadth that makes the entrant indifferent between infringing and not infringing the patent, while still generating positive profits for the entrant – i.e., \( \tilde{b} \in (q_e^*,1] \) and solves \( \Pi_e^{NI}(\tilde{b}) = E(\Pi_e^I(\tilde{b})) > 0 \). The entrant will enter and not infringe when \( b \in (0,\tilde{b}] \), while the entrant will enter and infringe when \( b \in (\tilde{b},1] \) (the assumption is made that when the entrant is indifferent she will choose to not infringe the patent). The expression for \( \tilde{b} \) is derived in the Appendix.

The patent breadth \( \tilde{b} \) is a function of the R&D effectiveness parameter, \( \beta \), the validity parameter, \( \alpha \), and the trial costs \( C_e \). The relationship between \( \tilde{b} \) and the above parameters is such that, the greater are the costs of producing the higher quality product, the greater is the validity parameter and the smaller are the trial costs, the smaller is the breadth of the patent that makes the entrant indifferent between infringing and not infringing the patent, \( \frac{\partial \tilde{b}}{\partial \beta} \leq 0 \), \( \frac{\partial \tilde{b}}{\partial \alpha} < 0 \) and \( \frac{\partial \tilde{b}}{\partial C_e} > 0 \forall \beta \geq \frac{4}{9}, \alpha \in (0,1] \text{ and } C_e \geq 0 \) (for a proof see the Appendix). The above results occur because, the more costly it is to produce the better quality product, the closer the entrant is forced to locate to the patentee and the smaller is the breadth of patent protection that makes it unprofitable for the entrant to not infringe the patent. In addition, the greater is the value of the validity parameter, the greater is the effect that patent breadth has on the probability that the validity of the
patent will be upheld and the smaller is the patent breadth that makes it profitable for the entrant to infringe the patent. Finally, the greater are the trial costs, the less appealing is infringement to the entrant. The entrant in this case will infringe only if the breadth is so large that her cost structure does not allow her to locate outside the patentee’s patent claims. Case III is illustrated in Figure 2, panel (iv).
**Figure 2.** The Entrant’s Profits under Infringement and No Infringement When Entry Can be Deterred – Panels (i) and (ii) – and When Entry Cannot be Deterred – Panels (iii) and (iv)
Figure 3 illustrates the combinations of $\beta$ and $C_e$ values, for a given $\alpha$ value, ($\alpha = 0.5$) that give rise to each of the three cases. Entry deterrence (Case I), where there exists a patent breadth $\hat{b}$ such that $\hat{b}_N \leq \hat{b} \leq \hat{b}_I$, is represented by the dotted area on Figure 3 and occurs for relatively high trial costs, $C_e$, and high $\beta$ (low R&D effectiveness) values. Entry with no infringement (Case II), where there is no patent breadth $\hat{b}$ that can deter entry and no patent breadth $\tilde{b}$ that can induce non infringement, is represented by the horizontally hatched area in Figure 3 and occurs for relatively high trial costs $C_e$, and low $\beta$ (high R&D effectiveness) values. Finally, entry and inducement of infringement/no infringement (Case III), where there exists a patent breadth $\tilde{b}$ such that $\hat{b}_I < \tilde{b} < \hat{b}_N$, occurs for low trial cost values, $C_e$.

**Figure 3.** Combinations of $\beta$ and $C_e$ values for a given $\alpha$ value ($\alpha = 0.5$) that generate Cases I, II and III
As demonstrated in Figure 4, the validity parameter $\alpha$ affects the precise combination of $\beta$ and $C_e$ values that gives rise to a particular case. Specifically, the larger is $\alpha$, the smaller is the parameter area in which the entrant will enter and not infringe the patent (the area to the left of locus $\tilde{b} = 1$ and for $\beta \in \left[\frac{4}{9}, \frac{8}{9}\right]$), and the smaller is the parameter area that can deter entry (the area to the right of locus $\hat{b}_l = \hat{b}_{NI}$ and for $\beta \geq \frac{8}{9}$). These results follow directly from the impact that $\alpha$ has on the probability that the validity of the patent will be upheld during trial, $\mu$. As $\alpha$ becomes larger, the greater is the probability that the patent will be found invalid, for any given patent breadth, $b$. As a consequence, entry is harder to deter and when entry does occur, the entrant is less likely to not infringe the patent.

**Figure 4.** Combinations of $\beta$ and $C_e$ values that give rise to Cases I, II and III, for $\alpha=1$, $\alpha=0.75$ and $\alpha=0.25$
The relationship between the existence of a patent breadth \( \hat{b} \in (q_e^*,1] \) that can deter entry and a patent breadth \( \tilde{b} \in (q_e^*,1] \) the makes the entrant indifferent between infringing and not infringing the patent is formally described in the propositions that follow.

**Proposition 1.** If a \( \tilde{b} \in (q_e^*,1] \) and a \( \hat{b} \in (q_e^*,1] \) do not exist it is never optimal for the entrant to infringe the patent.

**Proof:**

At the entrant’s most preferred location \( q_e^* \) non infringement is always more profitable than infringement for the entrant. That is, for \( b = q_e^* = \frac{4}{9\beta} \), \( E(\Pi_e^I) - \Pi_e^{NI} = \frac{128\alpha^2}{6561\beta^3} - C_E - \frac{8}{81\beta} < 0 \quad \forall \beta \geq \frac{4}{9} \land \alpha \in (0,1] \land C_e \geq 0 \). In addition, at \( q_e^* \), \( \Pi_e^{NI} = \frac{1}{9\beta} > 0 \quad \forall \beta \geq \frac{4}{9} \). The above conditions imply that if a \( \tilde{b} \in (q_e^*,1] \) does not exist (i.e., there is no patent breadth that makes \( E(\Pi_e^I) = \Pi_e^{NI} > 0 \)), then \( E(\Pi_e^I) - \Pi_e^{NI} < 0 \quad \forall b \in (0,1] \) which implies that \( \Pi_e^{NI} > E(\Pi_e^I) \quad \forall b \in (0,1] \). Since there is no \( \hat{b} \in (q_e^*,1] \) either there is no \( \hat{b}_{NI} \) such that \( \Pi_e^{NI} = 0 \) which implies that \( \Pi_e^{NI} > 0 \quad \forall b \in (0,1] \). This result is depicted in Figure 2 in panel (iii) and in Figure 3 as the horizontally hatched area. \( \square \)

**Proposition 2.** If a \( \tilde{b} \in (q_e^*,1] \) does not exist, the only patent breadth \( \hat{b} \in (q_e^*,1] \) that can deter entry is the patent breadth that satisfies the non-entry condition under no infringement, i.e., \( \hat{b}_{NI} \).

**Proof:**

From Proposition 1 it is known that for \( b = q_e^* \), \( E(\Pi_e^I) - \Pi_e^{NI} < 0 \). If \( \tilde{b} \) that makes \( E(\Pi_e^I) = \Pi_e^{NI} > 0 \) does not exist then \( \forall b \in (0,1] \quad E(\Pi_e^I) - \Pi_e^{NI} < 0 \Rightarrow \Pi_e^{NI} > E(\Pi_e^I) \). If there is a patent breadth \( \hat{b}_{NI} \) that satisfies the non-entry condition under no infringement this implies that for
Given that $\Pi^N_I > E(\Pi^N_E)$, when $b = \hat{b}_N$, the entry deterrence condition is also satisfied. Thus, any $b \in [\hat{b}_N, 1]$ can deter entry. This case is depicted in Figure 2 in panel (ii). □

4.2 Stage 1 – The Patent Breadth Decision

In stage 1 of the game, the patentee chooses the patent breadth $b$ that maximizes profit, given his knowledge of the entrant’s behavior in the second stage of the game. Since the entrant’s behavior depends on the values of $C_e$, $\alpha$ and $\beta$, the patent breadth chosen by the patentee also depends on these parameters. Specifically, three situations are possible, each one corresponding to one of the cases outlined above. These situations are presented in Figure 5 and are analyzed below.
**Stage one**

**Patentee:** chooses patent breadth $b$

---

**Scenario A**

Entry can be deterred and $\tilde{b}$ exists

**Patentee:** chooses $\hat{b}$

**Payoffs: A**

\[
\begin{align*}
\text{P: } & \pi_p^* = \Pi_p^M \\
\text{E: } & \pi_e^* = 0
\end{align*}
\]

---

**Scenario B**

Entry cannot be deterred and $\tilde{b}$ does not exist

**Patentee:** chooses $b_{\text{max}} = 1$

**Payoffs: B**

\[
\begin{align*}
\text{P: } & \pi_p^* = \Pi_p^{NI} \\
\text{E: } & \pi_e^* = \Pi_e^{NI}
\end{align*}
\]

---

**Scenario C**

Entry cannot be deterred and $\tilde{b}$ exists

**Payoffs: C**

\[
\begin{align*}
\text{P: } & \pi_p^* = \mathcal{E}(\Pi_p^I) \\
\text{E: } & \pi_e^* = \mathcal{E}(\Pi_e^I)
\end{align*}
\]

---

**Payoffs: D**

\[
\begin{align*}
\text{P: } & \pi_p^* = \Pi_p^{NI} \\
\text{E: } & \pi_e^* = \Pi_e^{NI}
\end{align*}
\]

---

**Induces infringement**

\[b > \tilde{b}\]

---

**Induces non infringement**

\[b \leq \tilde{b}\]

---

**Figure 5.** The Patentee’s Strategic Patent Breadth Decision
**Scenario A – Choose Patent Breadth to Deter Entry**

If there are values of $\beta$, $\alpha$ and $C_e$ are such that entry can be deterred – i.e., if there exists a $\hat{b} \in (q_e^*,1]$ – then the patentee should always choose to deter entry. By deterring entry, the patentee earns monopoly profits $\Pi_p^M$. Since these profits are higher than what can be earned under a duopoly, the patentee always finds it optimal to deter entry.

**Scenario B – Choose Maximum Patent Breadth**

When the values of $\beta$, $\alpha$ and $C_e$ are such that the entrant will always enter and not infringe the patent, regardless of the patent breadth (i.e., case II), the patentee always chooses the maximum patent breadth. The reasoning is straightforward. With both firms operating in the market, the profits of the patentee are increasing in the quality chosen by the entrant – i.e., $\pi_p^* = \frac{q_e}{9}$ (see equation (2)). As equation (5) indicates, the entrant will choose $q_e = b$ for $b \geq \frac{4}{9\beta}$. Thus, the patentee can earn maximum profits by choosing the largest possible patent breadth, which in turn causes the entrant to chose the largest possible value of $q_e$.

**Scenario C – Allow Entry and Induce Either Infringement or Non Infringement**

If the values of $\beta$, $\alpha$ and $C_e$ are such that the entrant will enter and either infringe or not infringe depending on patent breadth, the patentee must decide whether to induce infringement or not. Consider first the profits the patentee earns if he induces the entrant to not infringe. Recall from equation (2) that the patentee’s profits equal $\pi_p^* = \frac{q_e}{9}$ when the entrant enters without infringing.

Recall also (see equation (6)) that the entrant will always choose $q_e^{Ni} = \frac{4}{9\beta}$ if $b < \frac{4}{9\beta}$, while the
entrant chooses $q_e^{NI} = b$ when $b \geq \frac{4}{9}\beta$. Thus, if the patentee induces non infringement, his profits are given by:

$\Pi_{p}^{NI} = \begin{cases} \frac{4}{81\beta} & \text{if } b < \frac{4}{9}\beta \\ \frac{b}{9} & \text{if } \frac{4}{9}\beta \leq b < \tilde{b} \end{cases}$

Since the patentee’s profits can always be increased by choosing $b \geq \frac{4}{9}\beta$, the patentee can earn maximum profits and not induce infringement by choosing $b^{NI} = \tilde{b}$. The patentee’s profits are thus:

$\Pi_{p}^{NI} = \frac{\tilde{b}}{9}$.

The profits earned from inducing non infringement have to be compared to the expected profits earned by inducing infringement. Recall that the entrant chooses $q_e^{I} = \frac{4\alpha b}{9\beta}$ when she enters and infringes the patent, and that the probability of the patent being found valid is $\mu = 1 - \alpha b$. The patentee’s expected profits are given by: $E(\Pi_{p}^{I}) = \mu \Pi_{p}^{M} + (1 - \mu)\pi_{p} - C_{p}$. The problem facing the patentee is thus:

$max_{b} E(\Pi_{p}^{I}) = (1 - ab)\Pi_{p}^{M} + \frac{4\alpha^2 b^2}{81\beta} - C_{p}$

s.t. $\tilde{b} + e \leq b \leq 1$ where $e \rightarrow 0$

The patent breadth $b$ that solves equation (13) does not result in maximum profits for the patentee, since the second-order conditions do not hold – i.e., $\frac{\partial^2 E(\Pi_{p}^{I})}{\partial b^2} = \frac{8\alpha}{81\beta} > 0$. Thus, the optimal patent breadth $b^{I}$ that induces infringement is one of the corner values – i.e., $b^{I} = \tilde{b} + e$ or
$b' = 1$. Note, however, that under this scenario the patent breadth chosen must violate the entry deterrence condition, that is, $\hat{b}_I < b' < \hat{b}_{NI}$. When $b' = 1$ the condition $\hat{b}_I < b' < \hat{b}_{NI}$ holds only for values of $\beta$ such that, $\frac{4}{9} \leq \beta < \frac{8}{9}$. With $b' = 1$, the patentee’s expected profits are:

$$E(\Pi^{\prime}_{p})_{b'=1} = (1 - \alpha)\Pi^M_p + \frac{4\alpha^2}{81\beta} - C_p$$

while with $b' = \tilde{b} + e$, the expected profits are:

$$\lim_{e \to 0} E(\Pi^{\prime}_{p})_{b'=\tilde{b}+e} = (1 - \alpha\tilde{b})\Pi^M_p + \frac{4\alpha^2}{81\beta}\tilde{b}^2 - C_p$$

Assuming the patentee induces infringement, the patentee chooses $b' = 1$ when

$$E(\Pi^{\prime}_{p})_{b'=1} > E(\Pi^{\prime}_{p})_{b'={\tilde{b}}} \quad \text{and} \quad \frac{4}{9} \leq \beta < \frac{8}{9}.$$ 

This condition is satisfied when $\frac{4\alpha}{81\beta}(1 + \tilde{b}) > \Pi^M_p$ and $\frac{4}{9} \leq \beta < \frac{8}{9}$. Thus, the patentee is more likely to induce infringement by choosing the maximum patent breadth when $\alpha$ is large, $\beta$ is small, $\tilde{b}$ is large and $\Pi^M_p$ is small.

The above results show that the smaller are the monopoly profits that the patentee makes when his patent is found valid at trial, the greater is the patentee’s incentive to claim the maximum breadth of protection and risk having his patent revoked. This occurs because under infringement the entrant’s location is proportional to the breadth of the patent (i.e., $q_e^{\prime} = \frac{4\alpha}{9\beta}b$) so the greater is patent breadth, the further away from the patentee the entrant locates and the greater are the profits at the last stage of the game for both players. Thus, in this case, the effect of the loss of monopoly profits due to the large patent breadth is smaller than the effect of the increased profits brought by the increased level of differentiation between the two products. The reverse is true for large values of the monopoly profits.
Having determined the optimal patent breadth decision and the patentee’s expected profits when he induces infringement and non infringement the next step to the analysis is to determine when the patentee will find it optimal to induce infringement or non infringement. Figure 6 depicts the possible outcomes of a comparison between the patentee’s expected profits when he induces infringement and his profits when he induces non infringement when the optimal patent breadth under inducement of infringement is \( b^I = \tilde{b} + e \) (panel (i)) and \( b^I = 1 \) (panel (ii)).

\[
\begin{align*}
\Pi_P^{NI} & \quad \Pi_P^{NI} \\
0 & \quad 0 \\
\tilde{b} & \quad \tilde{b} + e \\
1 & \quad 1 \\
A & \quad A \\
B & \quad B \\
C & \quad C \\
D & \quad D \\
E(\Pi_P^{I}) & \quad E(\Pi_P^{I})
\end{align*}
\]

(i) \( b^I = \tilde{b} + e \) (ii) \( b^I = 1 \)

**Figure 6.** The Patentee’s Expected Profits under Infringement and his Profits under Non Infringement under Scenario C

Even though a direct comparison of the patentee’s profits when he induces infringement and when he induces non infringement is not possible without knowledge of the values of the parameters that affect the patent breadth decision, i.e., \( \beta, \alpha, \Pi_P^{NI}, C_e \) and \( C_p \), we can observe the impact of some of the exogenous parameters on the incentive to induce infringement when \( b^I = \tilde{b} + e \) and when \( b^I = 1 \). Let \( Z_p^1 = E(\Pi_p^{I})_{b^I=\tilde{b}+e} - \Pi_P^{NI} \) and \( Z_p^2 = E(\Pi_p^{I})_{b^I=1} - \Pi_P^{NI} \). Then it can be shown that, the greater are the monopoly profits, the greater is the patentee’s incentive to
induce infringement, with the increase greater for the case where \( b' = \tilde{b} + e \) (i.e., \( Z_p^1 \geq \Pi_p^M \)).

\[
\frac{\partial Z_p^2}{\partial \Pi_p^M} \geq 0 \quad \text{and} \quad \frac{\partial Z_p^1}{\partial \Pi_p^M} \leq \frac{\partial Z_p^2}{\partial \Pi_p^M} \quad \text{– for a proof see the Appendix).}
\]

This result occurs because the only chance the patentee has to realize monopoly profits is when his patent is infringed and its validity is upheld during the infringement trial. At the same time, as expected, the greater are the patentee’s trial costs, the smaller are the benefits (greater are the losses) from inducing infringement (i.e.,

\[
\frac{\partial Z_p^1}{\partial C_p} < 0, \quad \frac{\partial Z_p^2}{\partial C_p} < 0 \quad \text{– for a proof see the Appendix).}
\]

4. Concluding Remarks

Existing studies have limited the analysis of the innovator’s patenting behavior to the study of his decision to patent or not to patent his innovation. The innovator’s patent breadth decision that affects, whether the patent will be granted, the breadth of protection granted and the viability of the patent after grant and thus determines the innovation rents that can be captured with the patent, have not been explicitly modeled in the literature. Instead, it has been traditionally assumed that the innovator will apply for the broadest protection possible.

In this paper a simple game theoretic model is used to describe the patenting behavior of an innovator who, having invented a patentable drastic product innovation and having decided to seek patent protection, determines the breadth of protection that maximizes the appropriability of the innovation rents enabled by the patent. To determine the optimal breadth of patent protection claimed, the patentee acts strategically, choosing the breadth of protection that induces the desired behavior by the entrant. The patentee is foresighted and anticipates that he may have to incur costs to enforce and/or defend his patent rights. The model suggests that the breadth of patent protection
that maximizes the innovators ability to appropriate innovation rents, depends on the entrant’s R&D cost structure, the patentee’s and the entrant’s trial costs and the effect that patent breadth has on the probability that the validity of the patent will be upheld during an infringement/validity trial.

Contrary to what it is traditionally assumed, the results show that it is not always optimal for the patentee to claim the maximum patent breadth possible. In fact, only for certain values of the parameters that determine the patent breadth decision it is optimal for the patentee to claim the maximum breadth of patent protection. The patentee claims maximum patent protection when he cannot deter entry and the entrant’s R&D effectiveness and trial costs are such that she always finds it optimal to not infringe the patent (i.e., when the entrant’s R&D costs are very low). The maximum breadth of patent protection may also be claimed when the patentee cannot deter entry and he finds it optimal to induce infringement. This case occurs, however, only for relatively small monopoly profits and when the entrant’s R&D costs are very low.

The results hold under the assumption of a fencepost patent system, which implies that the events that the patent is infringed and the patent is invalid can be treated as mutually exclusive and exhaustive. In addition, it has been assumed that the market can only support two products, and that the R&D process is deterministic. Relaxing the above assumptions is the focus of future research.
References


APPENDIX

- Existence of patent breadth \( \tilde{b} \).

If a patent breadth \( \tilde{b} \) that makes the entrant indifferent between infringing and not infringing the patent, while still generating positive profits for the entrant, exists it should satisfy the conditions \( \tilde{b} \in (q_e^*,1] \) and

\[
\Pi_e^{NI}(\tilde{b}) = E(\Pi_e(\tilde{b})) > 0. 
\]

The solution of \( \Pi_e^{NI}(\tilde{b}) = E(\Pi_e(\tilde{b})) \Rightarrow \left( \frac{8\alpha^2}{81\beta} + \frac{\beta}{2}\right)\tilde{b}^2 - \frac{4}{9} \tilde{b} - C_e = 0 \) in terms of \( \tilde{b} \) yields the following two roots:

\[
\tilde{b}_{1,2} = \frac{9(4\beta \pm \sqrt{2\sqrt{16C_e\alpha^2 + 8\beta + 81C_e\beta^2}})}{16\alpha^2 + 81\beta^2}.
\]

The root \( \tilde{b}_1 \) is rejected since \( q_e^* < \tilde{b} \leq 1 \). The root \( \tilde{b}_2 \) is accepted as a possible solution. If \( \tilde{b} = \frac{9(4\beta + \sqrt{2\sqrt{16C_e\alpha^2 + 8\beta + 81C_e\beta^2}})}{16\alpha^2 + 81\beta^2} \) exists it should also satisfy the conditions \( q_e^* < \tilde{b} \leq 1, \Pi_e^{NI}(\tilde{b}) > 0 \) and \( E(\Pi_e(\tilde{b})) > 0 \). It is easily verified that the condition \( \tilde{b} - q_e^* > 0 \) is satisfied \( \forall \beta \geq \frac{4}{9}, \alpha \in (0,1] \land C_e \geq 0 \). That is,

\[
\tilde{b} - q_e^* = \frac{9(4\beta + \sqrt{2\sqrt{16C_e\alpha^2 + 8\beta + 81C_e\beta^2}})}{16\alpha^2 + 81\beta^2} - \frac{4}{9} \beta > 0 \quad \forall \beta \geq \frac{4}{9}, \alpha \in (0,1] \land C_e \geq 0. 
\]

The condition \( \tilde{b} \leq 1 \) is satisfied for certain combinations of \( \beta, \alpha \) and \( C_e \) values. To determine the combinations of \( \beta, \alpha \) and \( C_e \) values which satisfy the condition \( \tilde{b} \leq 1 \), the pairs of \( \beta, \alpha \) and \( C_e \) values that satisfy the above constraint as an equality (\( \tilde{b} = 1 \)) are determined first. The solution of \( \tilde{b} - 1 = 0 \) with respect to \( C_e \) yields:

\[
C_e = \frac{16\alpha^2 - 72\beta + 81\beta^2}{162\beta}. 
\]

The combination of \( \beta \) and \( C_e \) values, for a given \( \alpha \) value, for which \( \tilde{b} - 1 = 0 \) is represented by the locus \( \tilde{b} = 1 \) in Figure 3. The area to the right of the locus \( \tilde{b} = 1 \) represents all
combinations of \(\beta\) and \(C_e\) values, for a given \(\alpha\) value, for which \(\tilde{b} < 1\). If \(\tilde{b}\) exists it must also satisfy the conditions \(\Pi_e^M(\tilde{b}) > 0\) and \(E(\Pi_e^M(\tilde{b})) > 0\). Thus, \(\tilde{b}\) must take values in the interval \(\hat{b}_I < \tilde{b} < \hat{b}_{NI} - \tilde{b}\) must not satisfy the entry deterrence condition. To determine the combination of \(\beta\), \(\alpha\) and \(C_e\) values for which \(\hat{b}_I < \tilde{b} < \hat{b}_{NI}\) the locus \(\hat{b}_I = \hat{b}_{NI}\) must first be determined. The locus \(\hat{b}_I = \hat{b}_{NI}\) depicted in Figure 3 refers to the pairs of \(\beta\), \(\alpha\) and \(C_e\) values for which \(\frac{8}{9\beta} = \sqrt{\frac{81C_E\beta}{8\alpha^2}}\) holds true. Solution of the above condition with respect to \(C_e\) yields: \(C_e = \frac{512\alpha^2}{6561\beta^3}\). All combinations of \(\beta\) and \(C_e\) values, for a given \(\alpha\) value, below the locus \(\hat{b}_I = \hat{b}_{NI}\) are such that \(\hat{b}_I < \tilde{b} < \hat{b}_{NI}\).

Given the above, \(\tilde{b}\) exists for all combinations of \(\beta\) and \(C_e\) values, for a given \(\alpha\) value, in the area below the locus \(\tilde{b} = 1\) and below the locus \(\hat{b}_I = \hat{b}_{NI}\) represented by the vertically hatched area in Figure 3. This case is also depicted in Figure 2, panel (iv).

- The effect of \(\beta\), \(\alpha\) and \(C_e\) on \(\tilde{b}\).

\[
\frac{\partial \tilde{b}}{\partial \beta} = \frac{(9(16\alpha^2 - 81\beta^2))(\sqrt{2}C_e(16\alpha^2 + 81\beta^2)^2 + 8(2\sqrt{2}\beta + \sqrt{\beta}\sqrt{16C_E\alpha^2 + 8\beta + 81C_E\beta^2})}{\sqrt{2}\sqrt{16\alpha^2 + 81\beta^2})^2} \leq 0
\]

\[\forall \beta \geq \frac{4}{9}, \alpha \in (0,1) \text{ and } C_E \geq 0.\]

\[
\frac{\partial \tilde{b}}{\partial \alpha} = -\frac{\left(144\alpha\sqrt{\beta}(\sqrt{2}C_e(16\alpha^2 + 81\beta^2) + 8(2\sqrt{2}\beta + \sqrt{\beta}\sqrt{16C_E\alpha^2 + 8\beta + 81C_E\beta^2})\right)}{(16\alpha^2 + 81\beta^2)(16C_E\alpha^2 + 8\beta + 81C_E\beta^2)} < 0
\]

\[\forall \beta \geq \frac{4}{9}, \alpha \in (0,1) \text{ and } C_E \geq 0.\]

\[
\frac{\partial \tilde{b}}{\partial C_E} = \frac{9\sqrt{\beta}}{\sqrt{2}\sqrt{16C_E\alpha^2 + 8\beta + 81C_E\beta^2}} > 0, \forall \beta \geq \frac{4}{9}, \alpha \in (0,1) \text{ and } C_E \geq 0.
\]

- The effect of \(\Pi_p^M\) and \(C_p\) on \(Z_p^1\) and \(Z_p^2\).
\[ Z_p^1 = (1 - \alpha) \Pi^\mu_p + \frac{4\alpha^2}{81\beta} - C_p - \frac{\tilde{b}}{9} \]

\[ \frac{\partial Z_p^1}{\partial \Pi^\mu_p} = 1 - \alpha \geq 0, \quad \frac{\partial Z_p^1}{\partial C_p} = -1 < 0 \]

\[ Z_p^2 = (1 - \tilde{a}\tilde{b}) \Pi^\mu_p + \frac{4\alpha^2\tilde{b}^2}{81\beta} - C_p - \frac{\tilde{b}}{9} \]

\[ \frac{\partial Z_p^2}{\partial \Pi^\mu_p} = 1 - \tilde{a}\tilde{b} \geq 0, \quad \frac{\partial Z_p^2}{\partial C_p} = -1 < 0. \]
Vertical integration, exclusive dealing and product line differentiation in retailing

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June 25, 2003

Abstract

We analyze vertical integration and exclusive dealing in a model of vertical differentiation in which retailers compete in product lines. Depending on quality and cost differentials, the equilibrium is characterized either by integration and partial product lines differentiation or by exclusive dealing and complete product lines differentiation. The model leads us to recommendations for antitrust policy makers: exclusive dealing should be banned per se, while a rule of reason approach of vertical integration should be adopted.

Key-words: Vertical integration, exclusive dealing, product line differentiation, antitrust policy.

JEL Classification: L13, L22, L42.

1 Introduction

Retailing is characterized by the frequency of both exclusive dealing contracts and vertical integration between the retailers and their suppliers. This is true for a wide variety of products, from food and clothing1 to cable and satellite TV. In a recent empirical analysis of the role of vertical integration

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1Prominent examples are the British chain of department stores Marks & Spencer, that relies heavily on exclusive dealing, and the Swiss chain of supermarkets Migros, that makes extensive use of vertical integration. See also Fearne (1998) and Hughes and Merton (1996) for a presentation of the vertical links between British food retailers and their suppliers.
in the US cable television industry, Chipty (2001) shows that vertically integrated cable systems operators tend to exclude rival program services, which reduces the welfare of consumers located in the areas where these operators are in a monopoly position. Indeed, the frequency of vertical integration and exclusive dealing in the retailing sector rises the two questions of (i) the incentives that manufacturers and retailers have to enter in such relations and (ii) the impact of these relations on welfare.

There is an important theoretical literature on each of these topics, but it doesn’t take into account a critical characteristic of this sector: retailers offer several varieties of each product and face a strategic choice as regards the range of varieties they offer and the differentiation of their product line from the product lines of other retailers.

Absent differentiation between products, the qualitative effects of exclusive dealing and vertical integration are identical: there is the same number of firms competing on the final market. Assuming that there are two suppliers at the upstream level\(^2\), neither exclusive dealing nor vertical integration succeed in preventing entry or inducing exit at the downstream level: in the case of a downstream duopoly, both downstream firms have access to the intermediate good and, as a consequence, are present on the final market.

In the retail case, it means that both retailers offer the product. However, despite this similarity of the qualitative effects, the quantitative effects of exclusive dealing and vertical integration are different: both the price paid by the downstream firm linked to one producer and the price paid by its

\(^2\)There is an important literature on the use of exclusive dealing and vertical integration as a barrier to entry at the upstream level that we don’t discuss here, since it is out of the scope of our analysis. See Bernheim and Whinston (1998) for a recent and comprehensive presentation.
rival are different in the exclusive dealing case and in the vertical integration case. In other words, the rising rivals’ costs effect has a different strength in each case. It is in fact not clear what type of vertical relation leads to the largest difference between the price paid by each of the two downstream firms. Indeed, whereas exclusive dealing just means foreclosure, a vertically integrated firm may either sell intermediate good on the market (as in Hart and Tirole (1990)) or foreclose (as in Salinger (1988) and Ordover, Saloner and Salop (1990)) or even strategically purchase this good (as in Gaudet and Van Long (1996) and Avenel and Barlet (2000)). Furthermore, whereas the internal transfer price within the integrated firm is just the marginal cost of producing the intermediate good, it may for strategic reasons differ from the marginal cost in an exclusive dealing relation, either toward higher prices or toward lower prices (see Rey and Stiglitz (1988) and Caillaud and Rey (1995)). In this literature, exclusive dealing and vertical integration differ in their *quantitative* aspects, but each and every firm proposes the same product as its competitors. For the reasons previously exposed, this is not best suited to the analysis of the retailing sector.

Introducing competition in product lines in the analysis creates a *qualitative* difference between the respective effects of exclusive dealing and vertical integration on downstream competition: the number of firms offering each variety of the product in equilibrium is different. Evidence from the European satellite television industry (collected by the authors) illustrates this point. Exclusivity trivially leads to complete product lines differentiation. When BSkyB paid £1.1 billion for the exclusivity of the (UK) Premier League, ITV Digital was left with lower level football matches. In contrast, vertical integration doesn’t always imply foreclosure. For example, the two French
integrated groups supply each other with news channels: CanalSatellite proposes the news channel LCI produced by TF1, a major shareholder of the rival operator TPS, and TPS proposes the news channel Itelevision produced by Canal+, the parent establishment of CanalSatellite.

Our objective in this paper is twofold. First, it is to contribute to the strategic management literature by providing an analysis of both the product line differentiation between firms linked to their suppliers through vertical relations and the benefits and drawbacks of vertical integration as compared to exclusive dealing in the retailing sector. Secondly, it is to provide guidance for policy makers by asserting the effect of vertical integration and exclusive dealing on welfare in the retailing sector. This question was raised recently in the giant vertical merger between Vivendi and Universal reviewed by the merger task force of the European Commission. We discuss this case, as well as a French case about exclusive sports rights, in the conclusion.

We consider a model of vertically differentiated products, with two qualities. The high quality is produced by a monopolist and the low quality by a perfectly competitive industry. The pattern of vertical relations between manufacturers and retailers is the result of a multi-stage game in which retailers can propose exclusive dealing contracts or vertical integration to the high quality manufacturer. We determine the vertical relationships and the resulting product lines of retailers in equilibrium, and, contrary to Gilbert and Matutes (1993) and De Fraja (1996), don’t obtain a “head-to-head” equilibrium in which firms match exactly each other’s product line. We then

3Gilbert and Matutes (1993) considers a variation of the basic model in which firms can offer different product lines in equilibrium, but this is due to a Stackelberg assumption that is not present in our paper. Champsaur and Rochet (1989) also find differentiated product lines in equilibrium, but in a model of Bertrand competition in which firms offer intervals of qualities, whereas we consider a finite number of varieties and Cournot competition.
determine the optimal policy that a competition authority should implement towards vertical integration and exclusive dealing. Whereas, as could be expected, exclusive dealing should be banned per se, the treatment of vertical integration should be based on a rule of reason approach, not because of efficiency gains, that we assume away, but because of the impact of vertical integration on product lines and competition.

The plan of the paper is as follows: we present the model in section 2; in section 3, we determine the equilibrium on the wholesale and the retail market when exclusive dealing and vertical integration are ruled out and examine retailers’ incentives to differentiate their product line from the rival’s one through exclusive dealing agreements; in section 4, we determine the equilibrium of the complete game in which retailers can propose exclusive dealing and vertical integration to the high quality manufacturer; section 5 presents the welfare analysis and policy recommendations. Section 6 discusses some evidence from the satellite TV industry and concludes.

2 The model

We consider an industry with two identical downstream retailers, $D_1$ and $D_2$, who buy from an upstream producer, $A$, and a competitive fringe, $B$. $A$ produces a high quality product at marginal cost $c$ while the competitive fringe produces a low quality product at marginal cost 0. The retailing costs are 0. Let $q_H = 1$ be the high quality and $q_L < 1$ be the low quality. There is a unit mass of consumers, each of whom is interested in buying at most one unit. The utility of consumers is of the Mussa-Rosen (1978) type: each consumer obtains a utility $\theta q_i - p_i$ if he buys one unit of good $i$, where $\theta$ is distributed uniformly on the interval $[0, 1]$, and a utility 0 if he does not buy
Competition on the final market is of the Cournot type. We denote respectively by $y_H^i$ and $y_L^i$ the quantity of the high quality and the low quality product offered by $D_i$. Given consumers’ preferences, inverse demand functions for the two qualities are as follows:

\begin{align}
\left\{ \begin{array}{l}
\rho_L (y_H^1, y_H^2, y_L^1, y_L^2) = (1 - y_H^1 - y_H^2 - y_L^1 - y_L^2) q_L \\
\rho_H (y_H^1, y_H^2, y_L^1, y_L^2) = 1 - y_H^1 - y_H^2 - (y_L^1 + y_L^2) q_L
\end{array} \right.
\end{align}

The strategic interactions between upstream and downstream firms are represented by a four stage game:

Stage 1: Retailers simultaneously propose exclusive dealing contracts or takeover offers to producer A. Producer A either accepts one of the offers or rejects both.

Stage 2: If A rejects both offers, A proposes to $D_1$ and $D_2$ an identical two-part tariff, $T(y_H^i) = wy_H^i + F, i = 1, 2$. If A has vertically integrated with one of the retailers, then it offers a two-part tariff to the other retailer.

Stage 3: Retailers simultaneously accept or refuse the contract offered by the manufacturer (if any).

Stage 4: Retailers (integrated or not) simultaneously choose $(y_H^i, y_L^i)_{i=1,2}$.

Note that the retailers can buy the low quality of the good from the competitive fringe at a price equal to 0. Information in this game is both complete and perfect. In particular, contracts are public and cannot be secretly renegotiated. We solve the game by backward induction. In the next section, we show that retailers make acceptable offers in stage 1. The solution of the game is presented in section 4.
3 Retailers’ incentives for product line differentiation

To prove that retailers make acceptable offers in stage 1, we show that retailers would be better off offering an acceptable ED contract in stage 1 than making no acceptable offer. Doing this requires us to first characterize the equilibrium of the "arm’s length relationships" subgame beginning in stage 2 when \( A \) rejects both offers in stage 1.

3.1 Arm’s length relationships

Assuming hereafter that \( c \) is not too large\(^4\), \( A \) supplies at least one retailer in equilibrium. Whether it supplies one or both depends on the franchise fee. In both cases, \( A \) saturates retailers’ participation constraints. Denote by \( \pi^i (w_i, w_j) \) the gross profit\(^5\) of retailer \( i \) when he pays \( w_i \) and retailer \( j \) pays \( w_j \) for each unit of the high quality good (\( w_i = +\infty \) means that \( D_i \) is not supplied by \( A \)). With \( F \equiv \pi^i (w, w) = \pi^i (+\infty, w) \), \( A \) supplies both retailers. Rising the franchise fee to \( \pi^i (w, +\infty) - \pi^i (+\infty, +\infty) \), it supplies only one.

In appendix A, we solve the downstream competition game (stage 4) and establish the expressions of \( \pi^i, y^i_H \) and \( y^i_L \) as a function of wholesale prices. We provide the expressions of outputs in the following lemma.

**Lemma 1** Given \( (w_i, w_j) \), retailers offer the following quantities of each quality on the final market:

(i) If \( (w_i, w_j) = (w, +\infty) \) and \( 0 \leq w \leq \frac{1 - q_L}{3} \), \( \{ y^i_H, y^j_L, y^i_H, y^j_L \} = \{ \frac{2 - q_L - 2w}{4 - q_L}, 0, 0, \frac{1 + w}{4 - q_L} \} \).

(ii) If \( (w_i, w_j) = (w, +\infty) \) and \( w \geq \frac{1 - q_L}{3} \), \( \{ y^i_H, y^j_L, y^i_H, y^j_L \} = \{ \frac{1 - q_L - w}{2(1 - q_L)}, \frac{3w - (1 - q_L)}{6(1 - q_L)}, 0, \frac{1}{3} \} \).

(iii) If \( (w_i, w_j) = (w, w) \), \( \{ y^i_H, y^j_L, y^i_H, y^j_L \} = \{ \frac{(1 - q_L) - w}{3(1 - q_L)}, \frac{w}{3(1 - q_L)}, \frac{1 - q_L - w}{3(1 - q_L)}, \frac{w}{3(1 - q_L)} \} \).

---

\(^4\)More precisely, the high quality good is sold in equilibrium iff \( c < 1 - q_L \).

\(^5\)\( \pi^i \) includes the profits realized on both qualities.
In (i), the differentiation of product lines is complete, while, in (ii), it is partial, since both firms sell the low quality. The difference between (i) and (ii) is that, in (i), the wholesale price of the high quality is sufficiently low for the supplied retailer to decide not to sell the low quality.

**Corollary** If \((w_i, w_j) = (w, +\infty)\) and \(w \geq \frac{1-q_L}{3}\), \(y^i_H + y^j_L = y^j_L = \frac{1}{3}\) and \(p_L = \frac{1}{3} q_L\).

In (ii), the impact of \(w\) is limited to interbrand competition within retailer \(i\).

We denote by \(w_D\) and \(w_{DD}\) the wholesale prices offered in equilibrium in stage 2 by \(A\) respectively when there is one and two retailers. Appendix B provides the expressions of \(w_D\) and \(w_{DD}\).

**Lemma 2** \(w_D \leq c\), with a strict inequality for \(c < c_a\).

Proof. See appendix B and note that \(\frac{2c(4-q_L)-(2-q_L)q_L}{4(2-q_L)} < c\) since \(c < 1-q_L\).

By charging a low \(w_D\), the manufacturer induces retailer \(i\) to be more aggressive, which is profitable, since the outputs of retailer \(i\) (high quality) and retailer \(j\) (low quality) are strategic substitutes. See Caillaud and Rey (1995) for a discussion of these precommitment effects.

The corresponding profits are

\[
\Phi (w_D, +\infty) = \max_{w} (w - c) y^i_H (w, +\infty) + \pi^i (w, +\infty) - \pi^i (+\infty, +\infty) \\
\Phi (w_{DD}, w_{DD}) = \max_{w} 2 (w - c) y^i_H (w, w) + 2\pi^i (w, w) - 2\pi^i (+\infty, w)
\]

Introducing the joint profits of manufacturer \(A\) and retailer \(i\) for wholesale prices \((w_i, w_j)\), \(\Pi (w_i, w_j)\), we rewrite (2) as

\[
\Phi (w_D, +\infty) = \Pi (w_D, +\infty) - \pi^i (+\infty, +\infty) \\
\Phi (w_{DD}, w_{DD}) = \Pi (w_{DD}, w_{DD}) - \pi^i (+\infty, w_{DD})
\]

(3)
When $A$ supplies only one retailer, the rent left to this retailer is $\pi^i (+\infty, +\infty)$. Since this rent is constant, when $A$ maximizes $\Phi$, it also maximizes $\Pi$. When $A$ supplies both retailers, the rent left to retailer $i$ is an increasing function of the wholesale price on $[0; \frac{1-q_L}{3}]$ and a constant on $[\frac{1-q_L}{3}; 1 - q_L]$ (see corollary of lemma 1). Let us define $\hat{w} = \text{ArgMax}_w \Pi(w, w)$. If $w_{DD} \geq \frac{1-q_L}{3}$, $\Pi(w_{DD}, w_{DD}) = \Pi(\hat{w}, \hat{w})$ and $\pi^i (+\infty, w_{DD}) = \pi^i (+\infty, +\infty)$. If $w_{DD} < \frac{1-q_L}{3}$, $\Pi(w_{DD}, w_{DD}) < \Pi(\hat{w}, \hat{w})$ and $\pi^i (+\infty, w_{DD}) < \pi^i (+\infty, +\infty)$: switching from one to two retailers allows $A$ to reduce the rent left to each supplied retailer. This is what we call the ”rent effect”. Of course, the joint profits are no longer maximized. However, the relevant comparison is not between $\Pi(w_{DD}, w_{DD})$ and $\Pi(\hat{w}, \hat{w})$, but between $\Pi(w_{DD}, w_{DD})$ and $\Pi(w_D, +\infty)$. As soon as $\Pi(w_{DD}, w_{DD}) < \Pi(w_D, +\infty)$ and $\pi^i (+\infty, w_{DD}) < \pi^i (+\infty, +\infty)$, it is not clear what retailing structure is optimal for the manufacturer. Indeed, it faces a trade-off between sharing a large cake with one retailer, but leaving it a high rent and sharing a smaller cake with two retailers, but leaving each of them a smaller rent. There is a ”joint profits effect” opposite to the rent effect. The manufacturer charges a franchise fee selecting only one retailer iff

$$\Phi(w_D, +\infty) > \Phi(w_{DD}, w_{DD})$$

(4)

or, equivalently,

$$\Pi(w_D, +\infty) - \Pi(w_{DD}, w_{DD}) > \pi^i (+\infty, +\infty) - \pi^i (+\infty, w_{DD})$$

(5)
Proposition 1 The equilibrium in the retailing market is as follows:

(i) If \( c \geq c_a \), the manufacturer is indifferent between supplying one retailer or two.

(ii) If \( c_b \leq c < c_a \), the manufacturer supplies only one retailer. This retailer provides only the high quality while the other retailer provides only the low quality.

(iii) If \( c < c_b \), the manufacturer supplies both retailers. The two retailers either provide only the high quality or both high and low qualities.

Proof: We provide the expression of \( c_b \) and a graphical representation of \( c_a \) and \( c_b \), as well as a detailed characterization of the equilibrium in appendix C.

When \( c \geq c_a \), choosing a price \( w_{DD} \) below \( \frac{1-q_a}{3} \) is prohibitively costly for the manufacturer, so that the rent effect vanishes in equilibrium and the profits of the retailers are the same when one retailer is supplied and when two retailers are supplied. As a consequence and because we assume public contracts, \( A \) is indifferent to the number of retailers that it supplies: in both cases, it maximizes the profits of the industry and receives the same part of this profit. For intermediate values of \( c \), it is still very costly for the manufacturer in terms of joint-profits to reduce the rent by manipulating the wholesale price, while in the “one retailer” case, it becomes easier to increase the joint-profits by lowering the wholesale price. This optimal price ensures that the retailer offering the high quality no longer offers the low quality. Note that, although the low quality good is free, it is not profitable for the vertical chain that the retailer offers this quality, because of the interbrand competition that this would create. For low values of \( c \), the rent effect is strong enough for the manufacturer to decide to serve the two retailers. There
is then no differentiation in product lines between retailers.

3.2 Exclusive dealing vs. arm’s length relationships

Since exclusive dealing is not an issue for $c \geq c_a$, we assume hereafter that $c < c_a$.

If $c < c_b$, the manufacturer supplies both retailers. It doesn’t maximize its joint-profits with any of these two retailers since it distorts the wholesale price in order to reduce the rent. There is thus a possibility for one of the retailers to increase its profit by offering the manufacturer an acceptable exclusivity contract in the first stage.

If $c \geq c_b$, each retailer knows that with probability $1/2$, the exclusive retailer of the high quality good will be the other retailer and thus has an incentive to make sure in stage 1 that it will be the exclusive retailer by signing a contract with the manufacturer.

**Proposition 2** The manufacturer receives at least one acceptable offer in the first stage.

Proof: See above.

Vertical restraints are always present in equilibrium and, as will be seen in section 4, they play a key role in the determination of product lines differentiation. To illustrate this point, we consider here a variation of the game in which retailers can propose exclusivity contracts, but no takeover offer, to the manufacturer in the first stage.

**Corollary** If exclusive contracts have been offered by the retailers at the first stage, there is a complete differentiation.

The exclusivity contract accepted by the manufacturer stipulates the wholesale price $w_D$ and the franchise fee $\Pi(w_D, +\infty) - \pi^i(+\infty, w_D)$ such
that the retailer is indifferent between signing the contract and renouncing to the high quality good. Because of the competition between retailers in the first stage, the opportunity to propose exclusive dealing in this stage leads to lower profits for the retailers.

4 Equilibrium structure and product line differentiation

The retailer that obtains an exclusive supply of high quality good has monopoly power on this quality, but the other retailer has free access to the low quality good. In this section, we examine whether a retailer can further strengthen its position in the retail market by acquiring the manufacturer of the high quality good. In other words, we analyze the difference between exclusive dealing arrangements and vertical integration, thus solving the first stage of the game. The first step is to analyze the strategy of the vertically integrated retailer on the intermediate market.

4.1 The integrated retailer’s strategy

The integrated retailer receives the profit of the whole industry less the reservation profit of the nonintegrated retailer. This reservation profit is independent from the wholesale price charged by the integrated retailer. As a consequence, the integrated retailer maximizes the profits of the whole industry. To do that, it can either supply or foreclose the independent retailer.

**Proposition 3** The integrated retailer forecloses its non-integrated rival iff $c \geq \frac{1+qL}{3}$.

Proof: See appendix D.
For $c \geq \frac{1-q_L}{3}$, the integrated retailer offers both qualities of the good. Supplying $D_j$ induces $D_i$ to offer less high quality good (because $D_j$ offers more of this quality) and more low quality good (because $D_j$ offers less of this quality). Because the slope of reaction functions is smaller than 1, intrabrand competition increases for both qualities and interbrand competition increases within both retailers. This reduces the industry’s profits.

For $c < \frac{1-q_L}{3}$, the integrated retailer doesn’t offer the low quality good, so that there is no intrabrand competition for the low quality and no interbrand competition within retailer $i$. Vertical foreclosure is not optimal in this case. The nonintegrated retailer sells the high quality good, which reinforces intrabrand competition on this quality, but he reduces its offer of low quality good, which reduces interbrand competition. The vertically integrated retailer gives the non-integrated retailer an (restricted) access to the high quality good (at wholesale price $w_I$).

### 4.2 The trade-off between vertical integration and exclusive dealing

From the previous section, we know that the manufacturer is in equilibrium necessarily bound with one retailer by an exclusive dealing contract rather than an arm’s length contract. However, if integration leads to higher joint profits, it emerges in equilibrium instead of exclusive dealing. The condition for the emergence of vertical integration in equilibrium is thus:

$$\Pi (c, w_I) > \Pi (w_D, +\infty)$$  \hspace{1cm} (6)

If $A$ and retailer $i$ merge, $D_i$ has access to the high quality good at an internal transfer price equal to the marginal cost of production $c$, whereas
in the exclusivity contract, it pays $w_D \leq c$ (lemma 2). In this sense, there is a cost of integration: the retailer can no longer commit to an aggressive behavior. There is also a benefit of integration, since the integrated firm supplies $D_j$ at a price $w_I$ that is not necessarily prohibitive.

**Proposition 4** For any value of $q_L$, there is a value $c_c$ such that $0 \leq c_c \leq c_a$ and

(i) If $c < c_c$, vertical integration emerges in equilibrium. There is no foreclosure and product lines are partially differentiated (the integrated retailer doesn’t offer the low quality of the good).

(ii) If $c_a \geq c \geq c_c$, there is exclusive dealing in equilibrium. Product lines differentiation is complete, each retailer offering a different quality of the good.

Proof: See appendix E.

Figure 1 summarizes the equilibrium structure of the industry.

![Figure 1](image-url)
If the high quality good has a sufficiently low cost of production, vertical integration is profitable and is the equilibrium structure of the industry, because it induces an equilibrium of partial product lines differentiation. With exclusive dealing, competition between high and low quality is tough. \( D_i \) benefits from the supply of its rival with high quality good because it reduces this interbrand competition without creating too much intrabrand competition on high quality. In other words, vertical integration is an equilibrium because it leads to an increase in the profits of the industry that is not fully captured by the non-integrated retailer.

5 Welfare analysis and policy implications

In this section, we move from positive to normative analysis. The optimal policy for a social welfare maximizing antitrust authority (AA) is to forbid any subset of strategies such that the surplus realized in equilibrium without these strategies in the set of strategies is higher than the surplus realized in equilibrium with these strategies in the set of strategies. Proposition 5 describes the optimal policy for the framework considered in this model.

**Proposition 5** Exclusive dealing should be considered as per se illegal, while the following rule should be used in the treatment of vertical integration: the AA should block a submitted vertical merger project if, previous to the merger, the two retailers sell the high quality good. If, previous to the merger, only one retailer proposes the high quality good, the merger should be blocked if the degree of vertical differentiation is low and it should be allowed if the degree of vertical differentiation is high.

Proof: See appendix F.
Figure 2 summarizes the optimal policy.

It is optimal to ban exclusive dealing because it has either no effect or a negative effect on the social surplus due to the elimination of intrabrand competition on the high quality.

Vertical integration reduces intrabrand competition on the high quality, and thus social welfare, if both retailers are supplied under arm’s length relations. On the contrary, it can be optimal to allow vertical integration if under arm’s length relations only one retailer is supplied with the high quality. Indeed, the integrated firm will supply both retailers. This is however not a sufficient condition, because, whereas under arm’s length relations the supplied retailer is supplied at a wholesale price lower than the marginal cost, vertical integration implies an internal transfer price equal to marginal cost, which reduces the welfare. There is thus a trade-off that is solved in favor of vertical integration when the quality differential is strong enough.
We conclude the analysis of welfare by a discussion of the robustness of proposition 5 if we relax the assumption that contracts are nondiscriminatory. Assume that $A$ receives no acceptable offer in stage 1. If it can discriminate between retailers in stage 2, it offers contracts $(w_1, F_1)$ and $(w_2, F_2)$, with $(w_1, w_2)$ in general different from $(w_D, +\infty)$ and $(w_{DD}, w_{DD})$. This does not imply that we will not observe ED or VI at the equilibrium of the whole game. Indeed, it may be possible for one of the retailers to make an acceptable exclusivity offer to the manufacturer in stage 1. To keep things simple, assume that retailer 1 offers an exclusivity contract with $w = w_D$ and retailer 2 makes no offer. If $A$ refuses this offer, retailer 1 will make a profit equal to $\pi^1 (+\infty, w_2)$. It is thus profitable for retailer 1 to make in stage 1 an acceptable offer that leaves him a profit at least equal to $\pi^1 (+\infty, w_2)$. Note that, if $A$ proposes exclusivity to retailer 1 in stage 2, it must leave him a profit at least equal to $\pi^1 (+\infty, +\infty) > \pi^1 (+\infty, w_2)$. Retailer 1 makes in stage 1 an offer that he would refuse in stage 2. This is why exclusivity may appear in equilibrium. $A$ prefers $((w_1, F_1), (w_2, F_2))$ to an exclusivity contract with $w = w_D$ leaving retailer 1 a profit equal to $\pi^1 (+\infty, +\infty)$, but it may accept in stage 1 an exclusivity contract with $w = w_D$ that leaves retailer 1 a lower profit. The same argument holds for takeover offers. It turns out that, in equilibrium, $A$ accepts in stage 1 either an exclusive dealing contract or a takeover offer and that proposition 4 holds. This does not imply that proposition 5 also holds, since the arm’s length equilibrium is different. What still holds is that exclusive dealing should be banned per se and that a rule of reason approach should be adopted toward vertical integration because it is socially optimal for a set of values of $c$ and $q_L$. 
6 Conclusion

In this paper, we analyze product line differentiation between retailers competing on a vertically differentiated market. The specificity of our model is that we include in the analysis the vertical relations between retailers and manufacturers. As far as we know, this was not done in any previous work. This feature proves to be crucial for the determination of product line differentiation. In particular, we find an equilibrium in which product lines are partially differentiated, which is a new result. Our analysis suggests that exclusive dealing should be banned per se, while a rule of reason approach should be adopted toward vertical integration. This is related to the fact that integration doesn’t necessarily imply foreclosure.

Our model sheds some light on competition policy issues in the satellite TV sector. Consumers have the choice between bundles of channels, but demand is driven mainly by sport and movies. Assuming that each consumer values either sport or films, our model describes the competition between satellite TV operators for the demand of either of these two groups of consumers. Exclusivity of sport events, in particular football matches, is an important and intensely advertised element of competition between European broadcasters. In October 2002, the French professional football league invited bids for the rights on Ligue 1 football matches for 2004-2007. CanalSatellite’s offer included an exclusivity premium of 290 millions euros per year. This offer was accepted in November. Immediately, TPS, the rival operator, referred matter to the Competition Council which, in January, broke the deal6.

Our results support the Council’s decision, since they suggest that if Canal-Satellite had kept exclusive rights on Ligue 1 football matches, the surplus would have been reduced. Between November 2002 and January 2003, the estimated number of clients lost by TPS because of the exclusivity granted to CanalSatellite is between 15000 and 20000. Exclusivity is also central in the relations between major film studios and broadcasters. However, in 2000, the European Commission examined a merger between Vivendi, Canal+ and Seagram that had important implications in the sector\(^7\). Universal studios were part of Seagram and Canal+ controlled CanalSatellite. In its appreciation of the case, the Commission considered that, after the merger, Universal would not be willing to supply rival broadcasters. This view is not supported by our analysis. Indeed, we show that vertical integration emerges only if the integrated firm supplies its downstream rival (although at a potentially high price). We would thus mitigate the Commission’s view on this point\(^8\).

Our model is quite general and can be useful to analyze the retailing of a wide variety of products. Among the issues left open by the present analysis, the most promising avenue for future work is to endogenize quality levels by introducing in the model negotiations between manufacturers and retailers on the characteristics of the products. Indeed, there is a growing evidence that retailers, especially in the food sector, are more and more involved in the definition of products (quality, packaging, ...).

\(^7\)Case n° COMP/M.2050 - Vivendi / Canal+ / Seagram, available at http://europa.eu.int/comm/competition/mergers/cases/decisions/m2050_en.pdf

\(^8\)But we would not reject it, since it is also based on another argument, namely that “Universal's acquisition by Vivendi is likely to have a significant impact on the ability of Canal+ both to renew its existing contracts with the majors and to enter into new contracts with those majors who have not signed with it yet”. This second point is out of the scope of our paper in which the high quality producer is a monopolist.
Appendices

7.1 Appendix A : Equilibrium values of outputs and profits (stage 4)

Inverse demand functions are given by:

\[
\begin{align*}
    p_L(y^1_H, y^2_H, y^1_L, y^2_L) &= (1 - y^1_H - y^2_H - y^1_L - y^2_L) q_L \\
    p_H(y^1_H, y^2_H, y^1_L, y^2_L) &= 1 - y^1_H - y^2_H - (y^1_L + y^2_L) q_L
\end{align*}
\]

We determine the equilibrium strategies of retailers in stage 4. We consider a general case in which discrimination can happen in order to get results that apply when one of the retailers is vertically integrated. Without loss of generality, we assume that \( w_i \leq w_j \). Franchise fees are not relevant at this stage of the game.

The equilibrium strategic profile \( \{y^i_H (w_i, w_j), y^i_L (w_i, w_j), y^j_H (w_j, w_i), y^j_L (w_j, w_i)\} \) satisfies the conditions defining a Nash equilibrium:

\[
\begin{align*}
    (y^i_H, y^i_L) &= \text{ArgMax}_{x_H, x_L} \left[ p_L(x_H, x_L, y^i_H, y^i_L) \right] x_L + \left[ p_H(x_H, x_L, y^i_H, y^i_L) - w_i \right] x_H \\
    (y^j_H, y^j_L) &= \text{ArgMax}_{x_H, x_L} \left[ p_L(y^j_H, y^j_L, x_H, x_L) \right] x_L + \left[ p_H(y^j_H, y^j_L, x_H, x_L) - w_j \right] x_H
\end{align*}
\]

The interior solution to this program (head-to-head competition on both qualities) is

\[
\{y^i_H (w_i, w_j), y^i_L (w_i, w_j), y^j_H (w_j, w_i), y^j_L (w_j, w_i)\} = \left\{ \frac{(1-q_L)-2w_i+w_j}{3(1-q_L)}, \frac{2w_i-w_j}{3(1-q_L)}, \frac{(1-q_L)-2w_i-w_j}{3(1-q_L)}, \frac{2w_j-w_i}{3(1-q_L)} \right\}
\]

The program admits an interior solution iff \( w_j \leq 2w_i \) and \( w_i \leq \frac{1-q_L}{3} \) or \( w_j \leq \frac{w_i+1-q_L}{2} \) and \( 1-q_L \geq w_i \geq \frac{1-q_L}{3} \). We characterize below the corner solutions.

- Partial product line differentiation (on low quality)
\begin{align*}
\{ y_H^i (w_i, w_j), y_L^i (w_i, w_j), y_H^j (w_j, w_i), y_L^j (w_j, w_i) \} \\
= \left\{ \frac{1 + w_i - 2 w_i}{3}, 0, \frac{2(1-q_L)-w_j(4-q_L)+2w_i(1-q_L)}{6(1-q_L)}, \frac{w_j}{2(1-q_L)} \right\}
\end{align*}

Condition of emergence: \( 2w_i \leq w_j \leq \frac{2(1-q_L)(1+w_i)}{4-q_L} \). This condition requires \( w_i \leq \frac{1-q_L}{3} \).

- Complete product line differentiation

\begin{align*}
\{ y_H^i (w_i, w_j), y_L^i (w_i, w_j), y_H^j (w_j, w_i), y_L^j (w_j, w_i) \} \\
= \left\{ \frac{2-q_L-2w_i}{4-q_L}, 0, \frac{1+w_i}{4-q_L} \right\}
\end{align*}

Condition of emergence: \( w_j \geq \frac{2(1-q_L)(1+w_i)}{4-q_L} \) and \( 0 \leq w_i \leq \frac{1-q_L}{3} \).

- Partial product line differentiation (on high quality)

\begin{align*}
\{ y_H^i (w_i, w_j), y_L^i (w_i, w_j), y_H^j (w_j, w_i), y_L^j (w_j, w_i) \} \\
= \left\{ \frac{(1-q_L)-w_i}{2(1-q_L)}, \frac{3w_i-(1-q_L)}{6(1-q_L)}, 0, \frac{1}{3} \right\}
\end{align*}

Condition of emergence: \( w_j \geq \frac{w_i+1-q_L}{2} \) and \( 1 - q_L \geq w_i \geq \frac{1-q_L}{3} \).

- Head-to-head competition on low quality

\begin{align*}
\{ y_H^i (w_i, w_j), y_L^i (w_i, w_j), y_H^j (w_j, w_i), y_L^j (w_j, w_i) \} \\
= \{ 0, \frac{1}{3}, 0, \frac{1}{3} \}
\end{align*}

Condition of emergence: \( w_i \geq 1 - q_L \).

We now come back to the ”no discrimination” framework and consider the two possible cases.

**First case:** \( (w_i, w_j) = (w, +\infty) \)

There is either product line differentiation on high quality or complete product line differentiation or head to head competition on low quality, depending on \( w \).
If $0 \leq w \leq \frac{1-q_L}{3}$, \( \{y_H^i, y_L^i, y_H^j, y_L^j\} = \left\{\frac{2-q_L-2w}{4-q_L}, 0, 0, \frac{1+w}{4-q_L}\right\} \)

Profits (gross of franchise fees) are given by:
\[
\pi^i (w, +\infty), \pi^j (+\infty, w) = \left(\left(\frac{2-q_L-2w}{4-q_L}\right)^2, \left(\frac{1+w}{4-q_L}\right)^2 q_L\right)
\]

If $1 - q_L \geq w \geq \frac{1-q_L}{3}$, \( \{y_H^i, y_L^i, y_H^j, y_L^j\} = \left\{\frac{(1-q_L)-w}{2(1-q_L)}, \frac{3w-(1-q_L)}{6(1-q_L)}, 0, \frac{1}{3}\right\} \)

Profits (gross of franchise fees) are given by:
\[
\pi^i (w, +\infty), \pi^j (+\infty, w) = \left(\frac{5q_L^2-q_L(14-18w)+9(1-w)^2}{36(1-q_L)}, \frac{q_L}{9}\right)
\]

If $w \geq 1 - q_L$, \( \{y_H^i, y_L^i, y_H^j, y_L^j\} = \{0, \frac{1}{3}, 0, \frac{1}{3}\} \)

\[
\pi^i (w, +\infty) = \pi^j (+\infty, w) = \frac{q_L}{9}.
\]

**Second case**: \((w_i, w_j) = (w, w)\)

There is head-to-head competition, either on both qualities or on the low quality, depending on \(w\).

If $0 \leq w \leq 1 - q_L$, \( \{y_H^i, y_L^i, y_H^j, y_L^j\} = \left\{\frac{(1-q_L)-w}{3(1-q_L)}, \frac{w}{3(1-q_L)}, \frac{(1-q_L)-w}{3(1-q_L)}, \frac{w}{3(1-q_L)}\right\} \)

Profits (gross of franchise fees) are given by:
\[
\pi^i (w, w) = \pi^j (w, w) = \frac{(1-w)^2-q_L(1-2w)}{9(1-q_L)}.
\]

If $w \geq 1 - q_L$, \( \{y_H^i, y_L^i, y_H^j, y_L^j\} = \{0, \frac{1}{3}, 0, \frac{1}{3}\} \)

\[
\pi^i (w, w) = \pi^j (w, w) = \frac{q_L}{9}.
\]
7.2 Appendix B : Equilibrium values of wholesale prices

7.2.1 The “one retailer” case

\( w_D \) is the solution of firm \( A \)'s profit maximization program:

\[
\arg\max_w \Phi (w, +\infty)
\]

with \( \Phi (w, +\infty) = (w - c) y_H (w, +\infty) + \pi^t (w, +\infty) - \pi^t (+\infty, +\infty) \).

The expression of \( \Phi (w, +\infty) \) depends on \( w \) as follows (see appendix A):

For \( w \in [0, 1-q_L/3] \), \( \Phi (w, +\infty) = (w - c) \left( \frac{2-q_L-2w}{4-q_L} \right) + \left( \frac{2-q_L-2w}{4-q_L} \right)^2 - \frac{q_L}{9} \).

For \( w \in [1-q_L/3, 1-q_L] \), \( \Phi (w, +\infty) = (w - c) \left( \frac{1-q_L-w}{2(1-q_L)} \right) + \frac{5q_L^2-q_L(14-18w)+9(1-w)^2}{36(1-q_L)} \).

\( \Phi \) is strictly concave on each interval and continuous at \( w = 1-q_L/3 \). We solve the program on each interval and compare the solutions to determine \( w_D \).

The solution to the producer’s program in the one retailer case is:

\[
w_D = \begin{cases} 
0 & \text{for} \ (q_L \leq \tilde{q} \text{ and } c \leq c_0 (q_L) \text{ or } (q_L \geq \tilde{q} \text{ and } c \leq c_2 (q_L)) \\
\frac{2c(4-q_L)-(2-q_L)q_L}{4(2-q_L)} & \text{for} \ (q_L \leq \tilde{q} \text{ and } c \leq c_0 (q_L) \text{ or } (q_L \geq \tilde{q} \text{ and } c \leq c_1 (q_L)) \\
c & \text{for} \ (q_L \leq \tilde{q} \text{ and } c \leq c_1 (q_L) \text{ or } (q_L \geq \tilde{q} \text{ and } c \leq c_2 (q_L))
\end{cases}
\]

with \( \tilde{q} \simeq 0.721 \), \( c_0 (q_L) = \frac{2-q_L}{2(4-q_L)} \), \( c_1 (q_L) = \frac{\sqrt{2-3q_L}+q_L}{3\sqrt{2}} \) and \( c_2 (q_L) = \frac{(1-q_L)\sqrt{3q_L+2\sqrt{L+q_L}}}{3(1-q_L)} \) (see figure below). Hereafter, we define \( c_a \) by

\[
c_a (q_L) = \begin{cases} 
c_1 (q_L) & \text{for } q_L \leq \tilde{q} \\
c_2 (q_L) & \text{for } q_L \geq \tilde{q}
\end{cases}
\]

482
Equilibrium wholesale price with one retailer

7.2.2 The “two retailers” case

\( w_{DD} \) is defined by

\[
w_{DD} = \text{ArgMax}_w \Phi(w, w)
\]

with

\[
\Phi(w, w) = \left( (w - c) y^i_H (w, w) + \pi^i(w, w) - \pi^i(+\infty, w) \right) + \left( (w - c) y^j_H (w, w) + \pi^j(w, w) - \pi^j(+\infty, w) \right)
\]

Because \( y^i_H (w, w) = y^j_H (w, w) \), \( \pi^i(w, w) = \pi^j(w, w) \) and \( \pi^i(+\infty, w) = \pi^j(+\infty, w) \), this simplifies to:

\[
\Phi(w, w) = 2 \left( (w - c) y^i_H (w, w) + \pi^i(w, w) - \pi^i(+\infty, w) \right)
\]
Since \( \pi^i (+\infty, w) \) has a different expression on \([0; \frac{1-q_L}{3}]\) and on \([\frac{1-q_L}{3}; 1-q_L]\),
this is also the case for \( \Phi(w, w) \).

\[
\Phi(w, w) = \begin{cases} 
2 \left[ (w - c) \frac{(1-q_L) - w}{3(1-q_L)} + \frac{(1-w)^2-q_L(1-2w)}{9(1-q_L)} - \left( \frac{1+w}{4-q_L} \right)^2 q_L \right] & \text{for } w \in [0; \frac{1-q_L}{3}] \\
2 \left[ (w - c) \frac{(1-q_L) - w}{3(1-q_L)} + \frac{(1-w)^2-q_L(1-2w)}{9(1-q_L)} - \frac{q_L}{9} \right] & \text{for } w \in [\frac{1-q_L}{3}; 1-q_L]
\end{cases}
\]

\( \Phi(w, w) \) is strictly concave on each interval, continuous at \( w = \frac{1-q_L}{3} \). We solve the program on each interval and compare the solutions to determine \( w_{DD} \).

Finally, the solution to the producer’s program with two retailers is:

\[
w_{DD} = \begin{cases} 
0 & \text{for } (0 \leq c \leq c_3 (q_L) \text{ and } q_L \in [\hat{q}; 1]) \\
\frac{-16-3c(-4+q_L)^2+42q_L-27q_L^2+q_L^3}{2(-32+7q_L+7q_L^2)} & \text{for } (0 \leq c \leq c_4 (q_L) \text{ and } q_L \in [0; \hat{q}]) \\
\frac{1}{4} (1+3c-q_L) & \text{for } c_3 (q_L) \leq c \leq c_4 (q_L) \text{ and } q_L \in [\hat{q}; 1]) \\
\frac{1}{9} \left( -15 + 3q_L + 2\sqrt{2} \sqrt{32 - 7q_L - 7q_L^2} \right) & \text{for } c_4 (q_L) < c \leq 1 - q_L
\end{cases}
\]

with \( \hat{q} = 13 - 3\sqrt{17} \simeq 0.63 \), \( c_3 (q_L) = \frac{(-16+26q_L-q_L^2)(1-q_L)}{3(1-q_L)^2} \) and \( c_4 (q_L) = \frac{1}{9} \left( -15 + 3q_L + 2\sqrt{2} \sqrt{32 - 7q_L - 7q_L^2} \right) \) (see figure below).
7.3 Appendix C: Proof of proposition 1

Defining $c_b$ by

$$c_b(q_L) = \begin{cases} 
-90 + 153q_L - 72q_L^2 + 9q_L^3 + \sqrt{2560 - 9520q_L + 13112q_L^2 - 7290q_L^3 + 277q_L^4 + 1162q_L^5 - 301q_L^6 - 60q_L + 48q_L^2} & \text{on } [0, \overline{q}] \\
\frac{1 - q_L}{\sqrt{q_L}(-138 + 51q_L + 6q_L^2)} + \sqrt{3\sqrt{-640 + 3980q_L - 2140q_L^2 - 557q_L^3 + 322q_L^4 + 7q_L^5}} & \text{on } [\overline{q}, 1]
\end{cases},$$

with $\overline{q} \approx 0.389$, the comparison of $\Pi(w_D, +\infty) - \Pi(w_{DD}, w_{DD})$ with $\pi^i(+\infty, +\infty) - \pi^i(+\infty, w_{DD})$ shows that the number of supplied retailers, the wholesale price and the resulting product lines are as follows:

For $(\widehat{q} \leq q_L \text{ and } 0 \leq c \leq c_3(q_L))$, the manufacturer supplies both retailers and charges $w_{DD} = 0$. The retailers distribute only the high quality.

For $(q_L \leq \widehat{q} \text{ and } 0 \leq c \leq c_b(q_L))$ or $(\widehat{q} \leq q_L \text{ and } c_3(q_L) \leq c \leq c_b(q_L))$, the manufacturer supplies both retailers and charges $w_{DD} = \frac{-16 - 3c(-4 + q_L)^2 + 42q_L - 27q_L^2 + 9q_L^3}{2(-32q_L + 7q_L^2)}$. The retailers distribute both qualities.
For \((c_b(q_L) < c \leq c_a(q_L))\), the manufacturer supplies only one retailer and charges \(w_D = 0\) for \(c \leq c_0(q_L)\), \(w_D = \frac{2c(4-q_L)-(2-q_L)q_L}{4(2-q_L)}\) for \(c \geq c_0(q_L)\). In both cases, product line differentiation is complete, i.e. one retailer proposes the high quality and the other proposes the low quality, since both 0 and \(\frac{2c(4-q_L)-(2-q_L)q_L}{4(2-q_L)}\) are less than \(\frac{1-q_L}{3}\) for the values of \(c\) and \(q_L\) considered.

For \(c_a(q_L) < c\), the manufacturer is indifferent between supplying one retailer, with \(w_D = c\), or two retailers, with \(w_{DD} = \frac{1+3c-q_L}{4}\).

For \(c_a(q_L) < c\), the manufacturer is indifferent between supplying one retailer, with \(w_D = c\), or two retailers, with \(w_{DD} = \frac{1+3c-q_L}{4}\).

Arm’s length relationships-subgame equilibrium

7.4 Appendix D: Proof of proposition 3

Appendix A provides the expressions that we need in this appendix. Simply replace \((w_i,w_j)\) by \((c,w_j)\).

The profit maximization program for the integrated firm is as follows:

\[
\begin{align*}
\max_{w_j,F_j} & \quad \pi_I(c,w_j) + (w_j - c) y_H^I(w_j,c) + F_j \\
\text{st} & \quad \pi^I(w_j,c) - F_j \geq \pi^I(+\infty,c)
\end{align*}
\]
The constraint is binding and the program simplifies to:

\[
\max_{w_j} \pi^I(c, w_j) + (w_j - c) y_H^I(w_j, c) + \pi^j(w_j, c) - \pi^j(+\infty, c)
\]

The solution to this program is:

\[
w^I = \begin{cases} 
\frac{2(1-q_L)+c(2+7q_L)}{4+6q_L} & \text{for } c \leq \frac{2(1-q_L)}{3(2+q_L)} \\
2c & \text{for } \frac{2(1-q_L)}{3(2+q_L)} \leq c \leq \frac{1-q_L}{3} \\
+\infty & \text{for } c \geq \frac{1-q_L}{3}
\end{cases}
\]

with \( F^I = \pi^I(w^I, c) - \pi^j(+\infty, c) \) for \( c < \frac{1-q_L}{3} \) and \( F^I = 0 \) otherwise.

### 7.5 Appendix E: Proof of proposition 4

We show that there exists a function \( c_c \) defined by:

\[
c_c(q_L) = \begin{cases} 
\frac{2q^3 - 62q^2 + 172qL - 112q^2 + 2qL + 8}{2(-120 + 34qL + 49q^2 + q^3)} & \text{on } [0; 0.436] \\
\frac{2(-1+qL)qL(-8-22qL+3q^2+\sqrt{-192+288qL+500q^2+196q^2+5q^4})}{64+16qL-16q^2+16q^3+q^4} & \text{on } [0.436; 1]
\end{cases}
\]

such that, for \( c < c_c(q_L) \), \( \Pi(c, w_I) - \Pi(w_D, +\infty) > 0 \) and vertical integration is an equilibrium, while for \( c > c_c(q_L) \), \( \Pi(c, w_I) - \Pi(w_D, +\infty) < 0 \) and exclusivity is an equilibrium.

### 7.6 Appendix F : Proof of proposition 5

The first step of the proof is to compare the value of the social surplus for each of the possible cases. Let us denote \( AL \) for arm’s length relationships, \( ED \) for exclusive dealing and \( VI \) for vertical integration. We show that :

\( \blacklozenge AL \succeq ED \) for any \( (c, q_L) \).
The function $c_5$ defined by

$$c_5(qL) = \begin{cases} 
-2 + qL & \text{for } qL \leq 0.356 \\
2(1-qL+qL^2) & \text{for } 0.356 < qL \geq 0.915 \\
24-30qL+6qL^2-(4-qL)^2 \sqrt{16-qL} & \text{for } qL \geq 0.915 
\end{cases}$$

is such that

$ED \succ VI$ for $c \in [c_5(qL) ; c_a(qL)]$

while $ED \prec VI$ otherwise

$AL \prec VI$ for $(c \in [c_b(qL) ; c_5(qL)]$ and $qL < 0.344)$

while $AL \succ VI$ otherwise.

Thus, except for values of $c$ and $qL$ such that $(c \in [c_b(qL) ; c_5(qL)]$ and $qL < 0.344)$, $AL$ dominates both $ED$ and $VI$ from the social point of view. Forbidding both $ED$ and $VI$ is thus an optimal policy.

For $(c \in [c_b(qL) ; c_5(qL)]$ and $qL < 0.344)$, $AL$ and $ED$ are equivalent and $AL \prec VI$. Furthermore, for these values of $c$ and $qL$, $VI$ emerges in equilibrium in the game in which it is allowed and $ED$ is forbidden. It is thus optimal to forbid $ED$ and allow $VI$. Putting together these two results leads to the proposition.
8 References


The Duopolistic Firm with Endogenous Risk Control

Case of Persuasive Advertising and Product Differentiation

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This Version: January 2003

Abstract

In this paper, we demonstrate the impacts of uncertainty and mode of competition on duopoly firms when firms choose to follow an equity maximization strategy. We show that equilibrium price and quantity outcomes are significantly different compared to the standard industrial organization models of profit maximization. We also find that firms will optimally switch from quantity to price competition when advertising costs are low, demand is high, or if idiosyncratic risk is reduced.

Keywords: persuasive advertising, product differentiation, quantity (Cournot) competition, price (Bertrand) competition, CAPM, systematic risk, strategic trade policy.

JEL Codes: F12, G12, L13

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1. Introduction

The goal of this paper is to investigate firm pricing and production decisions building from a model of equity value maximization under imperfect competition and uncertainty. The vast majority of industrial organizational theory is constructed on the premise that firms maximize profits. In practice however, firm managers driven by incentive packages tend to focus on equity valuation, which is only partially derived by profitability. Stability of profits and maximizing the anticipated growth in profits represent major goals of most firms. In this paper, we pay attention to the endogenous control of risk when firms can differentiate their products through persuasive advertising. Products differentiated through promotion-induced brand identity usually enjoy less elastic demand leading to stable market shares and possibly more stable revenue flows. As a result, firms view a product as a contribution to capital value through either profit accumulation and/or stabilizing future revenue.

In the present paper, we focus on perceived differences generated from promotional activities of the firm facing uncertain demand.\footnote{Of course, one might also consider the case that firms invest in R&D or innovation activities to differentiate products intrinsically. Evaluating the tradeoff between generating perceived versus intrinsic product differentiations would also be a topic worth pursuing in future research.} For example, with each generation of Nike basketball shoes, Nike, the largest sports shoe company, enjoys tremendous brand differentiation even though its products are not much different from competitor lines such as Adidas.
1.1 Risk Reduction, Systematic Risk, and Imperfect Competition

The basic single-period model of the firm in an imperfectly competitive market usually assumes that the demand function is known with certainty. Furthermore, when uncertain demand is incorporated, it is generally assumed to be exogenous.\(^2\) Alternatively, this paper considers the case that the risk can be partially controlled, which has implications in the equity market of a firm’s capital. The significance of such an behavioral assumption rests on the common observations of firm behavior. Most firms use tools to reduce risk exposure, including those available in the product and financial markets: For instance, 1) hedging transactions in which firms make trades in the financial market to reduce the risk of price or interest rate changes or currency fluctuations, 2) R&D exploratory investment in which firms face technological uncertainty, 3) supply chain management strategies that secure uncertain supplies of raw inputs, and 4) advertising in which firms face demand uncertainty in the product market. Point 4 is the focus of the present paper. In particular, we show the linkages between the persuasive advertising leading to brand loyalty and more inelastic demand, which in turn positively affects equity values. When firms act to reduce risk and maximize profits, significant differences in duopoly price and quantity outcomes are possible.

We evaluate cash flows from a retail product using a certainty equivalence approach. The risk-adjusted net present value of cash flows, realized at the end of the project, is given by the single period Sharpe-Lintner Capital Asset Pricing Model (CAPM), which requires us to further develop the idea of systematic versus nonsystematic risk. In the CAPM of Sharpe (1964), Lintner (1965), and Mossin (1966), systematic (nondiversifiable) risk measures

\(^{2}\)For several aspects of decision making with uncertain demand, see, for example, Baron (1971), Sandmo (1971), Leland (1972), and Klemperer and Meyer (1986).
how rates of return on the security issued by an individual firm relate with that of the market portfolio. The underlying market structure and/or the microeconomic determinants of the product market are given scant attention. In reality, however, most firms operate in the environment where they interact with others continuously as most of market structures are neither purely monopolistic nor perfectly competitive. It is apparent that the strategic interactions among firms may have impacts on their financial variables. In their seminal work, Subrahmanyam and Thomadakis (1980) successfully integrate real and financial views of the firm. Since we consider that only two firms operate in the market, the impacts of market structures on the systematic risk are also discussed.

1.2 Mode of Competition, Product Differentiation, and Advertising

We analyze a differentiated duopoly proposed by Dixit (1979), in which each firm simultaneously chooses either a quantity to produce or a price to charge. The demand structure is linear and restricted to the case of substitute goods. Firms have constant marginal costs and no capacity constraints. In addition, both horizontal and vertical product differentiations are endogenous through advertising. By horizontal differentiation, we mean that brands are not uniformly ranked among all customers given equal prices because of the variety of preferences.

There are several related contributions to the strand of literature on the mode of competition and product differentiation. Singh and Vives (1984) discuss the nature of duopoly competition in Bertrand and Cournot markets. For the case of substitutes, they conclude that Cournot competition always yields higher prices, higher profits, but lower social welfare compared to Bertrand competition. Klemperer and Meyer (1986) consider the role un-
certainty plays for firms to determine the choice variables in the single-period context. The present paper is different from theirs as we emphasize the endogenous uncertainty and product differentiation. Motta (1993) also deals with different modes of competition. However, he only considers the case of vertical and endogenous product differentiation.

There are several views of advertising. According to Kaldor (1950) and Bain (1956), (persuasive) advertising is socially wasteful because it changes tastes and enhances brand loyalty by subjective or perceived product differentiation. Alternatively, Stigler (1961) and Telser (1964) emphasize the informative role of advertising. This view holds that (informative) advertising primarily affects demand by conveying information, lowering search costs and increasing competition. There has been considerable theoretical research on the role of informative advertising. For example, see Nelson (1974), Grossman and Shapiro (1984), Milgrom and Roberts (1986), and Bagwell and Ramey (1988).\(^3\) However, there is relatively little theoretical work on the role of purely persuasive advertising.

To our knowledge, the literature on persuasive advertising is generally not clear about how advertising may affect consumers’ preferences. Becker and Murphy (1993) assume that advertising enters into consumers’ utility function and advertising is complementary to the consumption of the advertised product. More directly, advertising is assumed to “shift demand” for the advertised goods, for example, Dixit and Norman (1978, 1979, 1980), Fisher and McGowan (1979), and Shapiro (1980).

In our model, we consider the case that advertising creates the product differentiation and then explore the role of advertising on in terms of the shift and rotational impacts on demand and reduction in revenue shocks to the

\(^3\)Stigler and Becker (1977) proposed the concept of complementary advertising. See Bagwell (2001) for an excellent survey on different views of advertising.
firm. One closely related model is in Von der Fehr and Stevik (1998) where the authors distinguish the effects of persuasive advertising on preferences in three ways: increases willingness to pay, changes ideal product variety, and increases perceived product differences. However, our model differs from theirs in at least three aspects: First, we consider different modes of competition whereas they consider only price competition. Second, we investigate the impact of uncertainty on firms’ optimal advertising strategies. Third, we use the linear demand of representative agents as opposed to a linear Hotelling model of differentiated goods.

The overall purpose of the research in this paper is to explore risk reduction and its link to firm equity values when firms can differentiate their products through the persuasive advertising. We connect the issues of systematic risk, market power, product differentiation, and mode of competition. The remainder of the paper is organized as follows. Section 2 describes the model and provides some benchmark cases where the advertising can only create subjective product differentiation. Comparative statics and simulations of the basic model are demonstrated in section 3. Conducting simulations is to show what the symmetric pure-strategy equilibrium looks like, as the analytical results are not available. Conclusive remarks and possible extensions are discussed in section 4.

2. The Model

2.1 The Setup

The basic model we investigate is a two-stage sequential duopoly game. In the first period, each firm differentiates its single product through persuasive advertising. In the second period, each firm produces its product with two
factors of production, labor and capital, both of which arrive to the firm from perfectly competitive factor markets. Assume that each firm faces uncertain demand and constant marginal cost that is known with certainty. Both firms’ revenues are subject to a random shock that neither can observe at the time strategic variables are chosen.

The timeline is given in Figure 1. Firm $i$ finances the whole project by borrowing from the investment bank with the risk-free interest rate $r$. The borrowed cash in the first period is $m_i = K_i + g(A_i)$, where $K_i$ is firm $i$’s capital stock for production, $A_i$ is the advertising level, and $g(A_i)$ is the cost of advertising. Firm $i$ learns $g(A_i)$ before choosing $A_i$. Note that capital is a numeraire in the model. In the second period, the wealth of firm $i$ is $W_i = \tilde{R}_i - wL_i - (1 + r)m_i$, where $\tilde{R}_i$ is the total revenue of firm $i$, $w$ is the wage rate, and $L_i$ is the input of labor. As a result, the net present discounted value of the undertaken project in period 1 is

$$NPV_i = \frac{W_i}{1 + r} = \frac{\tilde{R}_i - wL_i}{1 + r} - K_i - g(A_i)$$

---

4In this paper, we do not deal with the conflict interests between debt-holders and equity-holders. We assume that the decisions are made by owner-managers or that there exists no agency problem between investors and managers.

5The timing of learning $g(A_i)$ is crucial in the model. If firms know the cost structure of advertising after choosing $A_i$, they must have an expectation over $g(A_i)$. This creates issues of incomplete information.
According to Equation (1), the total cost of production valued in the first period is

\[ C_i = \frac{wL_i}{1 + r} + K_i \]

That is, we assume that the firms build up some amount of capital stock\(^6\) in the first period and pay for the employment of labor in the second period. In other words, capital is purchased in advance of production while labor is purchased as production proceeds. Finally, we assume \( wL_i = cX_i \), where \( c \) is the constant marginal cost and \( X_i \) is quantity produced.\(^7\)

On the revenue side, firm \( i \)'s total revenue is given by

\[ \tilde{R}_i = p_iX_i(1 + \tilde{\epsilon}), E(\tilde{\epsilon}) = 0, Var(\tilde{\epsilon}) = \sigma^2_e \] (2)

where the random variable \( \tilde{\epsilon} \) is an idiosyncratic shock on the revenue of firm \( i \). Without loss of generality, we assume it to have mean zero. \( \sigma_e \) is the standard deviation of shock.\(^8\)

Suppose firms face a linear inverse demand function\(^9\) in period 2.

\[ p_i = \alpha - (b - \gamma)X_i - \gamma X_j, \ b/2 \geq \gamma \geq 0, i, j = 1, 2, i \neq j \] (3)

\( \gamma \geq 0 \) implies directly the case of substitutes and \( b/2 \geq \gamma \) implies that the own effect \( (b - \gamma) \) is at least as large as the cross effect \( (\gamma) \).

According to this setting, there exist two effects when \( \gamma \) changes, i.e., a shift in demand and a rotation of demand curve. For example, when products

\(^6\)\( K_i \) is sufficiently large, so there is no capacity constraint. On the other hand, it cannot be too large for non-negative profits. The fixed capital stock in the first period is assumed. We will discuss the relevant extensions in the last section.

\(^7\)This assumption is still valid under Bertrand competition as long as the marginal cost is constant. See Baron (1971) and Klemperer and Meyer (1986).

\(^8\)We further assume for every demand curve that the support of the noise is small enough so that negative revenue never occurs.

\(^9\)See also Dixit (1979), Singh and Vives (1984), and Vives (1999).
are more differentiated, $\gamma$ decreases, the residual demand for firm $i$ is

$$p_i = (\alpha - \gamma X_j) - (b - \gamma)X_i$$

where both the intercept and the absolute value of slope of demand are increased. These two effects are depicted in Figure 2.

It is worthwhile to note that the aggregate demand in the industry does not change when $\gamma$ varies. As a result, any activities engaging in changing product differentiation, for instance, advertising in this paper, change the substitutability between products, but do not affect the size of the market. We will investigate the case of changes in the market size in section 4.

We also define $\delta = \gamma/(b - \gamma)$ to model the degree of (horizontal) product differentiation.\(^{10}\) The more differentiated the products ($\delta \to 0$), the smaller effect of change in quantity (price) of brand $j$ on the price (quantity) of brand

\(^{10}\)Note that our definition is different from that in the literature, for instance, Shy (1995).
Note that by assumption $0 \leq \delta \leq 1$. Therefore, we rewrite (3) as

$$p_i = \alpha - \frac{b}{1 + \delta} (X_i + \delta X_j), \quad 1 \geq \delta \geq 0, i, j = 1, 2, i \neq j$$  \hspace{1cm} (4)

Turning now to the important issue of product differentiation, we characterize the perceived product differences in the following manner.

Let the degree of differentiation be $\delta = \bar{\delta} - A_i - A_j$, where $\bar{\delta}$ is the initial degree of differentiation, $A_i$ and $A_j$ are advertising levels of firm $i$ and $j$ respectively.\(^{12}\) Since we consider the case where products are ex-ante homogeneous, $\bar{\delta} = 1$.\(^{13}\) Intuitively, each firm has more market power when its product is more differentiated. It is reasonable to expect that both firms tacitly cooperate in advertising to earn more increased equity values. This will be clear later in the paper. On the cost side, suppose the cost of advertising is the same for both firms and is given by

$$g(A_i) = \frac{\mu A_i^n}{n}, \quad i = 1, 2.$$ \hspace{1cm} (5)

where $\mu \geq 0, n > 1$.\(^{14}\) Note that a fixed cost of advertising is assumed. That is, this cost is sunk in the first period and it is not varied with the quantity produced in the second period.

### 2.2 CAPM

Because money capital raised in a financial market is characterized by Sharpe-Lintner equilibrium, we will derive some useful results and the formula of

\(^{11}\)This statement will be more clear when we derive the corresponding demand function in section 2.3.

\(^{12}\)Considering a symmetric equilibrium $A_j = A_i, 0 \leq A_j = A_i \leq \bar{\delta}/2$.

\(^{13}\)We can relax this assumption to see the effect of the initial degree of differentiation on the optimal advertising level. Further, each consumer may have a different degree of initial differentiation. We may characterize this by employing a distribution on the initial differentiation. However, our qualitative results still hold under these extensive settings.

\(^{14}\)We will use a quadratic cost function in our simulations; that is, $n = 2$. 
systematic risk \((\beta)\) in this section. By CAPM, the firm’s market value is given by:

\[
v_i = \frac{E(\tilde{R}_i) - \lambda \text{Cov}(\tilde{R}_i, \tilde{r}_m)}{1 + r} = \frac{\text{wL}_i}{1 + r}, \quad \text{where} \quad \lambda = \frac{E(\tilde{r}_m) - r}{\sigma_m^2},
\]

\(\sigma_m\) is the standard deviation of the return of market portfolio and \(\lambda\) is the market price of risk per unit of variance.\(^{15}\)

Because \(\text{Cov}(\tilde{R}_i, \tilde{r}_m) = \text{Cov}(\tilde{e}, \tilde{r}_m) R_i\) and \(\text{wL}_i = cX_i\),

\[
v_i = \frac{R_i(1 - \lambda \text{Cov}(\tilde{e}, \tilde{r}_m))}{1 + r} = \frac{\text{wL}_i}{1 + r} = \frac{\phi R_i - \text{wL}_i}{1 + r} = \frac{\phi X_i (p_i - d)}{1 + r}
\]

where certainty equivalent \(\phi = 1 - \lambda \text{Cov}(\tilde{e}, \tilde{r}_m)\). In general, \(\phi \in [0, 1]^{16}\) and \(d = c/\phi\) adjusted marginal cost.\(^{17}\) To avoid a trivial result, we assume \(\alpha > d\).

By CAPM, the systematic risk

\[
\beta_i = \frac{\text{Cov}(\tilde{R}_i, \tilde{r}_m)}{\text{Var}(\tilde{r}_m)} = \frac{\text{Cov}(\tilde{R}_i, \tilde{r}_m)}{v_i \text{Var}(\tilde{r}_m)} = \frac{R_i \text{Cov}(\tilde{e}, \tilde{r}_m)}{\phi R_i \text{Var}(\tilde{r}_m)}
\]

We can compute \(R_i/v_i\) as follows using the middle component from (6)

\[
\frac{R_i}{v_i} = \frac{(1 + r) R_i}{\phi R_i - \text{wL}_i} = \frac{\phi p_i X_i}{\phi p_i c} = \frac{1 + r}{\phi} \frac{p_i}{p_i - d}
\]

which is the inverse of adjusted price-cost margin (Lerner index).

\(^{15}\)Dixit and Pindyck (1994) use the New York Stock Exchange Index as the market, \(E(\tilde{r}_m) - r \approx 0.08\) and standard deviation \(\sigma_m \approx 0.2\), so \(\lambda \approx 2\). Note that they measure the market price of risk based on per unit of standard deviation. See also Kaplan and Ruback (1995) and Brealey and Myers (2000).

\(^{16}\)A parallel literature studies the decisions of firms under uncertainty. The firm is assumed to have a utility function and maximizes expected utility in the sense of von Neumann-Morgenstern, for example, Sandmo (1971) and Leland (1972). The justification of this approach can be found in Sandmo (1971). However, the difficulty of constructing a utility function of firms remains, see Fama and Miller (1972), pp. 67-68.

\(^{17}\)We may incorporate cost uncertainty in equation (6) by defining \(\theta\) as a certainty equivalent parameter on the cost side. For a strictly convex cost function, \(\theta > 1\). After redefining \(d = c\theta/\phi\), equation (6) still works well as long as two sources of uncertainty are independent of each other. The new adjusted marginal cost is higher than the original one. However, because we assume the cost function is linear, there is no need to adjust the cost uncertainty.
Let $Cov(\tilde{e}, \tilde{r}_m) = \rho \sigma_e \sigma_m$ and $Var(\tilde{r}_m) = \sigma_m^2$, where $\rho$ is the correlation coefficient between the revenue shock and the return of market portfolio. Moreover, certainty equivalent $\phi = 1 - \lambda Cov(\tilde{e}, \tilde{r}_m) = 1 - \lambda \rho \sigma_e \sigma_m$. Therefore, we have

$$\beta_i = \frac{\rho \sigma_e}{\sigma_m} \frac{1 + r}{\phi} \frac{p_i}{p_i - d} = \left\{ \frac{1 + r}{\rho \sigma_e - \lambda \sigma_m^2} \right\} \frac{p_i}{p_i - d}$$

Then, we will focus on the following two equations.

$$v_i = \frac{1}{1 + r} \frac{1 - \lambda \rho \sigma_e \sigma_m}{p_i - d} X_i(p_i - d) \quad (7)$$

$$\frac{1}{\beta_i} = \frac{1}{1 + r} \frac{1 - \lambda \sigma_m^2}{p_i}(1 - \frac{d}{p_i}) \quad (8)$$

It is worthwhile to discuss the role of production cost in equation (8). In the industrial organization literature, the production cost is generally normalized to zero for simplicity of analysis and virtually no attention is paid to the financial market. The connection between the financial market and the production market cannot be clearly shown if we neglect the effect of production cost. For example, if $c = 0$, then $d = 0$ implying that $\beta_i$ is independent of firm’s pricing strategy. Our model suggests that firm’s pricing strategy can influence its systematic risk level.

Since the model assumes products are perfectly homogeneous but allows advertising to create subjective differentiation, as mentioned before, a two-stage game is considered. To solve the model, we start from the last stage of the game by using the backward induction.

### 2.3 Different Modes of Competition in Period Two

Under quantity competition, both firms choose quantity strategies simultaneously taking each other’s strategy as given. Substituting equation (4) into...
the value of firm, we get
\[ v_i = \frac{\phi X_i(p_i - d)}{1 + r} = \frac{\phi}{1 + r} X_i \left[ \alpha - \frac{b}{1 + \delta} (X_i + \delta X_j) - d \right] \]  
\[ (9) \]
Taking a derivative with respect to \( X_i \) and rearranging yield
\[ (\alpha - d) \frac{1 + \delta}{b} = 2X_i + \delta X_j \]
\[ (10) \]
Equation (10) implicitly defines firm \( i \)'s reaction function. Let \( \alpha^c(\delta) = (\alpha - d) \frac{1 + \delta}{b} \). Figure 3 illustrates reaction curves of both firms. Figure 3 also shows the impacts of an increase in product differentiation. By the definition of \( \alpha^c(\delta) \), we know
\[ \frac{\partial \alpha^c}{\partial \delta} > 0, \quad \frac{\partial (\alpha^c/\delta)}{\partial \delta} < 0 \]
An increase in product differentiation implies that \( \delta \) decreases, \( \alpha^c \) decreases and \( \alpha^c/\delta \) increases. These changes are shown by dash lines in Figure 3.

Solving for the optimal quantity and price yields
\[ X_i^c = \frac{(\alpha - d)(1 + \delta)}{b(2 + \delta)} \],  
\[ p_i^c = \frac{\alpha + (1 + \delta)d}{2 + \delta} \]
\[ (11) \]
Therefore, the value and inverse of beta of the firm in Cournot equilibrium become

\[ v_i^c = \frac{\phi(\alpha - d)^2}{b(1 + r)} \frac{1 + \delta}{(2 + \delta)^2} \] (12)

\[ \frac{1}{\beta_i^c} = \frac{1}{1 + r} \left[ \frac{1}{\rho \sigma_e} - \lambda \sigma_m \right] \left[ 1 - \frac{(2 + \delta)d}{\alpha + (1 + \delta)d} \right] \] (13)

Turning now to competition in price space, by equation (4), we have the corresponding demand function

\[ X_i = \frac{1}{b(1 - \delta)}[\alpha(1 - \delta) - p_i + \delta p_j] \] (14)

Substituting (14) into (7) we get

\[ v_i = \frac{\phi X_i(p_i - d)}{1 + r} = \frac{\phi}{1 + r \frac{1}{b(1 - \delta)}}[\alpha(1 - \delta) - p_i + \delta p_j](p_i - d) \] (15)

Solving the first order condition of (15) and rearranging, we get

\[ 2p_i = \delta p_j + \alpha(1 - \delta) + d \] (16)

Equation (16) implicitly defines firm \( i \)'s reaction function. Let \( \alpha^B(\delta) = \alpha(1 - \delta) + d \). Figure 4 illustrates reaction curves of both firms. It also shows the impacts of a decrease in \( \delta \).

Therefore, in equilibrium, we get

\[ p_i^B = \frac{\alpha(1 - \delta) + d}{2 - \delta}, \quad X_i^B = \frac{\alpha - d}{b(2 - \delta)} \] (17)

\[ v_i^B = \frac{\phi(\alpha - d)^2}{b(1 + r)} \frac{1 - \delta}{(2 - \delta)^2} \] (18)

\[ \frac{1}{\beta_i^B} = \frac{1}{1 + r} \left[ \frac{1}{\rho \sigma_e} - \lambda \sigma_m \right] \left[ 1 - \frac{(2 - \delta)d}{\alpha(1 - \delta) + d} \right] \] (19)
2.4 The Effects of Changes in Degree of Product Differentiation

In this section we explore fully the role of product differentiation. Before doing so, we first present two extreme benchmark cases.

(a) Minimal Differentiation

Initially the industry products are homogeneous. Firms can select advertising to differentiate at a known price and impact on the market. As $\mu$ increases in (5), there comes a point in which advertising is cost prohibitive and products remain homogeneous. The competition will drive prices down to the usual cases in which prices equal marginal costs under the price competition or typical Cournot results under the quantity competition.

When $\mu \to \infty$, $\delta = 1$. In this instance, we get

$$X_i^c = \frac{2(\alpha - d)}{3b}, \quad p_i^c = \frac{\alpha + 2d}{3}, \quad v_i^c = \frac{2\phi(\alpha - d)^2}{9b(1 + r)},$$

$$\frac{1}{\beta_i^c} = \frac{1}{1 + r} \left[ \frac{1}{\rho \sigma_e} - \lambda \sigma_m^2 \right] \left[ \frac{\alpha - d}{\alpha + 2d} \right]$$
\[ X_i^B = \frac{\alpha - d}{b}, \quad p_i^B = d, \quad v_i^B = 0, \quad \frac{1}{\beta_i^B} = 0 \]

Under price competition, each firm has zero value and incurs the infinite systematic risk. This is not likely the case. Economists usually ignore the financial variables as well as the interplay between financial and product markets. This benchmark suggests that the standard Bertrand duopoly model with homogeneous products is not appropriate if we incorporate the concerns of financial variables.

(b) Maximal Differentiation

Suppose firms can differentiate their products without incurring any costs, i.e., \( \mu = 0 \). It is easy to see that all \( v_i, p_i, \) and \( 1/\beta_i \) are decreasing in \( \delta \). That is, firms will differentiate goods such that their products are independent of each other, which obviously generates the monopoly outcome for price and quantity competition.

\[
\begin{align*}
X_i^c &= X_i^B = \frac{\alpha - d}{2b} \\
p_i^c &= p_i^B = \frac{\alpha + d}{2} \\
v_i^c &= v_i^B = \frac{\phi(\alpha - d)^2}{4b(1 + r)} \\
\frac{1}{\beta_i^c} &= \frac{1}{\beta_i^B} = \frac{1}{1 + r} \left[ \frac{1}{\rho} - \frac{\lambda \sigma_m^2}{\alpha + d} \right] \left[ \frac{\alpha - d}{\alpha + d} \right]
\end{align*}
\]

The results of price competition and quantity competition coincide and represent the joint profit maximization. Each firm performs just like a monopolist on his product.\(^{18}\)

\(^{18}\)It is also interesting to compare our model with the spatial competition of a “linear city.” In terms of spatial competition (e.g., Hotelling model), the equilibrium has the two firms locating at the two extremes of the city (maximal differentiation). Since each firm incurs no costs when choosing the location, each firm locates as far from its rival as possible in order not to trigger a low price, and thus price competition is not so harsh. Assuming
(c) Intermediate Cases

For intermediate cases where $0 < \delta < 1$, with equation (11), (12), (17), and (18), it is easy to get the following lemma.

**Lemma 1** \( \frac{\partial X_j}{\partial \delta} > 0, \frac{\partial p_j}{\partial \delta} < 0, \frac{\partial v_j}{\partial \delta} < 0 \), where \( j = c, B \).

**Proof.** It is straightforward to derive this by differentiating (11), (12), (17), and (18) with respect to \( \delta \). ■

Lemma 1 implies that both Bertrand and Cournot firms prefer producing more differentiated goods. The more differentiated the products, the less \( \delta \), and then the more \( v_c \) and \( v_B \). Lemma 1 is directly linked to benchmark (b) of maximal differentiation where differentiating products is costless.

**2.5 Comparison of Quantity Competition and Price Competition**

In addition, comparing Cournot competition with Bertrand competition, we have the following proposition.

**Proposition 1** Suppose firms face the same demand and the degree of product differentiation is exogenous,

(a) We arrive at the standard industrial organization results. That is, Cournot firms produce less quantities but charge higher prices than Bertrand firms, and therefore obtain higher profits. The differences between Bertrand and Cournot in terms of prices, quantities, and profits are widest when products are homogeneous \( (\delta = 1) \) and smallest when products are totally differentiated \( (\delta = 0) \).

(b) When firms maximize capital value, the differences of prices, quantities, representative consumers in the markets allows us to analyze the price competition as well as the quantity competition, and then their differences without concern for market coverage.
and profits are less divergent than standard industrial organization results of
duopolistic competition.

**Proof.** (a) From equation (11), (17), and $0 \leq \delta \leq 1$, we have

$$
\Delta p = p_i^c - p_i^B = \frac{\alpha + (1 + \delta)d}{2 + \delta} - \frac{\alpha(1 - \delta) + d}{2 - \delta} = \frac{\delta^2(\alpha - d)}{4 - \delta^2} \geq 0 \quad (24)
$$

$$
\Delta X = X_i^c - X_i^B = \frac{(\alpha - d)(1 + \delta)}{b(2 + \delta)} - \frac{\alpha - d}{b(2 - \delta)} = -\frac{(\alpha - d)\delta^2}{b(2 + \delta)(2 - \delta)} \leq 0 \quad (25)
$$

Moreover, by equation (12) and (18),

$$
\Delta v = v_i^c - v_i^B = \phi(\alpha - d)^2 \frac{2\delta^3}{b(1 + r)^2(2 + \delta)^2} \geq 0 \quad (26)
$$

Together with

$$
\frac{\partial \Delta p}{\partial \delta} > 0, \quad \frac{\partial \Delta X}{\partial \delta} < 0, \quad \frac{\partial \Delta v}{\partial \delta} > 0, \quad \forall \delta \in (0, 1].
$$

The results of part (a) follow.

(b) Without uncertainty, the differences in (24)-(26) turn out to be

$$
\Delta p^* = \frac{\delta^2(\alpha - c)}{4 - \delta^2}, \quad \Delta X^* = -\frac{(\alpha - c)\delta^2}{b(2 + \delta)(2 - \delta)}, \quad \Delta v^* = \frac{(\alpha - c)^2 2\delta^3}{b(1 + r) (2 + \delta)^2(2 - \delta)^2}
$$

Because $\phi < 1$ in the uncertain case, we know that $\alpha - d = \alpha - c/\phi < \alpha - c$ and $\phi(\alpha - d)^2 < (\alpha - d)^2 < (\alpha - c)^2$. Thus, $|\Delta p| < |\Delta p^*|$, $|\Delta X| < |\Delta X^*|$, and $|\Delta v| < |\Delta v^*|$. ■

Part (a) of proposition 1 formally presents the benchmark cases in section 2.4. $\Delta p \geq 0$, $\Delta X \leq 0$, and $\Delta v \geq 0$ are typical results of Singh and Vives.
However, we will show that these results may not hold if firms can choose the degree of differentiation of their products. That is, firms may choose different levels of differentiation under different modes of competition, and therefore charge higher prices and yield more profits under the price competition in some ranges of parameters.

2.6 Risk Reduction

Under the assumption of (2), we get the variance of revenue

$$Var(\hat{R}_i) = R_i^2 \sigma_e^2$$

Therefore, the standard deviation of revenue is $\sigma_R = R_i \sigma_e$. Suppose $\sigma_e$ is fixed, $\sigma_R$, the risk facing the firm is increasing in total revenue $R_i$. From equation (11) and (17) we get

$$R_i^c = p_i^c X_i^c = \frac{\alpha - d}{b} [\frac{(1 + \delta)(\alpha + (1 + \delta)d)}{(2 + \delta)^2}]$$ (27)

$$R_i^B = p_i^B X_i^B = \frac{\alpha - d}{b} [\frac{\alpha(1 - \delta) + d}{(2 - \delta)^2}]$$ (28)

By equation (27) and (28), we have lemma 2.

**Lemma 2** For all $\delta \in [0, 1]$ and $\alpha > d$,

(a) $R_i^c$ is concave in $\delta$. $R_i^c$ has a maximum with an interior $\delta^c = 2d/(\alpha - 2d)$ if $d \leq \alpha/4$; with a corner $\delta^c = 1$ otherwise.

(b) The sufficient condition for a concave $R_i^B$ in $\delta$ is $d < \alpha/3$. $R_i^B$ has a local maximum at $\delta^B = 2d/\alpha$. $\delta^B$ is interior if $d \leq \alpha/2$.

**Proof.** (a) From equation (27),

$$\frac{\partial R_i^c}{\partial \delta} = \frac{\alpha - d}{b} \left[\frac{2d - (\alpha - 2d)\delta}{(2 + \delta)^3}\right]$$ (29)

$$\frac{\partial^2 R_i^c}{\partial \delta^2} = \frac{2(\alpha - d)}{b} \left[\frac{-\delta(1 - \delta)\alpha - d(1 + 2\delta)}{(2 + \delta)^4}\right] < 0, \ \forall \delta \in [0, 1]$$ (30)
\( d \leq \alpha/4 \) guarantees an interior solution because \( 0 \leq \delta^c = 2d/(\alpha - 2d) \leq 1 \).

(b) Similarly, by equation (28),

\[
\frac{\partial R^B_i}{\partial \delta} = \frac{\alpha - d}{b} \left[ 2d - \delta (2 - \alpha) \right]
\]

\( \frac{\partial^2 R^B_i}{\partial \delta^2} = \frac{2(\alpha - d)}{b} \left[ \frac{-(\alpha - 3d) - \alpha \delta}{(2 - \delta)^4} \right]
\]

\( d < \alpha/3 \) ensures \( \frac{\partial^2 R^B_i}{\partial \delta^2} < 0 \). Plugging \( \delta^B \) into equation (32), it is easy to see that \( \frac{\partial^2 R^B_i(\delta^B)}{\partial \delta^2} < 0 \). Moreover, \( d \leq \alpha/2 \) implies \( 0 \leq \delta^B = \frac{2d}{\alpha} \leq 1 \).

From lemma 2, we have the following proposition:

**Proposition 2** For any given \( \sigma_e \) and \( d \leq \alpha/4 \), \( \sigma^c_R \) and \( \sigma^B_R \) are concave in \( \delta \) for all \( \delta \in [0, 1] \). \( \sigma^c_R \) and \( \sigma^B_R \) have maxima with interior \( \delta^c \) and \( \delta^B \) respectively.

Proposition 2 implies that as long as the adjusted marginal cost is sufficiently small compared to demand, the risk of the firm is concave in the degree of product differentiation under either Bertrand or Cournot competition. It turns out that the risk of the firm, \( \sigma^c_R \) is increasing in \( \delta \) if \( \delta \in [0, \delta^c) \), but decreasing in \( \delta \) if \( \delta \in (\delta^c, 1] \). Likewise, \( \sigma^B_R \) is increasing in \( \delta \) if \( \delta \in [0, \delta^B) \), but decreasing in \( \delta \) if \( \delta \in (\delta^B, 1] \). As a result, departing from the case of homogeneous products where \( \delta = 1 \), as the product is more differentiated, that is, \( \delta \) decreases, the risk of firm increases first and then decreases. Figure 5 depicts this feature.

Moreover, it is easy to check that \( \delta^c > \delta^B \) which implies that Cournot firms have a wider range of product differentiation for risk reduction than Bertrand firms. On the other hand, Bertrand firms may have incentives to engage in more aggressive advertising activities than Cournot firms from the point of view of risk reduction.

We conclude that under the setting of our model where the sources of uncertainty come only from the demand side, revenue maximization cannot
be an objective that firms appeal because it is associated with risk magnification. Together with lemma 1, proposition 2 also demonstrates that profit maximization and risk reduction are congruent by differentiating products. Therefore, profit maximization always implies risk reduction as long as the costs of differentiating products are not too high. That is, $\mu$ in equation (5) is small enough such that optimal $\delta^*$ in $[0, \delta^c)$ for Cournot firms or in $[0, \delta^B)$ for Bertrand firms.

In addition, from Lemma 2 we can also examine the case when $\alpha/4 < d < \alpha/3$. In this case, $\delta^c = 1$ and $\delta^B$ is interior and higher. This means that risk reduction for Cournot firms starts immediately from $\delta = 1$ and happens earlier for Bertrand firms. It also implies that for any given $\alpha$, risk reduction plays a more important role with higher adjusted production cost $d$, i.e., higher marginal cost of production ($c$) and/or more risky market (smaller certainty equivalent $\phi$).
2.7 The Advertising Game - Optimal Degree of Differentiation

Up to this point, we have only evaluated the way uncertainty affects quantity and price setting outcomes in a capital value model. Now we move backwards to period 1 of the timeline described in Figure 1 in which optimal advertising and thus the degree of differentiation for each mode of competition are solved.

In the first period, firm $i$ chooses $A_i$ given its rival $j$’s strategy $A_j$. Substituting (12) and (5) into (1) yields the net present discounted value of the undertaken project under quantity competition

$$NPV_i^c = \frac{\phi(\alpha - d)^2}{b(1+r)} \frac{2 - A_i - A_j}{(3 - A_i - A_j)^2} - K_i - \frac{\mu A_i^n}{n}, \quad i, j = 1, 2, i \neq j$$

The first order condition for firm $i$ is

$$\frac{\partial NPV_i^c}{\partial A_i} = \frac{\phi(\alpha - d)^2}{b(1+r)} \frac{1 - A_i - A_j}{(3 - A_i - A_j)^3} - \mu A_i^{n-1} = 0, \quad i, j = 1, 2, i \neq j \quad (33)$$

From equation (18), the net present discounted value of firm $i$ under price competition is

$$NPV_i^B = \frac{\phi(\alpha - d)^2}{b(1+r)} \frac{A_i + A_j}{(1 + A_i + A_j)^2} - K_i - \frac{\mu A_i^n}{n}, \quad i, j = 1, 2, i \neq j$$

The first order condition is

$$\frac{\partial NPV_i^B}{\partial A_i} = \frac{\phi(\alpha - d)^2}{b(1+r)} \frac{1 - A_i - A_j}{(1 + A_i + A_j)^3} - \mu A_i^{n-1} = 0, \quad i, j = 1, 2, i \neq j \quad (34)$$

In a symmetric equilibrium, $A_j = A_i$. Solving (33) for $A_i$ and $A_j$, we obtain optimal advertising, associated price, quantity, value of firm, and systematic risk under quantity competition. Similarly, we can solve (34) for optimal advertising and other variables under price competition. Basically, the solution for $A_i$ involves a quartic equation in each first order condition if $n = 2$ is assumed. It is not possible to obtain a closed-form solution from equation (33) or (34). Therefore, we will proceed toward a simple simulation approach.
Before doing so, we first examine the comparative statics of changes in the exogenous parameters on endogenous variables in the system.

3. Comparative Statics and Simulations of the Basic Model

In this section, we explore the effects of changes in the exogenous parameters on the equilibrium prices, quantities, and advertising levels as well as firm’s value and systematic risk. These effects are most easily derived by totally differentiating equation (33) and (34). According to the envelope theorem, we may simplify our computations by rearranging (33) and (34) respectively as:

\[
\frac{\phi(\alpha - d)^2}{\mu b(1 + r)} = \frac{A_i(3 - A_i - A_j)}{1 - A_i - A_j} \tag{35}
\]

\[
\frac{\phi(\alpha - d)^2}{\mu b(1 + r)} = \frac{A_i(1 + A_i + A_j)}{1 - A_i - A_j} \tag{36}
\]

Note that \( n = 2 \) and \( d = c/\phi \). Because \( \lambda = \frac{E(\tilde{r}_m) - r}{\sigma_m^2} \),

\[
\phi = 1 - \lambda \rho \sigma_e \sigma_m = 1 - [E(\tilde{r}_m) - r] \frac{\rho \sigma_e}{\sigma_m} \tag{37}
\]

We want to see how the change in \( \alpha, b, \rho \sigma_e, \sigma_m, E(\tilde{r}_m) - r, c, \) or \( \mu \) has an impact on \( A_i \). Because in the symmetric equilibrium \( A_j = A_i \), \( \frac{\partial A_j}{\partial z} = \frac{\partial A_i}{\partial z} \),

where \( z = \alpha, b, \rho \sigma_e, \sigma_m, E(\tilde{r}_m) - r, c, \) and \( \mu \), we need the following lemma to get a monotonic impact on the optimal advertising level.

**Lemma 3** The right hand sides of equations (35) and (36) are monotonically increasing if \( A_i \in [0, 0.5) \).

**Proof.** (a) Using the fact that \( A_j = A_i \) in equilibrium and taking a derivative
with respect to $A_i$ on the right hand side of (35) yield

$$\frac{d}{dA_i} A_i(3 - 2A_i)^3 = \frac{(3 - 2A_i)^2(3 - 8A_i + 12A_i^2)}{(1 - 2A_i)^2}$$

(38)

It is easy to check that $3 - 8A_i + 12A_i^2 > 1/3$. Therefore, equation (38) is strictly greater than 0 for all $A_i \in [0, 0.5)$. This completes the proof for Cournot competition.

(b) From equation (36), we have

$$\frac{d}{dA_i} A_i(1 + 2A_i)^3 = \frac{(1 + 2A_i)^2(1 + 8A_i - 12A_i^2)}{(1 - 2A_i)^2}$$

(39)

$1 + 8A_i - 12A_i^2 \geq 1, \forall A_i \in [0, 0.5)$. As a result, equation (39) is strictly greater than 0 for all $A_i \in [0, 0.5)$. Part (b) completes the proof for Bertrand competition.

---

It is worth considering the unique role of advertising here. In our model, advertising serves as a vehicle to shift and rotate the demand curve. Because of this specific setting, the income effect never dominates the substitution effect even though the slope of demand curve is sufficiently high. Therefore, advertising performs like a normal good. The above lemma indicates that, subject to the costs, advertising is always beneficial to the value of firm.

3.1 Impacts on $A_i$

With lemma 3, we are ready to examine the impacts of $z$ on $A_i$.

**Proposition 3** Assuming that $\alpha > d$, an increase in $\alpha$ or $\sigma_m$ will increase the equilibrium $A_i$, while an increase in $b$, $\rho\sigma_e$, $E(\tilde{r}_m) - r$, $c$, or $\mu$ will decrease the equilibrium $A_i$. 

514
Proof. (a) Using the fact that $A_j = A_i$ and differentiating equation (35) with respect to $\alpha$, we have

$$\frac{2\phi(\alpha - d)}{\mu b(1 + r)} = \frac{(3 - 2A_i)^2(3 - 8A_i + 12A_i^2)}{(1 - 2A_i)^2} \frac{\partial A_i}{\partial \alpha}$$

Using lemma 3 and $\alpha > d$, we have $\frac{\partial A_c}{\partial \alpha} > 0$. The parallel logic can be applied to equation (36), which yields $\frac{\partial A_B}{\partial \alpha} > 0$.

(b) Now, applying the relations in equation (37), we can easily get the results that the left hand sides of equation (35) and (36) are increasing in $\sigma_m$ but decreasing in $b$, $\rho\sigma_e$, $E(\tilde{r}_m) - r$, $c$, and $\mu$.

(c) Following the similar steps in part (a) of the proof, it is straightforward to obtain the rest of conclusions. ■

The results of proposition 3 are presented in column (1) of Table 1. Proposition 3 shows that the equilibrium advertising level increases as its marginal benefit raises whereas the converse is true if the marginal benefit of advertising declines.

Taking $\alpha$ as an example, an increase in consumers’ willingness to pay $\alpha$ leads to an increase in the equilibrium advertising level. This is because shift out in demand tends to raise the yield on a given firm’s advertising, as marginal benefits of advertising are more likely to increase. In addition, because $\delta = 1 - A_i - A_j$, $\delta$ is decreasing as $A_i$ or $A_j$ increases. In fact, $\frac{\partial \delta}{\partial z} = -2\frac{\partial A_i}{\partial z}$ in the symmetric equilibrium, where $z$ is any exogenous variable. With these two facts in hand, we are able to examine changes of variables in equation (11)-(13) and (17)-(19).
Table 1 Comparative Statics

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<td>$p$</td>
<td>$X$</td>
<td>$v$</td>
<td>$\beta$</td>
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<td>$\alpha$ Bertrand</td>
<td>+</td>
<td>+</td>
<td>?</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>Cournot</td>
<td>+</td>
<td>+</td>
<td>?</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>$b$ Bertrand</td>
<td>–</td>
<td>–</td>
<td>?</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>Cournot</td>
<td>–</td>
<td>–</td>
<td>?</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>$\rho \sigma_e$ Bertrand</td>
<td>–</td>
<td>?(–)</td>
<td>?(+</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>Cournot</td>
<td>–</td>
<td>?(–)</td>
<td>?(+</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>$\sigma_m$ Bertrand</td>
<td>+</td>
<td>?(+</td>
<td>?(–)</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>Cournot</td>
<td>+</td>
<td>?(+</td>
<td>?(–)</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>$E(\bar{r}_m) - r$ Bertrand</td>
<td>–</td>
<td>?(–)</td>
<td>?(+</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>Cournot</td>
<td>–</td>
<td>?(–)</td>
<td>?(+</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>$\mu$ Bertrand</td>
<td>–</td>
<td>–</td>
<td>?</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>Cournot</td>
<td>–</td>
<td>–</td>
<td>?</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>$c$ Bertrand</td>
<td>–</td>
<td>?</td>
<td>?</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>Cournot</td>
<td>–</td>
<td>?</td>
<td>?</td>
<td>–</td>
<td>+</td>
</tr>
</tbody>
</table>

* "?(–)" and "?(+)" denote that the impact is generally undetermined, but more likely to be negative and positive respectively. See section 3.3.

3.2 Changes in $\alpha$, $b$, and $\mu$

We will explore the effects of changes in $\alpha$ under Cournot competition first. Rewrite equation (11) as $b(2 + \delta)X_i^c = (\alpha - d)(1 + \delta)$ and $(2 + \delta)p_i^c = \alpha + (1 + \delta)d$, then take differentiation with respect to $\alpha$ and rearrange, we have

\[
(2 + \delta)\frac{\partial p_i^c}{\partial \alpha} = 1 - (p_i^c - d)\frac{\partial \delta}{\partial \alpha} = 1 + 2(p_i^c - d)\frac{\partial A_i}{\partial \alpha} \quad (40)
\]

\[
b(2 + \delta)\frac{\partial X_i^c}{\partial \alpha} = (1 + \delta) + (\alpha - d - bX_i^c)\frac{\partial \delta}{\partial \alpha} = (1 + \delta) - 2(\alpha - d - bX_i^c)\frac{\partial A_i}{\partial \alpha} \quad (41)
\]
It is easy to check that and $\frac{\partial p_i^c}{\partial \alpha} > 0$ because $\frac{\partial A_i}{\partial \alpha} > 0$ and $p_i^c \geq d$. The second term on the right hand side of equation (41) is weakly greater than 0 because in equilibrium $X_i = X_j$, equation (3) turns out to be $p_i^c = \alpha - bX_i^c$. Again, $p_i^c - d \geq 0$.

As a result, the sign of $\frac{\partial X_i^c}{\partial \alpha}$ depends on $\frac{\partial A_i}{\partial \alpha}$. That is,

$$\frac{\partial X_i^c}{\partial \alpha} > 0, \text{ if } \frac{\partial A_i}{\partial \alpha} < \frac{(1 + \delta)(2 + \delta)}{2(\alpha - d)}.$$  \hfill (42)

From equation (12), we have

$$\frac{\phi(\alpha - d)^2}{b(1 + r)} = \frac{(2 + \delta)^2}{1 + \delta} v_i^c$$  \hfill (43)

Differentiating it with respect to $\alpha$ yields

$$2 \frac{\phi(\alpha - d)}{b(1 + r)} = \frac{(2 + \delta)^2}{1 + \delta} \frac{\partial v_i^c}{\partial \alpha} + \frac{\delta(2 + \delta)}{(1 + \delta)^2} v_i^c \frac{\partial \delta}{\partial \alpha}.$$  \hfill (44)

Therefore, $\frac{\partial v_i^c}{\partial \alpha} > 0$. Last, from equation (8),

$$\frac{\partial \beta_i}{\partial \alpha} = -\left(1 + \frac{1}{\rho \sigma_v} - \lambda \sigma_m^2\right)^{-1} \frac{d}{(p_i - d)^2} \frac{\partial p_i}{\partial \alpha}$$  \hfill (45)

Under Bertrand competition, the results are the same as of Cournot competition except the change of equilibrium quantity. From equation (17),

$$b(2 - \delta)X_i^B = \alpha - d$$

Taking differentiation with respect to $\alpha$ and rearranging, we get

$$b(2 - \delta)^2 \frac{\partial X_i^B}{\partial \alpha} = (2 - \delta)(\alpha - d) \frac{\partial \delta}{\partial \alpha} = (2 - \delta) - 2(\alpha - d) \frac{\partial A_i}{\partial \alpha}$$  \hfill (46)

This shows us the impact of change in $\alpha$ on $X_i^B$ depends on $\frac{\partial A_i}{\partial \alpha}$.

$$\frac{\partial X_i^B}{\partial \alpha} > 0, \text{ if } \frac{\partial A_i}{\partial \alpha} < \frac{2 - \delta}{2(\alpha - d)}.$$  \hfill (47)

We may summarize the above discussions in the following proposition.
Proposition 4 If consumers’ willingness to pay ($\alpha$) increases, under either Cournot or Bertrand competition
(a) the equilibrium advertising level, price, and firm’s value increase, but the systematic risk decreases.
(b) the impact on the equilibrium quantity ($\frac{\partial X_j}{\partial \alpha}, j = c, B$) depends on the impact on the equilibrium advertising level ($\frac{\partial A_j}{\partial \alpha}$). The conditions are given in equation (42) and (45).

An increase in consumers’ willingness to pay generates additional firm profits, but also reduces systematic risk. Firms engage in more advertising and produce more differentiated goods. However, the influence on quantity is ambiguous because it depends on changes in advertising level. Changes in advertising create two effects; shifts in demand and rotation of the demand curve. For an outward shift, the demand curve will generate an increase in price and quantity. However, a less elastic demand curve will increase price but decrease quantity. These two effects offset each other for equilibrium quantity. Obviously, when the rotation effect is small, the price and quantity will increase.

Applying the similar logic, we also have the following proposition.

Proposition 5 If the slope of demand curve ($b$) or the cost parameter of advertising ($\mu$) increases, under either Cournot or Bertrand competition
(a) the equilibrium advertising level, price, and firm’s value decrease, but the systematic risk increases.
(b) the impacts on the equilibrium quantity ($\frac{\partial X_j}{\partial z}, z = b, \mu; j = c, B$) depends on the impacts on the equilibrium advertising level ($\frac{\partial A_j}{\partial z}$). The conditions are given in equations (46) and (47).

From (35) and (36), it is easy to see that $b$ and $\mu$ play the same role
when we compute the impacts of their changes. Similar to proposition 4, the conditions in proposition 5 (b) are
\[
\frac{\partial X_i^c}{\partial z} < 0, \quad \text{if} \quad \frac{\partial A_i}{\partial z} > -\frac{(1 + \delta)(2 + \delta)}{2z}. \quad (46)
\]
\[
\frac{\partial X_i^B}{\partial z} < 0, \quad \text{if} \quad \frac{\partial A_i}{\partial z} > -\frac{2 - \delta}{2z}. \quad (47)
\]
where \( z = b, \mu \).

If we define the slope elasticity of quantity \( \eta_{xb} \) and the slope elasticity of advertising \( \eta_{Ab} \) respectively as
\[
\eta_{xb} = \frac{b}{X} \frac{\partial X}{\partial b}, \quad \eta_{Ab} = \frac{b}{A} \frac{\partial A}{\partial b} \quad (48)
\]
\( \eta_{x\mu} \) and \( \eta_{A\mu} \) are defined in the similar way, together with \( \delta = 1 - 2A_i \) in equilibrium, conditions (46) and (47) have alternative expressions as follows.
\[
\eta_{xz}^c < 0, \quad \text{if} \quad \eta_{Az} > -\frac{(2 - 2A_i)(3 - 2A_i)}{2A_i}. \quad (49)
\]
\[
\eta_{xz}^c < 0, \quad \text{if} \quad \eta_{Az} > -\frac{1 + 2A_i}{2A_i}. \quad (50)
\]
where \( z = b, \mu \). Of course, readers can find that we may have similar formulas for (42) and (45).

3.3 Changes in \( \rho \sigma_e, E(\tilde{r}_m) - r, \) and \( \sigma_m \)

From equation (37), we know \( \rho \sigma_e, E(\tilde{r}_m) - r, \) and \( \sigma_m \) serve the similar roles which changes firms’ certainty equivalence, \( \phi \), as we derive the comparative statics.\textsuperscript{19} Therefore, we define the risk elasticity of quantity \( \eta_{x\phi} \), the risk elasticity of price \( \eta_{p\phi} \), and the risk elasticity of product differentiation \( \eta_{\delta\phi} \) as
\[
\eta_{x\phi} = \frac{\phi}{X} \frac{\partial X}{\partial \phi}, \quad \eta_{p\phi} = \frac{\phi}{p} \frac{\partial p}{\partial \phi}, \quad \eta_{\delta\phi} = \frac{\phi}{\delta} \frac{\partial \delta}{\partial \phi} \quad (51)
\]
\textsuperscript{19}The only difference is from the computation of effect on \( \beta \). However, the conclusion is the same.
From $\frac{\partial \delta}{\partial z} = -2\frac{\partial A_i}{\partial z}$, equation (37), and proposition 3, $\eta_{\delta \phi} < 0$. Thus, we have lemma 4.

Lemma 4 Under either Cournot or Bertrand competition,

(a) $\eta_{x \phi}$ is bounded above while $\eta_{p \phi}$ is bounded below.

$\eta_{x \phi} < 0$ and $\eta_{p \phi} > 0$ if $\eta_{\delta \phi} \ll 0$.

(b) $\frac{\partial \eta}{\partial \delta} > 0$.

Proof. (a) Under Cournot competition, differentiating $b(2 + \delta)\phi X_i^c = (\phi \alpha - c)(1 + \delta)$ with respect to $\phi$ and rearranging yield

$$(2 + \delta)bX_i^c(1 + \eta_{x \phi}^c) = \alpha(1 + \delta) + (p_i^c - d)\delta \eta_{\delta \phi}$$

As a result, $\eta_{x \phi}^c$ is bounded above. For the price, $(2 + \delta)\phi p_i^c = \alpha \phi + (1 + \delta)c$, we get

$$(2 + \delta)p_i^c(1 + \eta_{p \phi}^c) = \alpha - (p_i^c - d)\delta \eta_{\delta \phi}$$

Unlike $\eta_{x \phi}^c$, $\eta_{p \phi}^c$ is bounded below. Moreover, $\eta_{x \phi}^c < 0$ (or $\frac{\partial X_i^c}{\partial \phi} < 0$) and $\eta_{p \phi}^c > 0$ (or $\frac{\partial p_i^c}{\partial \phi} > 0$) if $\eta_{\delta \phi} \ll 0$ (or $\frac{\partial \delta}{\partial \phi} \ll 0$).

(b) From equation (43), taking a derivative with respect to $\phi$, we get

$$\frac{(\alpha + d)(\alpha - d)}{b(1 + r)} = (2 + \delta)^2 \frac{\partial v_i^c}{\partial \phi} + [2(2 + \delta)v_i^c] \frac{\partial \delta}{\partial \phi}$$

which shows that $\frac{\partial v_i^c}{\partial \phi} > 0$. We omit the proof for Bertrand competition because the logic is the same.

Lemma 4 indicates that effects on $X_i$ and $p_i$ from a change in the risk attitude or, equivalently, certainty equivalence cannot be extremely positive and negative, respectively. It is quite intuitive that $\eta_{x \phi}$ ($\eta_{p \phi}$) is bounded
above (below). It implies that the less averse the risk attitude, the less quantity produced and the higher price charged. If an increase in $\phi$ can induce a large increase in the optimal advertising, i.e., $\eta_{\phi\phi}$ or $\frac{\partial \delta}{\partial \phi}$ is significantly negative, $\eta_{x\phi}$ is negative while $\eta_{p\phi}$ is positive. This will dramatically simplify our analysis.

The facts that $\eta_{x\phi}$ is bounded above and $\eta_{p\phi}$ is bounded below are also supported by the result that $\frac{\partial v_i}{\partial \phi} > 0$.

By equation (37), we may build up the following relations:

$$\frac{\partial \phi}{\partial (\rho \sigma_e)} = -\frac{E(\tilde{r}_m) - r}{\sigma_m} < 0$$

(52)

$$\frac{\partial \phi}{\partial (E(\tilde{r}_m) - r)} = -\frac{(\rho \sigma_e)}{\sigma_m} < 0$$

(53)

$$\frac{\partial \phi}{\partial \sigma_m} = \frac{(E(\tilde{r}_m) - r) \rho \sigma_e}{\sigma_m^2} > 0$$

(54)

Taking $\rho \sigma_e$ as an example, from lemma 4, we get $\frac{\partial X_i}{\partial (\rho \sigma_e)}$ is bounded below and $\frac{\partial p_i}{\partial (\rho \sigma_e)}$ is bounded above. Moreover, $\frac{\partial X_i}{\partial (\rho \sigma_e)} > 0$ and $\frac{\partial p_i}{\partial (\rho \sigma_e)} < 0$ if $\frac{\partial \delta}{\partial (\rho \sigma_e)} \gg 0$.

In addition, $\frac{\partial v_i}{\partial (\rho \sigma_e)} < 0$.

Let us examine how $\beta$ can be changed. By equation (13), differentiating with respect to $\rho \sigma_e$ yields

$$\frac{(1 + r)}{\beta^2} \frac{\partial^2 \beta^c}{\partial (\rho \sigma_e)}$$

$$= \frac{1}{(\rho \sigma_e)^2} \left[ 1 - \frac{(2 + \delta)d}{\alpha + (1 + \delta)d} \right] + \left[ \frac{1}{\rho \sigma_e} - \lambda \sigma_m^2 \left\{ \frac{\alpha(2 + \delta)d' + d(\alpha - d)\delta'}{(\alpha + (1 + \delta)d)^2} \right\} \right]$$

where

$$d' = \frac{\partial d}{\partial (\rho \sigma_e)} = \frac{\partial d}{\partial \phi} \frac{\partial \phi}{\partial (\rho \sigma_e)} = (-\frac{c}{\phi^2})(-\frac{E(\tilde{r}_m) - r}{\sigma_m}) > 0$$

$$\delta' = \frac{\partial \delta}{\partial (\rho \sigma_e)} = -2 \frac{\partial A_i}{\partial (\rho \sigma_e)} > 0$$

It turns out that $\frac{\partial \beta^c}{\partial (\rho \sigma_e)} > 0$. 

521
For Bertrand competition, we omit the computations as the qualitative results are the same. To conclude this section, we summarize the impacts of $\rho \sigma_e$ and $E(\tilde{r}_m) - r$ as well as $\sigma_m$ in the following proposition.

**Proposition 6** Under either Cournot or Bertrand competition, 
(a) an increase in the correlation between the undertaken project and the market portfolio multiplied by the volatility of the project ($\rho \sigma_e$) or an increase in the excess rate of return on the market portfolio ($E(\tilde{r}_m) - r$) decreases the equilibrium advertising level and firm’s value, but increases the systematic risk while changes in prices (quantities) are generally undetermined but more likely to be negative (positive) with significantly positive $\frac{\partial \delta}{\partial (\rho \sigma_e)}$ or $\frac{\partial \delta}{\partial (E(\tilde{r}_m) - r)}$. 
(b) an increase in the volatility of market portfolio ($\sigma_m$) increases the equilibrium advertising level and firm’s value, but decreases the systematic risk while changes in prices (quantities) are generally undetermined but more likely to be positive (negative) with significantly negative $\frac{\partial \delta}{\partial \sigma_m}$.

The above proposition provides the link from the risk attitude $\phi$ to other related variables. When the certainty equivalence rises as the project risk decreases, the excess rate of return on the market portfolio decreases, or the volatility of market portfolio increases, the relative benefits of project are increasing but the systematic risk is decreasing.

Finally, let us deal with the case of changes in the marginal cost of production $c$.

### 3.4 Changes in $c$

The effects of a change in the marginal cost of production $c$ can be presented in the following proposition.

**Proposition 7** Under either Cournot or Bertrand competition, when the
marginal cost of production $c$ increases,

(a) the equilibrium advertising level and firm’s value decrease but the systematic risk increases.

(b) the impacts on the equilibrium quantity and price $(\frac{\partial X_i}{\partial c}, \frac{\partial p_i}{\partial c}, j = c, B)$ depend on the impact on the equilibrium advertising level $(\frac{\partial A_i}{\partial c})$. The conditions are given in equation (55) and (56).

**Proof.** (a) We omit the proof of part (a) as it is similar to what we did above.

(b) Similar to proposition 4, we only report those conditions here.

\[
\frac{\partial X_i^c}{\partial c} < 0, \quad \frac{\partial p_i^c}{\partial c} > 0, \quad \text{if} \quad \frac{\partial A_i}{\partial c} > \frac{(1 + \delta)(2 + \delta)}{2\phi(\alpha - d)}. \tag{55}
\]

\[
\frac{\partial X_i^B}{\partial c} < 0, \quad \frac{\partial p_i^B}{\partial c} > 0, \quad \text{if} \quad \frac{\partial A_i}{\partial c} > -\frac{2 - \delta}{2\phi(\alpha - d)}. \tag{56}
\]

Table 1 presents the results of comparative statics. The analysis shows that exogenous variables have clear relations with the optimal advertising level, value of firm and systematic risk, whereas impacts on the price and quantity are varied and some effects are undetermined. However, the above discussions lead us to narrowing down the results, for example, with significantly negative $\frac{\partial A_i}{\partial \phi}$, the effects on the price (quantity) is negative (positive) for $\rho \sigma_e$ and $E(\tilde{r}_m) - r$, but positive (negative) for $\sigma_m$.

In section 3.5 we will investigate some simulations to see what the symmetric pure-strategy equilibrium looks like as the analytical results are not available.
3.5 Simulations of the Basic Model

As discussed in the comparative statics, $b$ and $\mu$ serve the similar role, so do $\sigma_m$, $\rho \sigma_e$, and $E(\tilde{r}_m) - r$. We conduct the simulations in which changes in $\alpha$, $\mu$, $\rho$, and $\sigma_e$ are examined.

In our simulations, the parameters of the base case include $b = 1$, $r = 0.05$, $c = 0.1$, $\sigma_m = 0.2$, $\lambda = 2$, $\sigma_e = 0.2$, $\rho = 0.5$, $\alpha = 1$, $\mu = 0.1$, and $n = 2$. Therefore, $\phi = 1 - \lambda \rho \sigma_e \sigma_m = 1 - 2 \times 0.5 \times 0.2 \times 0.2 = 0.96$. Moreover,

$$\frac{\phi (\alpha - d)^2}{b (1 + r)} = \frac{0.96 (1 - 0.1/0.96)^2}{1 + 0.05} = 0.7337,$$

which is less than the one with certainty, in which $(1 - 0.1)^2/(1 + 0.05) = 0.7714$.

The simulation results present in Table 2 where (a) $\mu$ is from 0 to 0.2; (b) $\alpha$ is from 0.5 to 1.5; (c) $\rho$ is from 0 to 1; (d) $\sigma_e$ is from 0 to 0.4; and (e) $c$ is from 0 to 0.2. The change in $\mu$ is to capture the effect of changes in the advertising cost, the change in $\alpha$ is to capture the effect of shift in demand, the change in $\rho$ or $\sigma_e$ is to capture the impact of changes in the revenue shock, finally the change in $c$ is to capture the effect of changes in the production cost. The results confirm the previous comparative statics.

From an aspect of the comparisons between Bertrand competition and Cournot competition, these results also indicate the following observations.

1. Bertrand firms engage in more advertising activities.
2. In general, Cournot firms enjoy more net present value. However, this relation is reversed when the marginal cost of advertising is small, consumers’ willingness to pay is large, production cost is small, and/or the risk is small. For example, the case happens when $\mu \leq 0.08$ in Table 2(a), $\alpha \geq 1.1$ in Table 2(b), and $c \leq 0.03$ in Table 2(e).
Table 2(a)
µ
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.10
0.11
0.12
0.13
0.14
0.15
0.16
0.17
0.18
0.19
0.20
1
2

Bertrand
A
0.5000
0.4759
0.4565
0.4402
0.4262
0.4139
0.4030
0.3931
0.3842
0.3760
0.3684
0.3614
0.3549
0.3488
0.3431
0.3377
0.3326
0.3277
0.3231
0.3188
0.3146

p
0.5521
0.5410
0.5317
0.5236
0.5164
0.5099
0.5039
0.4985
0.4934
0.4887
0.4842
0.4800
0.4761
0.4723
0.4687
0.4653
0.4620
0.4589
0.4558
0.4529
0.4501

X
0.4479
0.4590
0.4683
0.4764
0.4836
0.4901
0.4961
0.5015
0.5066
0.5113
0.5158
0.5200
0.5239
0.5277
0.5313
0.5347
0.5380
0.5411
0.5442
0.5471
0.5499

v
0.1834
0.1822
0.1810
0.1798
0.1786
0.1775
0.1764
0.1754
0.1744
0.1734
0.1724
0.1715
0.1706
0.1697
0.1688
0.1680
0.1672
0.1664
0.1656
0.1648
0.1640

Bertrand
A
0.2364
0.2740
0.3045
0.3298
0.3508
0.3684
0.3834
0.3961
0.4071
0.4165
0.4246

α
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5

2

p
0.2312
0.2797
0.3297
0.3807
0.4323
0.4842
0.5364
0.5886
0.6408
0.6930
0.7452

X
0.2688
0.3203
0.3703
0.4193
0.4677
0.5158
0.5636
0.6114
0.6592
0.7070
0.7548

v
0.0284
0.0476
0.0717
0.1006
0.1342
0.1724
0.2154
0.2629
0.3151
0.3720
0.4334

β
0.1305
0.1311
0.1316
0.1321
0.1326
0.1330
0.1334
0.1338
0.1342
0.1345
0.1349
0.1352
0.1355
0.1358
0.1361
0.1364
0.1367
0.1369
0.1372
0.1375
0.1377

Cournot
A
0.5000
0.4720
0.4430
0.4133
0.3836
0.3547
0.3273
0.3019
0.2786
0.2576
0.2388
0.2221
0.2072
0.1939
0.1820
0.1714
0.1618
0.1532
0.1454
0.1383
0.1318

p
0.5521
0.5399
0.5279
0.5163
0.5054
0.4953
0.4861
0.4780
0.4709
0.4647
0.4593
0.4547
0.4506
0.4471
0.4440
0.4413
0.4389
0.4367
0.4348
0.4331
0.4316

X
0.4479
0.4601
0.4721
0.4837
0.4946
0.5047
0.5139
0.5220
0.5291
0.5353
0.5407
0.5453
0.5494
0.5529
0.5560
0.5587
0.5611
0.5633
0.5652
0.5669
0.5684

v
0.1834
0.1822
0.1809
0.1797
0.1785
0.1773
0.1762
0.1752
0.1743
0.1735
0.1727
0.1720
0.1714
0.1709
0.1704
0.1700
0.1696
0.1693
0.1690
0.1687
0.1684

σR
0.0495
0.0497
0.0498
0.0499
0.0500
0.0500
0.0500
0.0499
0.0498
0.0498
0.0497
0.0496
0.0495
0.0494
0.0494
0.0493
0.0493
0.0492
0.0492
0.0491
0.0491

β
0.1305
0.1312
0.1319
0.1326
0.1333
0.1340
0.1347
0.1353
0.1359
0.1364
0.1369
0.1373
0.1377
0.1380
0.1383
0.1386
0.1388
0.1390
0.1392
0.1394
0.1395

Simulation Results – Changes in α
σR
0.0124
0.0179
0.0244
0.0319
0.0404
0.0500
0.0605
0.0720
0.0845
0.0980
0.1125

β
0.1926
0.1687
0.1547
0.1457
0.1394
0.1349
0.1314
0.1286
0.1264
0.1246
0.1230

Cournot
A
0.0528
0.0824
0.1175
0.1567
0.1981
0.2388
0.2766
0.3097
0.3378
0.3610
0.3801

p
0.2409
0.2790
0.3197
0.3632
0.4098
0.4593
0.5112
0.5645
0.6186
0.6730
0.7274

X
0.2591
0.3210
0.3803
0.4368
0.4902
0.5407
0.5888
0.6355
0.6814
0.7270
0.7726

v
0.0323
0.0510
0.0742
0.1022
0.1350
0.1727
0.2153
0.2627
0.3148
0.3716
0.4330

σR
0.0125
0.0179
0.0243
0.0317
0.0402
0.0497
0.0602
0.0717
0.0843
0.0979
0.1124

β
0.1865
0.1689
0.1570
0.1484
0.1419
0.1369
0.1329
0.1298
0.1273
0.1252
0.1235

b = 1, r = 0.05, c = 0.1, σ m = 0.2, λ = 2, σ e = 0.2, ρ = 0.5, and µ = 0.1.
The numbers with bold type indicate Bertrand firms enjoy more firm value than Cournot firms.

Table 2(c)
ρ
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1

σR
0.0495
0.0497
0.0498
0.0499
0.0499
0.0500
0.0500
0.0500
0.0500
0.0500
0.0500
0.0499
0.0499
0.0498
0.0498
0.0498
0.0497
0.0497
0.0496
0.0496
0.0495

b = 1, r = 0.05, c = 0.1, σ m = 0.2, λ = 2, σ e = 0.2, ρ = 0.5, and α = 1.
The numbers with bold type indicate Bertrand firms enjoy more firm value than Cournot firms.

Table 2(b)

1

Simulation Results – Changes in µ

Bertrand
A
0.3721
0.3714
0.3706
0.3699
0.3692
0.3684
0.3677
0.3669
0.3662
0.3654
0.3646

p
0.4840
0.4840
0.4841
0.4841
0.4842
0.4842
0.4843
0.4843
0.4844
0.4845
0.4846

X
0.5160
0.5160
0.5159
0.5159
0.5158
0.5158
0.5157
0.5157
0.5156
0.5155
0.5154

v
0.1818
0.1799
0.1780
0.1762
0.1743
0.1724
0.1706
0.1687
0.1668
0.1650
0.1631

Simulation Results – Changes in ρ
σR
0.0499
0.0499
0.0499
0.0499
0.0499
0.0500
0.0500
0.0500
0.0500
0.0500
0.0500

β
0.0000
0.0266
0.0533
0.0803
0.1075
0.1349
0.1625
0.1903
0.2183
0.2466
0.2751

Cournot
A
0.2477
0.2460
0.2442
0.2424
0.2406
0.2388
0.2370
0.2352
0.2333
0.2314
0.2295

p
0.4594
0.4593
0.4593
0.4593
0.4593
0.4593
0.4593
0.4594
0.4594
0.4594
0.4595

b = 1, r = 0.05, c = 0.1, σ m = 0.2, λ = 2, σ e = 0.2, α = 1, and µ = 0.1.

525

X
0.5406
0.5407
0.5407
0.5407
0.5407
0.5407
0.5407
0.5406
0.5406
0.5406
0.5405

v
0.1820
0.1801
0.1783
0.1764
0.1746
0.1727
0.1709
0.1690
0.1672
0.1653
0.1635

σR
0.0497
0.0497
0.0497
0.0497
0.0497
0.0497
0.0497
0.0497
0.0497
0.0497
0.0497

β
0.0000
0.0269
0.0541
0.0815
0.1091
0.1369
0.1649
0.1932
0.2217
0.2505
0.2795


Table 2(d)  Simulation Results – Changes in $\sigma_c$

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<th>$\sigma_c$</th>
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<th>$X$</th>
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Table 2(e)  Simulation Results – Changes in $c$

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</table>

$^1 b = 1, \gamma = 0.5, \sigma_m = 0.2, \lambda = 2, \rho = 0.5, \alpha = 1, \sigma = 0.2.$ $^2$ The numbers with bold type indicate Bertrand firms enjoy more firm value than Cournot firms.
(3) An increase in $\alpha$ or a decrease in $\rho \sigma_e$, $c$, or $\mu$ tend to benefit Bertrand firms more than Cournot firms. This can be shown by taking a difference between any two corresponding pair of entries in Table 2.

Up to this point, we only examine the effects of advertising on the product differentiation taking the market size and risk parameter $\sigma_e$ as given. In the next section, we will extend our model to incorporate the impacts of advertising on the market size and the reduction of risk parameter $\sigma_e$.

4. Conclusions and Extensions

In this paper, we developed a model of equity value maximization that allows persuasive advertising to influence the risk facing firms and thereby affecting the competition between duopolists. Because firms tend to endogenously choose the degree of perceived product differentiation they desire, advertising activities in our model increase demand by causing outward shifts in the demand curve and also act to rotate the demand curve steeper. If firms can effectively reduce the risk by differentiating products, the marginal benefits of advertising become higher. Consequently, firms advertise more, enjoy more cash flows and incur less systematic risks. These results are applicable under either Bertrand or Cournot competition.

The conventional industrial organization case is always that that Bertrand firms engage in the higher degree of competition than Cournot firms, earn fewer profits, but incur higher systematic risks. Our model suggests that this may not always occur when advertising costs are low, demand is high, and/or idiosyncratic risk is reduced. These results may have some empirical implications. For example, it suffices to test the mode of competition in the concentration product spaces highly branded products (i.e. soft drink market).
If we allow firms to endogenously choose the mode of competition somewhere between $t = 1$ and $t = 2$, say, $t = 1.5$ on the timeline of Figure 1, in a companion paper we show that only symmetric equilibria exist, i.e., both firms play a quantity setting game (Cournot) or a price setting game (Bertrand). It cannot be an asymmetric equilibrium where the one chooses quantity and the other chooses price. Let us consider a duopoly in which a single home firm competes with a foreign firm in a third-country market. The optimal trade policy under the current setting would be the one that government subsidizes advertising in the first period and imposes an export tax on the product in the second period. By doing so, the firm is induced to compete in price and earns more firm value while government’s expenditure on advertising can be (partially) balanced by imposing taxes on the product.\(^{20}\)

The results of the paper are derived under the assumptions that the sources of uncertainty come from the demand side, the shock is proportional to the revenue, demand is linear, and so on. These assumptions are somehow restrictive. Reasonable generalizations should include the supply shock, the general impacts of shock, and the general format of demand. In addition, we do not address the role of capital stock $K_i$ in this paper. If we relax the assumption of fixed capital stock, it may raise some relevant issues such as risk management and the interplay of production and capital structure. Froot, Scharfstein, and Stein (1993) argue that the risk management is important as the appropriate strategies may avoid unnecessary fluctuations in either funds.

\(^{20}\)Along the strand of strategic trade policy, Maggi (1996) indicates that capacity subsidy is generally a welfare improving policy regardless of the mode of competition whereas Bagwell and Staiger (1994) point out that R&D subsidies might also be the best policy in both Cournot and Bertrand settings. Similar to our conclusion, Neary and Leahy (2000) show that a first best policy would be a combination of R&D tax (subsidy) with export subsidy (tax).
raised from outside investors or investment spending if the external sources
of finance, for example, borrowing, are more costly than internally generated
funds, such as existing cash flows. Second, while the financial variable, sys-
tematic risk is affected by real variables of production, the financial variable,
such as financial structure or debt-equity ratio may also have impacts on the
product side. The influential work is pioneered by Brander and Lewis (1986)
in which they examine the strategic role of debt with limited liability. It is
worthwhile to incorporate more financial concerns into the current framework
of model.

As mentioned above, one of most important issues in the present paper
is the risk reduction. In addition to the advertising we have addressed, from
our observations the vehicle of risk reduction may include contracting, R&D,
growth option, and so on. Let us take “contracting” as an example as they
share a common feature on either the demand or supply side.

Imagine that there are several downstream and upstream firms in the in-
dustry. To reduce the risk, upstream firms may want to sign contracts with
downstream firms to ensure certain amount of sales before the uncertainty
of demand realizes; likewise, downstream firms may have incentives to sign
contracts with upstream firms to ensure some amount of supply.21 In addi-
tion, those upstream or upstream firms may merge horizontally or integrate
vertically to achieve the same goal of risk reduction. The risk reduction pro-
vides a different point of view on the boundary of firm as the transaction
cost approach is familiar to most economists. This research avenue is worth
investigating in the future.

21 Note that hold-up problems may impose additional costs on the risk reduction.
References


INFORMATION SHARING AND OLIGOPOLY IN AGRICULTURAL MARKETS: THE ROLE OF COOPERATIVE BARGAINING ASSOCIATIONS

BRENT HUETH AND PHILIPPE MARCOUL
INFORMATION SHARING AND OLIGOPOLY IN AGRICULTURAL MARKETS: THE ROLE OF COOPERATIVE BARGAINING ASSOCIATIONS

Abstract. We study incentives for information sharing (about uncertain future demand for final output) among agricultural intermediaries in imperfectly competitive markets for farm output. Information sharing always increases expected grower and consumer surplus, but may reduce expected intermediary profits. Even when expected intermediary profits increase with information sharing, firms face a Prisoner's Dilemma where it is privately rational for each firm to withhold information, given that other firms report truthfully. This equilibrium can be avoided if firms' information reports are verifiable, and if firms commit to an \textit{ex ante} contract that forces \textit{ex post} information revelation. We argue that agricultural bargaining represents one means to achieve verifiability and to implement such a contract.

Introduction

Many markets for farm output are plausibly characterized by some degree of imperfect competition. This is certainly true in most fruit and vegetable markets where growers are numerous, and where intermediation (e.g., processing or shipping/packing) is relatively concentrated. Processing or packing cooperatives, and cooperative bargaining among farmers, may in some instances be institutional responses to these market imperfections. For example, Sexton (1990) studies the role that processing cooperatives can play in promoting competitive behavior among non-cooperative processors. In the case of farm bargaining, a number of authors have argued that collective price negotiation by growers can countervail the market power of intermediaries (e.g., Helmberger and Hoos, 1965; Ladd, 1964). This perspective emphasizes the effect of cooperation on market structure, and on the transfer of economic surplus from intermediaries (and possibly consumers) to growers. An alternative view—the one we explore in this paper—is that bargaining has efficiency consequences independent of changes in market structure.

Briefly, we consider an imperfectly competitive market for farm output where information sharing among intermediaries (about uncertain future demand for final output) potentially leads to higher expected aggregate surplus. In this context, we show that a bargaining
association can solve a Prisoner’s Dilemma among intermediary firms where all parties (firms, consumers, and growers) are better off when information is fully shared, but where each firm’s equilibrium strategy is to not reveal its information given that other firms report truthfully. The bargaining association serves two roles: First, the association invests costly resources in verification of firm reports (firms can choose not to reveal their information, but if they do reveal, it is impossible to lie); and second, mandatory bargaining provides a mechanism where all parties commit to reveal their information. Below, we argue that these two functions are reasonable descriptions of what bargaining associations actually do (among other things), and that they serve to solve the Prisoner’s Dilemma noted above.

In what follows, we begin with a description of bargaining in agricultural markets. We then develop a model of information sharing in the spirit of work by Vives (1984), Raith (1996), and Li (1985) (see Vives (1999), Chapter 8 for an excellent summary of this literature), and demonstrate how mandatory bargaining can lead to efficiency gains. The final section concludes and discusses the empirical implications of our model.

Bargaining and Price Discovery in Agricultural Markets

Our intent in this section is not to provide an exhaustive overview of agricultural bargaining, but rather to point out ways in which descriptions of the institutional features of bargaining associations seem consistent with the notion that bargaining has efficiency consequences independent of changes in market structure, and, in particular, that bargaining facilitates price discovery via formalized “information sharing.”

Bargaining occurs primarily in markets for processing fruits and vegetables (Hueth and Marcoul, 2003). This particular set of markets comprises only a small portion of all agricultural markets, and it is natural to ask why bargaining associations are not more widespread. If the success of bargaining as an institution hinges on delivering higher prices to growers, we should perhaps expect to observe bargaining in a larger class of commodities. In this respect, it is noteworthy that fruit and vegetable processors obtain their output primarily through forward contracts, so that traditional modes of price discovery are mostly absent. Moreover, procurement decisions are typically made in the context of uncertainty about the state of future demand (e.g., prior to planting). To the extent that price negotiations during
bargaining facilitate industry-wide communication about future demand, bargaining can be viewed as a sort of indirect price discovery mechanism.

Results and discussion from two studies of farm bargaining seem consistent with this notion. First, in a national survey of processing fruit and vegetable bargaining associations, Iskow and Sexton (1992) note that “the majority of associations felt their role was not only to improve the well-being of grower-members, but also to provide services to processors.” Of the services provided, “increased price stability,” “improved information,” and “improved price discovery process” were most frequently cited.\(^1\) Lacking similar responses from processing firms, it is difficult to know whether, in fact, such services were provided and valued. Nevertheless, that nearly all respondents viewed price discovery and improved information as important services provided by their respective associations is certainly consistent with the hypothesis that an important consequence of farm bargaining is information transmission among market participants.

Similarly, Bunje (1980) offers a comprehensive description of bargaining in U.S. agricultural markets.\(^2\) In summarizing the role of farm bargaining he notes that:

“Bargaining associations can fill the needs of the market as well as the needs of the individual producer. They can serve a supply coordinating function for the market and furnish market intelligence for the producer. They can operate as a price discovery vehicle, establish market prices, and establish uniform terms of trade that serve the producer and the marketplace.”

While such a quote might be viewed as self-serving coming from a representative of bargaining associations, it again conveys the idea that, at least in the minds of those who operate bargaining associations, bargaining is much more than simply “price enhancement.”

Of course, there are many other possible explanations for the relative prominence of bargaining in processing fruit and vegetable markets. For example, Knoeber (1983) notes that “liquidated damage” (“most-favored customer”) clauses in contracts between bargaining associations and growers (processors) can mitigate incentives for either party to renege on

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\(^1\)Of the 36 associations sampled, 31 cited increased price stability, 32 cited improved information, and 25 cited improved price discovery. When queried about services offered to growers, only “price negotiation” and “time and method of payment” were similarly cited by more than 30 associations.

\(^2\)Ralph Bunje was a leading spokesman and proponent of farm bargaining for over 30 years during his tenure as manager of the California Canning Peach Association (forward to citation in text above).
contract terms.\(^3\) To the extent that contract reliability is a problem peculiar to processing fruit and vegetable markets, the benefits from third party (i.e., bargaining association) contract enforcement may be relatively high. Alternatively, it may indeed be the case that the degree of imperfect competition in these markets is particularly severe. For example, Iskow and Sexton (1992) note that the four largest firms handled over 75 percent of total production in 23 of 34 markets studied.

In any case, it is not our intent in the present paper to empirically identify the primary role of bargaining in agricultural markets. Indeed, it is entirely possible that bargaining serves multiple roles. Our more modest goal is to identify and analyze a role for bargaining that seems to have gone mostly unnoticed in formal analyses of the farm bargaining problem. Importantly, our analysis suggests that bargaining, to the extent that it results in “information sharing,” is efficiency enhancing. This is in contrast to the “price enhancement” hypothesis, which suggests the possibility of net welfare losses from farm bargaining.

We begin our analysis below by developing an oligopoly model of \(n\) firms who produce substitute final goods, and who obtain their raw farm input from a group of homogeneous growers represented by an aggregate supply relation. Prior to procurement, each firm is uncertain about the true state of future demand, but receives an imperfect signal of demand. We study private incentives for firms to share (or pool) their signals, and corresponding welfare implications. In this context, we interpret the intensive communication that occurs during the annual bargaining process, and ultimately the setting of a bargained price for contracted output, as a means of implementing information sharing.

**Model**

*The Setup*

There are \(n\) firms who convert farm output into a vector of final consumption goods \(q = (q_1, \ldots, q_n)\), where \(q_i\) represents the quantity of final goods sold by firm \(i\). For simplicity, we suppose that each firm transforms \(q_i\) into final output in Leontief fashion with constant

\(^3\)For example, suppose a grower and intermediary form a contract for future delivery of produce at some agreed price (or pricing mechanism). As the delivery date approaches, unanticipated opportunities for purchase (in the case of the intermediary) or sale (in the case of the grower) of the relevant produce may arise and thus provide incentives for one or the other party to renege on the original contract.
marginal cost (normalized to zero), and, moreover, that a single unit of farm output yields a
single unit of final output. Thus, for given output price \( p_i(q_i, q_{-i}) \), and farm price \( r(q_i, q_{-i}) \),
firm \( i \)'s profits are given by \( \Pi(q_i, q_{-i}) = [p_i(q_i, q_{-i}) - r(q_i, q_{-i})]q_i \), where \( q_{-i} \) represents the \( n-1 \)
vector of outputs other than \( i \)'s. Growers are represented by an aggregate supply function
\( r = a + bQ \), where \( Q = \sum_{i=1}^{n} q_i \) is the aggregate quantity of farm output purchased.\(^4\)

Final goods are differentiated and valued by a representative consumer with utility function
\[
U(q) = (\bar{\alpha} + \varepsilon) \sum_{i=1}^{n} q_i - \frac{1}{2} \left( \beta \sum_{i=1}^{n} q_i^2 + 2\gamma \sum_{i \neq j} q_i q_j \right),
\]
where \( \beta > \gamma > 0, \bar{\alpha} > 0 \), and where \( \varepsilon \) is a normally distributed, aggregate source of uncer-
tainty from the perspective of growers and intermediaries. We suppose that all uninformed
agents believe that \( \varepsilon \) has mean 0 and variance \( \sigma_\varepsilon \). For a given vector of prices \( p = (p_1, \ldots, p_n) \),
consumers choose quantities to maximize \( U(q) - \sum_{i=1}^{n} p_i q_i \), yielding inverse demand schedules
for each firm’s output given by
\[
p_i(q_i, q_{-i}) = \bar{\alpha} + \varepsilon - \beta q_i - \gamma \sum_{j \neq i} q_j.
\]

The timing of actions in our model is as follows: In period 0, each intermediary firm
privately receives and independent and costless signal \( s_i = \varepsilon + \nu_i \), where \( \nu_i \) is distributed
normally and independently of \( \varepsilon \) with \( E[\nu_i] = 0, E[\nu_i^2] = \sigma_\nu, E[\nu_i \nu_j] = 0 \) for \( i \neq j \). Thus,
formally each \( s_i \) represents imperfect, though unbiased, information on the state of future
demand.\(^5\) Informally, we can think of processing firms, as part of their everyday business
activities, receiving information from their respective retailers about the current state of
demand.\(^6\) Based on these signals, firms form expectations in period 1 about demand in
period 2, and coordinate with growers for delivery of some quantity of farm output that
arrives in period 2. Expectations depend on the information available to each firm, and we

\(^4\)This specification of the farm sector ignores grower heterogeneity, which may be important in considering
the incentives for growers to form a bargaining association. We would like to consider the industry-wide incentives to form a bargaining association, independent of the organizational and administrative difficulties created by grower heterogeneity.

\(^5\)Allowing firms to have asymmetric and correlated signal technologies (e.g., \( E[\nu_i^2] = \sigma_\nu^2 \), and \( E[\nu_i \nu_j] \neq 0 \))
would complicate presentation without significantly altering our qualitative conclusions. See Vives (1984)
for a treatment along these lines.

\(^6\)We do not analyze the possibility of costly information acquisition. However, doing so will not affect the
qualitative results of our analysis so long as the cost of information acquisition is contractible.
consider two scenarios: In the first, each firm keeps its information private, and forms an expectation based on $s_i$ (for firm $i$). Alternatively, firms pool their information and form expectations based on the full vector of signals $s = (s_1, \ldots, s_n)$. Finally, in period 2, firms noncooperatively choose prices to maximize their individual profit, given the quantities of output arranged for delivery in the previous period. We assume “efficient rationing” (e.g., Tirole, 1989) of quantities, so that equilibrium prices in period 2 are just those that form an equilibrium when all quantities are delivered to the market.

The structure of this market is formally equivalent to Bertrand competition with firms choosing capacities in an \textit{ex ante} period; here “capacities” are given by the quantity of output arranged for delivery during period 1. For this equivalence to hold, it is, of course, essential that no firm have the opportunity to obtain additional output in period 2 (relative to what was arranged for delivery during period 1). This is a natural feature of the markets we study, given the time interval required to produce most kinds of farm output.\textsuperscript{7}

\textit{Market Equilibrium Without Information Sharing}

In period 1, after each firm receives its signal $s_i$, the firms play a Cournot game in choosing quantities of output for delivery in period 2. For given $q_i$, the conditional expected profit of firm $i$ is given by

\begin{equation}
\Pi(q_i, q_{-i}|s_i) = \left(\alpha + E[\varepsilon|s_i] - \beta q_i - \gamma \sum_{j \neq i} E[q_j|s_i]\right) q_i,
\end{equation}

where $\alpha = \overline{\alpha} - a$, $\beta = \overline{\beta} + b$, and $\gamma = \overline{\gamma} + b$. Let $\rho = \sigma_{\varepsilon}/(\sigma_{\varepsilon} + \sigma_{\nu})$ represent the correlation between $s_i$ and $s_j$. Then firms update their priors on $\varepsilon$ with the formula $E[\varepsilon|s_i] = \rho s_i$, which is a weighted average of the prior and $s_i$.

Firm $i$ chooses $q_i$ to maximize conditional expected profit, given expectations about $\varepsilon$ and the production decisions of other firms. For any given strategy used by other firms (that will\textsuperscript{7}It is also worth noting that we take as a given each firm’s desire to coordinate with growers in period 1 (rather than compete for aggregate output in period 2). This is consistent with the notion that firms “contract” with growers, rather than purchase output on some kind of spot market. Understanding why firms choose to contract is an interesting problem, but one that lies beyond the scope of this paper. Interestingly, as noted in the previous section, the absence of spot markets (and the corresponding prevalence of contracted arrangements) seems to be a necessary condition for the establishment of bargaining associations.
be conditional on other firms’ signals), firm $i$’s best response is given by

$$q_i(q_{-i}) = \frac{\alpha + \rho s_i - \gamma \sum_{j \neq i} E[q_j|s_i]}{2\beta}.$$  

We find the equilibrium for this game by supposing that firms use strategies that are affine in their signals, and then verify that these strategies indeed form an equilibrium (Radner, 1962). Letting firm $i$’s equilibrium strategy be given by $q_i = c_0 + c_1 s_i$, and noting that $E[s_j|s_i] = \rho s_i$, it is straightforward to verify that an equilibrium is obtained setting $c_0 = \alpha/\delta$, and $c_1 = \rho/\delta\rho$, where $\delta = 2\beta + (n-1)\gamma$, and $\delta\rho = 2\beta + (n-1)\gamma\rho$. The equilibrium quantity for firm $i$ is then given by

$$q_i^p = \frac{\alpha}{\delta} + \frac{\rho s_i}{\delta\rho}.$$  

For future reference, we note that $E[q_i^p] = \alpha/\delta$, $E[(q_i^p)^2] = E[q_i^p]^2 + \sigma_\varepsilon^2\rho/\delta^2\rho$, and $E[q_i^p q_j^p] = E[q_i^p]^2 + \sigma_\varepsilon^2/\delta^2\rho$, for $i \neq j$.

The full information equilibrium level of production when $\varepsilon$ equals its expected value of zero is given by $\alpha/\delta$, so that firms increase or decrease their output relative to this benchmark, depending on whether the realization of $s_i$ is greater or less than zero. The variance of signal noise $\sigma_\nu$ has an ambiguous effect on the slope term $\rho/\delta\rho$. On the one hand, as $\sigma_\nu$ decreases, firms put more weight on their signals relative to their prior, and this makes firms more responsive to their signals. This effect is reflected in the numerator of the second term in equation (5) where a decrease in $\sigma_\nu$ increases $\rho$. On the other hand, a decrease in $\sigma_\nu$ increases the correlation of firms’ signals. This, in turn, implies that if some firm, say firm $i$, receives information suggesting high demand, it is likely that other firms have received similar information. Because the outputs of each firm are strategic substitutes, an equilibrium response to this is a reduction in firm $i$’s output. This effect is reflected in the denominator, where a decrease in $\sigma_\nu$ increases $\delta\rho$. Changes in $\sigma_\varepsilon$ have a similarly ambiguous, though reciprocal, effect on firm responsiveness. A reduction in $\sigma_\varepsilon$ lowers the weight placed on each firm’s signal, making firms less responsive, but also reduces the correlation of signals, and this tends to increase responsiveness.
Expected profit for each firm prior to observing their signal \( s_i \), but anticipating equilibrium behavior for any realization of \( s \), is given by

\[
\Pi_p = E \left[ \max_{q_i} \Pi(q_i, q_{-i}|s_i) \right],
\]

which from (3) and (4) reduces to \( \Pi_p = \beta E[(q^p_i)^2] \). Direct calculation from (5) then yields

\[
\Pi_p = \beta \left( \alpha^2 \frac{\delta^2}{\rho^2} + \sigma_{\epsilon} \sigma_{\nu} \right).
\]

The first term in this expression represents the profits each firm would receive if there were no uncertainty (\( \sigma_\nu = 0 \)). From this term, expected profits are high when aggregate demand and supply are high (high \( \bar{\alpha} \) or low \( a \)), or when the total price decrease resulting from a small increase in each firm’s output is small (low \( \delta \)). The second term, which is strictly positive so long as \( \sigma_\nu \) is finite, reflects the benefit from receiving a signal, relative to no information at all.

One consequence of information sharing is an increase in the precision with which firms estimate \( \epsilon \). Thus, before considering the market equilibrium with information sharing, it is instructive to consider how a reduction in the variance of the signal error \( \sigma_\nu \) (which reduces the variance of each firm’s estimate of \( \epsilon \)) affects expected firm profits when there is no information sharing. From (7), a reduction in \( \sigma_\nu \) has a similar qualitative effect on profits as on the equilibrium responsiveness of each firm’s output to their signal (described above). Firms benefit from a reduction in the variance of signal noise because their output decision more accurately reflects actual demand conditions. In particular, the mean square error of each firm’s estimate of \( \epsilon \) (given by \( \sigma_\epsilon \sigma_\nu / (\sigma_\epsilon + \sigma_\nu) \)) falls when \( \sigma_\nu \) falls. However, because the signals of each firm become more correlated, equilibrium outputs also have greater correlation, and this tends to reduce expected profits. This ambiguity suggests that whether or not firms gain from information sharing will generally depend on a direct comparison of expected profits in each regime. In the next section, we derive an expression for expected firm profits when information is shared, and make this comparison.
Market Equilibrium With Full Information Sharing

Here, we suppose that some mechanism is available for firms to share their information. Later in the paper, we will argue that bargaining can be one such mechanism. To focus on the potential benefits from information sharing, we continue to assume that firms act as oligopsonists in the market for farm output.\(^8\)

When information sharing occurs, each firm receives the full vector of signals \(s\), and thus all firms form a common estimate of \(\varepsilon\). With \(n\) independent signals, the best estimate of \(\varepsilon\) is given by \(E[\varepsilon|s] = \rho_n \bar{s}\), where \(\rho_n = \sigma_{\varepsilon}/(\sigma_{\varepsilon} + \sigma_{\nu}/n)\), and \(\bar{s}\) is the mean value of the vector \(s\) (DeGroot, 1970). Proceeding as in the previous section, firm \(i\)'s reaction function is then given by

\[
q_i(q_{-i}) = \frac{\alpha + \rho_n \bar{s} - \gamma \sum_{j \neq i} E[q_j|s]}{2\beta},
\]

yielding the equilibrium quantity

\[
q_i^* = \frac{\alpha + \rho_n \bar{s}}{\delta},
\]

with \(E[q_i^*] = E[q_i^p] = \alpha/\delta\), and \(E[(q_i^*)^2] = E[q_i^*q_j^*] = E[q_i^*]^2 + \sigma_{\varepsilon}\rho_n/\delta^2\).

Thus, equilibrium expected output is the same, regardless of whether or not firms share information on their common demand uncertainty. Firms are more responsive to their aggregate signal \(\bar{s}\) than to their private signal \(s_i\) when

\[
\frac{\rho_n}{\rho} \geq \frac{\delta}{\delta^*},
\]

and it is straightforward to verify that this condition is always satisfied (for \(\beta > \gamma\)). Information sharing increases the precision of each firm’s estimate of \(\varepsilon\), and this makes firms more responsive to their signals; but information sharing also leads to perfect correlation in firms’ strategies, and this makes firms less responsive to their signals. The satisfaction of the inequality (10) indicates that the net effect of these countervailing forces is always an increase in firm responsiveness.

\(^8\)Bargaining that leads to competitive pricing for farm output would, of course, generate efficiency gains, but we would like to evaluate the benefits from information sharing independent of changes in market structure.
As in the previous section, expected firm profits are given by \((\beta \text{ times})\) the expected value of equilibrium quantity squared. Thus, expected firm profits with information sharing are given by

\[
(11) \quad \Pi_s = \beta \left( \frac{\alpha^2}{\delta^2} + \frac{\sigma_s \rho_n}{\delta^2} \right),
\]

and comparison of profits under each regime reduces to a comparison between the relative magnitudes of \(\rho_n/\delta^2\) and \(\rho/\delta^2\).

**Welfare Comparison**

In this section we evaluate the effect of information sharing on total expected welfare, and on the expected welfare of firms, consumers, and growers individually. We evaluate *ex ante* welfare (prior to the firms receiving their signals), but suppose, as in the previous section, that firms anticipate the equilibrium outcome in either scenario for a given realization of \(s\).

We begin with the difference in expected firm profits with and without information sharing.

It is straightforward (though somewhat tedious) to show that \(\Pi_s \geq \Pi_p\) whenever

\[
(12) \quad 4 \beta (\beta - \gamma) - (n - 1) \gamma^2 (1 + n \rho) \geq 0.
\]

The following proposition summarizes the conditions under which information sharing leads to higher expected firm profits:

**Proposition 1.** (Firm Profits) *Information sharing increases expected firm profits when*

1. *outputs are highly differentiated* \((\gamma \text{ small})\);
2. *own demand is relatively inelastic* \((\beta \text{ large})\);
3. *there are few firms*;
4. *the correlation among firms’ signals is small* \((\sigma_\varepsilon \text{ small and } \sigma_\nu \text{ large})\).

Intuitively, a high degree of product differentiation is analogous to each firm acting as a monopolist in the downstream market for farm output. Improved information on future demand increases each firm’s ability to price discriminate, and this in turn increases expected profitability. Firms similarly gain from information sharing when own demand is sufficiently inelastic. When there are a small number of firms, and when the correlation among firms’
signals is relatively weak, correlation among firms’ strategies is relatively unimportant and this tends to make information sharing more attractive to firms.

Surplus for growers is given by \( \frac{1}{2}(r(Q) - a)Q = \frac{b}{2}Q^2 \), so that expected grower surplus is given by

\[
\frac{n b}{2} \left( E[q_i^2] + (n - 1)E[q_i q_j] \right). 
\]

Using the expressions for \( E[q_i^2] \) and \( E[q_i q_j] \) obtained in the previous sections, it is straightforward to verify that growers always benefit from information sharing. Intuitively, both growers and firms gain from increased precision in estimating aggregate demand. However, the increase in correlation among firms’ outputs lowers expected firm profits, and increases expected grower surplus. Thus, the two effects associated with information sharing—increased precision in estimating aggregate demand and increased correlation among firms’ outputs—are countervailing with respect to firm profits, but complementary with respect to grower surplus.

Consumer surplus is given by \( U(q) - \sum_{i=1}^{n} p_i q_i \). Taking expectations (and assuming equilibrium behavior by firms) yields

\[
\frac{n}{2} \left( \beta E[q_i^2] + (n - 1)\gamma E[q_i q_j] \right). 
\]

Thus, consumers also benefit from the correlation among firms’ outputs, but only when there is some degree of product substitutability. As with grower surplus, the effects of information sharing on consumer surplus tend to complement, though to a lesser degree since \( E[q_i q_j] \) is weighted by \( \gamma < \beta \). Using the expressions for \( E[q_i^2] \) and \( E[q_i q_j] \) from the previous section, consumers gain from information sharing whenever

\[
\frac{\rho n}{\rho} \geq \frac{\delta^2(\beta + (n-1)\gamma \rho)}{\delta^2(\beta + (n-1)\gamma)}. 
\]

Because \( \rho < 1 \), if information sharing leads to higher expected profits for intermediaries, then expected consumer surplus also increases. Also, note that when \( b = 0 \) this inequality will always be satisfied since then \( \delta = \beta + (n-1)\gamma \) and \( \delta_\rho = \beta + (n-1)\gamma \rho \). For \( b > 0 \), condition (15) will generally hold, but can be violated. Thus, consumers generally gain
from information sharing, though we cannot rule out the possibility that expected consumer surplus falls.

Adding up the expected surplus measures for each party, total expected surplus is given by

\[ \frac{n}{2} (3\beta E[q_i^2] + (n - 1)\gamma E[q_i q_j]) , \]

and is greater when information is shared if

\[ \frac{\rho n}{\rho} \geq \frac{\delta^2 (3\beta + (n - 1)\gamma \rho)}{\delta^2 (3\beta + (n - 1)\gamma)} . \]

As with expected consumer surplus, total expected surplus increases with information sharing whenever expected firm profits increase, but again we cannot rule out the possibility that expected total surplus falls. In general, however, it seems difficult to violate the inequality in (17).

The following proposition summarize the effects of information sharing on grower, consumer, and total surplus:

**Proposition 2.** (Welfare) Information sharing always benefits growers. Expected consumer and total surplus increase whenever expected firm profits increase, and may increase even as expected firm profits fall.

Because the expressions for changes in expected profit and consumer surplus resulting from information sharing yield ambiguous results, we evaluate these measures (and expected grower surplus) for a particular specification of our model. We set \( n = 5, \alpha = 1, \beta = 0.3, a = 0, b = 0.1, \sigma_e = 0.3, \) and \( \sigma_v = .1. \) With this specification, we then let \( \bar{\gamma} \) range from 0 to \( \bar{\beta} \) and evaluate differences in expected surplus with and without information sharing. The results are displayed in Figure 1. When outputs are sufficiently substitutable, expected firm profits fall when information is shared, though by a relatively small amount. Growers gain most from information sharing when outputs are highly differentiated. Interestingly, the change in expected consumer surplus with information sharing is initially increasing with the degree of product substitutability, then decreasing.

Figure 2 displays the results of a similar comparative static, but where we hold \( \bar{\gamma} \) constant at 0.05, and let \( n \) range between 2 and 10 firms. Again, information sharing leads to a
Figure 1. Difference in expected surplus with and without information sharing as firm outputs become increasingly substitutable in consumer preferences.

decrease in expected firm profits, but now for \( n \) sufficiently large. Information sharing benefits growers (and to a lesser degree, consumers) by a larger amount, as the number of firms increase.

Though not reported, a decrease in \( b \) (making supply more elastic for any given quantity of aggregate output) increases expected consumer surplus with information sharing, and reduces
expected surplus for growers. In all cases analyzed, expected total surplus increases from information sharing, and the benefit to firms is relatively small (and sometimes negative).

It is also noteworthy that growers seem to gain substantially from information sharing, relative to firms, thus adding further potential benefit from bargaining beyond what might be achieved through changes in markets structure (i.e., more competitive pricing of farm output). We commented briefly on this point earlier, where we stated our assumption that bargaining leaves market structure unaltered. For example, in the context of our model, rather than allow firms to compete *a la* Cournot, we could allow the bargaining association to fix some price \( \tilde{r} \) as the price of farm output and let firms compete at this (fixed) price. Growers gain further (relative to the information sharing equilibrium) for an appropriately chosen price, but this would only repeat arguments made in previous analyses regarding the role of bargaining in countervailing market power.

Finally, one further point: In the context of agricultural markets, supply is an important source of uncertainty, in addition to demand. Adding supply uncertainty to our model changes very little, and even enhances the potential role for a bargaining association, if the association can collect information about aggregate supply that is unavailable to each firm individually. To see this, suppose that \( r = a + \eta + bQ \), where now \( \eta \) is an aggregate source of supply uncertainty over which the association and firms share a common (normal) prior with \( E[\eta] = 0 \) and \( E[\eta^2] = \sigma_\eta \). If the association receives a signal \( s_0 = \eta + \omega \) with \( E[\omega] = 0 \), \( E[\omega^2] = \sigma_\omega \), and \( E[s_0s_i] = 0 \) for all \( i \), then it is simple to verify that adding \( s_0 \) to \( s \) in the information sharing regime unambiguously increases expected welfare for all parties, relative to information sharing without \( s_0 \). It seems plausible that a bargaining association, through its communication with all member growers (rather than the growers of a single processor) can add important information concerning current-period supply conditions, further enhancing “price discovery.”

*Private Incentives To Reveal Information and Implementation*

We have seen that information exchange among firms can lead to a market equilibrium that Pareto dominates the equilibrium with no information exchange; however, it turns out that when we examine each firm’s *private* incentive to share information, a firm increases its
expected profits by not reporting, given that all other firms have reported truthfully, and that reports become public information. More formally, suppose that firms play a two-stage game where each firm can truthfully report its signal or report nothing in the first stage, and

If reporting firms can prohibit nonreporting firms from receiving information submitted by reporting firms, then information sharing may be an equilibrium outcome. For a paper that considers exclusionary information sharing of this sort, see Kirby (1988). However, exclusionary information sharing presumes that firms
then firms choose quantities and prices noncooperatively in the second stage, conditional on equilibrium reports in the first stage. The following proposition (adapted from Raith (1996)) summarizes the first-stage equilibrium of this game:

**Proposition 3.** (Information Revelation) *In the two-stage game where firms first decide whether or not to report their signal to other firms, and then choose quantities and prices non-cooperatively (conditional on the vector of equilibrium first-stage reports), each firm’s dominant equilibrium first-stage strategy is to not report its signal.*

Proof: see Appendix.

In other words, given that all firms $j \neq i$ report their signals truthfully, firm $i$ gains by deviating and reporting nothing. Intuitively, given that all other firms report their signals, firm $i$ obtains the full benefits from increased precision in estimating aggregate demand, and, by withholding its signal, reduces the correlation among equilibrium outputs. This unambiguously raises expected profits for firm $i$, relative to the equilibrium in which it also reports its signal.

Thus, firms potentially face a Prisoner’s Dilemma in which all parties gain from information sharing, but equilibrium behavior is to not share. Moreover, as we’ve seen in the previous section, this equilibrium generally leads to lower expected welfare for consumers and growers. It is, thus, useful to consider the kinds of institutions that might lead to an efficient outcome. Vives (1990) and Kirby (1988) suggest that “Trade Associations” are such an institution in markets where firms’ outputs are strategic complements. With strategic complementarity, information sharing unambiguously increases expected firm profits, and it is a dominant strategy for firms to report their information. Thus, by collecting industry-wide information, and reporting back aggregate statistics, it is argued that these associations effectively implement an information sharing outcome.

However, even in this example where there is no Prisoner’s Dilemma, implementing the sharing equilibrium requires a highly detailed information gathering effort by the association. In particular, we noted earlier that firms’ reports of their signals must be *verifiable* in the sense that firms are unable to misreport their signals (though they can choose to not report

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are playing something other than a simultaneous move game at the information reporting stage. In any case, firms will reveal *some* information when choosing quantities, so that full exclusion will never be possible.
entirely). Ziv (1993) studies information sharing when firms can strategically distort their signals, and finds that firms will always choose to report nontruthfully. Thus, in practice, verifiability is likely to be a substantial informational barrier, and it is not clear from existing theoretical work whether trade associations actually overcome this barrier, or whether their primary service is in other dimensions (e.g., lobbying and promotional activities).

When firm outputs are strategic substitutes (as in the markets we study), implementation becomes even more difficult. However, assuming verifiability of information reports, there is a simple solution to the Prisoner’s Dilemma noted in Proposition 3. In particular, if reports can be verified in the sense described above, then firms can *contractually* implement the information sharing equilibrium. That is, each firm can formally commit to report its information, and with an appropriately chosen penalty for nonreporting, all firms will report in equilibrium.

A bargaining association can be viewed as an institution that facilitates information among industry participants. Indeed, the annual price negotiation that occurs with bargaining is an opportunity for explicit consideration of future supply and demand conditions (perhaps even the primary activity), and this facilitates verification of information reports by individual firms. Moreover, the structure of bargaining legislation effectively forces information revelation, since firms are *required* to engage in price negotiation under “good faith” bargaining provisions. Further, we can view the setting of a bargained price as a specific mechanism for implementing the information sharing equilibrium represented by equation (9). To see this, note that the supply price \( r \), given equilibrium strategies for each firm, is given by

\[
    r^* = a + b \frac{\bar{n} \bar{s}}{\delta} (\alpha + \rho_n \bar{s}).
\]

Thus, there is a strictly monotonic relationship between the supply price and the relevant aggregate statistic of firm reports. As a result, announcing \( r^* \) and letting firms compete at this *fixed* price is equivalent to announcing \( \bar{s} \) and letting firms compete *a la* Cournot. We summarize this result in the following Proposition:

**Proposition 4.** (Implementation) *There exists a unique supply price \( r^* \) that implements the information sharing equilibrium \( q_i^* \) for \( i = 1, \ldots, n \).*
Each firm’s information about downstream demand can thus be transmitted to competing firms through input price negotiation with the bargaining association. This result provides a clear link between information sharing and the traditional role of bargaining associations in setting an “industry” price, and contrasts with information sharing in the context of a trade association where there is no clear mechanism for implementation.

Conclusion

We provide a rationale for the existence of bargaining associations in agricultural markets that is entirely independent of the role they may play in countervailing market power. In markets with a large proportion of contracted production, and a corresponding absence of spot markets, traditional modes of price discovery are mostly absent. One possible substitute for price discovery via markets is direct communication among competing firms concerning expected future supply and demand conditions. In the spirit of work by Vives (1984), Li (1985) and Raith (1996), we model this communication as a Bayesian game among oligopolists in which each of $n$ firms receives a signal of future demand, and evaluate the welfare implications of each firm sharing its signal with other firms.

Information sharing tends to benefit consumers and growers, but has ambiguous consequences for expected firm profits. Information sharing allows firms to increase the precision of estimated future demand, but because the signals are positively correlated (a natural assumption, given the nature of the markets we study), information sharing also tends to increase the correlation among firms’ equilibrium strategies. In markets where final outputs are substitutes, firm strategies are strategic substitutes, so that a positive correlation of strategies reduces expected profit. Thus, the effects of information sharing tend to countervail with respect to expected profits, and complement with respect to consumer and grower surplus. Even when expected profits for firms increase as a result of information sharing, firms face a Prisoner’s Dilemma in which the equilibrium behavior of each firm is to not report its information (not reporting when other firms report reduces the correlation of strategies, with no effect on the precision of estimated future demand). This equilibrium can be overcome if firms form an $ex$ $ante$ contract requiring full information disclosure once signals have been received. We demonstrate how cooperative bargaining, and in particular
the setting of an industry price for farm output, represents one means of implementing such a contract.

Whether bargaining is primarily a mechanism for information exchange and price discovery, or a means for growers to countervail, or possibly even to exercise, market power has important consequences for the welfare effects of farm bargaining. Though it is not immediately clear how to go about testing the relative merits of these hypotheses, it is worth noting that our model encompasses both possibilities. Thus, with appropriate data one could test if predictions associated with information sharing add explanatory power, relative to a model based purely on the exercise of market power. Given the nested nature of these hypotheses in our model, such a test could, in principle, be carried out.
Appendix

Proof of Proposition 3:

To prove this result, we consider an equilibrium where \( n - k \) firms report their private signal whereas the \( k \) remaining firms do not. In the first step, we compute the equilibrium strategies of a firm who belongs to the set of non-revealing firms, and we derive the equilibrium expected profit for this firm. In the second step, we compute the equilibrium strategies and expected profit of the same firm when it reports its signal. Comparing expected profits in the two cases, we then show that choosing to reveal results in a lower expected profit for any \( k \in \{1, 2, ..., n\} \).

Step 1: We first define and compute a firm’s strategy when it belongs to the set of non-revealing firms. We use the subscript \( i \) (resp. \( j \)) when referencing non-revealing (resp. revealing) firms. Given the information available when production decisions are made, the expected profit for a nonrevealing firm is given

\[
\Pi_i \left( q_i, q_j \mid \sum_{j=1}^{n-k} s_j, s_i \right) = q_i \left[ \alpha + E \left( \varepsilon \mid \sum_{j=1}^{n-k} s_j, s_i \right) - \beta q_i - \gamma (k-1) E \left( q'_i \mid \sum_{j=1}^{n-k} s_j, s_i \right) - \gamma (n-k) q_j \right],
\]

where a prime is used to indicate nonrevealing firms other than \( i \). Similarly, the expected profit (conditional on information reports) of a revealing firm is given by

\[
\Pi_j \left( q_j, q_i \mid \sum_{j=1}^{n-k} s_j \right) = q_j \left[ \alpha + E \left( \varepsilon \mid \sum_{j=1}^{n-k} s_j, s_i \right) - \beta q_j - \gamma k E \left( q_i \mid \sum_{j=1}^{n-k} s_j \right) - \gamma (n-k-1) q'_j \right].
\]

We suppose that firms use strategies that are affine in the relevant signals, with the following form:

\[
q_i = C_{0i} + C_{1i} \sum_{j=1}^{n-k} s_j + C_{2i} s_i \tag{19}
\]

\[
q_j = C_{0j} + C_{1j} \sum_{j=1}^{n-k} s_j \tag{20}
\]
Noting that

\[
E \left( \varepsilon \mid \sum_{j=1}^{n-k} s_j, s_i \right) = \frac{\sigma_\varepsilon}{(n-k+1)\sigma_\varepsilon + \sigma_\nu} \sum_{j=1}^{n-k} s_j + \frac{\sigma_\varepsilon}{(n-k+1)\sigma_\varepsilon + \sigma_\nu} s_i,
\]

\[
E \left( \varepsilon \mid \sum_{j=1}^{n-k} s_j \right) = \frac{\sigma_\varepsilon}{(n-k)\sigma_\varepsilon + \sigma_\nu} \sum_{j=1}^{n-k} s_j,
\]

\[
E \left( s_{i'} \mid \sum_{j=1}^{n-k} s_j, s_i \right) = \frac{\sigma_\varepsilon}{(n-k+1)\sigma_\varepsilon + \sigma_\nu} \sum_{j=1}^{n-k+1} s_j \text{ with } i' \neq i, \text{ and}
\]

\[
E \left( s_i \mid \sum_{j=1}^{n-k} s_j \right) = \frac{\sigma_\varepsilon}{(n-k)\sigma_\varepsilon + \sigma_\nu} \sum_{j=1}^{n-k} s_j,
\]

and using the strategies defined in (19) and (20), we can then derive the first order conditions for each type of firm. Doing so yields,

\[
2\beta C_{0i} + 2\beta C_{1i} \sum_{j=1}^{n-k} s_j + 2\beta C_{2i} s_i = \alpha + \frac{\sigma_\varepsilon}{(n-k+1)\sigma_\varepsilon + \sigma_\nu} \sum_{j=1}^{n-k} s_j + \frac{\sigma_\varepsilon}{(n-k+1)\sigma_\varepsilon + \sigma_\nu} s_i - \gamma (k-1) C_{0i}
\]

\[
- \gamma (k-1) \sum_{j=1}^{n-k} s_j C_{1i} - \frac{\gamma (k-1)\sigma_\varepsilon}{(n-k+1)\sigma_\varepsilon + \sigma_\nu} \left( \sum_{j=1}^{n-k} s_j + s_i \right) C_{2i} - \gamma (n-k) \left( C_{0j} + C_{1j} \sum_{j=1}^{n-k} s_j \right)
\]

for firm \( i \), and

\[
2\beta C_{0j} + 2\beta C_{1j} \sum_{j=1}^{n-k} s_j = \alpha + \frac{\sigma_\varepsilon}{(n-k)\sigma_\varepsilon + \sigma_\nu} \sum_{j=1}^{n-k} s_j - \gamma k C_{0i} - \gamma k \sum_{j=1}^{n-k} s_j C_{1i}
\]

\[
- \frac{\gamma k\sigma_\varepsilon}{(n-k+1)\sigma_\varepsilon + \sigma_\nu} \left( \sum_{j=1}^{n-k} s_j C_{2i} + s_i \right) C_{2i} - \gamma (n-k-1) \left( C_{0j} + C_{1j} \sum_{j=1}^{n-k} s_j \right)
\]

for firm \( j \).

These first-order conditions yield a system of 5 equations in 5 unknowns. Solving this system yields

\[
C_{0i} = \frac{\alpha}{\delta}
\]

\[
C_{1i} = \frac{\sigma_1 (\sigma_1 (n-k) (2\beta - \gamma) + 2\beta \sigma_2)}{\delta [2\beta \sigma_1 (n-k+1) + 2\beta \sigma_2 + \gamma \sigma_1 (k-1)] (\sigma_1 (n-k) + \sigma_2)}
\]

\[
C_{2i} = \frac{\sigma_1}{2\beta [\sigma_1 (n-k+1) + \sigma_2] + \gamma \sigma_1 (k-1)}.
\]
with \textit{ex ante} expected profit

\[
\overline{\Pi}_i = \beta E \left[ (q_{i}^{ns})^2 \right] = \beta \left\{ \frac{\sigma^2}{\delta^2} + \text{Var} \left( C_{0i} + C_{1i} \sum_{j=1}^{n-k} s_j + C_{2i} s_i \right) \right\}
\]

\[
= \beta \left\{ \frac{\sigma^2}{\delta^2} + C_{1i}^2 \text{Var} \left( \sum_{j=1}^{n-k} s_j \right) + C_{2i}^2 \text{Var}(s_i) + 2C_{1i}C_{2i} \text{Cov} \left( \sum_{j=1}^{n-k} s_j, s_i \right) \right\}
\]

\[
= \beta \left\{ \frac{\sigma^2}{\delta^2} + \frac{\sigma^2 (n-k)(2\beta-\gamma+2\beta \sigma_2) \sigma_1 (2\beta (n-k)+\gamma (n+k)) + 2\beta \sigma_2 + 2\beta \sigma_1 (2\beta-\gamma) (n-k) \sigma_1^2}{\delta^2 (2\beta \sigma_1 (n-k) + 2\beta \sigma_2 + \gamma \sigma_1 (k-1))^2} \left( \sigma_1 + \sigma_2 \right)^2 \right\}.
\]

Step 2: Next, we compute the expected profit of a firm when it chooses to not report its signal. There are now \(n-k+1\) reporting firms and \(k-1\) nonreporting firms. Using the same reasoning as in Step 1, the first-order conditions can be stated as

\[
2\beta C_{0i} + 2\beta C_{1i} \sum_{j=1}^{n-k+1} s_j + 2\beta C_{2i} s_i = \alpha + \frac{\sigma^2}{(n-k+2)\sigma_e + \sigma_\nu} \sum_{j=1}^{n-k+1} s_j + \frac{\sigma^2}{(n-k+2)\sigma_e + \sigma_\nu} s_i - \gamma (k-2) C_{0i} - \gamma (k-2) \sum_{j=1}^{n-k+1} s_j C_{1i}
\]

\[
\gamma (k-2) \sum_{j=1}^{n-k+1} s_j C_{1i} - \frac{\gamma (k-2) \sigma_e}{(n-k+1)\sigma_e + \sigma_\nu} \left( \sum_{j=1}^{n-k+1} s_j + s_i \right) C_{2i} - \gamma (n-k+1) \left( C_{0j} + C_{1j} \sum_{j=1}^{n-k} s_j \right)
\]

for firm \(i\), and

\[
2\beta C_{0j} + 2\beta C_{1j} \sum_{j=1}^{n-k+1} s_j = \alpha + \frac{\sigma^2}{(n-k+1)\sigma_e + \sigma_\nu} \sum_{j=1}^{n-k+1} s_j - \gamma (k-1) C_{0i} - \gamma k \sum_{j=1}^{n-k} s_j C_{1i}
\]

\[
- \frac{\gamma k \sigma_e}{(n-k+1)\sigma_e + \sigma_\nu} \left( \sum_{j=1}^{n-k} s_j + s_i \right) C_{2i} - \gamma (n-k-1) \left( C_{0j} + C_{1j} \sum_{j=1}^{n-k} s_j \right)
\]

for firm \(j\).

Again, solving this system for the five unknown parameters in equations (19) and (20) yields a new set of equilibrium coefficients. In this case, we are only concerned with the coefficients associated with a reporting firm, which are given by

\[
C_{0j} = \frac{\alpha}{\delta}
\]

\[
C_{1j} = \frac{\sigma_1}{\delta (\sigma_1 n - \sigma_1 k + \sigma_2 + \sigma_1)}.
\]
Then *ex ante* expected profit for a reporting firm is

\[
\Pi_j = \beta \left\{ \frac{\alpha^2}{\delta^2} + \frac{\sigma_1^2 (n - k + 1)}{\delta^2 (\sigma_1 (n - k + 1) + \sigma_2)} \right\}.
\]

Finally, it is tedious but fortunately not difficult to show that \( \Pi_j \) is strictly smaller than \( \Pi_i \). In particular, we obtain

\[
(21) \quad \Delta \Pi = \Pi_i - \Pi_j = \frac{(\sigma_2(n-1)+\sigma_1(n-k))^2(\Pi_1+\Pi_2+\gamma n)+2\gamma \sigma_1(k-1)+4\beta \sigma_1)}{\delta^2(\gamma \sigma_1(n-k)+\sigma_2)} > 0.
\]

It is immediate to verify that the inequality (21) holds for any \( k \in \{1, 2, ..., n\} \), and therefore that nonrevelation is a dominant strategy for all firms. *QED.*
References


Price Promotion by Multi-Product Retailers

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Paper presented at the

First Biennial Conference of the Food Systems Research Group

Madison, Wisconsin, June 26 - 27, 2003

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Price Promotion by Multi-Product Retailers

Abstract

This paper examines the rationale underlying periodic price promotions, or sales, for perishable food products by supermarket retailers. Whereas previous studies explain sales in a single-product context as arising from informational, storage cost, or demand heterogeneity, this study focuses on the central role of retailers as multi-product sellers of complementary goods. By offering a larger number of discounted products within a particular category, retailers are able to offset the effect of lower margins on sale items by attracting greater volume for higher margin items. The implications that emerge from the resulting mixed-strategy equilibrium are tested in a product-level, retail-scanner data set of fresh fruit sales. Hypotheses regarding the rationale and effectiveness of sales are tested by estimating econometric models that describe: (1) the number of sales items per store, (2) the depth of a given sale, and (3) promotion effectiveness on product and category demand. The results of this econometric analysis support the hypothesis that the breadth and depth of price promotions are substitute marketing tools, but show that promoting many products with small discounts is likely preferred to relying on a few loss-leaders.

keywords: mixed-strategy equilibrium, loss-leadership, price promotion, price dispersion, retailing, sales.
Price Promotion by Multi-Product Retailers

1. Introduction

Supermarkets use periodic price promotions, or “sales” on a regular basis for a variety of products. Although the economic rationale underlying sales for fashion items (Pashigian; Epstein), consumer durables (Varian; Blattberg, Eppen, and Lieberman) and storable food products (Pesendorfer) is well established, relatively little is understood about why supermarkets promote perishable items such as fresh fruits and vegetables, dairy products or meat. This relative lack of attention is particularly surprising given the importance fresh produce plays in attracting consumers to an individual store (Produce Marketing Association) and the average profitability of perishable items (Supermarket News). Whether resulting from monopoly price discrimination, competitive equilibrium among heterogeneous consumers, shifting inventory costs, or any of the other many explanations, few theoretical models recognize the dominant feature of food retailing – supermarkets sell multiple products that meet often complementary needs. Bliss shows that demand complementary can explain the existence of loss-leaders in a retail environment, but does not offer an explanation for why retailers tend to offer several products on sale at the same time. Indeed, it seems natural to focus on the size of the discount as the means by which retailers compete through price promotions, but retailers rather use both the depth and breadth of promotions to build category volume. The objective of this paper is to demonstrate that sales among perishable food items are an equilibrium outcome of a general, multi-product model of retailer behavior in which retailers choose both the size of the promotion and the number of products to promote. Tests of the central hypotheses that follow from this model are conducted against several plausible alternative hypotheses, while recognizing the endogeneity of both promotions magnitude and the number of products offered.
2. The Rationale for Price Promotion

Theories of why retail firms may find it rational to periodically reduce prices, and then raise them again shortly thereafter, revolve around a few key assumptions regarding either the structure of the market, firm behavior, or consumer behavior. First, violations of the “law of one price” can arise within a competitive equilibrium provided consumers differ in the cost of search (Stigler 1961; Rob 1985), the degree of price-information they possess in an \textit{ex ante} or buy in an \textit{ex post} sense (Salop and Stiglitz 1977; Varian 1980; Burdett and Judd 1983; Carlson and McAfee 1983), their cost of inventory holding (Blattberg et al. 1981; Aguirregabiria 1999), their loyalty to a particular store (Villas-Boas 1995; Pesendorfer 2002) or their intensity of demand (Jeuland and Narasimhan 1985; Pesendorfer 2002) or if firms differ in their costs of production (Reinganum 1979).

Second, sales can result if supermarket retailers behave as price-discriminating monopolists maximizing revenue by allocating goods among high-value and low-value consumers either at one point in time, or over time as low-valuation consumers accumulate prior to a sale (Stokey 1979; Conlisk, Gerstner and Sobel 1984; Sobel 1984; Landsberger and Meilijson 1985). Third, promotions may arise if retailers are uncertain regarding the level of demand so must reduce prices in order to attract enough customers to clear their inventory (Rothschild 1974; Lazear 1986; Pashigian 1988). Fourth, retailers may conduct sales for strategic reasons, perhaps as trigger strategies designed to implicitly support a collusive oligopoly (Green and Porter 1984; Lal 1990) or out of a recognition that low prices now will invite relatively benign punishments from rivals (Rotemberg and Saloner 1986). Fifth, managers often regard price promotion as an essential part of introducing a new product (Bass 1980; Spatt 1981). None of these explanations, however, are appropriate in a retail food marketing environment where products are perishable, retailers sell multiple, possibly complementary, goods, and
individual stores tend to interact in highly competitive local markets.

Hess and Gerstner (1987), Bliss (1988), Epstein (1988), Lal and Matutes (1995), McAfee (1995) and Hosken and Reiffen (2001) explicitly allow for multiple-product interactions typical of food retailing, but do not provide convincing empirical evidence that loss-leaders, or even complementarity, are significant factors driving price promotions among food products. Moreover, these papers do not explain why, if retailers sell multiple-products, retailers tend to vary both the size of the discount and the number of products offered.

While many of the theoretical explanations, and empirical tests of these theories, consider fashion items, consumer durable or storable products, supermarkets often run sales on perishable items that are purchased frequently on a regular basis and are typically not stored for long. This rules out many existing explanations for sales among other types of goods. Nonetheless, other forms of price discrimination are perhaps more plausible as many consumers are loyal to a particular store for reasons of geographic proximity, product assortment, store attributes, or due to the effectiveness of a frequent shopper program. Moreover, with the importance of fresh produce to overall supermarket sales, motivations that exploit the complementarity of produce demand with other items may be particularly important.2

In the extreme, retailers can use “loss-leaders” where the sale price is set below cost in the hopes that increased demand for other products – through either higher store traffic or demand complementarity – compensates for lost profit on the sale item and any substitution effects from within the products’ category. Bliss (1988) explains the existence of loss-leaders by suggesting that retailers price according to Ramsey taxation rules such that losses on one product are made up by profits on

2 Fresh fruit and vegetable sales comprised 10.4% of total store sales in 2001 (Produce Marketing Association).
others. Lal and Matutes (1994) specify a model in which loss-leader sales increase total firm profit by generating higher store traffic. According to their logic, shopping involves significant economies of scale so, once attracted to a store through loss-leading promotions, consumers minimize per unit search costs by buying other items on the same trip. Hess and Gerstner (1987) develop a similar model in which they show that demand complementarity can cause retailers to offer loss-leaders and “rain checks” that allow consumers to receive the same deal in the future if the loss-leader sells out on a particular day. Giulietti and Waterson (1997) offer a multi-product retail pricing model similar to Bliss (1988) which admits the possibility of loss-leaders, but use this model to explain only continuous price variation and not periodic sales. Epstein (1988), on the other hand, develops a multi-product version of van Praag and Bode (1992) in which he maintains the dominant rationale for sales among fashion goods is the ability of sales among some goods to increase demand for others. Without relying as explicitly on potential complementarity, McAfee (1985) presents a multi-product version of Burdett and Judd’s (1983) price dispersion model. In this model, cross-sectional price variation is driven by a lack of ex post price information on the part of some consumers for commodities within a particular group, some of which may, in fact, be loss-leaders. In the closest theoretical model to this research, Hosken and Reiffen (2001) develop a model of perishable and non-perishable product sales in which increased revenue from non-discounted perishables supports deep price discounts among non-perishable products. Their model assumes, however, that retail managers price all products with cross-category considerations firmly in mind. This is not the case in reality. Moreover, their empirical analysis provides only weak support for the hypotheses of their model. Despite the theoretical importance of complementarity, empirical support for the effectiveness of loss-leaders, however, is weak.

In fact, Pesendorfer (2002) tests the impact of promotional pricing for ketchup on the demand for detergent, soup and yogurt sales in the same store and finds little empirical support for the sales
externalities that would be expected of a loss-leader. These other products, however, are sufficiently unrelated to ketchup that we would expect the loss-leader impact to be of second-order magnitude if present at all. Rather, any loss-leader evidence is more likely to be contained to the same general product category within the store – among goods that are complementary and not independent in demand. Nonetheless, Walters and McKenzie (1988) find results similar to Pesendorfer in a sample of weekly supermarket sales and profit performance for two stores over a 131 week period. On a weekly basis, only one of eight loss-leaders caused store traffic to increase and none were profitable, while double couponing was more profitable, but not due to a traffic effect. These results are also supported by findings by Arnold, Oum and Tigert (1983) in a broader study of the determinants of supermarket choice, who find that store location, overall low prices, and cleanliness are more important drivers of store traffic than weekly specials. It has yet to be determined, however, whether sales on produce items are more effective in generating sufficient complementary sales to justify their use.

Given the array of theoretical and empirical models that have been developed to explain price promotions for retail products, this study develops a new theoretical model that is consistent with the idiosyncracies of perishable food products and current industry practice. Further, the study seeks an alternative explanation to that which is commonly offered – the demand-complementarity, or loss-leader model – and to test this explanation in a large-scale retail food marketing environment. The empirical approach also recognizes that decisions regarding the depth of a promotion, the number of products to offer on sale and the impact of each are jointly endogenous. Although there are a few studies in the empirical industrial organization literature that test theories of price promotion (Villas-Boas 1995; Pessendorfer 2002), by far the majority of this work remains in the marketing field. Consequently, it is hoped that this study represents somewhat of a synthesis of these two fields.
3. Determining the Effectiveness of Price Promotions

Empirical studies of retail price promotion measure the impact of sales along several different dimensions. First, Blattberg, Eppen, and Lieberman (1981), Neslin, Henderson and Quelch (1985), and Bucklin and Gupta (1992) each estimate the effect of promotion on some type of contemporaneous consumer choice – what brand to choose, how much to buy, or when to buy it, while Gupta (1988) estimates all three. Gupta (1988) is notable in that he finds most of the sales increment due to price promotion for ground coffee comes from brand switching (84%), while only 14% is due to purchase acceleration and 2% due to stockpiling (a 14/84/2 rule). Pauwels, Hanssens, and Siddarth (2002), on the other hand, suggest that price promotions are likely to have significant dynamic components arising from both adjustment effects or permanent impacts and find that a 39/58/3 breakdown is a better description of long-run consumer response to a price promotion. Clearly, much more of the sales impact comes from an increase in purchase incidence relative to brand switching while very little is due to increased purchase volumes. Similar acceleration effects in highly perishable items, however, may lead to greater overall consumption because inventories cannot be held for long. Nijs et al. (2001) report evidence of superior promotion effectiveness for perishable products in a two-stage econometric model in which they first estimate response parameters among a large number of product categories using a VARX model and then explain differences in response in a second-stage generalized least squares approach. Other recent studies of the impact of promotion on purchase behavior go beyond estimation of the “primitive” elasticities of incidence, choice and quantity to conduct meta-analyses of the response parameters themselves. Bell, Chiang and Padmanabhan (1999) use this approach to find that storability has a positive effect on primary demand response to promotions (quantity, but not incidence) as well as a positive effect on secondary demand, or brand choice.
A second group of studies evaluate whether price promotions change consumer decisions in the future, such as a brand loyalty or price sensitivity (Lattin and Bucklin 1989; Guadagni and Little 1983) and find that frequent promotions tend to reduce consumers’ sensitivity of price-response as they come to expect and anticipate periodic price reductions. While both of these lines of research are of interest to retailers seeking to increase category demand, few studies investigate the ultimate, bottom line effects of price promotions on store traffic and profit. As described above, Walters and MacKenzie (1988) constitutes one study in this area in that they estimate the effect of price discounts on aggregate store sales and profitability. The theoretical model developed below, therefore, leads to an empirical approach to testing the impact of promotions at both a product- and store-level. In this way, the empirical model is able to separate promotion strategies that merely reallocate store-share among different products from those that truly generate incremental store traffic.

4. Theoretical Model of Price Promotions for Perishable Products

To be consistent with the nature of perishable product retailing, a theoretical model of price promotion must reflect the fact that sales are a competitive equilibrium outcome in a multi-product environment, even when storage is not possible. In doing so, it explains the existence of “loss-leaders” although selling below marginal cost is not a formal requirement of the model. Consumers buy a number of goods from each part of the store on each visit. Those who have search costs sufficiently low to warrant shopping (i.e. benefits of finding a lower price are greater than the cost of time) will consider a variety of goods prior to making their purchase decision. If all are offered at full retail price, then they

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3 Given the high markups characteristic of perishable products such as fresh fruits and vegetables (52%, on average: Supermarket News), deep discounts are possible without going below acquisition cost. The term loss-leader has developed a qualitative connotation independent of the technical definition.
will not buy. However, if they can find enough of their chosen group, or close substitutes, that are offered on sale, they will buy the entire assortment. In other words, demand accumulates across an assortment of goods until a sale stops the process in a similar manner to the intertemporal allocation of Sobel (1984) or Pesendorfer (2002) in non-perishables. If consumers were to buy only loss-leaders and leave the other products, then they would have to incur the cost of going to another store and repeating the process to fill their entire need. In this sense, shopping entails significant economies of scale (Warner and Barsky 1995).

Considering the dominant form of perishable product retailing, the model developed here consists of a static, multi-product generalization of Pesendorfer (2002). It differs from Pesendorfer (2002) primarily in that perishability rules out intertemporal demand accumulation among low valuation consumers or “shoppers.” Rather, a multi-product retail assortment ensures that demand builds horizontally, or across consumers who vary in their intensity of demand. Specifically, assume each of \( j = 1, 2, 3, \ldots, m \) retailers sells \( i = 1, 2, 3, \ldots, n \) products. The market consists of two groups of consumers. High-valuation consumers do not shop for the lowest-price product, so purchase from store \( i \) so long as the price is below their reservation price for that product, \( v_{1i} \). Retailers face a random wholesale price, \( c_i \), for their produce. All consumers will purchase one of each of the \( n \) products, so a proportion \( \frac{n_i}{m} \) \((0 < n_i < 1)\) of the high valuation group will purchase a particular product only from their chosen store at their reservation price.\(^4\) On the other hand, there are \((1 - n_i)\) low valuation consumers for each product who will shop for the lowest price, but then buy their entire

\(^4\) These consumers may differ in their willingness to pay due to store-loyalty (Pesendorfer 2002), degree of price information (Varian 1980), cost search (Stigler 1961; Rob 1985) or intensity of demand (Jeuland and Narasimhan 1985). Of the sources of heterogeneity that have been advanced in the literature, the model developed here only rules out those that involve intertemporal concerns such as the cost of storage (Blattberg et al. 1981) or rate of time preference (Epstein 1984). High valuation consumers also behave similar to the “impulse buyers” that Hess and Gerstner (1987) use to motivate their block-pricing loss-leader scheme.
basket of $n$ products as soon as they find one member, $j$ below their reservation price, $v_{2i} > v_{1i} > c_i$). In this sense, low-valuation consumers reduce the average price they pay for their entire basket by searching for, and not buying until they find, the loss-leader. Retailers compete for these consumers using the number of leader products offered at each point in time. As potential demand accumulates within the category, competing retailers will offer more and more goods on sale until low-valuation consumers are induced to buy. The “winning” retailer receives all of the low-valuation business, selling part at the sale price ($p_i$) and the remaining, non-sale products at the full list price. This mechanism captures the implicit complementarity of leaders and regular-priced goods, but does not fully describe the impact of demand complementarity in the sense of Bliss (1988) on store traffic.

Traffic refers to the total number of shoppers induced to buy from a particular store. Assuming each consumer buys one unit of each product, store demand is determined by its share of each type of consumer ($\pi_i$) and the total number of consumers. The number of consumers, in turn, depends upon whether the store is successful in its promotion ($q^s_i$) or a failure ($q^f_i$), where $q^s_i > q^f_i$. Assume also that the proportion of each consumer-type, the total number of consumers and all prices are symmetric among the goods. Given both share and traffic effects of a sale, therefore, aggregating over all products yields a total profit during a successful promotion period of:

$$
\pi = q^s (n - N) (\alpha / m + (1 - \alpha))(v_1 - c) + q^s N(\alpha / m + (1 - \alpha))(p - c),
$$

where $N = \max [N_1, N_2, N_3, \ldots N_m]$ is the number of sale-priced goods offered by the “winning” retailer in equilibrium and $N_j$ is the number of sale-priced goods offered by retailer $j$. In the absence of a sale, however, retailers sell all $n$ goods to only their high valuation consumers at their reservation, or list price.

The intuition underlying this specification of the demand function is simple. Retailers charge a
relatively high price for most goods, but recognize that the potential demand from low-valuation consumers builds as they search over stores that do not offer a sufficient number of sale products to attract them. Once a certain critical mass of shoppers is reached, it pays a retailer to cut his price on more products, thereby attracting this entire group of low-valuation consumers. Clearly, the value of $N_i$ must be such that each retailer has an incentive to avoid offering all $n$ products on sale, thus immediately earning the entire market. On the other hand, if a firm’s market consists only of high valuation consumers, Sobel (1984) shows that it effectively has a monopoly over this group, so derives a total profit of $q^n \left( \frac{m}{n} \right) (v_1 - c)$.

Varian shows that there is no pure-strategy equilibrium to such a pricing game. Rather, he uses the logic developed by Butters in arguing that price dispersion among stores can be supported as a mixed strategy equilibrium. In order for a mixed strategy equilibrium (MSE) to exist, the amount of expected profit earned by using a loss-leader strategy must be the same as that expected to be earned from focusing entirely on high-valuation consumers. To solve for the price distribution underlying the MSE, however, it is first necessary to describe the decision making process of produce retailers.

On the supply side, each retailer sets the price and promotion strategies for all products sold in his or her store simultaneously. We assume the retail supermarket industry is monopolistically competitive so stores are differentiated by location and other factors, but make zero economic profits after competing in prices. Therefore, the decision is whether to price at the high-valuation consumers’ reservation price, or to set a “sale price” below this level. In setting this price, a retailer observes the state of demand as summarized by $q^s$ and $N$ and uncertain product costs, retailing costs, and other components of the economic environment, $Z$. Retailers will only supply the product if the price they

---

5 Pesendorfer assumes all supply-side uncertainty comes through the wholesale price, but the source is immaterial to the results of the model so we make a more general assumption that non-sale pricing decisions are driven by a number of economic variables.
are able to charge is greater than their marginal acquisition cost, \( c \). Therefore, conditional on the vector of “industry conditions,” assume the price of each product \( i \) offered by firm \( j \) is drawn from a marginal probability density [distribution] function \( f_{i,j}^{i} (p_i | Z) \) \([F_{i,j}^{i} (p_i | Z)]\) in a manner similar to McAfee (1995).

Allowing for competition over the “low” customers, assume firms choose the price for each product at random according to the marginal density function above. Following this strategy, firm \( j \) will offer the lowest price on product \( i \) only if all other \( m - 1 \) firms offer a higher price. Assuming symmetric price distribution, and suppressing the \( Z \) notation, this event occurs with a probability \( (1 - F_{i,j}^{i} (p_i))^{m-1} \).

Therefore, at least one of the other \( m - 1 \) firms will offer a lower price on product \( i \) with probability \( (1 - (1 - F_{i,j}^{i} (p_i)))^{m-1} \), and thereby count one product toward its total offering of “lowest priced products” for that week. Assuming the marginal price distributions are symmetric over both products and firms, the joint distribution over all \( N \) products offered on sale by each firm is \( (1 - (1 - F_{i,j}^{i} (p_i)))^{m-1} \). This is the distribution of the lowest price offered by firms other than firm \( j \), which we denote as \( F^{j\{p\}} \) now defined, of course, over the vector of prices. To solve for the specific form of the price distribution of firm \( j \), it is necessary to first solve for the profit of firm \( j \) in terms of \( F^{j\{p\}} \) and then solve for \( F^{j\{p\}} \) in terms of the parameters of the profit function. In this way, both the form and existence of a mixed strategy equilibrium in loss-leaders is derived.

Taking the price distribution as given, the expected profit for firm \( j \) during a sale period becomes the sum of profit from high-valuation and low-valuation consumers (shoppers) buying each product multiplied by the probability of holding a successful sale:

\[
B[p_j] = [q^{j}(n - N)(\alpha_{h}/m + (1 - \alpha_{h})) (n - c) + q^{j}N(\alpha_{h}/m + (1 - \alpha_{h})(p - c)) (1 - F^{j\{p\}})].
\] (2)

But, the mixed strategy equilibrium requires this level of profit to equal the profit during non-sale periods in which the firm sells only to high-valuation consumers, or:
Solving for the distribution of the minimum prices charged by all other \( m - 1 \) firms:

\[
q^f_{n(\alpha_n/m)}(v_1 - c) = [q^f(n - N)(\alpha_n/m + (1 - \alpha_n))(v_1 - c) + q^fN(\alpha_n/m + (1 - \alpha_n))(p - c)](1 - F^f(p)).
\] (3)

so firm \( j \) draws its sale prices from a joint distribution over \( N \) products on the support \((v_1, c)\) defined as:

\[
F^f(p) = \frac{((q^f - q^f)n(\alpha_n/m) - q^fN(\alpha_n/m + (1 - \alpha_n))(v_1 - p))}{q^fN(\alpha_n/m + (1 - \alpha_n))(v_1 - p) - q^fN(\alpha_n/m + (1 - \alpha_n))(v_1 - c)},
\] (4)

The existence of this distribution as an equilibrium pricing strategy shows that retailers can maintain pricing strategies in which they sell some products at a lower price than others, using shoppers attracted for the low-price offerings to increase profit throughout the store. In practice, this equilibrium provides a snapshot of one point in a process by which a retailer offers an increasing number of products for sale, selling only to his loyal customers, until eventually offering the most discounted products in the market. At this point, he captures all of the non-loyal shoppers in the market and sells this group both the discounted and non-discounted products. If this distribution does indeed describe but one point in an ongoing pricing competition between retailers, then a winning retailer maintains \( N \) goods on promotion until another retailer offers more. Although this may appear to lead to a convergent process whereby retailers offer more and more products on sale until every store follows an everyday-low-price (EDLP) strategy, it may instead explain the movement of grocery retailers toward supercenter and club-store formats, where one benefit is the ability to offer a wider assortment of products on sale each
Because sales are driven by the multi-product nature of retailing, the model developed here is as much one of promotional breadth as it is a rationalization for price dispersion. The breadth of a promotion, defined as the number of products on sale in equilibrium, is found by solving for the level of $N$ where $F^j(p) = 0$:

$$N = \frac{(q^i - q^j) n(\alpha_n/m) + q^i (1 - \alpha_n))(v_1 - c)}{q^i(\alpha_n/m + (1 - \alpha_n))(v_1 - p)}.$$

So the number of sale products is directly related to the expected effectiveness of the promotion, the margin earned on non-promoted products (assuming $q^i > q^j$) and the total number of products in the category, but inversely related to the depth of the sale and the proportion of loyal customers. Finding that the number of sale products falls with the proportion of loyals is similar to Raju, Srinivasan and Lal who argue that the likelihood of promoting a single product is lower for products with stronger brand loyalty. In addition, however, it is clear that rival strategies and the intensity of competitive behavior in a particular market can also have an effect on the number of products offered for sale.

Differentiating (6) with respect to the equilibrium price shows that the number of sale products rises in their price. Therefore, if the reservation price for a particular product, $v_1$, is determined by fixed attributes, while the equilibrium price varies with the set of competitive factors summarized by the vector $Z$ above, then shocks that cause $p$ to rise will cause $N$ to rise as well. For example, assuming prices at rival stores are strategic complements ($dp/dp^j > 0$), a price increase by a rival will cause the number of sale products to rise. This illustrates the fundamental trade off between the depth of a promotion and the number of promoted products that each retailer faces – if prices are reduced by a greater amount during a sale, then a competitive retailer must offer fewer products at the sale price to
maintain a given level of profit. To the extent that a promoted product is very effective in generating traffic within a particular category, then a deeper cut may mean that it alone suffices to serve the objectives of the promotion. At the extreme, this is the definition of a loss-leader. Indeed, such a high proportion of fresh produce consumers purchase bananas on each trip to the store, retailers seldom need to promote anything else when bananas are on deal. The importance of loss-leadership in this model suggests that the equilibrium promotion depth is another key metric of promotion intensity that arises from this model.

Following the logic used in finding (6) above, the equilibrium “magnitude” of the sale, or the depth of the promotion, is found by solving for the difference between the maximum price for each product and the equilibrium sale price that causes the probability of a sale to equal zero:

\[
(v_1 - p) = \left(\frac{n}{N}\right) \left(\frac{(q^e - q^l)((\alpha_n/m) + q^l(1 - \alpha_n))(v_1 - c)}{q^l(\alpha_n/m + (1 - \alpha_n))}\right),
\] (7)

Again, the tradeoff between depth and breadth is evident here as well. A retailer will reduce prices further the fewer products are on sale relative to the entire size of the category. If loss-leaders are offered, then retailers need have very few products on sale. Because this is an equilibrium model of sales, it also suggests that there will be a high correlation among stores offering loss-leaders in a given market. In other words, we are not likely to observe a market in which only one store offers a loss-leader. Moreover, the deeper the sale, on average, the more effective it should be in increasing store traffic above the non-sale case. Although (6) and (7) address questions of significant theoretical research interest, on a practical level industry members are likely to be interested in the demand impact of price promotions.

More specifically, much of the marketing research in this area focuses on differentiating
between the impact of price promotion on: (1) volume or market share of a particular brand or variety and (2) overall store or category-level volume (Gupta 1988; Bell, Chiang and Padmanabhan 1999; Pauwels, Hanssens and Siddarth 2002). To examine the implications of the current model for these two measures, the equilibrium condition is solved for total number of consumers buying each product relative to the non-sale case. Expressed as an increment to historical sales, the gain from holding a price promotion on a per-product basis is written as:

\[
\frac{q^t - q^f}{q^f} = \frac{N(\alpha/m + (1 - \alpha))(v_1 - p) - N(1 - \alpha)(v_1 - c)}{n(\alpha/m)(v_1 - c)}.
\] (8)

Therefore, store traffic rises in the depth of the sale, as expected, but also in the number of products on sale if the ratio of loyals to non-loyals is greater than the ratio of the sale markup to what we have termed the depth of the promotion: 

\[
(\alpha/m) / (1 - \alpha) > (p - c) / (v_1 - p).
\]

If a firm has many loyal consumers, it will need to increase the depth at which it promotes its sale products if it wants to increase traffic by offering more products for sale. This result emphasizes the dual nature of the sales decision – both depth and breadth must be considered jointly and is similar to the conclusion reached by Raju, Srinivasan and Lal (1992) under a different set of assumptions. Although this condition is not defined for the pure “loss leader” case, in the limit \( p = c \) and competitive retailers all maintain an EDLP pricing strategy. Further, although not expressed explicitly as a matrix of cross-elasticities as in Bliss (1988), equation (8) reflects the fundamental logic of demand complementarity that he describes. If a sale in one product increases traffic through a particular part of the store, a certain number of consumers will be tempted to buy another product that they do not necessarily need. As a result of this “impulse purchase,” (Hess and Gerstner 1987) the demand for the second product rises when prices for the first are reduced.
Given that the equilibrium is symmetric among both firms and goods, multiplying both sides of (8) by the total number of goods offered by the store \( n \) gives the aggregate store-level demand, which clearly depends upon the same factors as the per-product demand, but differs according to the store’s incentives to carry a broader assortment of goods. To see this, write the increase in total demand for a particular store as the sum of the increment to all individual product sales:

\[
\mathcal{Q} = \frac{N(\alpha/m + (1 - \alpha)(v_1 - p)) - N(1 - \alpha)(v_1 - c)}{(\alpha/m)(v_1 - c)},
\]

for all stores, \( j = 1, 2, \ldots, m \). Notice from (9) that the average depth of promotion has a greater proportional impact on incremental sales at the store-level than the product level because consumers who are loyal to one product offered by the store are often loyal to other products as well. By aggregating over all of these “loyal groups,” the extent of the promotion becomes relatively more important. Further, recall that the vector \( p \) for an individual store is a function of rival prices. If the depth of a promotion is indeed relatively more important to store, as opposed to product-level sales, rival prices are likely to become more important at the store-level to the extent that they affect the perceived depth of a store’s promotion. Clearly, however, the relative impact of price promotions on product or store-level sales is a critical empirical question – one that is addressed in the next section.

5. Empirical Approach

Overview

Although the conceptual model developed above demonstrates that price promotions can be explained as mixed strategy equilibria among monopolistically competitive, multi-product retailers, the objective of
this paper is not to prove the underlying conditions for the existence of (5), but to test its empirical implications. Whereas other empirical studies in this area seek to explain the probability that a single product is offered for sale (Villas-Boas 1995, Pesendorfer 2002), this is clearly less relevant in a multi-product context where at least one product is offered on promotion at all times. The empirical contribution of this paper, therefore, is to (1) test among alternative hypotheses regarding the rationale for retail price promotions, defined in a continuous, multi-product retail environment as the number of products offered on sale each period, or its “breadth,” (2) determine the factors that explain the “depth” of retail promotions, (3) use measures of the depth and breadth of a promotion to estimate their respective impact on individual product and total perishable category sales.

In estimating these models, we account for the endogeneity of the decision to have a sale while determining its effectiveness. In this way, we develop a synthesis of the empirical industrial organization and marketing literatures on this issue, so hope to provide a more general empirical description of retail sales than either. Moreover, these empirical objectives are all specific to the fresh fruit category in order to highlight the idiosyncracies of a product category that is nearly “perfectly perishable.”

Conceptually, the econometric models consist of three inter-dependent regressions, which together address the questions posed above. Each are described in more detail below, so this brief overview serves to link them together into a coherent whole. The first model consists of a discrete, count-data regression which explains the number of products on promotion at each retail chain. Second, the depth of a store’s promotion is measured using a representative product from each store’s “promoted set.” This approach is required because averaging over sale products necessarily obscures the difference between normal price variation and a true price promotion. Because this representative product is not discounted each period, the empirical model of promotion depth consists of a censored-regression, or Tobit, specification. Auxiliary variables are then calculated from each of these first two
models and substituted into the third in order to account for the endogeneity of both aspects of the sales
decision while estimating the impact of price promotions on demand. This demand model includes both
lower-level, individual product demands (intra-store) as well as upper-level, product category demands
(inter-store) in order to separate product-specific from overall store effects. The upper level consists of
total chain-level sales of each of these product categories for each of six major U.S. metropolitan
markets. In this way, the empirical procedure accounts for both individual product as well as inter-
category and inter-store, or competitive, effects of a price promotion.

First Stage: Number of Sale Products

In the first stage, hypotheses regarding the determinants of the number of products offered for sale
each week by each chain in each market are tested. Because the number of sale products, \( N \), is a
multi-variate discrete variable, it is necessary to use an approach that explicitly accounts for the count-
data nature of the dependent variable. More formally, the number of products on promotion during a
given week are assumed to arrive according to a Poisson process, which is written in general form:

\[
\text{Prob}[N_t = x_t] = \frac{\lambda_t^x e^{-\lambda_t}}{x_t!}, \quad x_t = 0, 1, 2, \ldots.
\]  

where \( N_t \) is the number of products offered on promotion in week \( t \) by store \( i \), and \( \lambda \) is the average
number of products offered for sale during a typical week. Within this general framework, we test
hypotheses regarding the the number of sale products offered by retailer \( i \) by allowing \( \lambda \) to vary with
the vector of explanatory variables, \( Z \), according to:

\[
\ln \lambda_t = \beta' Z_t + \epsilon_t.
\]
where $Z_i$ consists of the arguments of (6) above, namely the total number of products sold by retailer $i$, the change in sales from the previous non-sale period, an estimate of the average margin obtained on non-sale products, the depth of the discounts offered, the number of products offered for sale by rivals, and wholesale price volatility. In this basic form, however, the Poisson model has been criticized for the over-simplistic assumption that its conditional mean and variance are equal. In practice, researchers typically reject this maintained hypothesis, finding instead that the variance is greater than the mean – a condition called “overdispersion.” Overdispersion leads to inconsistent estimates of the vector of parameters, $\psi$. Consequently, generalizations of the basic model take this into account, wherein the distribution of $N_t$ determines the specific form of the alternative model. Specifically, if $g(\cdot, \cdot)$ is gamma distributed, then $N_t$ follows a negative binomial distribution with density:

$$f(N_t) = \left( \frac{1}{\Gamma(\nu)} \right) \left( \frac{\nu \psi N_t}{\psi} \right)^\nu \exp \left( -\frac{\nu \psi N_t}{\psi} \right) \frac{1}{\psi},$$

where $\psi$ is the mean of the process, $\nu$ is the precision parameter, and $\Gamma$ is the gamma density function (Cameron and Trivedi). Cameron and Trivedi develop a simple regression-based test for overdispersion that is useful in selecting between a Poisson and the more general negative binomial models. Under the null hypothesis of no overdispersion, the variance of $N_t$ is equal to its mean, but under the alternative, the variance is some function of the mean:

$$H_0: \quad \text{Var}[N_t] = \psi$$
$$H_1: \quad \text{Var}[N_t] = \psi + \gamma h(\psi)$$

where Cameron and Trivedi assume simple linear or quadratic functional forms for $h(\psi)$. With either
of these assumptions, testing for overdispersion then involves running linear regressions of the variance of \( N \), on each \( h(\psi) \) and conducting t-tests for the significance of \( \psi \). If this parameter is significantly different from zero, the Poisson specification is rejected in favor of the negative binomial. Store profitability, however, is likely to be affected by the magnitude of the price promotion as well as the number of products offered on sale. This question is addressed in a second-stage econometric model.

**Second Stage: Depth of Promotion**

In single-product models of retail promotion, the magnitude of a discount is typically regarded as determined simultaneously with its frequency (Villas-Boas and Lal; Narasimhan and Jeuland). In a multi-product context, however, equation (7) shows that the depth of a promotion is related to the proportion of a store’s products offered for sale, as well as competitive factors that describe the relative costs and benefits of promoting each product. To test the individual impacts each of these variables has on promotional depth, a reduced-form version of (7) is estimated on a product-level basis. However, because each store typically offers many sale products on any given week, it is not possible nor necessary to explain the price of each product offered on sale. Rather, one product is chosen as a “representative sale product” from within each of \( K \) sub-categories (ie. apples, grapes and oranges) and the depth of its discount is estimated as a function of the variables in \( Z \) and the magnitude of the promotion offered on representative products from other sub-categories and other stores. In this way, model accounts for any potential substitute or complementary relationships both within and among stores.

By definition, however, the dependent variable in this model is not continuous. Rather, the variable measuring promotional depth is usually zero, but is non-zero during sale periods. Because each dependent variable is censored at zero, the sale-depth model is estimated as a set of simultaneous
Tobit models – one equation representing the promotion of each representative product. Defining the depth of a promotion for product \( i = 1, 2, ..., K \) offered by store \( j = 1, 2, ..., m \) as \( d_{ij} = (v_{1ij} - p_{ij}) \), the set of Tobit equations is written:

\[
d^*_j = \sum_{-\ell} \gamma_{-\nu} d_{-\nu} + \sum_{-f} \gamma_{-\mu} d_{-\mu} + \sum_{k} \alpha_k Z_k + e_{2j'}, \quad d^*_j = \max[0, d^*_j].
\]  

(14)

for all \( m \) stores and \( K \) sale products. Following the theoretical model above, equation (7) suggests that the vector \( Z \) consists of the ratio of products stocked by the store \( (n) \) to total sale products \( (N) \), the change incremental sales volume during the promotion week for the sale product \( (q^s - q^f) \), and the average margin obtained on non-sale products \( (v_1 - c) \), total volume of the reference product \( (q^s) \) and other competitive variables. By estimating the entire set of equations using Full Information Maximum Likelihood (FIML), the second-stage model captures both the effect of product and store characteristics as well as interaction effects between products and stores. From equation (8), the depth of promotion is of interest both in its own right and as a determinant of promotion effectiveness. This problem is addressed in the third-stage model.

**Third Stage: Promotion Effectiveness**

A third econometric model estimates the impact of each of these measures of “promotion intensity” – the number of products offered on sale and the depth of promotion – on individual product and category volume. In doing so, we explicitly recognize that each of these outcomes is determined simultaneously. As such, it would clearly be preferable to estimate all three stages together in one model. However, given the inherent complexity of the retail-sales decision framework, there is no representation sufficiently parsimonious to lend itself to a single model. Consequently, we use fitted
values of the Poisson intensity parameter from the first stage and fitted promotional-depth values from
the second-stage Tobit model as instrumental variables in the model of promotional effectiveness.

If perishable products are offered for sale as loss-leaders, it is expected that their impact will be
felt in two ways: (1) directly on own-product sales volume, and (2) indirectly on category, or more
specifically, store volume. Given the depth of a typical promotion, however, it is typically argued that
the greatest impact on store profitability derives from the leader’s effect on store volume.
Consequently, the econometric model accounts for both individual product and store choice effects.

Typically, studies that seek to decompose promotion impact into purchase incidence / brand
choice / purchase quantity effects do so using household-level panel data (Boizot, Robin and Visser;
Bell, Chiang and Padmanabhan, for recent examples). Such a perspective provides important
information to manufacturers interested in product-level competition, but is less relevant to retailers who
are interested in store profitability. Therefore, the third-stage model is cast in terms of a two-level
demand system, consistent with both consumer budget-allocation behavior and endogeneity of the
promotion decision.

In a typical two-level demand system, the lower-level consists of individual product choice, or
budget share equations \( w_i \), within a given product category, while the upper-level equations \( Q \)
consist of category choice equations. However, given the effect of price-promotions outlined above,
namely as loss-leaders within a multi-product, imperfectly competitive environment, here we model the
upper-level equations as describing consumers’ choice among stores, not product categories. At the
lower-level, on the other hand, the empirical model estimates the extent to which consumers substitute
among different products once attracted to a particular store. Consequently, the upper-level equations
here consist of the sales of each store, or chain more specifically, relative to others in a particular
market. Taken together, the response model forms a theoretically consistent two-level demand system
with strategic elements. Theoretical consistency in this context means that the demand system describes budget allocation within one branch of an $S$-branch utility tree in a way that adheres to the restrictions implied by constrained consumer utility maximization (Gorman 1959; Anderson 1979).

Specifically, at the lower-level, the demand system consists of six share equations, representing the three sale products and “all others” within each fruit subcategory, while the upper-level consists of a single equation representing all fresh fruit sales. Selection of the forms of this two-level system is constrained by the requirement that either: (1) the upper-level (among category allocation) is weakly separable and the lower-level (within category allocation) is homothetic-separable, or (2) the upper-level is additive (block) separable and the lower-level is of general form (Anderson 1979). Because the restriction of homothetic-separability on the individual product demands is unrealistic, we choose the latter and specify the upper-level demand equation as a linear-expenditure system (LES) (Stone) and the lower-level demands as a linear-approximate Almost Ideal Demand System (LAIDS) (Deaton and Muellbauer).

In addition, this model also accounts for the simultaneity of sales-response, the decision to promote products within each category and the depth of the promotion. To accomplish this in a straightforward way, a generalized Heckman approach is used wherein index values for each of the discrete variables in the prior stages are substituted into the third-stage model prior to estimation. As such, this method is similar to the class of simultaneous equations models with discrete / continuous selectivity developed by Lee, Maddala and Trost 1980. Given each of these considerations, the LES upper-level demands are written:

$$X_j = P_jQ_j - \Theta_{\mu}P_j + \Theta_{\mu}(S - \sum P_iQ_i) + \sum J_i + \Theta_{\mu}D_j + \sum J_i + \Theta_{\mu}Z_i + \mu_1.$$  \hspace{1cm} (15)$$

while the LAIDS, lower-level demands are given as:
where $\epsilon_1$ and $\epsilon_2$ are iid normal error terms, $j$ indexes a particular store, $r$ indexes all stores in a given market, $D_j$ is the average markdown among sale products in store $j$, $Y$ is total consumer income, $X_j$ is total fruit expenditure within store $j$, $N_j$ is the number of sale products offered by store $j$, and $Z_s$ is a set of $s$ exogenous store-demand variables. At the lower-level, $w_{ij}$ is the store-expenditure share of each product, $p_{ij}$ is the shelf-price of each product $i$ in store $j$, $d_{jk}$ is the depth of promotion for each representative sale item, $N_j$ is the total number of products offered for sale in store $j$, and $Z_t$ is a set of $t$ store-level demand variables. Products in this model are defined to include a “sale” and “non-sale” aggregate within each fruit type. While the definition of a “sale” product is provided in more detail below, the “non-sale” aggregate consists of all product codes of each type of fruit that are not chosen as the representative, or sale item. Its price, therefore, is a Stone’s price index calculated across all component items. Because the size of the discount and the number of products offered on promotion are endogenous, instruments for each variable are created by calculating the Poisson and Tobit indices, respectively, from equations (11) and (14) above and substituting them into (15) and (16):

$$
  \hat{d}_{jk} = \max[0, d_{jk}^{*}], \quad \hat{\lambda}_j = \sum k \hat{d}_{jk}/X_j, \\
  N_j = E[N_j] - \lambda_j. 
$$

(17)

By accounting for the simultaneity of each decision in this way all parameter estimates will be consistent, but not as efficient as they would be if they were all estimated in one step. Due to the complexity of the empirical model, however, doing so is not feasible. Further, note that in the LAIDS model, $\ln P_j$ is a Stone price index calculated as:
for all \( j = 1, 2, \ldots m \) stores. At the lower-level the restrictions of symmetry and homogeneity are tested and imposed with the following parameter restrictions:

\[
\sum_{\ell} \Theta_{d\ell} = 1, \quad \sum_{\ell} \Theta_{d1\ell} = 0, \quad \sum_{\ell} \Theta_{d2\ell} = 0, \quad \sum_{\ell} \Theta_{d3\ell} = 0.
\]

As is well known, however, the LAIDS parameters lack a direct interpretation, so price elasticities are calculated as:

\[
e_{d} = -\delta_{d} + \Theta_{d1} \Theta_{d2} \Theta_{d3} \nu_{1} \nu_{2}.
\]

while the expenditure elasticity for each store is:

\[
\eta_{d} = -1 + \Theta_{d2} \nu_{1} \nu_{2}.
\]

for all \( i = 1, 2, \ldots n \) products, where \( \delta_{d} \) is Kronecker’s delta and all other parameters are defined in (18).

At the upper-level, own-price elasticities provide a measure of market power for each store, while the cross-price elasticities are interpreted as strategic response parameters. In terms of the parameters of (18), the LES own-price elasticities are written:

\[
B_{d,i} = -1 + (1 - \Theta_{d2}) \Theta_{d1} \Theta_{d2} / \Theta_{d1} \Theta_{d2}.
\]

while the cross-price elasticities are:

\[
B_{d,i} = -\Theta_{d2} (P_{d,i} \Theta_{d1} / \Theta_{d2}).
\]
for all rival stores in the same market, indexed by \( j \). Own and cross-elasticities can also be defined for
the promotion magnitude and number of sale products in an obvious way. Estimating this entire set of
equations is only possible with a broad, panel data set of high-frequency scanner data, which are
described more fully in the next section.

6. Data and Methods

The data for this study consists of two years of weekly store-level scanner data supplied by Fresh Look
Marketing, Inc. of Chicago, IL. Product-level (UPC or PLU code) price and quantity data are
provided for each chain in six regional markets, for a total of 20 cross-sectional observations, each of
104 weeks in length. Because of the volume of individual product codes involved, the sample consists
of a representative group of high-volume products within the fresh fruit category. Although the data
describe all varieties of fresh apple, navel and valencia oranges, and all varieties of table grape, we
capture the multi-product nature of produce retailing while maintaining analytical tractability by defining
one “sale product” from each category – apples, grapes and oranges. However, stores vary in their
offerings and product descriptions, so it is not possible to define one “standard” product from each
category across all chains and markets. Rather, we define a reference product according to the
following criteria: (1) the product must be offered in all 104 weeks of the sample, (2) it must be among
the top five products within the category in sales volume, (3) its price must change at least twice by at
least 10\% on a week-to-week basis, and (4) if a bulk (bagged) product is chosen to represent one
chain in a particular market, then an equivalent bulk (bagged) product is chosen from other chains in the
same market. Defined this way, each sale product represents a key category-driver in each store and a
transparent point of reference for both consumers and all competing stores in the same market. For
each sale product, a price promotion is defined as a reduction in price greater than or equal to 10% from the previous week’s average selling price. Sensitivity analysis with respect to the definition of a promotion also considers 5% and 15% thresholds. For each category, “all other” price and quantity indices are defined in order to represent all products that are not the sale product. All prices and quantities are expressed in dollars per pound and pound-equivalents where bagged products are sold.

In addition to variables that can be calculated from the scanner data – such as the number of products on sale, the total number of different products offered to consumers, the average depth of promotion or rival activities – each model contains a set of exogenous factors that may otherwise influence the decision in question. Exogenous variables in the first-stage, count-data model include an estimate of the average margin, retailing costs and volatility of the wholesale price. Wholesale prices for each product are obtained from NASS-USDA and represent category-average, shipping-point FOB prices. As such, these prices do not exactly represent the variety of products offered at retail, but changes a representative FOB price will be highly correlated with any more precise product definition. Moreover, the volatility of this price, measured as the three-week moving coefficient of variation, will be very highly correlated with a more exact product match. Retailing costs are measured by an index of wages paid in the food-retail sector and are obtained from the Bureau of Labor Statistics on a monthly basis. All variables are left in nominal, rather than real, terms. With these data, the empirical models described above are estimated in three-stages using maximum likelihood. The final-stage standard errors are corrected for the induced heteroskedasticity inherent in this estimation procedure in the usual way (Greene 2001). Table 1 summarizes all of the data used in this analysis.

7. Results and Implications
Prior to testing the central hypotheses of the paper, a series of specification tests are conducted to ensure that each model is, if not the best, then at least appropriate to the problem at hand. This section presents the results from applying tests specific to each of the three models: (1) a count-data model for the number of sale products, (2) a Tobit model for the magnitude of the discount offered on each product, and (3) a two-level LES / LAIDS model to determine the relative impact of price discounts and offering multiple products on promotion at the same time. Ultimately, the results compare the relative effectiveness of the depth of promotions versus their breadth.

In the first-stage, the question is whether a Poisson model or Negative Binomial model is preferred. Selecting between these two alternatives depends upon whether there is evidence of overdispersion in the data. If so, then a Negative Binomial is appropriate. The regression-based specification test of Cameron an Trivedi involves regressing the Poisson variance against the squared-mean. A t-test finds that the resulting regression parameter, $\mu$ in table 2, is significantly different from zero at a 5% level of significance. Consequently, the remaining results in table 2 are found using a Negative Binomial model. As equation (6) indicates, the number of sale products is expected to rise with the total number of products in the category, the induced change in sales volume, and in non-sale margins, but fall in the level of the discount. After controlling for several measures of retailing cost, it is clear from these results that promotional breadth and depth are indeed substitutes. Specifically, the larger the discount offered on any individual product, the fewer products need to be offered on sale. Second, the number of sale products rises in the average non-sale margin over wholesale cost. Intuitively, a store will benefit more by offering complementary loss-leaders if it earns higher margins on impulse-buy products that are not offered on promotion. Third, the number of sale products rises with high grape and orange sales volume, but the evidence on this point is less clear in apples and total category volume. Fourth, the more different types of products (stock keeping units, or SKUs) sold by
a retailer, the more it will offer on promotion at any given time. This result is intuitive because a retailer would have to offer a similar proportion of goods on sale to maintain a perception of promoting as aggressively as a rival with fewer SKUs in total.

A fifth set of variables measures the strength of competitive reaction in terms of both prices and number of sale products. These variables can be thought of as measuring the degree of loyalty to a particular store as loyalty only has meaning relative to the strength or weakness of competitive interaction. If rival stores sell high-margin products at relatively high non-sale prices, then there is less pressure for a retailer to promote aggressively. The results in table 2 show that this is generally the case, although grape margins represent a contradiction. Moreover, it is expected that more sale products and total products offered by rivals will induce a like reaction from each store. However, the estimates find that retailers rather adopt an accommodation or “puppy dog” strategy and reduce sale offerings in the face of aggressive promotion by rivals. This result is similar to that predicted by Narasimhan (1988) who suggests that retailers with larger loyal segments tend to promote less frequently and with smaller discounts. If a retailer does enjoy a large loyal market segment, then he need not sacrifice profit in order to maintain share in the face of a rival’s frequent promotions. Whether this strategy is true of a second measure of promotion activity – the depth of the discount – is considered next.

Table 3 presents several goodness-of-fit measures for each Tobit model. Both the likelihood ratio chi-square statistic and the F-statistic of the overall model suggest that each model is preferred to a null alternative. As these are, however, only weak tests, this table also offers a more direct test of the
Tobit specification. Namely, if the Tobit “normalizing” parameter, $\Gamma$, is significantly different from zero, then we reject a non-censored alternative. Given that the Tobit is appropriate for these data, table 3 also presents the normalized MLE coefficients used to test each hypothesis regarding promotional depth. Based on the theoretical model given in (7), the magnitude of any given promotion, or the depth of the discount, will be positively related to the total number of products displayed, the product-specific margin, the degree of customer loyalty and the expected incremental gains from the promotion. On the other hand, the size of any discount is expected to fall in the number of products offered.

For each product, the substitutability between promotional breadth and depth appears to be the most important factor in determining the size of a discount. However, the total number of products offered is inversely related in two of the three cases, suggesting that stores with broad assortments do not necessarily promote more intensively as expected. Further, high-margin retailers appear to offer larger discounts in two of the three cases, although the third is not significant. Clearly, retailers use deep promotions on loss-leaders in order to sell more of their high margin products. However, there is only weak evidence that retailers respond to expected gains in category sales with larger discounts. Sales gains with Perhaps surprisingly, there appears to be little competitive interaction in either promotions or pricing (margins), but some further evidence of accommodative behavior in response to total product offerings. If rivals offer a greater array of products, it will be more difficult for consumers to determine which are on sale and which are not. Such confusion allows each retailer to offer smaller discounts and retain shoppers who would otherwise be induced to change stores. Whether or not either the number of products offered on sale, or the size of the discount actually result in greater sales is explored next.

[Table 3 in here]
The third estimation stage consists of one market-level LES equation that captures any potential rivalry among stores, and five store-level LAIDS expenditure-share equations. According to the goodness-of-fit statistics in table 4, the LES regression is highly significant and explains much of the variation in store-level sales. In this table, all results are expressed as elasticities, so suggest that whole category sales for an individual store are quite inelastic and only weakly substitutable with other stores in the same market. More important to the thesis of this paper, however, note that total store sales rise significantly in both the number of products offered on sale and the size of the associated discount. In terms of their relative elasticity values, promotional breadth appears more effective than depth in generating traffic. Thus, loss-leadership may not, in fact, be optimal. Instead, a store may be better off by offering a broad array of small discounts compared to a few, more significant, deals. Given marketing research that shows few consumers actually recall what constitutes a “normal” shelf price, the announcement effect of crowding a food-page ad with many different sale products may indeed be an effective strategy. Whereas the first two stages of the analysis – the number of sale products and the size of discount – suggested that inter-store rivalry in produce marketing is nearly absent, this does not appear to be the case at the market-level. Measured in terms of category-averages, prices between retailers in the same market appear to be statistically significant, yet somewhat small, strategic-substitutes. This result is consistent with industry observations that retailers, despite relatively low national market shares, tend to compete in tight local oligopolies. At this level of analysis, however, it is difficult to tell whether incremental volume is due to higher loss-leader sales or more profitable, high-margin products.
Estimates of a store-level LAIDS model can help answer this question. By dividing each product into “sale” and “non-sale” sub-groups, the model is able to determine whether any positive effect on volume accrues to higher margin, non-sale products or only to the products that are being promoted. If discounts only serve to increase promoted product-share, then the higher store volumes found in the market-level LES model will not likely lead to higher profit. In fact, the results in table 5 show that price discounts exhibit a nearly uniform pattern of increasing loss-leader share at the expense of high margin items. However, increasing the number of products on sale has the opposite effect of increasing high-margin product sales. Consequently, these results again suggest that increasingly promotional breadth may be a more profitable strategy than investing in a few loss-leaders. Further, by examining the own-price elasticities in this table, it appears as though virtually all products are nearly unit-elastic. Therefore, it is not obvious that price reductions will either increase or decrease total revenue for the promoted product. Neither does it appear to be the case that there is sufficient demand complementarity for loss-leaders to be effective in the sense of Bliss (1988) in increasing overall store profitability, although oranges and grapes do appear to be relatively strong complements. In general, however, these results appear to challenge the standard loss-leader orthodoxy in favor of more broad-based, yet shallow promotional strategies.

8. Conclusions

This paper seeks to explain the frequency and depth of price promotions – sales – of perishable food products by supermarkets and to determine their impact on overall store revenue. A theoretical model
of industry equilibrium under monopolistic competition shows that price promotions are mixed strategy equilibria in a dynamic, multi-product environment with heterogenous consumers. This theoretical model suggests a framework for an empirical model that is able to test hypotheses regarding: (1) the number of products offered on promotion at any given time, (2) the depth of price discount offered, and (3) the relative impact of each on store- and category sales volume. Importantly, the empirical approach recognizes that each aspect of the sales decision is endogenous in a simultaneous equations model with discrete / continuous selectivity. With this approach, the breadth of promotion across the product line is estimated with a Negative Binomial count-data model, while promotional depth is estimated using a Tobit framework. Ultimately, the impact of price promotion on product choice and category volume are estimated in a theoretically consistent two-level demand system framework. Estimates of this model in a store-level scanner data set consisting of two-years of weekly fruit sales provide evidence in support of the substitute relationship between promotional depth and breadth, but show that offering more products on sale at any given time is likely to be more profitable than relying on a few loss-leaders in each category. There is little evidence that price-promotions are effective tools for strategic interaction, but overall price levels are important in determining overall market share.

The implications of this research reach beyond the fresh fruit data that we use here. First, by estimating a more general model of price promotions that nests several competing explanations, this study provides guidance for future theoretical research that has tended to draw increasingly narrow assumptions regarding the cause of retail sales. Second, the empirical results show that the primary demand impacts of price promotions, both in terms of the number of promoted products and the size of the discount, in perishable food products are stronger than previously believed to be the case. Marketing managers, therefore, may find justification in using aggressive pricing tactics in conjunction with their category management programs. Third, existing empirical approaches to testing theories of
price promotions in the industrial organization literature, or the effectiveness of promotions in the empirical marketing literature, must recognize that the usual explanatory variables in both are jointly endogenous so must be estimated as such.

Future theoretical research in this area would benefit from pursuing a more general approach than that offered here. While this research explains the existence of promotions among an important class of products, it may not be appropriate for others. However, this paper shows that promotional breadth – a tool that had previously been ignored – does play an important role in food marketing strategy, so may for other products as well. Second, future empirical research may consider a broader selection of perishable products. Within fruit itself, including such items as bananas and strawberries may provide a more general results, particularly considering the frequency with which bananas are both purchased and promoted.
9. References


Table 1. Descriptive Statistics: Retail Fruit Scanner Data: 1998 - 1999

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std.Dev.</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple Price</td>
<td>1.02</td>
<td>0.19</td>
<td>0.50</td>
<td>1.42</td>
<td>2080</td>
</tr>
<tr>
<td>Apple Quantity</td>
<td>207.89</td>
<td>193.31</td>
<td>14.24</td>
<td>1412.53</td>
<td>2080</td>
</tr>
<tr>
<td>Sale Apple Price</td>
<td>0.86</td>
<td>0.32</td>
<td>0.20</td>
<td>1.59</td>
<td>2080</td>
</tr>
<tr>
<td>Sale Apple Quantity</td>
<td>33.93</td>
<td>44.03</td>
<td>23.00</td>
<td>768.44</td>
<td>2080</td>
</tr>
<tr>
<td>Grape Price</td>
<td>2.04</td>
<td>0.71</td>
<td>0.39</td>
<td>5.92</td>
<td>2080</td>
</tr>
<tr>
<td>Grape Quantity</td>
<td>83.94</td>
<td>109.46</td>
<td>11.01</td>
<td>1118.95</td>
<td>2080</td>
</tr>
<tr>
<td>Sale Grape Price</td>
<td>2.09</td>
<td>0.70</td>
<td>0.59</td>
<td>4.99</td>
<td>2080</td>
</tr>
<tr>
<td>Sale Grape Quantity</td>
<td>58.78</td>
<td>102.99</td>
<td>3.04</td>
<td>970.71</td>
<td>2080</td>
</tr>
<tr>
<td>Orange Price</td>
<td>0.91</td>
<td>0.33</td>
<td>0.27</td>
<td>1.99</td>
<td>2080</td>
</tr>
<tr>
<td>Orange Quantity</td>
<td>64.49</td>
<td>79.21</td>
<td>6.78</td>
<td>925.82</td>
<td>2080</td>
</tr>
<tr>
<td>Sale Orange Price</td>
<td>0.92</td>
<td>0.46</td>
<td>0.19</td>
<td>2.17</td>
<td>2080</td>
</tr>
<tr>
<td>Sale Orange Quantity</td>
<td>48.49</td>
<td>102.96</td>
<td>4.30</td>
<td>1043.34</td>
<td>2080</td>
</tr>
<tr>
<td>Number of Product Types</td>
<td>50.53</td>
<td>14.66</td>
<td>20.00</td>
<td>108.00</td>
<td>2080</td>
</tr>
<tr>
<td>Number of Sale Products</td>
<td>2.83</td>
<td>2.98</td>
<td>0.00</td>
<td>22.00</td>
<td>2080</td>
</tr>
<tr>
<td>Apple FOB</td>
<td>0.26</td>
<td>0.04</td>
<td>0.19</td>
<td>0.33</td>
<td>2080</td>
</tr>
<tr>
<td>Grape FOB</td>
<td>0.16</td>
<td>0.06</td>
<td>0.09</td>
<td>0.38</td>
<td>2080</td>
</tr>
<tr>
<td>Orange FOB</td>
<td>0.31</td>
<td>0.12</td>
<td>0.16</td>
<td>0.55</td>
<td>2080</td>
</tr>
</tbody>
</table>

In this table, all prices are in $/lb and quantities are in millions of pounds. For each product, “sale” prices refer to the average price of the representative sale product, not the discounted price.
Table 2. Negative Binomial Model: Number of Sale Products Per Store

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>t-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>15.375*</td>
<td>3.251</td>
</tr>
<tr>
<td>Input Price 1</td>
<td>0.007*</td>
<td>2.439</td>
</tr>
<tr>
<td>Input Price 2</td>
<td>-0.010</td>
<td>-1.189</td>
</tr>
<tr>
<td>Input Price 3</td>
<td>-0.006</td>
<td>-0.746</td>
</tr>
<tr>
<td>Input Price 4</td>
<td>-0.100*</td>
<td>-4.140</td>
</tr>
<tr>
<td>Change in Category Sales</td>
<td>0.000</td>
<td>1.308</td>
</tr>
<tr>
<td>Number of Product Types</td>
<td>0.016*</td>
<td>7.932</td>
</tr>
<tr>
<td>Rival Number of Sale Products</td>
<td>-0.007</td>
<td>-1.863</td>
</tr>
<tr>
<td>Rival Number of Total Products</td>
<td>0.008*</td>
<td>5.544</td>
</tr>
<tr>
<td>Apple Discount</td>
<td>-1.619*</td>
<td>-5.815</td>
</tr>
<tr>
<td>Grape Discount</td>
<td>-1.502*</td>
<td>-7.117</td>
</tr>
<tr>
<td>Orange Discount</td>
<td>-1.352*</td>
<td>-7.952</td>
</tr>
<tr>
<td>Apple Margin</td>
<td>1.008*</td>
<td>8.042</td>
</tr>
<tr>
<td>Grape Margin</td>
<td>0.446*</td>
<td>12.817</td>
</tr>
<tr>
<td>Orange Margin</td>
<td>-0.061</td>
<td>-0.891</td>
</tr>
<tr>
<td>Rival Apple Discount</td>
<td>-0.035</td>
<td>-0.812</td>
</tr>
<tr>
<td>Rival Grape Discount</td>
<td>0.073</td>
<td>0.012</td>
</tr>
<tr>
<td>Rival Orange Discount</td>
<td>0.018</td>
<td>0.016</td>
</tr>
<tr>
<td>Rival Apple Margin</td>
<td>-0.564*</td>
<td>-4.001</td>
</tr>
<tr>
<td>Rival Grape Margin</td>
<td>-0.004</td>
<td>-1.933</td>
</tr>
<tr>
<td>Rival Orange Margin</td>
<td>-0.055</td>
<td>-0.930</td>
</tr>
<tr>
<td>LLF</td>
<td>0.307*</td>
<td>14.102</td>
</tr>
<tr>
<td>Chi-Square</td>
<td>-4228.892</td>
<td></td>
</tr>
<tr>
<td></td>
<td>720.791</td>
<td></td>
</tr>
</tbody>
</table>

\* In this table, a single asterisk indicates significance at a 5% level. Quantity coefficients are scaled by 10^6 for presentation purposes and the product-number variables by 10^3. The significance of \* indicates rejection of the Poisson model in favor of a negative-binomial alternative. All estimates are obtained using a negative-binomial model. Input price 1 is an index of wages in the food retailing industry, input price 2 is an index of wages in the finance, insurance and real estate (FIRE) sector, input price 3 is an index of energy prices, and input price 4 is an index of capital costs.
Table 3. Tobit Estimates of Discount Magnitude - MLE: Apples, Grapes and Oranges

<table>
<thead>
<tr>
<th>Variable</th>
<th>Apple Discount</th>
<th>Grape Discount</th>
<th>Orange Discount</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>t-ratio</td>
<td>Estimate</td>
</tr>
<tr>
<td>Constant</td>
<td>1.462</td>
<td>0.168</td>
<td>-10.623</td>
</tr>
<tr>
<td>Number of Sale Products</td>
<td>-0.105*</td>
<td>-9.219</td>
<td>-0.136*</td>
</tr>
<tr>
<td>Number of Products</td>
<td>-0.735</td>
<td>-1.829</td>
<td>2.755*</td>
</tr>
<tr>
<td>Rival Number of Sale Products</td>
<td>-0.330</td>
<td>-0.415</td>
<td>1.431</td>
</tr>
<tr>
<td>Rival Number of Products</td>
<td>-1.034*</td>
<td>-3.332</td>
<td>0.656</td>
</tr>
<tr>
<td>Margin</td>
<td>0.056*</td>
<td>2.327</td>
<td>0.064*</td>
</tr>
<tr>
<td>Rival Margin</td>
<td>-0.001</td>
<td>-0.032</td>
<td>0.000</td>
</tr>
<tr>
<td>Rival Discount</td>
<td>0.009</td>
<td>0.350</td>
<td>0.035*</td>
</tr>
<tr>
<td>Input Price 1</td>
<td>0.636</td>
<td>1.157</td>
<td>-2.383*</td>
</tr>
<tr>
<td>Input Price 2</td>
<td>-1.504</td>
<td>-0.957</td>
<td>6.266*</td>
</tr>
<tr>
<td>Input Price 3</td>
<td>0.087</td>
<td>0.057</td>
<td>-2.733</td>
</tr>
<tr>
<td>Input Price 4</td>
<td>0.704</td>
<td>0.156</td>
<td>11.354*</td>
</tr>
<tr>
<td>Change in Category Quantity</td>
<td>3.160</td>
<td>1.905</td>
<td>1.700</td>
</tr>
<tr>
<td>Market 1</td>
<td>-0.592*</td>
<td>-2.354</td>
<td>0.491</td>
</tr>
<tr>
<td>Market 2</td>
<td>-0.613</td>
<td>-0.413</td>
<td>-0.471</td>
</tr>
<tr>
<td>Market 3</td>
<td>0.656*</td>
<td>2.861</td>
<td>-0.315</td>
</tr>
<tr>
<td>Market 4</td>
<td>1.039*</td>
<td>3.823</td>
<td>-0.813*</td>
</tr>
<tr>
<td>Market 5</td>
<td>0.858*</td>
<td>3.359</td>
<td>-1.060*</td>
</tr>
</tbody>
</table>

| F | 3.482 | 18.627 | 2.881 | 20.397 | 2.647 | 17.643 |
| R² | 0.517 | 0.565 | 0.598 |
| P | 230.723* | 268.961* | 226.363 |
| F | 113.181* | 16.925* | 14.567 |
Estimates are obtained using a two-stage, sample selection procedure with $E[d^* | s = 1] = z + DF8$ where $d$ is the size of the price discount, $s$ is a binary indicator of a sale’s occurrence, $8 = N/M$ is the inverse Mill’s ratio calculated from the first-stage Probit equation, $F$ is the standard deviation of the second-stage regression and $D$ is the correlation between Probit and regression residuals.

The $P^2$ value is a likelihood-ratio test statistic comparing the estimated to a null model wherein all but the constant are restricted to zero. The critical value at 22 degrees of freedom and a 5% level of significance is 32.67. The critical $F$ value with 2 and 237 degrees of freedom at 5% is 3.00.
Table 4. SURE - LES Estimates of Category Promotion Impact: 1998 - 1999 Six Market Scanner Data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>t-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Own Price&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.070*</td>
<td>-1.991</td>
</tr>
<tr>
<td>Rival Price</td>
<td>0.012*</td>
<td>26.201</td>
</tr>
<tr>
<td>Total Market Expenditure</td>
<td>0.568*</td>
<td>22.872</td>
</tr>
<tr>
<td>Number of Products</td>
<td>-0.050</td>
<td>-1.462</td>
</tr>
<tr>
<td>Number of Sale Products</td>
<td>0.095*</td>
<td>5.192</td>
</tr>
<tr>
<td>Rival Products</td>
<td>-0.100*</td>
<td>-2.507</td>
</tr>
<tr>
<td>Rival Sale Products</td>
<td>-0.003</td>
<td>-0.320</td>
</tr>
<tr>
<td>Own Discount</td>
<td>0.035*</td>
<td>4.573</td>
</tr>
<tr>
<td>Own Margin</td>
<td>0.046</td>
<td>1.431</td>
</tr>
<tr>
<td>Rival Discount</td>
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<td>-1.434</td>
</tr>
<tr>
<td>Rival Margin</td>
<td>1.241*</td>
<td>26.124</td>
</tr>
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</table>

R<sup>2</sup> 0.897
F<sub>0.05, 16, 2043</sub> 1,116.400

<sup>a</sup> A single asterisk indicates significance at a 5% level. Table entries represent elasticities calculated at sample means. Other variables in model, for which elasticities are not relevant so are not presented, are: (1) an autoregressive term in category expenditures, and (2) five market-dummy variables.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Apples</th>
<th></th>
<th>Grapes</th>
<th></th>
<th>Oranges</th>
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<td>Non-Sale</td>
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<td>Non-Sale</td>
<td>Sale</td>
<td>Non-Sale</td>
<td>Sale</td>
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<td>0.054*</td>
<td>0.063*</td>
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<td>(3.277)</td>
<td>(2.158)</td>
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<td>(-56.250)</td>
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<tr>
<td>Apple Sale Price</td>
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<td>-0.032*</td>
<td>0.009</td>
<td>-0.081*</td>
<td>-0.074*</td>
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<tr>
<td></td>
<td>(2.953)</td>
<td>(-30.942)</td>
<td>(-3.122)</td>
<td>(0.571)</td>
<td>(-5.697)</td>
<td>(-2.929)</td>
</tr>
<tr>
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<td>-1.055*</td>
<td>0.023</td>
<td>-0.391*</td>
<td>-0.972*</td>
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<tr>
<td></td>
<td>(3.400)</td>
<td>(-2.520)</td>
<td>(-36.039)</td>
<td>(1.294)</td>
<td>(-18.714)</td>
<td>(-26.740)</td>
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<tr>
<td>Grape Sale Price</td>
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<td>0.037</td>
<td>-0.038*</td>
<td>-1.155*</td>
<td>-0.175*</td>
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<tr>
<td></td>
<td>(3.023)</td>
<td>(1.069)</td>
<td>(-2.465)</td>
<td>(-32.494)</td>
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<tr>
<td>Orange Price</td>
<td>-0.009</td>
<td>-0.076*</td>
<td>0.018</td>
<td>0.004</td>
<td>-1.022*</td>
<td>-0.432*</td>
</tr>
<tr>
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<td>(-1.024)</td>
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<td>(1.495)</td>
<td>(0.224)</td>
<td>(-36.654)</td>
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<tr>
<td>Orange Sale Price</td>
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<td>0.012</td>
<td>0.016</td>
<td>0.008</td>
<td>-0.073*</td>
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<tr>
<td></td>
<td>(1.908)</td>
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<td>(1.393)</td>
<td>(0.427)</td>
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<td>0.936*</td>
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<td>1.048*</td>
<td>0.929</td>
<td>0.213*</td>
</tr>
<tr>
<td></td>
<td>(160.533)</td>
<td>(67.638)</td>
<td>(146.788)</td>
<td>(75.012)</td>
<td>(1.774)</td>
<td>(7.905)</td>
</tr>
<tr>
<td>Number of Products</td>
<td>0.022</td>
<td>-0.124*</td>
<td>0.112*</td>
<td>-0.045</td>
<td>0.051</td>
<td>-0.506*</td>
</tr>
<tr>
<td></td>
<td>(1.293)</td>
<td>(-3.139)</td>
<td>(3.122)</td>
<td>(-1.102)</td>
<td>(0.026)</td>
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<tr>
<td>Number of Sale Products</td>
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<td>0.341*</td>
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<td>0.460</td>
</tr>
<tr>
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<td>(2.515)</td>
<td>(1.417)</td>
<td>(2.841)</td>
<td>(-2.263)</td>
<td>(1.789)</td>
<td>(0.143)</td>
</tr>
<tr>
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<td>0.000</td>
<td>-0.020</td>
<td>-0.018</td>
<td>-0.077</td>
<td>0.772</td>
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<tr>
<td></td>
<td>(2.750)</td>
<td>(-0.032)</td>
<td>(-1.388)</td>
<td>(-1.093)</td>
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<td>(0.433)</td>
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<tr>
<td>Rival Sale Products</td>
<td>-0.017</td>
<td>0.104*</td>
<td>0.018</td>
<td>0.029</td>
<td>-0.013</td>
<td>0.014</td>
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<tr>
<td></td>
<td>(-1.062)</td>
<td>(3.005)</td>
<td>(0.575)</td>
<td>(0.787)</td>
<td>(-1.350)</td>
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<tr>
<td>Discount Magnitude</td>
<td>-0.015</td>
<td>0.002*</td>
<td>-0.002*</td>
<td>0.032*</td>
<td>-0.001*</td>
<td>0.017*</td>
</tr>
<tr>
<td></td>
<td>(-1.891)</td>
<td>(2.857)</td>
<td>(-2.557)</td>
<td>(3.667)</td>
<td>(-3.843)</td>
<td>(4.200)</td>
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</tbody>
</table>

| R²                         | 0.736      | 0.776     | 0.551      | 0.596     | 0.846      | 0.675     |
| F                          | 438.832*   | 545.991*  | 193.525*   | 232.934*  | 867.841*   | 289.712   |
| D.W.                       | 2.644      | 2.359     | 2.779      | 2.412     | 2.359      | 2.188     |

*A single asterisk indicates significance at a 5% level. Values in parentheses are t-ratios. All models also include an autoregressive term in each product’s market share.*
BAYESIAN ESTIMATION
AND
SOCIOECONOMIC DETERMINANTS OF FAST FOOD CONSUMPTION

Thomas L. Marsh\textsuperscript{a}, Jasper Fanning\textsuperscript{a}, and Kyle Stiegert\textsuperscript{b}

2003 Biennial Research Conference of the Food Systems Research Group
University of Wisconsin

Abstract: Fast food consumption has increased dramatically over the past three decades in U.S., accounting for nearly 35.5% of total away-from-home expenditures in 1999 (USDA/ERS). Given dramatic changes in food consumption, and heightened public concern about health and obesity, there is a considerable need to understand better the factors affecting food consumption choices and the implications of these changes for the food industry and government policymakers. We specify a random utility maximization model to analyze factors influencing an individual’s food choice (food at home, fast food, and other food away from home). Bayesian analysis with Markov chain Monte Carlo methods is used to estimate a weighted extreme value logit model, which allows for sequential decision making. Data are from USDA’s Continuing Survey of Food Intakes by Individuals from 1994 to 1996 and the Supplemental Children’s Survey of 1998. Our results find highly significant and important (statistically and economically) interactions between the likelihood of fast food consumption and age, income, and household size.

Key Words: fast food, random utility maximization, logit, Bayesian, weighted likelihood

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1.0 Introduction

Fast food home is a large and growing component of U.S. food expenditure. Eating and drinking purchases have dominated food away from home expenditures over the last three decades (Putnam and Allshouse). As a share of disposable personal income, food away from home expenditure has risen from 3.6% in 1970 to 4.1% in 1997, while food at home has decreased from 10.2% in 1970 to 6.6% in 1997 (Putnam and Allshouse). In 1967, fast food accounted for 14.3% of total away-from-home expenditures and by 1999 it alone reached 35.5% (U.S. Department of Agriculture/Economic Research Service). Given this dramatic change in food consumption, as well as public concern about health and obesity (Jekanowski, Schlosser), there is a considerable need to identify those factors affecting fast food consumption and the implications of these changes for consumers, the food industry, and government policymakers. In this study, we specify a random utility maximization model to analyze factors influencing an individual’s food choice (food at home, fast food, and other food away from home). Bayesian analysis with Markov chain Monte Carlo methods is used to estimate a nested multinomial logit model using USDA’s Continuing Survey of Food Intakes by Individuals from 1994 to 1996 and the Supplemental Children’s Survey of 1998.

There is an abundance of literature illustrating the importance of food away from home (Byrne, Capps, and Saha; Sexauer), but limited research on fast food itself. McCracken and Brandt examined the factors influencing expenditures on food away from home, at restaurants, fast food establishments, and other commercial facilities using USDA’s 1977-1978 Nationwide Food Consumption Survey. They found household income, time value, size, and composition are important factors. Jekanowski, Binkley,
and Eales examined the effect of price, income, and demographic characteristics on fast food. Using aggregated fast food measures at the Metropolitan Statistical Area level, they suggested that growth in the fast food consumption is related to an increasing supply of convenience. In other words, consumers have increased consumption of fast food because it provides the incentives to do so with respect to price, time, and taste. Jekanowski suggested that the limited menu aspect of most major chains means that their growth can have a potentially large impact on a selected segment of the agricultural marketing system. Moreover, any menu changes by a major firm can have enormous and almost immediate effects on particular agricultural industries. Lin, Lucier, Allhouse, and Kantor examined the influence of fast food growth on frozen potato consumption. They report that on any given day that 13% of consumers eat french fries with fast food establishments accounting for 67% of the french fry market. They also report that french fry consumption varies by age, region, urbanization, race, and ethnicity, but independent of income. Given dramatic changes in food consumption, and heightened public concern about health and obesity, our focus is to understand better the factors affecting food choices and the implications of these changes for the food industry and government policymakers.

There is also an abundance of literature linking random utility maximization to logistic regression models (e.g., McFadden 1974, 1981; McFadden and Train 2000; Lahiri and Gao 2002). McFadden (1974) proved the multinomial logit model (MNL) is derived from utility maximization if and only if the residuals are distributed independently with an extreme-value distribution. McFadden (1981) extended the MNL model to the nested multinomial logit model (NMNL) by assuming the residuals were
distributed as a Type B extreme-value distribution. As an alternative to NMNL models, Cardell and Dunbar (1980) and McFadden and Train (2000) have examined the use of mixed logit models that can approximate any random utility model. The mixed logit overcomes three limitations of standard logit by allowing for random taste variation, unrestricted substitution patterns, and correlation in unobserved factors over time (McFadden and Train 2000; Train 2003).

The main objectives of our paper are to: (1) identify and quantify an empirical relationship between an individual consumer’s socioeconomic and demographic characteristics and their likelihood to consume food at home, fast food, and other food away from home; and (2) construct a Bayesian estimator of the nested multinomial logit model and compare it to the maximum likelihood estimator. The remainder of the paper proceeds in the following manner. The first section specifies a random utility model for a consumer making choices among multiple foods. The next section describes the Bayesian econometric estimation with Markov chain Monte Carlo methods used in the empirical analysis. Then the data used in the analysis are discussed. Results of the empirical model is presented and then concluding comments are provided.

2.0 Random Utility Maximization

Suppose that a consumer faces multiple choices such as food at home, fast food, and other food away from home. The random utility function for each choice can be represented as

\[ U_{ijr} = V_{ijr} + \varepsilon_{ijr} \]

(1)

where \( V_{ijr} \) is a deterministic utility function, \( \varepsilon_{ijr} \) is an unobserved random variable, the subscript \( i \) (\( i=1,\ldots,N \)) represents the individual, the subscript \( r \) (\( r=1,\ldots, R_i \)) represents
replications by individual \( i \), and the subscript \( j \) \( (j=1,\ldots,J) \) represents the food of choice among the \( J \) foods. The deterministic part of the utility function is often defined as \( V_{ijr} = X_{ijr} (\beta) \), where \( X_{ijr} \) is a \((1 \times K)\) matrix of characteristics of the \( j \)th alternative and the \( i \)th individual at the \( r \)th replication and \( \beta \) is the \((K \times 1)\) vector of unknown parameters to be estimated. The consumer’s choice problem is to define \( U^*_ij \) (dispensing with some subscript notation), the maximum from among the \( J \) utilities, or \( U^*_ij = \max\{U_{i1,\ldots,U_{ij}}\} \).

Under the random utility framework, the decision maker has a higher likelihood of choosing food choice \( j \) over all other food types if and only if the \( \Pr ob[U_{ij} > U_{ik}] \forall k \neq j \). Choice probabilities that satisfy nonnegativity, \( P_j[V] \geq 0, \sum_j P_j[V] = 1 \); translation invariance, \( P_j[V] = P_j[V + c] \) for \( c \in R \); nonnegative density, \( \partial P_j[V]/\partial V_k \geq 0 \), and symmetry, \( \partial P_j[V]/\partial V_k = \partial P_k[V]/\partial V_j \) are necessary and sufficient for locally compatible with additive RUM (see Borsh-Supan 1990; Koning and Ridder 1993).

McFadden (1974) proved the multinomial logit model (MNL) is derived from utility maximization if and only if the residuals are distributed independently with an extreme-value distribution. However, the independence assumption implies that the alternatives are dissimilar and that ratios of relative probabilities between two alternatives are invariant to the total number of choices (i.e., Irrelevance of Independent Alternatives, or IIA). McFadden (1981) extended the MNL model by assuming the residuals were distributed as a Type B extreme-value distribution.
\[ f(\varepsilon_1, \ldots, \varepsilon_r) = \exp \left\{ - \sum_{k \in E_o} b_k \left( \sum_{r \in F_k} \sum_{j \in G_r} \exp \left( -\varepsilon_j / \rho_k \right) \right) \right\} \]

where \( \rho_r, \rho_k, \rho_w \) are the coefficients of the inclusive values and satisfy \( 0 < \rho_r, \rho_k, \rho_w < 1 \) for global compatibility with RUM and overcoming the IIA property. This leads to the nested multinomial logit model, where the MNL model arises when \( \rho_r = 1 \). Exact measures of welfare are estimable given changes of prices or characteristics (cf. Hanemann; Herriges and Kling).

Figure 1 presents a nonnested structure of food consumption. The nonnested structure is among food at home, fast food, and other food away from home, which leads to the MNL model. Figure 2 presents a nested structure of food consumption. The two-level nested structure consists of choosing between food at home and food away from home and then between fast food and other food away from home, which yields a NMNL model. For present purposes other food away from home remains aggregated, but it is recognized that disaggregating (e.g., restaurants or vending machines) it may be beneficial to understanding better individuals food choices.

3.0 Econometric Estimation

3.1 Weighted Generalized Extreme Value Likelihood Function

Consider the likelihood function weighted by the ith individual

\[ L(\theta) = \prod_{i=1}^{N} \left( \prod_{r \in I_{ij}} (p_{ijr}(\theta))^{y_{ijr}} \right)^{\gamma_i} \]  

(2)

where \( \theta \) is a \((K \times 1)\) parameter vector, the \( p_{ijr}(\theta) \) are the probability at replication \( r \) of individual \( i \) choosing alternative \( j \) and \( y_{ijr} = 1 \) if at replication \( r \) individual \( i \) chooses
alternative $j$, otherwise 0. In (2), the vector of weights $w = (w_1, ..., w_N)'$ are assumed to be predetermined by individual. This weighting formulation fits the sample design for the USDA data used in the empirical section of this paper. Dupuis and Morgenthaler (2002) previously examined a robust weighted likelihood estimator with an application to bivariate extreme value problems.

### 3.2 Bayesian Estimation

The Bayesian procedure with Markov chain Monte Carlo (MCMC) methods avoids several difficulties associated with classical estimation procedures. Bayesian approaches can overcome convergence problems of numerical optimization routines (e.g., irregular surfaces of the likelihood function or local versus global maxima), issues of econometric consistency and efficiency brought about by restrictive assumptions, and use of inappropriate ad hoc economic restrictions (Train 2003). In this paper we follow closely the MCMC Bayesian nested logit analysis discussed in Lahiri and Gao (2002).

Let $h(\theta)$ be the prior distribution. Then, based on Bayes’ Theorem, the posterior distribution $G(\theta | Y)$ is proportional to the likelihood function times the prior density or

$$G(\theta | Y) \propto L(Y | \theta)h(\theta)$$

Hence, the probability that is assigned to a given value for the parameters after observing the sample is the probability that is ascribed to before seeing the sample times the probability that those parameter values would result in the observed choices. In the analysis below, the prior is defined as $h(\theta) = h_1(\beta)h_2(\rho)$ where

$$h_1(\beta | G, R) = \prod_i \left( \prod_j \prod_r \left( P_{ijr}(\beta | G, R) \right)^{y_{ijr}} \right)^{-w_i}$$ (3)
is the natural conjugate prior of MNL (Koop and Poirier 1993; Poirier 1996) and

\[
h_2(\rho) = \begin{cases} 
0 & \text{if } \rho \leq 0 \\
sp^{-1} \exp(-\rho^s) & \text{if } \rho > 0
\end{cases}
\]  

(4)

is a generalized exponential prior (Lahiri and Gao 2002). In (3) \(G\) and \(R\) are vectors of prior hyperparameters such that if \(G=\mathbf{0}\) a neutral case arises, leading to equal probabilities for all alternatives when evaluated at the prior model with \(\rho = 1\). The strength of the priors can be controlled with different values of \(R\) with larger values indicating stronger priors, while the prior becomes the uniform distribution as the values of \(R\) approach the zero vector. As alternatives to (4), Lahiri and Gao (2002) suggest Gamma or Beta prior densities for \(\rho\). Indeed, other densities can be used to represent the prior distribution with the explicit choice depending on the subjective view of the researcher and data at hand.

3.2.1 Markov Chain Monte Carlo

The basic Metropolis-Hasting (MH) algorithm proceeds in several steps. Start with an initial value \(\beta^0\), draw \(K\) independent values labeled as \(\beta^\ast\), and then create a candidate value \(\beta^\ast = \beta^0 + \varphi \Omega \beta^\ast\) where \(\varphi\) is a predetermined tuning constant and \(\Omega^\ast\) is the Cholesky decomposition of a covariance matrix \(\Omega\) from the proposal density \(\phi(\beta^\ast | b, \Omega)\). Next, draw a standard uniform variable \(\mu\) and calculate the ratio

\[
\alpha = \frac{L(\beta^\ast) \phi(\beta^\ast | b, \Omega)}{L(\beta^0) \phi(\beta^0 | b, \Omega)}
\]

If \(\mu \leq \alpha\), accept the candidate parameter \(\beta^\ast\) and let \(\beta^t = \beta^\ast\), else reject it and let \(\beta^t = \beta^0\). Repeat this process until convergence is reached at \(T^*\). Convergence criteria of the MCMC method for the nested and mixed logit estimators are discussed by Train (2003),
Lahiri and Gao (2002), and others. If appropriately structured this MC algorithm is computationally efficient and robust. The algorithm does not numerically optimize, but rather simulates a distribution of parameter values to obtain parameter estimates and standard errors of the parameters. This last point is important because despite the popularity of the NMNL model difficulties arise in numerically maximizing its likelihood function.

4.0 Data

The data used in this study are from the Continuing Survey of Food Intakes by Individuals (CSFII) of 1994-96 and the Supplemental Children’s Survey (SCS) of 1998. This survey conducted by the USDA measures individual food consumption. The goal of the 1994-1996 survey is to “obtain a nationally representative sample of noninstitutionalized persons residing in households in the United States.” The goal of the Supplemental Children’s Survey of 1998 was to “obtain nationally representative samples of noninstitutionalized persons 9 years of age or younger residing in the United States.” In both surveys individuals were interviewed on two nonconsecutive days during which they were asked to recall their food intake in the previous 24 hours. Along with the dietary information, specific demographic information was collected such as age, income, race, and gender. Observations recorded food intake amounts per individual for day 1 or day 2. In other words, each individual food item consumed on day 1 or 2 of the survey was recorded as a separate observation.

Table 1 presents variable definitions and descriptive statistics of the weighted data on a daily basis for day 1 records. The average household surveyed included 3.43 members with an average age of 34.6 years and a mean income of $42,228.24. Of the
individuals surveyed, 78.0% were classified as white, 12.8% as black, 3.0% as Asian/Pacific Islander, and 1.0% Native American or Alaskan with 89.4% being of non-Spanish or non-Hispanic origin. Over 47.2% were living in a Metropolitan Statistical Area (MSA) outside of a central city and 21.3% living in Non-MSA areas. The South, Midwest, West, and Northeast (regions defined in footnote of Table 1) had 34.9, 23.5, 22.0, and 19.6% of the weighted sample. In all, 26.9% (0.048%) of the individuals consumed a fast food item per day (per eating occasion).

5.0 Empirical Results

This illustrative model examines the likelihood of consuming food at home, fast food, or other food away from home in a two level structure (Figure 2) on a given eating occasion using nested multinomial logit regression. We specify an empirical model to test relationships between the likelihood of consuming and household size, income, age, gender, location, and eating occasion. Both maximum likelihood and Bayesian coefficient estimates are reported in Table 2 and were estimated using GAUSS. For the empirical analysis the CSFII and SCS data were randomly subsampled to obtain a database of 10,000 observations, which reduced the computational time to estimate the NMNL models and simplified the intertemporal structure (i.e., replications or time dependencies for individuals) of the data. To obtain the MCMC estimates, we used a burn in period of 30,000 iterations with a total simulation length of \( T^* = 100,000 \). A multivariate normal was used as the proposal density. Under maximum likelihood, the likelihood value was 7026.53 with numerical optimization of the likelihood using Newton-Raphson. Under Bayesian estimation using MCMC, the likelihood decreased to 7074.80. Further comparing across the two estimators, we find that signs of several
parameters were different across estimators (e.g., variables Age, Age*Age, and West for the other food away from home equation). These results demonstrate the apparent unreliability of numerical solvers for maximum likelihood estimation of the NMNL model with the current functional specification and data set. Finally the estimate of the inclusive value $\rho$ is positive and significantly different from either zero or one for the Bayesian model (while positive and much larger in magnitude for maximum likelihood), rejecting the MNL structure in Figure 1.

To summarize information for the probability of consuming fast food, response curves across household size, income, and age are presented in Figures 3-5. For example, to generate the probability response curve across household size in Figure 3, income and age are set to their mean values and discrete shift variables are set to zero. Inspecting the probability response curves, it is evident that the likelihood of fast food consumption predominately decreases as household size increases. Alternatively, the likelihood of fast food consumption minimizes at an income level of about $50,000. However, the response to income changes is very inelastic in comparison to household size. Relative to either household size or income, age exhibits larger responses in probability. The likelihood of fast food consumption per eating occasion is maximized at 20-30 years of age and decreases thereafter. Further investigation of results from Table 2 indicates that males have higher probability of consuming fast food, there is a higher probability of consuming fast food at lunch relative to other eating occasions, and the likelihood of fast food consumption is highest in the South and Midwest.

It is interesting to compare the findings reported above to previous research. For example, our results indicated that the West region has a lower likelihood of fast food
consumption. This is consistent with findings reported in Jekanowski, Binkley, and Eales. Meanwhile, Lin, Lucier, Allhouse, and Kantor reported that on average the South (followed by the Midwest region) had the highest french fry consumption on any given day. Lin, Lucier, Allhouse, and Kantor also reported that french fry consumption varies by age, region, urbanization, race, and ethnicity, but it was independent of income. Also, using the 1977-78 Nationwide Food Consumption Survey, McCracken and Brandt also reported no significant impact of income on fast food expenditures. We found that the likelihood of fast food consumption was statistically influenced by all of these variables (including income). However, while income was statistically significant in our illustrative fast food model, the probability response curves were very inelastic.

6.0 Conclusion

We specified a random utility maximization model and analyzed the likelihood that an individual consumed food at home, fast food, or other food away from home using nested multinomial logit model. Data used in the study were from the Continuing Survey of Food Intakes by Individuals of 1994-96 and the Supplemental Children’s Survey of 1998. This survey was conducted by the United States Department of Agriculture (USDA) and measures individual food consumption. Descriptive results of the analysis indicate that 26.9 (4.1) percent of individuals consumed fast food on a per day (meal) basis.

Several important empirical issues were investigated in an illustrative example. First, we specified an empirical model to test relationships between the likelihood of consuming fast food and household size, income, age, gender, location, and eating occasion. Next, maximum likelihood and Bayesian (using Markov Chain Monte Carlo) results were obtained and compared for the nested multinomial logit model. In effect, the
Bayesian results were more reliable and rejected the multinomial logit model in favor of the nested multinomial logit model.

Important regional and socio-demographic factors emerged. Consumers in the South and Midwest were most likely to consume fast food. In terms of gender, males were more likely to consume fast food than were females. Individuals were more likely to consume fast food until they reached 20-30 years of age at which point the likelihood that they consume fast food decreases throughout their life. Larger households (especially those with more than four persons) were less likely to consume fast food. Although the impact of income on the likelihood of consuming fast food was statistically significant, it was very inelastic. The likelihood of consuming fast food was much more sensitive to age relative to household size and least sensitive to income.

Over all, this preliminary information should help researchers and policy makers concerned with health and obesity to better understand the socioeconomic and demographic factors that influence fast food consumption and tradeoffs with other food away from home and food at home. This information is also relevant to retailers and wholesalers in the food industry that respond directly to primary consumption. Finally, the results should be helpful to those structuring government programs that directly or indirectly influence consumer behavior or agricultural markets in general.

Preliminary results of this study highlight some important limitations. First, numerical optimization of likelihood functions may be unreliable in some circumstances. Second, we need to reconsider the current categorization of aggregating into one group “other food away from home”. It is plausible that consumers behave differently to restaurant food relative to, say, vending machine consumption. Third, investigation of
the sensitivity of these results to different functional specifications should be investigated. Notwithstanding the empirical issues yet to be rectified, the preliminary results from this study provide important insight into the demographic and socioeconomic determinants that influence fast food consumption.
7.0 References


Table 1. Variable definitions and descriptive statistics from CSFII and SCS.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast Food</td>
<td>1 if consumed fast food, else 0 (/day)</td>
<td>0.269</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1 if consumed fast food, else 0 (/eating occasion)</td>
<td>0.048</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Household Size</td>
<td>Count of household members</td>
<td>3.428</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>Income</td>
<td>Approximate household income</td>
<td>42228.24</td>
<td>0</td>
<td>100000</td>
</tr>
<tr>
<td>Age</td>
<td>Age of household member</td>
<td>34.645</td>
<td>0</td>
<td>90</td>
</tr>
<tr>
<td>Region1</td>
<td>1 if Northeast, else 0</td>
<td>0.196</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Region2</td>
<td>1 if Midwest, else 0</td>
<td>0.235</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Region3</td>
<td>1 if South, else 0</td>
<td>0.349</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Region4</td>
<td>1 if West, else 0</td>
<td>0.220</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Urban1</td>
<td>1 if MSA/Central City, else 0</td>
<td>0.315</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Urban2</td>
<td>1 if MSA/Outside Central, else 0</td>
<td>0.472</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Urban3</td>
<td>1 if Non-MSA, else 0</td>
<td>0.213</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Female</td>
<td>1 if Female, else 0</td>
<td>0.511</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Race1</td>
<td>1 if White, else 0</td>
<td>0.780</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Race2</td>
<td>1 if Black, else 0</td>
<td>0.128</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Race3</td>
<td>1 if Asian/Pacific Islander, else 0</td>
<td>0.030</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Race4</td>
<td>1 if American Indian/Alaskan Native, else 0</td>
<td>0.006</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Race5</td>
<td>1 if Other, else 0</td>
<td>0.056</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Origin1</td>
<td>1 if Mexican/Mexican American/Chicano, else 0</td>
<td>0.049</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Origin2</td>
<td>1 if Puerto Rican, else 0</td>
<td>0.010</td>
<td>0</td>
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</tr>
<tr>
<td>Origin3</td>
<td>1 if Cuban, else 0</td>
<td>0.003</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Origin4</td>
<td>1 if Other Spanish/Hispanic, else 0</td>
<td>0.043</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Origin5</td>
<td>1 if None of the above, else 0</td>
<td>0.894</td>
<td>0</td>
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</tr>
<tr>
<td>Year1</td>
<td>1 if 1994, else 0</td>
<td>0.312</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Year2</td>
<td>1 if 1995, else 0</td>
<td>0.312</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Year3</td>
<td>1 if 1996, else 0</td>
<td>0.311</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Year4</td>
<td>1 if 1997, else 0</td>
<td>0.065</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Wt</td>
<td>Sample weight for individual intake</td>
<td>12090.170</td>
<td>340</td>
<td>226692</td>
</tr>
</tbody>
</table>

Notes:

a) Descriptive statistics are for day 1 records.
b) Metropolitan Statistical Area (MSA)-A geographic area consisting of a large population nucleus together with adjacent communities that have a high degree of economic and social integration with that nucleus; defined by the Federal Office of Management and Budget for use in the presentation of statistics by agencies of the Federal government.
Table 2. NMNL Maximum Likelihood and Bayesian Estimates.

<table>
<thead>
<tr>
<th>Fast Food</th>
<th>NMNL Coefficients</th>
<th>Bayesian Coefficients</th>
<th>StdErr</th>
<th>T-val</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-1.342075</td>
<td>-1.885553</td>
<td>0.124087</td>
<td>-15.20</td>
</tr>
<tr>
<td>Household Size</td>
<td>0.083870</td>
<td>0.105813</td>
<td>0.053793</td>
<td>1.97</td>
</tr>
<tr>
<td>Household Size * Household Size</td>
<td>-0.006035</td>
<td>-0.007764</td>
<td>0.006682</td>
<td>-1.16</td>
</tr>
<tr>
<td>Income</td>
<td>-0.068878</td>
<td>-0.141009</td>
<td>0.042838</td>
<td>-3.29</td>
</tr>
<tr>
<td>Income * Income</td>
<td>0.006908</td>
<td>0.013477</td>
<td>0.003745</td>
<td>3.60</td>
</tr>
<tr>
<td>Age</td>
<td>0.009458</td>
<td>0.037634</td>
<td>0.003869</td>
<td>9.73</td>
</tr>
<tr>
<td>Age * Age</td>
<td>-0.000203</td>
<td>-0.000721</td>
<td>0.000064</td>
<td>-11.33</td>
</tr>
<tr>
<td>Sex</td>
<td>0.023354</td>
<td>0.183990</td>
<td>0.047785</td>
<td>3.85</td>
</tr>
<tr>
<td>Northeast</td>
<td>-0.019269</td>
<td>-0.117297</td>
<td>0.059315</td>
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</tr>
<tr>
<td>South</td>
<td>0.145151</td>
<td>0.199829</td>
<td>0.049422</td>
<td>4.04</td>
</tr>
<tr>
<td>West</td>
<td>-0.064480</td>
<td>-0.194201</td>
<td>0.056847</td>
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<tr>
<td>Lunch</td>
<td>0.108823</td>
<td>0.534198</td>
<td>0.041291</td>
<td>12.94</td>
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<table>
<thead>
<tr>
<th>Other Food Away From Home</th>
<th>NMNL Coefficients</th>
<th>Bayesian Coefficients</th>
<th>StdErr</th>
<th>T-val</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.406656</td>
<td>-0.786899</td>
<td>0.087468</td>
<td>-9.00</td>
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<td>Household Size</td>
<td>-0.046607</td>
<td>-0.100935</td>
<td>0.026411</td>
<td>-3.82</td>
</tr>
<tr>
<td>Household Size * Household Size</td>
<td>0.003221</td>
<td>0.006886</td>
<td>0.003455</td>
<td>1.99</td>
</tr>
<tr>
<td>Income</td>
<td>0.038095</td>
<td>0.104117</td>
<td>0.025768</td>
<td>4.04</td>
</tr>
<tr>
<td>Income * Income</td>
<td>-0.003568</td>
<td>-0.008236</td>
<td>0.002259</td>
<td>-3.65</td>
</tr>
<tr>
<td>Age</td>
<td>-0.000833</td>
<td>0.006466</td>
<td>0.002753</td>
<td>2.35</td>
</tr>
<tr>
<td>Age * Age</td>
<td>0.000039</td>
<td>0.000036</td>
<td>0.000034</td>
<td>-1.06</td>
</tr>
<tr>
<td>Sex</td>
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<td>-0.071837</td>
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<td>-2.76</td>
</tr>
<tr>
<td>Northeast</td>
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<td>-0.021289</td>
<td>0.028886</td>
<td>-0.74</td>
</tr>
<tr>
<td>South</td>
<td>-0.070951</td>
<td>-0.090283</td>
<td>0.029911</td>
<td>-3.02</td>
</tr>
<tr>
<td>West</td>
<td>0.009093</td>
<td>-0.053062</td>
<td>0.029663</td>
<td>-1.79</td>
</tr>
<tr>
<td>Dinner</td>
<td>0.025660</td>
<td>0.108598</td>
<td>0.015670</td>
<td>6.93</td>
</tr>
<tr>
<td>ρ</td>
<td>31.130251</td>
<td>4.393893</td>
<td>0.265053</td>
<td>16.58</td>
</tr>
<tr>
<td>LL</td>
<td>7026.53</td>
<td>7074.80</td>
<td></td>
<td></td>
</tr>
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</table>
Figure 1. Nonnested Structure with MNL

Figure 2. Nested Structure with NMNL
Figure 3. Probability of fast food consumption (per eating occasion) across household size (number of members).
Figure 4. Probability of fast food consumption (per eating occasion) across income ($10,000).
Figure 5. Probability of fast food consumption (per eating occasion) across age (years).
Price Dynamics in a Vertical Sector: The Case of Butter

by

Jean-Paul Chavas

and

Aashish Mehta*

Abstract: We develop a reduced-form model of price transmission in a vertical sector, allowing for refined asymmetric, contemporaneous and lagged, own and cross price effects under time-varying volatility. The model is used to investigate wholesale-retail price dynamics in the US butter market. The analysis documents the nature of nonlinear price dynamics in a vertical sector, with implications for price transmission and the distribution of future prices. It finds strong evidence of asymmetric retail price responses, both in the short term and the longer term, but only weak evidence of asymmetric wholesale price responses. Asymmetric retail responses play a major role in generating a skewed distribution for butter price.

Key Words: price transmission, asymmetry, nonlinear dynamics, butter.

* Respectively, Professor and Graduate Assistant, Department of Agricultural and Applied Economics, University of Wisconsin, Madison 53706. This research was supported by a USDA grant to the Food System Research Group, University of Wisconsin, Madison.
1. Introduction

The issue of price transmission in a vertical sector has been the subject of much research. A common issue is that retail prices do not respond very quickly to changes in market conditions. Under fluctuating market conditions, this raises questions about the efficiency of vertical markets. Examples include situations where retail prices remain “sticky” in the face of large decreases in farm or wholesale prices (e.g., Borenstein et al.; Peltzman; Miller and Hayenga). Peltzman finds strong evidence that in many markets retail prices tend to rise faster than they fall, both in the short term and in the longer term.

This has stimulated research on the possible cause of asymmetric price adjustments. Potential explanations include imperfect competition and adjustment costs. A traditional explanation under oligopoly is a kinked-demand schedule that generates sticky prices. More generally, barriers to entry can create asymmetric economic adjustments (see Tirole for an overview). Many other sources of asymmetry have been explored. In general, in the presence of adjustment cost, firms and consumers may not respond to small or transitory price changes until the benefits of changing strategies outweigh the cost. Consider, for example, the unequal cost of maintaining high versus low inventory, where the high cost of experiencing a stockout can generate asymmetric price adjustments (e.g., Reagan and Weitzman). Also, consumers may not respond quickly to price changes in the presence of search costs. This can allow retailers to boost profits by increasing their prices fast as wholesale prices rise, and lowering them slowly when wholesale prices fall. In addition, menu costs can prevent firms from changing prices rapidly in response to small and transitory market changes (e.g., Blinder; Blinder et
Finally, sunk investment costs can create irreversibility in firms’ strategies (e.g., Dixit and Pindyck). Thus, there are many reasons why price transmission may be asymmetric in a vertical sector. Peltzman’s analysis suggests that current theories fail to explain the prevalence of price asymmetry. His empirical evidence covering many markets shows no correlation between price asymmetry and inventory cost, menu cost or imperfect competition. This raises significant challenges to our theory of markets. It also stresses the need for a better understanding of the empirical regularities found in price transmissions.

The objective of this paper is to investigate these empirical regularities. For this purpose, the paper develops a flexible dynamic reduced form model of asymmetric price transmission in a vertical sector. The analysis expands on previous models of dynamic price transmission by allowing asymmetry for both contemporaneous and lagged, own and cross price effects. It also allows for time varying volatility. The model is applied to wholesale-retail price dynamics in the US butter market. As illustrated in Figure 1, butter prices have exhibited large fluctuations over the last 10 years. This makes the butter market an interesting case study of dynamic price adjustments in a vertical sector. Following Peltzman, in the absence of a clear theory of asymmetric price adjustments, the analysis is unrepentantly descriptive. The empirical results provide evidence of asymmetric price transmissions in the US butter market. Although the evidence of asymmetry is weak for wholesale price adjustments, it is strong for retail price adjustments. For example, we find that retail prices respond strongly to wholesale price increases, but less to wholesale price decreases. The analysis shows that price volatility is much higher at the wholesale level than the retail level. Price volatility also varies with market conditions. For example, we find that wholesale price volatility increases with the
wholesale price level, a result that is consistent with theory linking storage behavior to asymmetric price adjustment (as discussed above). Finally, we evaluate the complex nature of nonlinear price dynamics in a vertical sector. We point out the effects of asymmetric responses on the skewness of the price distribution. This stresses the limitations of previous models of price dynamics that rely solely on autocovariance (or spectral density in the frequency domain). The analysis finds that the skewness in the price distribution is due in large part to the non-linear dynamics implied by asymmetric price transmission.

2. A Model of Price Dynamics

Consider a vertical sector involving m markets in a vertical sector. Let \( y_t = (y_{1t}, y_{2t}, \ldots, y_{mt})' \) be an \((m \times 1)\) vector of market prices at time \( t \). Assume that the price vector \( y_t \) has a dynamic reduced-form representation given by the vector autoregression (VAR) model

\[
y_t = \alpha + \sum_{k=1}^{K} A_k y_{t-k} + \epsilon_t, \quad (1)
\]

where \( \alpha \) is an \((m \times 1)\) vector, \( A_k \) is an \((m \times m)\) matrix, \( k = 1, \ldots, K \), and \( \epsilon_t \) is an \((m \times 1)\) error term independently and normally distributed with mean zero and variance \( \Omega \). This can be alternatively written in terms of the error-correction model (ECM)

\[
\Delta y_t = \alpha + B_0 y_{t-1} + \sum_{k=1}^{K-1} B_k \Delta y_{t-k} + \epsilon_t, \quad (2)
\]

where \( \Delta y_t = y_t - y_{t-1} \), \( B_0 = -[I_K - A_1 - A_2 - \ldots - A_K] \), and \( B_k = -[A_{k+1} + A_{k+2} + \ldots + A_K] \), \( k = 1, 2, \ldots, K-1 \).

Equation (2) means that \( \Delta y_t \) is stationary if and only if \([B_0 y_{t-1} + \sum_{k=1}^{K-1} B_k \Delta y_{t-k}]\) is stationary. Obviously, \( y_t \) being stationary is sufficient for \( \Delta y_t \) to be stationary. In addition,
if \( y_t \) is not stationary (e.g., in the presence of units roots), then a stationary \( \Delta y_t \) implies that \( [B_0 \ y_{t-1}] \) must be stationary. Such a process is cointegrated, and \( B_0 \) identifies stationary linear combinations of the non-stationary variables \((y_{1t}, \ldots, y_{mt})'\). In this case, the matrix \( B_0 \) is singular and can be written as \( B_0 \equiv \beta \gamma \), where \( \beta \) is an \((m \times c)\) matrix, \( \gamma \) is a \((c \times m)\) matrix of \( c \) cointegration vectors, with \( c = \text{rank}(B_0) \). In the error-correction model (2), the vector \( z_t \equiv [\gamma \ y_{t-1}] \) is stationary, reflecting long-term relationships among prices, and \( B_0 \ y_{t-1} \equiv \beta z_t \) (see Hamilton, p. 580). The general specification includes as a special case the situation where \( B_0 \equiv -[I_K - A_1 - A_2 - \ldots - A_K] = 0 \) and (2) implies that price dynamics can be properly analyzed using a VAR in differences. However, when \( \text{rank}(B_0) \geq 1 \), equation (2) shows that a VAR in differences is an inappropriate representation of price dynamics.

The linear specification (1) or (2) can be extended in a number of directions. First, the intercept \( \alpha \) can change over time in at least two ways: 1/ it can have a time trend (reflecting inflation, technical progress, or other long term changes); and 2/ it can involve seasonal effects. This corresponds to \( \alpha = a_0 + a_1 t + \sum_{s=1}^{S-1} \alpha_s D_{ts} \), where \( D_{ts} \) is a dummy variable for the \( s \)-th season: \( D_{ts} \) equals 1 if \( t \) is in the \( s \)-th season and zero otherwise, \( s = 1, \ldots, S \). Then, \((a_0 + a_1 t)\) is the intercept at time \( t \) in the \( S \)-th season, and \( a_1 \) measures the change in intercept between two successive periods.

Second, we consider the case where the dynamics in (1) or (2) vary between regimes. For simplicity we focus on the case of binary regimes denoted by the dummy variables \( R \). Let \( R_{it} = 1 \) if \( y_{it} \) is in regime 1 at time \( t \), and \( R_{it} = 0 \) if \( y_{it} \) is in regime 0 at time \( t \), \( i = 1, \ldots, m \). In equation (2), let \( B_k = \)
\[
\begin{bmatrix}
B^1_{k11}R_{1,t-k} + B^0_{k11}(1 - R_{1,t-k}) & \cdots & B^1_{k1m}R_{m,t-k} + B^0_{k1m}(1 - R_{m,t-k}) \\
\vdots & \ddots & \vdots \\
B^1_{km1}R_{1,t-k} + B^0_{km1}(1 - R_{1,t-k}) & \cdots & B^1_{kmn}R_{nt} + B^0_{kmn}(1 - R_{m,t-k})
\end{bmatrix}, \ k = 1, \ldots, K-1. \]

This means that the impact of \(\Delta y_{j,t-k}\) on \(\Delta y_{it}\) varies across regimes as \(\partial \Delta y_{it}/\partial \Delta y_{j,t-k} = B^1_{kij}R_{j,t-k} + B^0_{kij}(1-R_{j,t-k})\), which equals \(B^1_{kij}\) when \(y_{j,t-k}\) is in regime 1 but \(B^0_{kij}\) when in regime 0. As a result, at time \(t\), equation (2) becomes

\[
\Delta y_{it} = a_{i0} + a_{i1} t + \sum_{s=1}^{S-1} \alpha_{is} D_{it} + \sum_{j=1}^{m} B_{0ij} y_{j,t-1} + \sum_{k=1}^{K-1} \sum_{j=1}^{m} [B^1_{kij} R_{j,t-k} + B^0_{kij}(1-R_{j,t-k})B_k] \Delta y_{t-k} + \epsilon_{it}, \quad (3)
\]

\(i = 1, \ldots, m\). Equation (3) provides a framework to investigate whether price dynamics vary across regimes. Indeed, prices would exhibit the same dynamics under both regimes if \(B^1_{kij} = B^0_{kij}\) for all \((k, i, j)\). Alternatively, finding that \(B^1_{kij} \neq B^0_{kij}\) for some \((k, j, i)\) would be sufficient to conclude that price dynamics vary across regimes.

Next, consider the Cholesky decomposition of the variance of \(\epsilon_t\): \(\Omega = SS'\), where

\[
S = \begin{bmatrix}
s_{11} & 0 & \cdots & 0 \\
s_{21} & s_{22} & \cdots & 0 \\
\vdots & \vdots & \ddots & \vdots \\
s_{m1} & s_{m2} & \cdots & s_{mm}
\end{bmatrix}
\]

is a lower triangular matrix satisfying \(s_{ij} > 0, i = 1, \ldots, m\). It means that equation (2) can be alternatively written as

\[
S^{-1} \Delta y_t = S^{-1} \alpha + S^{-1} B_0 y_{t-1} + \sum_{k=1}^{K-1} S^{-1} B_k \Delta y_{t-k} + \epsilon_t, \quad (2')
\]

where \(\epsilon_t = S^{-1} \epsilon_t\) is normally distributed with mean zero and variance \(I_m\). Note that the off-diagonal elements of \(S\) capture the contemporaneous effects across dependent variables.

For example, the covariance between \(y_{1t}\) and \(y_{2t}\) is \(\text{Cov}(y_{1t}, y_{2t}) = s_{11} s_{21}\), and the contemporaneous impact of a shock in \(y_{2t}\) on \(y_{1t}\) is \(\partial y_{1t}/\partial y_{2t} = s_{21}/s_{11}\). Also, the contemporaneous cross-price effects vanish if \(s_{ij} = 0\) for all \(i > j\). Thus, the presence of
contemporaneous cross-price effects can be confirmed by rejection of the null hypothesis: 
\[ s_{ij} = 0 \] for all \( i > j \). In addition, if we are interested in exploring whether price volatility or contemporaneous cross-price effects are situation-specific, we can consider the more general specification: 
\[ s_{ij} = \sigma_{ij0} + \sigma_{ij} z_t, \] where \( z_t \) is a vector of predetermined variables at time \( t \), \( i \geq j \). In this context, constant variances implies \( \sigma_{ii} = 0 \) for \( i = 1, \ldots, m \). And constant contemporaneous effects across dependent variables implies that \( \sigma_{ij} = 0 \) for all \( i > j \). This means that finding \( \sigma_{ii} \neq 0 \) implies time-varying volatility for the \( i \)-th price. And finding \( \sigma_{ij} \neq 0 \) for some \( i > j \) would be sufficient to conclude that some contemporaneous cross-price effects vary over time. Econometrically, this corresponds to situations of heteroscedasticity where the covariance matrix \( \Omega_t \equiv S_t S_t' \) is time-varying. This provides a framework to analyze how price volatility and contemporaneous cross-price effects vary with market conditions.

In summary, the model exhibits three types of price transmission:

- contemporaneous cross price effects (captured by the specification for \( s_{ij} \));
- lagged effects (captured by \( B_k \), \( k = 1, \ldots, K \));
- and long term effects (captured by \( B_0 \)).

The model is novel in the flexibility with which it captures these different dynamic price relationships.

As discussed in the introduction, much recent research has focused on whether price dynamics respond symmetrically to price increases versus price decreases. The first area of flexibility, then, corresponds to \( R_{it} = 1 \) if \( \Delta y_{it} > 0 \) and \( R_{it} = 0 \) if \( \Delta y_{it} \leq 0 \). In this context, equation (3) extends previous specifications of asymmetric price response found in the literature.\(^4\) The \( B_{k0} \)'s and \( B_{k1} \)'s capture asymmetric response to price shocks after \( k \) lags, \( k = 1, \ldots, K \). This extends Wolffram’s specification, which restricts the \( B_{k1} \)'s to be the same for all \( k \). By allowing the \( B_{k1} \)'s to vary, equation (3) allows for dynamic
asymmetry to vary between the short run and the intermediate run (e.g., as investigated by Peltzman). Second, under cointegration, $[B_0 y_{t-1}]$ is the “error correction term” which captures deviations from long-term relationships among prices. While equation (3) reduces to the Miller-Hayenga specification when $B_0 = 0$, the Miller-Hayenga specification of asymmetric price response becomes inappropriate when $B_0 \neq 0$. Third, the specification $s_{ij} = \sigma_{ij0} + \sigma_{ij} z_t$ expands on both the Miller-Hayenga and the Peltzman specifications. It allows for price volatility as well as contemporaneous cross-price effects to be time-varying. The Miller-Hayenga specification implicitly assumes constant $s_{ij}$’s, thus restricting variances and contemporaneous cross-price effects to be constant. The Peltzman specification (Peltzman’s equation (2) on p. 476) corresponds to equation (2’) above with $y_1 =$ “output price” and $y_2 =$ “input price”. It allows for asymmetric contemporaneous effects from “input price” to “output price”, but implicitly assumes symmetric and constant contemporaneous effects from “output price” to “input price”. The specification $s_{ij} = \sigma_{ij0} + \sigma_{ij} z_t$ is more flexible and allows for more complex contemporaneous cross-price effects (see below).

Finally, as suggested by equations (1) and (2), one must choose between estimating the model “in levels” (equation (1)) or “in differences” (equation (2)). Both approaches can generate consistent parameter estimates. Below, we focus on the specification “in differences” for two reasons. First, the estimation of models “in differences” can perform better in small samples (Hamilton, p. 652). Second, hypothesis testing is easier “in differences” as test statistics exhibit more standard distributions (e.g., see Hamilton, p. 528-529; Toda and Phillips). Thus, the analysis presented below focuses on the estimation of equation (3). Equation (3) can be estimated by maximum likelihood,
which under a correct specification generates consistent and asymptotically efficient parameter estimates.

3. Application to the US Butter Sector

We apply model (3) to price dynamics in the vertical sector for US butter. The analysis focuses on the dynamics of two prices (m = 2): the wholesale and retail prices of butter. The analysis uses monthly data from the period January 1980 to August 2001. The wholesale price is the Chicago Mercantile Exchange AA butter cash price, and the retail price for butter is from the Bureau of Labor Statistics. They are presented in Figure 1.

We evaluated two basic properties of butter prices. First, we investigated possible skewness in the distribution of seasonally adjusted and trended butter prices over the sample period. The skewness coefficient was estimated to be 0.810 for wholesale prices and 0.259 for retail butter prices. The null hypothesis of zero skewness under normality was tested and strongly rejected (at the 1 percent significance level) for each price. This provides evidence that the probability distribution of butter prices is asymmetric and has a “long tail” associated with high prices. Below, we will investigate possible sources of this asymmetry.

Second, the augmented Dickey-Fuller (ADF) test for a unit root was implemented for each butter price. ADF testing of the null of a unit root yielded t-values of -1.38 for retail prices and -2.58 for wholesale prices. At the 5 percent significance level, the ADF critical value is -3.43. Thus, we fail to reject the null hypotheses of unit roots. This suggests that both prices are non-stationary.

Next, we investigated the nature of price dynamics in the butter market. For this purpose, we relied on the specification given in equation (3). For the i-th price at time t-k,
we defined two market regimes: $R_{i,t-k} = 0$ (regime 0) when $\Delta y_{i,t-k} \leq 0$, and $R_{i,t-k} = 1$ (regime 1) when $\Delta y_{i,t-k} > 0$. This provides a framework to investigate whether price dynamics differ for price increases versus price decreases, including both own price and cross price effects. In addition, we wanted to analyze whether contemporaneous price relationships change with market conditions. With $m = 2$, let $y_1 \equiv y_r$ represent the retail price, and $y_2 \equiv y_w$ represent the wholesale price. We allow the covariance between $y_{rt}$ and $y_{wt}$ to vary with market conditions and consider the specification

$$s_{wr} = \sigma_{wr,0} + \sigma_{wr,\Delta w} \Delta y_{w,t-1} + \sigma_{wr,\Delta r} \Delta y_{r,t-1},$$

where $s_{wr}$ is the off-diagonal element in the Cholesky decomposition of the variance of $e_t$. When $\sigma_{wr,\Delta w} \neq 0$ and/or $\sigma_{wr,\Delta r} \neq 0$, this specification allows market conditions to affect the contemporaneous cross price effects between $y_r$ and $y_w$. For example, finding that $\sigma_{wr,\Delta r} > 0$ ($\sigma_{wr,\Delta w} > 0$) would mean that a rise in retail price (wholesale price) would increase the contemporaneous covariance between retail and wholesale prices. Note that, unlike the Peltzman specification, this allows retail market conditions to affect the contemporaneous relationships between retail and wholesale prices. In addition, we allow the variance of prices to vary with market conditions. We let

$$s_{ii} = \sigma_{ii,0} + \sigma_{ii,w} y_{w,t-1} + \sigma_{ii,r} y_{r,t-1}, i = (w, r),$$

where the $\sigma_{ii}$’s correspond to the diagonal elements in the Cholesky decomposition of the variance of $e_t$. This can be motivated from the theory of competitive storage. Indeed, when stocks are positive, competitive stockholding can help stabilize prices. But such stabilizing effects disappear when stocks vanish, which is often associated with high market prices (see Williams and Wright; Deaton and Laroque, 1992, 1996). This means that high price volatility is expected to be associated with high prices. Our variance
specification can capture such effects. It will help shed some light on the dynamics of price volatility.

Model specification (3) requires choosing the number of lags K. The Schwartz criterion suggested choosing K = 2.\textsuperscript{8} We evaluated the implications of this choice for the serial correlation of the standardized error terms \( \varepsilon_t = S_t^{-1} e_t \). The null hypothesis that \( \varepsilon_t \) is white noise was tested using the Ljung-Box test for serial correlation up to \( p \) lags, \( p = 1, \ldots, 6 \). Under the null hypothesis, the Ljung-Box test statistic has a chi-square distribution with \( p \) degrees of freedom. The results are presented in Table 1. We fail to reject the null hypothesis at the 5 percent significance level. This shows that the standardized error terms in (3) appear serially uncorrelated up to 6 lags. This suggests that the dynamic specification gives an appropriate representation of price movements.

Given \( K = 2 \), the model was estimated using the maximum likelihood method. The resulting econometric estimates are presented in Table 2. Many of the estimates are found to be significant. In general, the coefficients (\( \alpha_{i} \)) of the monthly seasonal dummies \( D_{st} \) show more evidence of seasonality in wholesale prices than in retail prices. Also, the time trend effects differ: the trend coefficient \( a_{1} \) is negative but insignificant for wholesale price, while it is positive and significant for retail price. This reflects that the marketing margin (\( y_r - y_w \)) has increased over time during the sample period. Finally, a number of the coefficients on lagged prices are significant, indicating the presence of significant dynamic adjustments in the US butter market.

The nature of the dynamic relationships between \( y_r \) and \( y_w \) was investigated. First, we implemented a Johansen cointegration test for model (3). The null hypothesis of a cointegration relation between \( y_r \) and \( y_w \) was investigated using a likelihood ratio test of the rank of the \( B_0 \) matrix. Testing the null hypothesis that \( \text{rank}(B_0) = 0 \) versus the
alternative rank($B_0$) = 1, the Johansen test statistic was 44.94, which is significant at the 5 percent level. This provides evidence that a VAR in differences would be misspecified. Testing the hypothesis that rank($B_0$) = 1 versus the alternative rank($B_0$) = 2, the Johansen test statistic was 2.11, which is not significant at either the 5 or 10 percent level. Thus, there is statistical evidence that the $B_0$ matrix has rank 1. In conjunction with the results to the Augmented Dickey Fuller test, this suggests that wholesale and retail butter prices are cointegrated, i.e. that they exhibit long-term relationships. Using Johansen’s approach, the cointegration vector is estimated to be (0.801, -1). This shows that, after taking into consideration trend and seasonality effects, the wholesale price tends to be about 80 percent of the retail price in the long run.

Second, we tested for lagged effects among prices. In particular, we investigated whether lagged price changes $\Delta y_{jt-1}$ affect current prices $\Delta y_{it}$ using likelihood ratio tests. The corresponding null hypotheses involve $B_{1ij} = 0$ and $B_{ij}^0 = 0$ with $i, j = (r, w)$. The associated test statistics have a chi-square distribution under the null hypothesis (Hamilton, p. p. 529). For lagged cross price effects (with $i \neq j$), the test statistic is 245.65 for the effects of lagged wholesale on retail price, and 1.21 for the effects of lagged retail on wholesale price. At the 5 percent significance level and with 2 degrees of freedom, the critical value is 5.99. Thus, we find strong evidence that lagged wholesale prices affect retail prices. However, we fail to reject the null hypothesis that lagged retail prices have no impact on wholesale prices. Thus, butter price transmission is such that lagged cross effects are strong from wholesale to retail, but weak from retail to wholesale. Such effects will be further evaluated below. For lagged own price effects (with $i = j$), the test statistic is 59.53 for retail price and 14.16 for wholesale price. With 2 degrees of freedom, we strongly reject the null hypothesis of zero own lagged effects for
each price. This provides evidence of significant dynamic adjustments in both wholesale and retail prices.

Third, we evaluated the symmetry of lagged price effects. In the context of equation (3), the symmetry of dynamic effects of price $j$ on price $i$ corresponds to the null hypothesis $B_{1ij}^1 = B_{1ij}^0$. Using a likelihood ratio test, the associated test statistics are 23.00 for $(i, j) = (r, r)$, 0.04 for $(i, j) = (w, w)$, 15.81 for $(i, j) = (r, w)$, and 0.001 for $(i, j) = (w, r)$. Based on a chi square distribution with 1 degree of freedom, the critical value is 3.84 at the 5 percent significance level. Thus, we strongly reject the symmetry of dynamic adjustments for retail prices (corresponding to $(i, j) = (r, r)$ and $(r, w)$). For example, the estimates in Table 2 show that retail prices respond much more strongly to a lagged wholesale price increase than to an equivalent price decrease. This asymmetry implies non-linear dynamics. The implications of non-linear dynamics for both retail and wholesale prices are evaluated below. In contrast, we fail to reject the null hypothesis of symmetry for wholesale prices (corresponding to $(i, j) = (w, w)$ and $(w, r)$). This result can be sensitive to model specification in interesting ways. In particular, the evidence against symmetry in wholesale price adjustments was found to become stronger when time-varying volatility is neglected (i.e., under homoscedasticity). This stresses the importance of considering heteroscedastic error structures in the analysis of asymmetric price transmission. Finally, we should keep in mind that these test results only concern lagged price effects (e.g., they do not reflect contemporaneous cross price effects).

Fourth, we investigated the presence of contemporaneous cross price effects. This is captured by the Cholesky term $s_{wr} = \sigma_{wr,0} + \sigma_{wr,\Delta w} \Delta y_{w,t-1} + \sigma_{wr,\Delta r} \Delta y_{r,t-1}$. The null hypothesis that $\sigma_{wr,0} = \sigma_{wr,\Delta w} = \sigma_{wr,\Delta r} = 0$ implies a zero correlation between $y_r$ and $y_w$ and thus zero contemporaneous effects between retail and wholesale prices. A likelihood ratio
test of this hypothesis yielded a test statistic of 36.57. Based on a chi-square distribution with 3 degrees of freedom, we strongly reject the null hypothesis. This provides evidence of significant contemporaneous cross price effects between the two butter prices.

Fifth, we explored the nature of contemporaneous cross price effects. The estimates reported in Table 2 give $s_{wr} = \sigma_{wr,0} + \sigma_{wr,\Delta w} \Delta y_{w,t-1} + \sigma_{wr,\Delta r} \Delta y_{r,t-1}$. The estimates $\sigma_{wr,\Delta w} = -0.0645$ and $\sigma_{wr,\Delta r} = 0.0778$ are each significant at the 5 percent level. It means that an increase in wholesale price has a negative effect on the covariance between $y_{rt}$ and $y_{wt}$. And a rise in retail price has a positive effect on the covariance between $y_{rt}$ and $y_{wt}$. This provides statistical evidence that the contemporaneous effects of one price on the other are sensitive to market pressure. It suggests that the contemporaneous linkages between retail and wholesale prices become weaker (stronger) when the wholesale (retail) price increases. This is another form of asymmetry between retail and wholesale butter prices. Note that such patterns are not consistent with competitive pricing. We interpret them to reflect short-term market imperfections. For example, as argued by Chevalier et al., such price behavior may be due to interactions between retail pricing rules and advertising effects. This would stress the importance of retailers’ behavior in short-term price determination.

Sixth, we investigated the time-varying nature of price volatility. This is captured by the Cholesky terms $s_{ii} = \sigma_{ii,0} + \sigma_{ii,w} y_{w,t-1} + \sigma_{ii,r} y_{r,t-1}$, $i = (w, r)$. The null hypothesis that the $s_{ii}$’s are constant over time was tested using a likelihood ratio test. The test statistic is 269.07, with 4 degrees of freedom. Thus, we strongly reject the null hypothesis. This provides strong evidence that price variances vary over time, i.e. that butter price volatility changes with market conditions. Evaluated at sample means, the estimated standard deviation of $e_i$ is 0.078 for wholesale prices and 0.043 for retail prices, with a
correlation coefficient of 0.095. This shows that, on average, volatility is much higher for wholesale butter prices than for retail prices. From the estimates reported in Table 2, the retail price $y_{r,t-1}$ has a positive effect on price volatility (although only the effect on retail price volatility is significant). The wholesale price $y_{w,t-1}$ has statistically significant effects on the contemporaneous volatility of both prices. The effect on wholesale price volatility is positive: a rise in wholesale price tends to increase wholesale price volatility. As discussed above, this can be attributed to storage behavior. Indeed, competitive stockholding can help stabilize prices but only when stocks are positive, which is likely to happen when prices are relatively low. To the extent that storage services are mainly performed at the wholesale level, this suggests that wholesale price volatility would rise with the wholesale price level. Our estimated positive effect of wholesale butter price on wholesale price volatility is thus consistent with stockholding behavior. Somewhat surprisingly, opposite results are obtained for retail price volatility: a rise in wholesale price tends to lower retail price volatility (see Table 2). Why would retail prices become more stable under higher wholesale price? At this point, this seems difficult to explain. Again, this stresses the need to understand better retailers’ behavior and its impact on short-term price determination.

Finally, to evaluate explanatory power, predicted prices were obtained from the estimated model and compared with actual prices during the sample period. The results are presented in Figure 1. The model has high explanatory power and provides a good fit to the butter price data. Figures 2a and 2b presents the estimated standard deviations and correlation coefficients of $e_t$ for retail and wholesale prices. Figure 2a illustrates the time-varying nature of butter price volatility. It shows a large increase in price volatility since 1990. It also shows that the wholesale price is consistently more volatile than the retail
price. The correlation coefficient presented in Figure 2b indicates how the covariance between retail and wholesale prices varied during the sample period. As noted above, our parameter estimates imply that the contemporaneous linkages between retail and wholesale prices become weaker (stronger) when the wholesale (retail) price increases. Evaluated under June 1991 conditions, the marginal contemporaneous effect of a change in retail (wholesale) price on the wholesale (retail) price is estimated to be 0.149 (0.050). This shows contemporaneous cross price effects are stronger from wholesale price to retail price than vice versa.

4. Price Dynamics

The empirical results show strong evidence of asymmetry in price effects and dynamics in the US butter market. This asymmetry means that price dynamics are nonlinear in two ways: 1/ contemporaneous cross-price effects vary with market conditions; and 2/ price dynamics vary across regimes between situations of price increases and price decreases. These nonlinearities mean that, in general, the forward path of prices depends on initial conditions (Potter). As a result, the dynamic price response to exogenous shocks is typically situation specific. To evaluate the nature of dynamic adjustments in the US butter market, dynamic stochastic simulations of the estimated model were performed. The nonlinear dynamics imply that there is no simple way of summarizing price effects (since the results always depend on initial conditions). Below, we report selected simulation results that illustrate the dynamic implications of the estimated model.

The stochastic simulations were performed as follows. A random number generator was used to generate pseudo-random draws for the standardized error terms \( \varepsilon_t = \)


$(\varepsilon_{rt}, \varepsilon_{wt})$' distributed $N(0, I_2)$. For given initial conditions (say at time $\tau$), these error terms were used to simulate forward the estimated model (3) with $e_{t+i} = S_{t+i} \varepsilon_{t+i}, i = 0, 1, 2, \ldots$, where $\Omega_t \equiv S_t S_t'$. Repeated dynamic simulation generated a distribution of prices $y_{t+i}$ at time $\tau+i$, $i = 0, 1, 2, \ldots$ This simulates the distribution of predicted prices at time $\tau+i$, based on the information available at time $\tau$. In addition, for given pseudo-random draws for the $\varepsilon_t$'s, the dynamic simulation can be repeated after shocking the system at time $\tau$. Comparison of the paths of the simulated series with and without the shock provides a basis for measuring numerically the effects of the shock on the dynamics and distribution of prices. It measures the dynamic impulse response to the initial shock, which can shed light on the nature of price dynamics. We consider two kinds of shock: a shock in retail price at time $\tau$, and a shock in wholesale price at time $\tau$. The former is represented by an exogenous change in $\varepsilon_{rt}$, and the latter by an exogenous change in $\varepsilon_{wt}$.

In general, under nonlinear dynamics, the impulse response depends not just on the initial conditions, but also on the nature and magnitude of the shock (Potter). To evaluate the effects of asymmetric price adjustments, we distinguish between positive and negative shocks to prices.

The distribution of impulse- responses to 10% shocks (both positive and negative) in wholesale price in June 1991 is presented in Figure 3. Figure 3 shows the evolution of the 10th, 25th, 50th, 75th, and 90th percentiles of the distribution over the 11-month period following the shock. Figures 3A and 3C show the own price response to a wholesale price shock. Following the initial shock, the wholesale price overreacts in the following 2 months, with a longer-term effect that slowly declines over time. From Figures 3B and 3D, a positive (negative) shock in wholesale price has a positive (negative) impact on
retail price. The impact is small in the short run, increases and is largest after 3 months, and then decays slowly over time.

Figure 3 illustrates the effects generated by a positive shock versus a negative shock. It shows how the distribution of the impulse response can vary. From Figures 3A and 3C, compared to a negative shock, a positive wholesale shock generates lower short-term variability in wholesale price. Figures 3A and 3C also suggest that the distribution of wholesale price response is approximately symmetric around its mean. However, nonlinear dynamics generate a skewed distribution of retail price responses to a wholesale price shock. For example, Figure 3B shows that a positive wholesale shock yields a retail price distribution with a long tail for high prices.

Similarly, Figure 4 presents the distribution of impulse response to 5% shocks (both positive and negative) in retail price in June 1991. From Figures 4A and 4C, a positive (negative) shock in retail price tends to have a positive (negative) impact on wholesale price. Note that this impact is small in the short run and that it does not decay quickly in the longer term. Figures 4B and 4D show the own price response to a retail price shock. The effect of the initial shock on the retail price slowly declines over time, but it persists for many months. The differences between a positive and a negative shock are quite apparent comparing Figure 4A with 4C, or Figure 4B with 4D. The effect on retail price persists longer for a positive shock (Figure 4B) than for a negative shock (Figure 4D). And the variability of both wholesale and retail price responses is larger for a retail price increase than for a retail price decrease. Figures 4B and 4D also indicates the presence of skewness in the distribution of the retail price response. For example, a positive retail shock yields a retail price distribution with long tail for high prices.
To show that the results presented in Figures 3 and 4 can be sensitive to initial conditions, we evaluate the impulse responses to price shocks for other selected periods. These are presented in Figure 5. Contrasting Figures 3 and 4 with Figure 5 illustrates the important effects of initial conditions on dynamics. Dynamic conditions are always “local” in nonlinear models, making price forecasts much more complex. In all cases, in response to a retail shock, price variability tends to be larger for wholesale prices than retail prices. This reflects the fact that the variance of $e_w$ is always larger than the variance of $e_r$. The contemporaneous impacts on wholesale price of retail shocks in December 1995 (Figure 5A) are much larger than in June 1991 (Figures 4A). The comparison between Figure 4A and 5A shows that initial conditions affect not only the scale but also the shape of the median and distribution of the impulse response of wholesale price. Also, Figures 4B and 5B illustrate how retail response to retail shocks can vary greatly across scenarios. Compared to June 1991 (Figure 4B), December 1995 (Figure 5B) shows lower short-term variability, an initial overshooting after 2 months, and a slower decay in longer run effects. It illustrates how regime switching can affect price dynamics and the distribution of forecasted prices.

Figures 5C and 5D present impulse response for November 1987, when the covariance between $e_r$ and $e_w$ is negative. This negative covariance means that contemporaneous cross-price effects are negative. As shown in Figure 2b, while such situations are not very common, they do occur within the sample period. Figure 5C shows the wholesale response to a 5% positive retail shock. In contrast with Figure 4A (which corresponds to a positive covariance), Figure 5C shows negative cross-price effects that peaks after 2 months, but then decay faster. Figure 5D shows the impact of a 10% positive wholesale shock on the retail price. It illustrates that, despite an initial negative
impact, the retail price response climbs rapidly out of the negative range after a few months. In the longer term, most of the initial wholesale shock ($0.15) is transferred to the retail sector. Figures 5C and 5D illustrate well the asymmetry of price response between retail and wholesale markets, with wholesale prices exhibiting much larger longer term adjustments. It also stresses the importance of dynamics in the study of price transmission.

The implications of nonlinear dynamics for the asymmetry of impulse response to positive versus negative shocks are investigated further. Table 3 reports the testing of the hypothesis of symmetry. Formally, the null hypothesis is $H_0$: the distribution of impulse responses at a point in time is symmetric for a price increase versus an equivalent price decrease. This is done using a chi-square Pearson test. The results in Table 3 are presented for different initial conditions, different shock sizes and at different time intervals (1, 5 and 11 months of simulation after the shock date). First, Table 3 makes it clear that the magnitude of the shock has a large impact on the presence of asymmetry. The evidence of asymmetry is very weak in the case of a small shock (e.g., 1% shock), but becomes strong with increases in the size of the shock. This reflects in large part the piece-wise linearity in model (3): it may take large changes to switch from one regime to another. As a result, the model can still exhibit “linear properties” locally, i.e. in the neighborhood of some path. The non-linearities become apparent only globally, when path changes are large enough to induce regime switching.

Second, the evidence of asymmetry is stronger for retail price response compared to wholesale price response (see Table 3). This is true irrespective of whether the shock is at the wholesale or retail level. Also, retail responses to retail shocks are the most asymmetric, followed by retail responses to wholesale shocks. The evidence of
asymmetry is weakest for the wholesale price response to retail price shocks, especially in the short run (after 1 month). The reason is two-fold: 1/ wholesale price dynamics do not exhibit strong evidence of asymmetry; and 2/ the retail price does not have a strong effect on wholesale price. However, dynamic asymmetric adjustments in retail prices eventually affect the dynamics of wholesale prices: Table 3 reports evidence of asymmetry for wholesale prices in the longer-term. To the extent that asymmetry is motivated by adjustment costs, finding that asymmetry is much stronger for retail price responses (compared to wholesale price responses) indicates the presence of significant short-term adjustment costs in the butter retail sector. This includes adjustment costs for consumers (e.g., search cost) as well as retailers (e.g., menu cost).

We evaluate the skewness of the distribution of impulse response. Table 4 presents the relative skewness obtained from the simulated effects of shocks in June 1991. It also reports tests of the null hypothesis of zero skewness (corresponding to a symmetric distribution of an impulse response around its mean). This is done using the Bera-Jarque test. The evidence against the null hypothesis is weak when considering the longer-term effect of a wholesale shock on the wholesale price. However, some statistical evidence of skewness is present in all other cases, and is found to be particularly strong in the effect of a retail shock on the retail price, both in the short run and the longer run. The importance of skewness indicates that mean-variance representations cannot provide sufficient statistics for the distribution of future prices. This shows the limitations of previous analyses of price dynamics based solely on autocovariance (or spectral density in the frequency domain, as used by Miller and Hayenga). Table 4 also shows that, when significant, positive (negative) shocks tend to generate positive (negative) skewness in the long run. This is true for wholesale price response as well as retail price response.
This indicates the nonlinear dynamics under regime switching can help explain the skewed distribution of butter prices (which as seen earlier exhibit a “long tail” for high prices).

Finally, we investigate whether nonlinear dynamics are in fact the main source of price skewness. To answer this question, we tested for skewness of the standardized regression residuals $\varepsilon_t = S_t^{-1} e_t$. The relative skewness was 0.0001 and 0.0012 for $\varepsilon_r$ and $\varepsilon_w$, respectively. The Bera-Jarque test of the null hypothesis of zero skewness has a p-value of 0.958 and 0.819 for retail price and wholesale price, respectively. Thus, we find no strong evidence that the standardized residuals $\varepsilon_t$ have a skewed distribution. If the standardized residuals are symmetrically distributed, this means that nonlinear dynamics are indeed the main source of the skewness in the distribution of butter prices reported in section 3. In other words, the nonlinear dynamics in our model of asymmetric price response effectively capture the skewed distribution of observed butter prices at both the retail and wholesale level.

5. Concluding remarks

This paper developed a model of asymmetric price transmission in a vertical sector, allowing for refined asymmetry for both contemporaneous and lagged own and cross price effects. Applied to wholesale-retail price dynamics in the US butter market, the model provides strong evidence of asymmetric price transmissions. The asymmetry generates nonlinear dynamics in price adjustments in a vertical sector. We document the complex nature of price dynamics in the butter market. The effects of market shocks depend on initial conditions. For example, the impact of a change in retail price on wholesale price is found to vary significantly with market conditions (see Figures 3 and...
5). Despite this sensitivity to initial conditions, the following regularities appear. First, the evidence of asymmetry grows with the size of the shock. Second, we show how asymmetric price responses affect the distribution of prices. We find strong evidence of skewness in the response to large price shocks. This highlights the limitations of previous analyses of price dynamics that relied only on the autocovariance (or spectral density in the frequency domain). Third, the asymmetric response is particularly strong for retail prices, both in the short run and the longer run. It is found that retail prices respond more strongly to a wholesale price increase than to a wholesale price decrease. This is consistent with the presence of consumer search costs and/or menu costs facing retailers. Fourth, the evidence of asymmetry in wholesale price response is weaker. However, some evidence of asymmetric adjustments remains for wholesale prices, due in part to linkages with asymmetric retail price adjustments. This illustrates how non-linear dynamics can affect price behavior in different stages of a marketing channel. Finally, we find that the non-linear dynamics are in fact the main source of skewness in the distribution of prices. This indicates how non-linear price transmission across markets can help better anticipate the distribution of price forecasts.

The analysis has focused on vertical price adjustments in the butter sector. It can be extended in several directions. First, it would useful to investigate whether our empirical findings hold for other sectors. Second, there may be more complex forms of nonlinear dynamics that are relevant in vertical price adjustments. Finally, following Peltzman, our empirical findings suggest significant challenges for improving our conceptual understanding of dynamic market adjustments. These are good topics for further research.
Table 1: Ljung-Box test of white noise for standardized errors:

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<th>Number of lags (p) months</th>
<th>Wholesale price</th>
<th>Retail price</th>
</tr>
</thead>
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<tr>
<td></td>
<td>Test statistic</td>
<td>P-Value</td>
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<td>0.699</td>
</tr>
<tr>
<td>2</td>
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<td>0.773</td>
</tr>
<tr>
<td>3</td>
<td>0.579</td>
<td>0.901</td>
</tr>
<tr>
<td>4</td>
<td>0.596</td>
<td>0.963</td>
</tr>
<tr>
<td>5</td>
<td>2.991</td>
<td>0.701</td>
</tr>
<tr>
<td>6</td>
<td>8.835</td>
<td>0.183</td>
</tr>
</tbody>
</table>

Table 2: Maximum likelihood estimate of the parameters

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<th>Parameter</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>Parameter</th>
<th>Estimate</th>
<th>Std. Error</th>
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<td></td>
<td>Retail price</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$a_{w0}$</td>
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<td>$a_0$</td>
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<td>0.0232</td>
</tr>
<tr>
<td>$a_{w1}$</td>
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<td>$a_1$</td>
<td>0.0004**</td>
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</tr>
<tr>
<td>$\alpha_{w1}$</td>
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<td>0.0340</td>
<td>$\alpha_{r1}$</td>
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<td>0.0147</td>
</tr>
<tr>
<td>$\alpha_{w2}$</td>
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<td>$\alpha_{r2}$</td>
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<td>0.0160</td>
</tr>
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<tr>
<td>$\sigma_{ww,w}$</td>
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Log Likelihood = 796.85. Number of Observations = 258.

Double asterisks (**) means significantly different from zero at the 5 percent level; single asterisk (*) means significantly different from zero at the 10 percent level.
Table 3: Testing the symmetry of impulse price response to price increase versus a price decrease.

<table>
<thead>
<tr>
<th>Shock-Date</th>
<th>Months Elapsed</th>
<th>Shock Size</th>
<th>P-Values for the Null Hypothesis that Wholesale Shocks Produce Symmetric Wholesale Price Responses.</th>
<th>P-Values for the Null Hypothesis that Retail Shocks Produce Symmetric Wholesale Price Responses.</th>
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Table 4: The Relative Skewness of distributions of Price Responses to Shocks in June 1991.

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<th>A Positive Retail Shock</th>
<th>A Negative Wholesale Shock</th>
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<td>Retailer</td>
<td>P-Value</td>
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</table>
Figure 1: Actual and predicted butter prices: January 1980-August 2001.
Figure 2a: Estimated standard deviations of error terms for butter prices: January 1980-August 2001.
Figure 2b: Estimated contemporaneous correlation between wholesale and retail butter prices: January 1980-August 2001.
Figure 3: Impulse Responses to 10% Wholesale Price Shocks in June 1991: 10th, 25th, 50th, 75th and 90th Percentiles

A: Wholesale Response to a Positive Wholesale Shock

B: Retail Response to a Positive Wholesale Shock

C: Wholesale Response to a Negative Wholesale Shock

D: Retail Response to a Negative Wholesale Shock

$/lb

Months since Shock

$/lb

Months since Shock
Figure 4: Impulse Responses to 5% Retail Shocks in June 1991: 10th, 25th, 50th, 75th and 90th Percentiles

A: Wholesale Response to a Positive Retail Shock

B: Retail Response to a Positive Retail Shock

C: Wholesale Response to a Negative Retail Shock

D: Retail Response to a Negative Retail Shock
Figure 5: Impulse Responses to Price Shocks for selected periods: 10th, 25th, 50th, 75th and 90th Percentiles

A: Wholesale Response to a 5% Positive Retail Shock in December 1995

B: Retail Response to a 5% Positive Retail Shock in December 1995

C: Wholesale Response to a 5% Positive Retail Shock under Negative Covariance: November 1987

D: Retail Response to a 10% Positive Wholesale Shock under Negative Covariance: November 1987
References


Footnotes

1 See Zellner and Palm for a discussion of the linkages between a structural model of price determination and the time series representation (1).

2 Note that equation (3) can be equivalently expressed in “levels” as

$$y_{it} = a_i + a_i t + \sum_{s=1}^{S-1} \alpha_{is} D_{ts} + \sum_{k=1}^{K} \sum_{j=1}^{m} [A_{kij}^1 R_{j,t-k} + A_{kij}^0 (1-R_{j,t-k})B_k] y_{t-k} + e_{it},$$

$i, = 1, \ldots, m$, where the $A$’s satisfy $\sum_{k=1}^{K} A_{kij}^1 = \sum_{k=1}^{K} A_{kij}^0$, for $i, j = 1, \ldots, m$.

3 Equation (3) restricts the $B_{0ij}$’s to be the same across regimes. It assumes that cointegration relationships among the dependent variables are not regime specific. This will prove convenient in the implementation of the Johansen test for cointegration (see below).

4 More general forms of asymmetry can treat the regime switching as endogenous. This includes threshold autoregression (TAR; see Hansen, and Koop and Potter), or Markov chains with regime switching (e.g., Hamilton, chapter 22).

5 There are two scenarios where $B_0 \neq 0$: when $y_i$ is stationary; or when $y_i$ has a unit root and is cointegrated.

6 The skewness coefficient for a random variable $y$ is $\{E[y - E(y)]^3 \}/\{E[y - E(y)]^2 \}^{3/2}$ where $E$ is the expectation operator. It provides a standard measure of the asymmetry of a probability distribution around its mean. The skewness coefficient is equal to zero for a symmetric distribution. And it is positive (negative) for an asymmetric probability distribution with a “long tail” above (below) the mean.

7 Allowing the $s_{ij}$’s to become time-varying means that the model specification changes with the ordering of the prices. To evaluate this issue, we also estimated the same model with $y_1 = y_w$ and $y_2 = y_r$. This resulted in a lower log-likelihood value of the sample.
The Schwartz criterion selects the specification that maximizes \[\ln(\text{likelihood function}) - \frac{1}{2} k \ln(T)\], where \(k\) is the number of parameters and \(T\) the number of observations.

However, under cointegration, hypothesis testing involving the \(B_{0i}\)'s generates test statistics that can have non-standard distributions. This includes testing for Granger causality (Toda and Phillips).

This seems inconsistent with competitive pricing. Also, it is inconsistent with “sticky” retail pricing rules that are modified only when the wholesale price is high. Note that Peltzman also found some linkages between price volatility and price dynamics. He argues that reconciling such empirical results with current theories remains a significant challenge.

The Bera-Jarque test was also used to test for kurtosis, i.e. whether the fourth moment of \(\varepsilon_t\) is consistent with a normal distribution. The test results found evidence of excess kurtosis, indicating the presence of thick tails in the distribution of \(\varepsilon_t\). This suggests that our model may underestimate the likelihood of rare events (when prices are either very high or very low). Yet, it still provides consistent estimate of the parameters underlying price dynamics. And compared to a homoscedastic structure, our heteroscedastic specification provides efficiency gains in the parameter estimates.
Regional Concentration in the Global Food Economy

Mark Gehlhar


1 Mark Gehlhar is a senior economist in the Market and Trade Division, ERS-USDA.
Abstract

The global food manufacturing industry is comprised of diverse firms, varying in their geographic coverage and product portfolios. While the largest firms have wide product portfolios and global coverage, many concentrate on few product categories or in regional markets. There are variations in the four-firm concentration ratio across regions at the aggregate level and at the product-specific level. In addition, firm concentration varies across countries within the same region. Sales concentration in packaged food is highest in Latin America and Australasia and lowest in Asia Pacific and Eastern Europe.
Introduction

Large and growing food companies are a prominent feature in the landscape of the global food industry. Some predict that in the near future there will be four or five large retail firms and about twenty or twenty-five manufacturers operating globally (Grievink, Josten, Valk 2002). Many industries have evolved into markets with a transnational dimension where the leading firms in an industry are the leading firms in the same industry of other countries (Connor 1985). However, outside of Western Europe and the United States little is known about the structure at the manufacturing level in processed food. Evidence is scant whether large multinational manufacturers have dominate positions in food markets globally or whether local firms have a greater presence in home markets.

The current structure of world food industry is unlike other manufacturing such as auto, aircraft, or electronics, which are dominated by large firms with manufacturing facilities located in few locations. Food manufacturing comprises of a wide array of industries, each using different inputs and producing products that require specific marketing expertise and brands for individual markets. This provides broader scope for different firms tailoring product for specific consumer demands. In many cases different sized firms have advantages allowing for their coexistence in world food. In the United States, for example, there is a growing bimodal distribution of firms as larger firms expand and the number of smaller firms increases (Rogers 2001).

Consolidation in food manufacturing is continuing in Western Europe and the United States (Cotterill 1999). However it is debatable whether the food industry structure will converge to a similar structure as other manufacturing with few dominant firms. Although the largest
multinational food companies may become proportionately larger in the next decade, this may or
may not lead to more concentrated markets. International expansion and sheer size of companies
do not necessarily translate to greater market power (Scherer and Ross 1991). It is not the size of
a corporation that confers power, but the nature of the market in which a firm operates and their
position in these markets. The ability of firms to gain access to retail channels and heighten
entry barriers can lead to higher concentration in specific food markets.

The paper provides a global view of the structure of food manufacturing by identifying key
players and examining levels of concentration at the global and regional level. It begins with
reasons why and how some food manufacturers have evolved into the largest firms in the world.
Early history of the firm and incentives for acquisition are important for understanding industry
structure in global food manufacturing. Concentration is examined using the four-firm
concentration ratio (CR4). Differences in concentration are compared across regions by
examining concentration at the product and country-specific level. Cases of firm dominance are
also examined and in specific cases brands are identified which may play a role in determining a
firm’s position in international food markets.

**Diversity of firms and their global presence**

An important feature in global food markets is the diversity of firms in terms of size, uniqueness
in products and brands, and geographic coverage. Large firms coexists with many smaller firms,
with the top twenty-five firms in the world accounting for less than 25 percent of global
packaged food sales. The structure of an industry is influenced by firm history, brand
acquisition, geographic coverage, and resistance towards expansion either from legal authorities or by firm choice.

**History’s role**

Simply being first in a market has been important in the success of the world’s largest food corporations. Large-scale commercial food processing and retailing originated in Western Europe and the United States. Of the world’s fifty largest food manufacturing firms, thirty-six are based either in the United States or Western Europe (table 1). The most renowned food companies today were founded in the late 1800’s and during the turn of the 20th century when household incomes grew rapidly with the industrial revolution. As households could no longer afford the time processing farm products, entrepreneurs gained greater access to capital from private and public sources for launching new food companies. This led to strong growth in commercial processing in the United States and Western Europe where the two regions today account for more than 53 percent of global packaged food sales (table 2). Product innovations in some food categories such as ready meals, frozen foods, and meal replacement drinks are marketed mainly in the United States and Western Europe accounting for nearly 70 percent of global sales (table 2)². The high level of packaged food sales gave U.S. and European firms more opportunity to introduce new products and establish consumer loyalty.

The three largest companies in packaged food sales, Nestlé, Unilever, and Kraft continue to have their most profitable activity in products they established in their early history. The Nestlé Company, founded in 1865 in Switzerland by Henri Nestlé started with an initial focus on infant

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² All data for this paper is from Euromonitor International (www.euromonitor.com) a private vendor for global consumer markets and business data.
nutrition and later was followed by other milk-based products. This company is now the world’s largest food company with a strong focus on the same items. Unilever is the global leader in ice cream and spreadable oils and fats. Its roots can be traced to the 1930 merger between a Dutch margarine manufacturer, Margarine Unie, and the British company, Lever Brothers, a company that had previously diversified into ice cream. In 1903, James Kraft began a wholesale cheese business in Chicago which later became Kraft Foods, and is now the world’s largest cheese supplier to retail markets.

Food companies soon realized they needed recognizable brands in order to differentiate their products from competitors to retain and expand their customer base. Technology employed by food processing firms was relatively unsophisticated and could easily be replicated by rivals. Preserving their product identity with brands was essential in preventing displacement by competitors using similar processing technology. For example, Kraft Foods would not have attained its global presence without its famous cheese brands, patented trademarks, and the longstanding goodwill earned from consumers. In the food industry, these intangible assets are often more important than capital and technology.

*Brand acquisition*

Firm expansion with new products and brands are less frequent in the contemporary food industry. Rather the expansion of food companies, particularly the largest firms, is principally achieved through acquisition of existing brands. This strategy has been employed in numerous occasions in recent years for growth and entering new markets. For example Unilever’s
acquisition of the successful meal replacement drink (Slim fast) significantly helped the company in this product category in the U.S. market

Global food industry structure has evolved from a series of acquisitions over time. Large diversified companies have accumulated premium brands in their core product categories (table 3). Nestlé and Unilever compete with each other in ice cream markets globally. Recently they became more aggressive in the U.S. market as incentives to acquire U.S. brands were amplified with consumer demand shift toward premium ice cream. In 2000, Unilever acquired the U.S. ice cream manufacturer Ben and Jerry’s Ice Cream. Nestlé, on the other hand expanded its ice cream core business by acquiring General Mill’s stake in Ice Cream Partners USA, giving it ownership of the premium Häagen-Dazs in the United States. In 2002, Nestlé acquired a majority stake in Dreyers’s Grand Ice Cream.

The combination of processing technology and specific brands helped Unilever differentiate its oils and fat products from those of its rival ConAgra. For example, some of Unilever’s margarine products, having a butter-like flavor, opened an opportunity to attract more consumers away from other margarine. The strategy helped Unilever compete with ConAgra’s strong domestic margarine brands (table 3) acquired previously from Nabisco’s table spread business.

Accumulating high-performance brands is a way for firms to boost their regional presence and compete for market share. Nestle’s acquisition of the Stouffers brand in the United States gave the company the leading position in the “ready meals” product category. ConAgra, the second largest supplier of ready meals has acquired many brands through the purchase of companies
such as International Home Foods, GoodMark Foods (meat snacks), Golden Valley Foods (microwaveable popcorn), Knotts Berry Farm Foods, and Beatrice Foods. In another example, General Mills extended its presence in bakery goods, canned and frozen foods, and snacks foods through acquisition of Pillsbury in 2001. This substantially increased its market share in North America and provided the company with strong brands, including Betty Crocker, Old El Paso, and Green Giant.

**Geographic expansion**

Geographic expansion will likely become a more important growth strategy in the future as Western European and North American markets become saturated. Developing country markets will be critical for food volume growth. Only a few companies currently have sales in every region in the world, and firms with a global presence are not necessarily associated with product and size (table 4). Firms with a global presence generally have extensive expertise in certain product categories where they have an inherent technological and marketing advantage. Nestlé exemplifies this point with its global sales in baby food products, drawing expertise from its extensive research and development program in infant formulation. The company is the largest food manufacturer with a diversified product portfolio and extensive geographic sales reach. Similarly, Unilever has extensive geographic coverage in its core products. Technology and marketing expertise of smaller firms help them achieve a global presence as well. Two examples are the Wrigley Jr. Company specializing in confectionery, and the newly formed Fonterra Cooperative Group specializes in dairy products. Wrigley has less than one tenth the sales in packaged food as Nestlé, yet it is a truly global company specializing in gum products, supported by extensive product development and global marketing expertise. The Fonterra Cooperative
Group, based in New Zealand, has sales in more than 140 countries and maintains extensive research and development and dairy technology. The U.S. based ConAgra Company is at the other extreme where it has limited geographic sales in its packaged food but has a diverse product portfolio. Its primary geographical market is North America. L

Local orientation would characterize Dean Foods (USA) and Meiji Dairies (Japan). They have limited product portfolios specializing in milk products. Despite their current local orientation many companies are striving for extending their geographical coverage. Meiji a leading dairy, ice cream, and baby food manufacturer for the Asia Pacific region is targeting South East Asia, where it has subsidiaries in Indonesia and Thailand. In Western Europe Arla Foods Amba is Europe’s largest dairy co-operative with a regional market orientation. However, Arla Foods is setting up a new Middle East subsidiary in the United Arab Emirates.

PepsiCo, another U.S. based company is continuously extending its geographical reach with its international marketing arm in snack foods focusing on Latin America, Eastern Europe and Asia. The Heinz Company is capitalizing on its brand strength and strong growth potential in Eastern Europe and Asia Pacific where it is building its presence through local acquisitions and joint ventures. Danone is developing stronger presence in Africa and the Middle East through investments in fresh dairy products and bakery products. Italy’s popular confectionery company Ferrero is expanding operations in North America, Australasia, Asia-Pacific and Eastern Europe. Geographic expansion will likely become the most important growth strategy in the future as the food demand outside of North America and Western Europe grow with faster growth in incomes.
and population. Latin America and Asia are regions where U.S. and European-based firms are trying to establish themselves for the future growth.

There are certain forces resisting further acquisition and the drive for diversification. In some cases, a firm may choose to limit itself, or in other cases the legal environment may restrain firm activities in specific markets. Firms must constantly evaluate whether there is a good fit between their inherent strengths and the new opportunities that lie ahead. Diversifying a firm’s product portfolio may reduce marketing focus and prevent the firm from achieving economies of scale.

Multinationals have not gained a strong foothold in all regions of the world. Local firms hold leading positions in certain regional markets. In such cases firms may have a greater identity with consumers and the general public. This is noticeable in Northern Europe and East Asia. In Scandinavian countries Danish and Swedish firms hold the top positions (table 5). There seems to be support for locally owned and managed companies among the East Asian countries of Japan, South Korea, and China. For example Korea’s top four food manufacturing firms (Lotte, Nong Shim, Namy Dairy Products, and Cheil Jedang) are nationally owned companies. In sharp contrast, Brazil’s leading manufacturing firms are all European based multinationals (Nestlé, Unilever, Pamalat, and Danone). Lack of domestic capital is one reason for greater foreign investment but many laws still prevent foreign control of domestic assets.

**Aggregate concentration by region**

There are wide variations in firm concentration ratios within geographic regions. How concentration is calculated can matter in some cases. For example the CR4 ratio for Western
Europe, treating the regional as an aggregate, is 12.2. In contrast, the simple average CR4 using all individual countries in Western Europe is 22, with a range from 39.8 to 11.8 (listed in table 6). Northern European countries, Denmark, Finland, Norway and Sweden, all have CR4 ratios above 27. Many national food manufacturers make up the leading firms in these countries such as, Arla Amba Foods, Danish Crown Amba, Tine, Norske Meireier, and Valio Oy. The rest of Western Europe is less concentrated. In these other countries, multinational such as Nestlé, Unilever, Danone, and Kaft share the packaged food market more evenly with national companies. Germany, France, Italy, and the United Kingdom all have CR4’s below 19. Eastern Europe is the least concentrated region in the world with an aggregate CR4 ratio of 6 and a simple average CR4 for individual countries of 13, ranging from 5.4 in Russia to 20 in Hungary. In this region, the leading four firms are nearly exclusively national firms and with no single firm having a share above 7 percent.

The structure for packaged food sales in North America is closer to that of the largest Western European countries. Canada and the United States both have CR4 ratios both of 19 percent. Kraft Foods is the leading firm in both countries, but is the only common firm in the top four. As in many industrialized countries, each have their own national firms, such as Maple Leaf Foods in Canada and ConAgra Foods in the United States which share their respected markets with other multinationals. In contrast to North America, Australia and New Zealand have very different market structures. New Zealand is the most concentrated with a CR4 ratio of 44.1. In this case, concentration is largely accounted by New Zealand’s biggest firm, Fonterra, having a dominant position (22 percent) in New Zealand’s total packaged food sales. In Australia, Nestlé is the leading firm with only 6 percent of packaged food sales.
Asia Pacific and Latin America have wide variations in firm concentration across individual countries. In these regions, countries with more multinationals in leading positions tend to have higher concentration levels. South East Asian countries have higher concentration levels than East Asian countries, where multinationals are noticeable absent from in the top four positions. In Latin American countries, however, Nestlé, Unilever and Parmalat are pervasive throughout the region.

**Importance of concentration in product markets**

The global size of firms and widening disparity in the size of firms is inevitable as the global food industry evolves. But differences in the relative size of firms is not itself directly related to concentration, rather the degree of control firms possess in individual product markets is of more importance. The tendency for firms to specialize in specific product categories by acquiring brands and obtaining exclusive rights to retail channels raises questions regarding concentration levels.

Aggregate industry level data is often too broad to reflect a true economic market. Industrial organization economists have traditionally defined markets as a break in the distinct chain of substitutes that exist for an array of products. They are primarily concerned with the extent to which consumers differentiate substitute products. Industry classifications are based on similarity of production technologies and major inputs purchased. The problem is that many products within the industry may not be substitutes in consumption. Other market definition problems are caused by differences in the geographic scope of product markets. Food industries
in particular often are comprised of local and regional markets. The relevant market becomes more local as one moves down the distribution channel towards consumers (Cotterill 2003).

Which company acquires another has implications for how concentration changes in specific markets. The U.S. confectionery industry comprises individual product markets where concentration could become a concern to regulators if further acquisitions were to take place in the future. Wrigley and Pfizer are the largest firms in the U.S. gum market, whereas Hershey, Mars, and Nestlé are major suppliers of chocolate confectionery products. If Nestlé had acquired in Hershey, concentration would have increased in the U.S. chocolate confectionery market, as Nestlé share would have increased from 6 percent to 38 percent. However if Wrigley had acquired Hershey, concentration in chocolate confectionery would not have increased. Wrigley is not a supplier of chocolate products to the U.S. market, so concentration in the chocolate market would remain unchanged. On the other hand, the U.S. gum market would become more concentrated. The reason is that Wrigley would have acquired Hershey’s share of the U.S. gum market (12 percent), add to its current share (43 percent) of U.S. market. Thus, concern over concentration may differ under each acquisition scenario due to specificity of the products involved.

As described earlier, Nestlé has extensive sales throughout the world and across many product categories, making it the leading food manufacturer in the world. But, one can hardly say that the global food industry is concentrated with Nestlé having only a 3 percent share of world food. A very different story emerges by progressing from the aggregate level to individual country and product specific markets (table 8). Market dominance becomes more evident in core categories
of the firm in individual countries. Nestlé shares at the regional level for total packaged food ranges from 1.3 percent in Asia Pacific to 6.3 percent in Latin America. At the product level in its core categories, its global share ranges from 25.7 percent in pet food to 0.5 percent in bakery products. But for these same product categories, its shares increase considerably in individual regions and countries. While Nestlé holds 6.3 percent share of the Latin American packaged food market, it commands a substantially higher share of the baby food products in Latin America (60.7 percent). And at the sub-product level, Nestlé has near-monopoly control (91.2 percent) in infant milk-based formula market in Brazil. Similar examples are evident for other core categories, including chocolate confectionery in the U.K (24.6 percent), dehydrated soup in Russia (58.9 percent), cat food in the United States (40 percent), milk in the Philippines (48.3 percent), and cookies in Israel (42.3 percent).

With local brand ownership of foreign firms consumers are sometimes unaware they are purchasing products from a multinational company. For example, the top-three baby food brands in Brazil (Mucilon, Nan, and Nestogeno, and Neston) are brands owned by Nestlé. It is Nestlé local brand ownership that gives it strong presence in the Brazilian baby food market. Gerber a global brand owned by Novartis accounts, for only 1 percent of this market.

The next example of firm dominance is Unilever. It is a very large and diverse global food manufacturer but with a different mix of product categories than Nestlé (table 9). Similar to Nestlé it has does not have a dominate position in any particular region (4 percent in Western Europe and 1 percent in Asia Pacific). But at the global-product level, its core products have noticeably higher shares ranging from 39 percent in meal replacement drinks to 7 percent in
spreads. It has a dominant position in Austrian ice cream market (60 percent) and a near-monopoly control (81 percent) in the sub-product category of impulse ice cream.

A weak position at the regional level does not leave the door shut for attaining a strong position in a specific country market in the same region. This is the case oils and fats in the Asia Pacific region, where it has a weak overall presence (4.4 percent). However, in Indonesia Unilever controls more than a third of the country’s oil and fats product category, with 84 percent of the spreadable oils and fats. It achieves this high share through a single brand (Blue Brand) in the e oils and fats. This type of single brand market penetration is seen elsewhere where it achieved high market shares with its Slim Fast (meal replacement drink) in the United States, Knorr (soup) in Poland, and Hellman’s (Ketchup) in Argentina.

At the global level, sales concentration using the four-firm concentration ratio reveals wide differences. As a result of previous brand acquisitions by leading firms, certain products are becoming increasingly dominated by fewer firms. Pet food, soups, breakfast food, and baby foods have concentration ratio of greater than 50 percent. For example the CR4 ratio for global pet food is 63, with Nestlé alone accounting for 26 percent of global pet foods sales. Evidently there is strong incentives among leading food firms to acquire high-margin premium brands in this product category. The same can be seen in soups and baby foods. In baby foods, global brands such as Enfamil, Gerber, and Similac account for 70 percent of world sales. For soup, Campbells, Knorr, Maggi, and Progresso brands account for nearly 60 percent of the global soup sales.
At the regional level, there are differences in concentration within each product category. For example, breakfast cereals in Latin America have the highest level of concentration (CR4 = 91), while Eastern Europe is much lower (CR4 = 42). In many cases the level of concentration will depend on a single firm with a dominant position. In Latin America Kellogg’s has a dominant position, with over 40 percent of sales compared with only 5 percent Eastern Europe. Multinationals can have territorial specialization leading to high concentration in selected regions. This is illustrated in the case of baby food where the CR4 ratio is 39 in Asia Pacific but 93 in Australasia. The reason for this is that Heinz has a dominant position with 50 percent of baby food sales in Australasia but has little or no baby food sales in Asia Pacific. This is also true in confectionery but with Cadbury Schweppes dominating the Australasia region while having only a minor presence in Asia Pacific. There appears to be a tendency for firms to be territorial in many cases.

Summary

In the global food manufacturing industry most firms operate in regional markets with few large companies having a truly global geographic reach. The world food industry is made up of many types of firms that specialize in product and regional markets. Both local and global brands help firms penetrate foreign markets and enter retailer channels, but products and brands are often tailored to specific markets to compete with national firms. Large firms are better able to manage brands with international appeal, giving them extensive geographical reach in sales such as Kraft Foods, Nestlé, and Unilever. There is not a clear tendency for firms to continue to expand by diversifying their product portfolios. Rather many firms specialize in core product categories. This is what leads to more concentrated regional markets.
Wide differences in concentration levels can be found across countries even within the same region. This is most evident in Western Europe and Asia Pacific. Aggregate sales concentration is highest in Latin America, Australasia and lowest in Asia Pacific and Eastern Europe. High concentration is observed where both national and transnational firms are present. There is a stronger tendency for firms, large and small, to focus on specific core categories. Brand acquisition will likely be an important strategy for firms to enter new markets. In some cases this can lead to a single-firm achieving a dominant position.
References


Table 1. Leading 50 food manufacturing firms in packaged food sales worldwide

<table>
<thead>
<tr>
<th>Sales Rank</th>
<th>Company name</th>
<th>Country origin</th>
<th>Firm sales in packaged food percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nestle</td>
<td>Switzerland</td>
<td>51.7</td>
</tr>
<tr>
<td>2</td>
<td>Kraft Foods</td>
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</tr>
<tr>
<td>3</td>
<td>Unilever</td>
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<td>7</td>
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Source: Euromonitor International, product categories are defined by Euromonitor consistently across all regions
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Source: Euromonitor International
Table 5. Leading four firms in packaged food sales by individual country

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<tr>
<td>Switzerland</td>
<td>Migros</td>
<td>Nestle</td>
<td>Unilever</td>
<td>Chocoladefabriken</td>
</tr>
<tr>
<td>Taiwan</td>
<td>Uni-President</td>
<td>Wei Chuan Foods</td>
<td>I-Mei Foods</td>
<td>Kraft Foods</td>
</tr>
<tr>
<td>Thailand</td>
<td>Nestle</td>
<td>Saha Pathana</td>
<td>Friesland Coberco</td>
<td>Unilever</td>
</tr>
<tr>
<td>Turkey</td>
<td>Ulker Gida</td>
<td>Unilever</td>
<td>Nestle</td>
<td>Eti Gida</td>
</tr>
<tr>
<td>Ukraine</td>
<td>Shepetovsky</td>
<td>Cherkasskaya</td>
<td>Keivsky</td>
<td>Kamenents</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>Unilever</td>
<td>Cadbury Scheppes</td>
<td>Mars</td>
<td>Nestlé</td>
</tr>
<tr>
<td>USA</td>
<td>Kraft Foods</td>
<td>PepsiCo</td>
<td>ConAgra</td>
<td>Dean Foods</td>
</tr>
<tr>
<td>Venezuela</td>
<td>Empresas Polar</td>
<td>Cargil</td>
<td>Parmalat</td>
<td>Kraft Foods</td>
</tr>
<tr>
<td>Vietnam</td>
<td>Haihaco</td>
<td>Kinh Do 3</td>
<td>Generics</td>
<td>Vietnam Dairy</td>
</tr>
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</table>

Source: Euromonitor International, with abbreviated company names
Table 6. Four-firm concentration ratio in aggregate packaged food sales of individual countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Region</th>
<th>Four-firm concentration (CR4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Israel</td>
<td>Africa and Middle East</td>
<td>43.4</td>
</tr>
<tr>
<td>South Africa</td>
<td>Africa and Middle East</td>
<td>33.2</td>
</tr>
<tr>
<td>Morocco</td>
<td>Africa and Middle East</td>
<td>31</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>Africa and Middle East</td>
<td>20.1</td>
</tr>
<tr>
<td>Egypt</td>
<td>Africa and Middle East</td>
<td>9.4</td>
</tr>
<tr>
<td>Philippines</td>
<td>Asia Pacific</td>
<td>27.7</td>
</tr>
<tr>
<td>Malaysia</td>
<td>Asia Pacific</td>
<td>26.9</td>
</tr>
<tr>
<td>Indonesia</td>
<td>Asia Pacific</td>
<td>25.2</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>Asia Pacific</td>
<td>23.3</td>
</tr>
<tr>
<td>South Korea</td>
<td>Asia Pacific</td>
<td>21.5</td>
</tr>
<tr>
<td>Thailand</td>
<td>Asia Pacific</td>
<td>19.8</td>
</tr>
<tr>
<td>Singapore</td>
<td>Asia Pacific</td>
<td>17.6</td>
</tr>
<tr>
<td>India</td>
<td>Asia Pacific</td>
<td>17.2</td>
</tr>
<tr>
<td>Taiwan</td>
<td>Asia Pacific</td>
<td>15.1</td>
</tr>
<tr>
<td>Vietnam</td>
<td>Asia Pacific</td>
<td>13.7</td>
</tr>
<tr>
<td>China</td>
<td>Asia Pacific</td>
<td>10.1</td>
</tr>
<tr>
<td>Japan</td>
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<td>10.1</td>
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<tr>
<td>New Zealand</td>
<td>Australasia</td>
<td>44.1</td>
</tr>
<tr>
<td>Australia</td>
<td>Australasia</td>
<td>21.7</td>
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<tr>
<td>Hungary</td>
<td>Eastern Europe</td>
<td>20.1</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>Eastern Europe</td>
<td>19.8</td>
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<tr>
<td>Slovakia</td>
<td>Eastern Europe</td>
<td>16.5</td>
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<tr>
<td>Ukraine</td>
<td>Eastern Europe</td>
<td>15.9</td>
</tr>
<tr>
<td>Poland</td>
<td>Eastern Europe</td>
<td>12.1</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>Eastern Europe</td>
<td>11.2</td>
</tr>
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<td>Romania</td>
<td>Eastern Europe</td>
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<tr>
<td>Russia</td>
<td>Eastern Europe</td>
<td>5.4</td>
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<tr>
<td>Venezuela</td>
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<td>35</td>
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<tr>
<td>Argentina</td>
<td>Latin America</td>
<td>31.6</td>
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<tr>
<td>Chile</td>
<td>Latin America</td>
<td>29.9</td>
</tr>
<tr>
<td>Colombia</td>
<td>Latin America</td>
<td>28.1</td>
</tr>
<tr>
<td>Mexico</td>
<td>Latin America</td>
<td>26.3</td>
</tr>
<tr>
<td>Brazil</td>
<td>Latin America</td>
<td>18.5</td>
</tr>
<tr>
<td>Canada</td>
<td>North America</td>
<td>19.1</td>
</tr>
<tr>
<td>USA</td>
<td>North America</td>
<td>18.5</td>
</tr>
<tr>
<td>Norway</td>
<td>Western Europe</td>
<td>39.8</td>
</tr>
<tr>
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<td>Western Europe</td>
<td>37.1</td>
</tr>
<tr>
<td>Portugal</td>
<td>Western Europe</td>
<td>33.5</td>
</tr>
<tr>
<td>Ireland</td>
<td>Western Europe</td>
<td>29.3</td>
</tr>
<tr>
<td>Denmark</td>
<td>Western Europe</td>
<td>27.3</td>
</tr>
<tr>
<td>Sweden</td>
<td>Western Europe</td>
<td>27.3</td>
</tr>
<tr>
<td>Austria</td>
<td>Western Europe</td>
<td>18.7</td>
</tr>
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<td>France</td>
<td>Western Europe</td>
<td>18.7</td>
</tr>
<tr>
<td>Switzerland</td>
<td>Western Europe</td>
<td>17.8</td>
</tr>
<tr>
<td>Belgium</td>
<td>Western Europe</td>
<td>17.6</td>
</tr>
<tr>
<td>Spain</td>
<td>Western Europe</td>
<td>16.7</td>
</tr>
<tr>
<td>Greece</td>
<td>Western Europe</td>
<td>16.3</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>Western Europe</td>
<td>16.3</td>
</tr>
<tr>
<td>Netherlands</td>
<td>Western Europe</td>
<td>16</td>
</tr>
<tr>
<td>Turkey</td>
<td>Western Europe</td>
<td>15.5</td>
</tr>
<tr>
<td>Germany</td>
<td>Western Europe</td>
<td>13.7</td>
</tr>
<tr>
<td>Italy</td>
<td>Western Europe</td>
<td>11.8</td>
</tr>
</tbody>
</table>

Source: Euromonitor International
Table 7. Global sales share of top 5 food companies by product category

<table>
<thead>
<tr>
<th>Product Category</th>
<th>Nestlé sales share (%)</th>
<th>Kraft sales share (%)</th>
<th>Unilever sales share (%)</th>
<th>PepsiCo sales share (%)</th>
<th>Danone sales share (%)</th>
<th>Mars sales share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confectionery</td>
<td>9.0</td>
<td>5.6</td>
<td></td>
<td></td>
<td></td>
<td>9.4</td>
</tr>
<tr>
<td>Bakery Products</td>
<td>0.5</td>
<td>3.0</td>
<td>1.0</td>
<td>1.2</td>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td>Ice cream</td>
<td>8.9</td>
<td>0.1</td>
<td>19.3</td>
<td>0.2</td>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td>Dairy Products</td>
<td>4.4</td>
<td>3.7</td>
<td>0.3</td>
<td>4.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Savory Snacks</td>
<td>0.1</td>
<td>3.0</td>
<td>32.4</td>
<td>0.3</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Snack bars</td>
<td>3.1</td>
<td>4.0</td>
<td>5.7</td>
<td>9.9</td>
<td>1.3</td>
<td>1.7</td>
</tr>
<tr>
<td>Meal replacement drinks</td>
<td>0.2</td>
<td></td>
<td></td>
<td>38.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ready meals</td>
<td>9.7</td>
<td>5.7</td>
<td>3.0</td>
<td>0.2</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>Soup</td>
<td>6.9</td>
<td>0.2</td>
<td>17.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pasta</td>
<td>4.6</td>
<td>3.1</td>
<td>0.1</td>
<td>0.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noodles</td>
<td>1.3</td>
<td>0.4</td>
<td>1.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canned food</td>
<td>0.7</td>
<td>0.6</td>
<td>1.1</td>
<td>0.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frozen food</td>
<td>6.1</td>
<td>2.6</td>
<td>4.2</td>
<td></td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>Dried food</td>
<td>2.3</td>
<td>3.2</td>
<td>3.3</td>
<td>0.2</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>Chilled food</td>
<td>0.9</td>
<td>2.6</td>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oils and fats</td>
<td>0.3</td>
<td>0.4</td>
<td>13.4</td>
<td></td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>Sauces, dressings, condiments</td>
<td>3.0</td>
<td>4.3</td>
<td>10.7</td>
<td>0.8</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>Baby food</td>
<td>16.9</td>
<td>0.2</td>
<td>0.2</td>
<td>0.1</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>Spreads</td>
<td>0.6</td>
<td>2.2</td>
<td>7.1</td>
<td>0.2</td>
<td>0.4</td>
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<tr>
<td>Dog and cat food</td>
<td>25.7</td>
<td>0.5</td>
<td></td>
<td></td>
<td></td>
<td>24.0</td>
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</table>

Source: Euromonitor International
Table 8. Firm sales share at regional, country, and product levels: The case of Nestlé

<table>
<thead>
<tr>
<th>Region</th>
<th>W. Europe</th>
<th>E. Europe</th>
<th>N. America</th>
<th>Latin America</th>
<th>Asia Pacific</th>
<th>Africa and Middle East</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global Market share %</td>
<td>(4.0)</td>
<td>(2.3)</td>
<td>(2.3)</td>
<td>(6.3)</td>
<td>(1.3)</td>
<td>(5.8)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Global Product category</th>
<th>Confectionery</th>
<th>Soup</th>
<th>Pet food</th>
<th>Baby Food</th>
<th>Dairy Products</th>
<th>Bakery Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market share %</td>
<td>(9.0)</td>
<td>(17.3)</td>
<td>(25.7)</td>
<td>(13.0)</td>
<td>(4.4)</td>
<td>(0.5)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Region</th>
<th>W. Europe</th>
<th>E. Europe</th>
<th>N. America</th>
<th>Latin America</th>
<th>Asia Pacific</th>
<th>Africa and Middle East</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product category Market share %</td>
<td>Confectionery</td>
<td>Soup</td>
<td>Pet food</td>
<td>Baby Food</td>
<td>Dairy Products</td>
<td>Bakery Products</td>
</tr>
<tr>
<td></td>
<td>(12.5)</td>
<td>(25.7)</td>
<td>(30.7)</td>
<td>(60.7)</td>
<td>(5.2)</td>
<td>(1.5)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Country</th>
<th>U.K</th>
<th>Slovakia</th>
<th>USA</th>
<th>Brazil</th>
<th>Philippines</th>
<th>Israel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product category Market share %</td>
<td>Confectionery</td>
<td>Soup</td>
<td>Pet Food</td>
<td>Baby food</td>
<td>Dairy Products</td>
<td>Bakery Products</td>
</tr>
<tr>
<td></td>
<td>(20.2)</td>
<td>(52.5)</td>
<td>(31.0)</td>
<td>(82.4)</td>
<td>(37.2)</td>
<td>(8.0)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Country subproduct category</th>
<th>U.K.</th>
<th>Russia</th>
<th>USA</th>
<th>Brazil</th>
<th>Philippines</th>
<th>Israel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market share %</td>
<td>(24.6)</td>
<td>(58.9)</td>
<td>(40.0)</td>
<td>(91.2)</td>
<td>(48.3)</td>
<td>(42.4)</td>
</tr>
</tbody>
</table>

Source: Euromonitor International
Table 9. Firm sales share at regional, country, and product levels: The case of Unilever

<table>
<thead>
<tr>
<th>Global Market share %</th>
<th>Packaged Food (2.7)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional Market share %</td>
<td>W. Europe (4.2)</td>
<td>E. Europe (1.4)</td>
</tr>
<tr>
<td>Global Product category Market share %</td>
<td>Ice cream (19.3)</td>
<td>Soup (32.9)</td>
</tr>
<tr>
<td>Region Product category Market share %</td>
<td>W. Europe (30.5)</td>
<td>E. Europe (25.7)</td>
</tr>
<tr>
<td>Country Product category Market share %</td>
<td>Austria (59.6)</td>
<td>Poland (38.4)</td>
</tr>
<tr>
<td>Country Product Subproduct Market share %</td>
<td>Austria (81.2)</td>
<td>Poland (76.5)</td>
</tr>
</tbody>
</table>

Source: Euromonitor International

Table 10. Four-Firm Concentration (CR4) by product category and region

<table>
<thead>
<tr>
<th>Pet food</th>
<th>Soups</th>
<th>Breakfast Cereal</th>
<th>Baby food</th>
<th>Confectionery</th>
<th>Cheese</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Western Europe</td>
<td>67.9</td>
<td>64</td>
<td>61.7</td>
<td>65.6</td>
<td>38.4</td>
</tr>
<tr>
<td>Eastern Europe</td>
<td>79.4</td>
<td>65.8</td>
<td>41.8</td>
<td>46.2</td>
<td>33.4</td>
</tr>
<tr>
<td>North America</td>
<td>62.7</td>
<td>73.3</td>
<td>78.3</td>
<td>89.8</td>
<td>51.2</td>
</tr>
<tr>
<td>Latin America</td>
<td>63.4</td>
<td>87.5</td>
<td>90.6</td>
<td>75.9</td>
<td>42.2</td>
</tr>
<tr>
<td>Asia Pacific</td>
<td>49.9</td>
<td>56.1</td>
<td>73.9</td>
<td>38.7</td>
<td>26</td>
</tr>
<tr>
<td>Australasia</td>
<td>75.1</td>
<td>88.5</td>
<td>89</td>
<td>93</td>
<td>79.1</td>
</tr>
<tr>
<td>Africa Middle East</td>
<td>60.3</td>
<td>88.1</td>
<td>60.8</td>
<td>67.5</td>
<td>36.4</td>
</tr>
</tbody>
</table>

Source: Euromonitor International
STATE TRADING ENTERPRISES IN A DIFFERENTIATED ENVIRONMENT: THE CASE OF GLOBAL MALTING BARLEY MARKETS

Presentation to the First Biennial Food System Research Group Conference
July 26, 27; Madison Wisconsin

By
Fenxia Dong, Iowa State University
Thomas Marsh, Kansas State University
Kyle Stiegert, University of Wisconsin-Madison

ABSTRACT

The lack of transparency in the pricing and operational activities of State Trading Enterprises (STEs) has generated concerns that certain countries’ STEs are circumventing Uruguay Round commitments on export subsidies, domestic support, or market access. Critics argue that STEs pursue activities that mask export subsidies or import tariffs and that STE’s exclusive purchase/sell rights in domestic country or world market may be used to create monopsonist/monopolist opportunities.

The purpose of this study is to examine the market structure of the differentiated world malting barley market in which two STEs (the Canadian Wheat Board and Australian Barley Board) maintain jointly a very large share of the export market. In particular, this study focuses on the exclusive procuring and pricing policies used by both STEs to test if these intra-country mechanisms can generate leadership and shift rent from other exporting countries. A conceptual and empirical framework is also provided to test if STEs set their initial payments at optimal levels.

The empirical approach proceeded in two stages: an output stage analysis and a precommitment stage in which STEs endogenously set their respective purchase price. Empirical results from the output stage indicate that the CWB, the ABB, and other export sectors do not react to each other’s output choices and thus are in Cournot equilibrium. Empirical results from the precommitment stage show that both STEs do not set their initial payments low enough to achieve leadership status.

The study suggests that some distortionary impacts from the STE prepayment systems are possible, but even if significant benefits are available, it does not appear to be a tool either STE seems to effectively use. Perhaps political realities about lowering the initial payments constrain the system. Perhaps enough product differentiation exists that there are simply other strategies better suited for this market. Regardless of the plausible reasons, the STE prepayment systems cannot be seen as a distorting factor in the global malting barley market.
Introduction

As early as 1947, the General Agreement on Tariffs and Trade (GATT) acknowledged State Trading Enterprises (STEs) as legitimate participants in international trade. The World Trade Organization (WTO) defines STEs as “government and nongovernmental enterprises, including marketing boards, which have been granted exclusive or special rights or privileges, including statutory or constitutional powers, in the exercise of which they influence through purchases or sales the level or direction of imports or exports” (see Economic Research Service 1997). Because STEs may be privately owned, the defining consideration is thus not governance, but exclusive privileges. State trading is more prevalent in agriculture than in other economic sectors. In 1995 and 1996, 32 countries notified the WTO of 96 agricultural enterprises or organizations as STEs. STEs operate in a broad range of agricultural commodities. However, they have been most active in grains and dairy products.

The Australian Barley Board (ABB) has made strong claims of net public benefits emanating from its single desk status. It claimed to have gained between $19 million and $41 million per year in demonstrable market premiums between 1985/86 and 1994/95, and could price discriminate among countries. The single desk of the ABB also had the potential to extract premiums and economic rents as a monopoly seller to domestic maltsters. The Center for International Economics (CIE) examined the claims of the ABB. They found no evidence of any price premiums in export markets for malting barley exported by the ABB. The CIE also pointed out that the claims of the ABB were overstated, because the ABB did not consider other effects, such as different qualities of barley and services, different time of sale and shipping times, etc, in its analysis.

Given the exclusive or special rights of STEs, the potential to exert considerable influence on the world markets is certainly possible. Controversial issues such as price pooling strategies and single desk marketing functions of several large agricultural based STEs [Canadian Wheat Board (CWB); the Australian Wheat Board (AWB), and the ABB] have been major concern in the U.S. over the past decade (GAO, 1995). Moreover, with increasing commitments toward free trade, the functions of STEs have come under greater scrutiny. The fundamental question is whether or not STEs could maintain and/or advance a distortionary market presence while the rest of the world made significant commitments to free, undistorted trade via tariffication of quotas, scheduled tariff reductions and a real, or at least perceived, loss of national autonomy through the WTO trade dispute process.

The U.S. Congress commissioned the General Accounting Office (GAO) to conduct two studies investigating STE behavior (GAO, 1995, 1996). In these studies, although STEs were shown to use policy tools that have reasonably clear WTO compliance rules (including price supports and export subsidies), several other STE activities seem more problematic under WTO law, such as export licenses, tax advantages, transportation subsidies, and delayed producer payments, etc. The delayed payment system was recognized by the GAO as a source of pricing flexibility because the initial payments are set before export marketing is realized. Typically, the STEs pay upstream producers a below-market initial payment, and then provide a lump-sum reimbursement after proceeds are generated in the downstream international markets. As a result, the prepayment approach is capable of creating a credible marginal cost advantage for the STEs in the international market and generating essentially the same precommitment effect as an export subsidy (Brander and Spencer, 1985). In the case of STEs, Hamilton and Stiegert (2000) established the formal equivalence between the delayed producer payment system and these more familiar forms of precommitment. The purpose of the research in this study is to evaluate STE behavior in the international malting barley market.

A key point from the seminal article by Brander and Spencer (1985) was that rent-shifting is only possible when markets are imperfect and there exists some form of a
precommitment stage. Brander and Spencer demonstrated that this precommitment can occur when governments set a credible export subsidy in advance of the quantity decision by firms. Other forms of rent-shifting are certainly possible. Fershtman and Judd (1987) demonstrate rent-shifting through intra-firm incentive systems. Bensaii and Gary-Bobo show that rent-shifting can occur through union contracts.

The delayed payment system utilized by STEs has the potential to create a credible marginal cost advantage because STEs make below market initial payments in acquiring exportable products, which provides similar effects as an export subsidy. Indeed, Hamilton and Stiegert (2002) found that CWB initial payment structure to durum producers provided a precommitment to shift rent in most of the years since 1973. The market for malting barley is quite different however. Malting barley markets operate with two STE’s both of which maintain a similar initial payment structure. Malting barley maintains a sensitive product quality structure and much of what is planted for malting markets ends up as a lower priced feed barley. Thus, the challenges in this paper include extending the model by Hamilton and Stiegert (2002) to include a market structure for two STE’s and move toward an estimating model that properly accounts for product differentiation while testing for rent shifting.

Literature

Previous empirical research offers a mixed view regarding the influence of international grain STE’s. Dixit and Josling (1997) show that distortions are possible under current WTO rules by using traditional tariff equivalents and the corresponding export subsidy equivalents. But many circumstances are not so simple as to be represented as tariff/export subsidy equivalents, especially for STEs. They pointed out that exclusive purchasing/selling rights could enhance the market power and rents available to STEs and encourage price discrimination across export markets. Brooks and Schmitz (1999) tested whether the CWB could price discriminate among international feed barley markets by straightforward comparisons of differences between market prices. The CWB realized an average price difference of $20.73/ton between Japan and the rest of the world over the 1980/81 to 1994/95 period. Lavoie found support for price discrimination behavior by the CWB by first controlling for the theoretical factors that explain competition and second evaluating a set of variables that reject pure competition.

Several other studies could not substantiate claims that STEs distort the market. Carter (1993) found no evidence of price discrimination for CWB barley and suggested that the CWB did not exercise market power in the barley export market. He concluded that price variation was more likely linked to export service and grain quality factors. He also found that lack of competitive disciplines in the selling process resulted in excessive handling costs for the CWB and the lack of market signals to producers resulted in the misallocation of resources. In rebuttal, Schmitz, Gray, Schmitz, and Storey (1997) argued that some of the costs addressed by Carter were not unique to CWB grain marketing and would be incurred by producers and governments in the absence of the CWB. Carter, Loyns, and Berwald (1998) showed that even if the CWB somehow earned a large premium in world markets, it did not pass the premium on to producers. The costs of protein overdelivery, excess handling charges, demurrage, and over-cleaning under the CWB’s monopoly rights over the supply of marketing services to farmers extracted the surplus that farmers would have in a competitive environment.

Empirical market power research under the assumption of product heterogeneity is relatively sparse and neither as extensive nor refined as homogeneous product industry research (Vickner and Davies, 1999). Baker and Bresnahan (1985) pioneered the application of residual demand analysis to brewing firms with differentiated products. The residual demand curve is the relationship between firms’ prices and quantities, taking the reactions of all other firms into account. By comparing the changes in residual demand elasticities, they determined the changes
in the firms’ market power after merging. Since the residual demand elasticities depend both on
the structural demand elasticities and on the reaction function elasticities, only the total effect, not
the individual effect, is identified.

Subsequently, Carter, MacLaren, and Yilmaz (1999) estimated the residual inverse
demand elasticities, which are viewed as a measure of the degree of competition, for each of the
three exporting countries (US, Canada, and Australia) for the Japanese wheat market. They
found that the U.S. had a price leadership role and Australia and Canada competed in the fringe
market. But their non-nested tests did not support the above result and they could not
discriminate between the monopsony and competitive models.

Conceptual Model

The essence of Brander and Spencer’s (1985) study is that the government’s prior action
in setting an export subsidy changes the domestic firm’s set of “credible actions” (its reaction
function) in the output competition with its rival. If firms are not cooperative, then the Nash-
equilibrium is changed in favor of the domestic firm. As introduced before, initial payments for
commodities brokered by the CWB and the ABB are usually set at substantially below-market
prices. Consequently, the delayed payment approach has the potential of creating a credible
marginal cost advantage because STEs pay less on acquiring exportable products and thus has the
same effect as an export subsidy. Moreover, in the case of STEs, the final payment in a delayed
producer payment system, which is typically delivered in a lump-sum fashion, provides an
explicit method of transfer back to the input supplier that rationalizes the system. Therefore, the
delayed producer payment structure is equivalent in this regard to a policy of direct export
subsidization. Under noncooperative competition, the export subsidy is able to shift rent from the
rival and move the domestic firm to the position of Stackelberg leader. In a method similar to
Brander and Spencer (1985)’s analysis, STEs are able to act first and set subsidy levels (or initial
payment levels) before output levels, with their understanding of how export subsidies would
influence the output equilibrium. Firms take as given export subsidy levels and decide their
output levels in the export market. This could be expressed by a subgame perfect equilibrium in a
two-stage model in which governments set subsidy levels in the first stage and then firms decide
output levels in the second stage.

The analysis in this study will be conducted on global malting barley markets. Several
specific issues arise immediately. Agronomic practices, soil characteristics, and climatic
conditions determine barley varieties grown in different regions, and downstream brewers have
specific quality requirements in terms of acceptable varieties, protein, plumpness and germination.
In addition, products are also differentiated by consumers due to geographical origin, personal
taste, and suppliers (who vary in terms of their credit policies, delivery date, and ancillary
services). Therefore, the malting barley market is considered to consist of imperfect substitutes.
We begin with a theoretical model that proposes endogenous control of an upstream supply in
that STEs choose the initial prices of their principal raw commodity and then compete in an
international market of imperfect substitutes (see figure 1). We presume throughout that STEs
and producers are vertically aligned and that the government grants the STE exclusive purchase
rights of the raw commodity. The vertical structure analyzed here consists of two stages solved
by backward induction. The first stage is a precommitment stage, in which both STEs
simultaneously choose their initial payments for the material input. In this stage, we employ a
subset of the output-stage results to characterize the value of the trade policy parameter associated
with the optimal degree of rent-shifting, which is consistent with the previous assumption that the
government sets a subsidy level with the understanding of how it influences the output
equilibrium. The second stage is an output stage, in which the STEs and other exporting firms
maximize profits by choosing quantities and maintain the ability to either store non-optimal

693
supplies or downgrade the quality of non-optimal supplies for sale to a residual feed barley market. We estimate the output stage by considering STE trade policy as a given shift parameter in the domestic marginal cost function.

Let $x_1, x_2,$ and $x_3$ represent total sales of malting barley to the world market by the CWB (1), ABB (2), and the other malting barley-exporting countries (3), respectively, and denote the downstream inverse demand functions of malting barley marketed by the CWB, the ABB, and Other Exporting Countries as $P_1, P_2,$ and $P_3,$ respectively.

The country specific inverse demand functions of malting barley are as follows:

$$P_1 = P_1(x_1, x_2, x_3; \Phi_1) \tag{1}$$

$$P_2 = P_2(x_1, x_2, x_3; \Phi_2) \tag{2}$$

$$P_3 = P_3(x_1, x_2, x_3; \Phi_3) \tag{3}$$

where $\Phi_1, \Phi_2,$ and $\Phi_3$ are exogenous variables. If barley varieties were perfect substitutes or homogeneous, all the prices would be equal except for transport costs; if barley varieties were imperfect substitutes, each demand change could have a different impact on each price.

In the output stage, the STEs and the firms in other exporting countries choose their outputs to maximize profits by

$$\max_{x_1} \pi_1(x_1) = P_1 x_1 - w_1 x_1 \tag{4}$$

$$\max_{x_2} \pi_2(x_2) = P_2 x_2 - w_2 x_2 \tag{5}$$

$$\max_{q} \pi_3(q) = P_3 q - c_3 q \tag{6}$$

where $w_1$ and $w_2$ are initial payments set in the precommitment stage by the CWB and the ABB, respectively, and $c_3$ is the price received by farmers of other exporting countries. We assume that there are $n$ symmetric firms in the other exporting countries and thus $q = (1/n)x_3$. We chose outputs as the strategic variable because STEs and other exporting firms have the ability to either store non-optimal supplies or downgrade the quality of non-optimal supplies for sale to a residual feed barley market.1

Under Cournot competition, exporters do not react to competition quantity changes, implying that all quantity derivatives with respect to other quantities are zero. Maximization of equations (4), (5) and (6) with respect to $x_1, x_2,$ and $q,$ respectively yield the first order conditions:

$$P_1 + x_1 P_{11} - w_1 = 0 \tag{7}$$

$$P_2 + x_2 P_{22} - w_2 = 0 \tag{8}$$

$$P_3 + x_3 P_{33} - c_3 = 0 \tag{9}$$

where $P_{11}=\partial P_1/\partial x_1, P_{22}=\partial P_2/\partial x_2,$ and $P_{33}=\partial P_3/\partial x_3$. The second order conditions yield necessary stability conditions (Novshek, 1985):

$$2P_{11} + x_1 P_{111} \leq 0 \tag{10}$$

$$2P_{22} + x_2 P_{222} \leq 0 \tag{11}$$

$$2P_{33} + x_3 P_{333} \leq 0 \tag{12}$$

where $P_{iii}=\partial^3 P_i/\partial x_i^3$.

---

1 As we move from purely homogeneous products to highly differentiated products, the consequences of choosing the incorrect choice variable diminishes. At the extreme, products are not related and each firm offering a single product would behave as separate monopolists. (Friedman, 1983).
Let $x_i(w_1, w_2; \Phi_i)$ represent the equilibrium levels of sales from country $i$ in the output stage, given initial payments of $w_1$ and $w_2$. In the precommitment stage, the STEs select transfer prices, $w_1$ and $w_2$, so as to

$$\text{Max}_{w_1} \pi_{1p} = P_1(x_i(w_1, w_2; \psi_i), x_2(w_1, w_2; \psi_2), x_3(w_1, w_2; \psi_3))x_i(w_1, w_2; \psi_i) - c_c x_i(w_1, w_2; \psi_i) - F_1$$

$$\text{Max}_{w_2} \pi_{2p} = P_2(x_i(w_1, w_2; \psi_i), x_2(w_1, w_2; \psi_2), x_3(w_1, w_2; \psi_3))x_2(w_1, w_2; \psi_2) - c_a x_2(w_1, w_2; \psi_2) - F_2$$

where $\pi_{1p}$ and $\pi_{2p}$ are the profit of producers under the CWB and the ABB, respectively. The variables, $c_c$ and $c_a$, are the marginal production costs for producers in Canada and Australia, respectively. For simplification of the problem, production costs are assumed to be constant. The variable, $\Phi_i$, are exogenous variables affecting supplies. $F_1$ and $F_2$ are fixed costs that could include marketing and administration costs incurred by the CWB and the ABB, respectively.

Let $w_i^*$'s denote the optimal initial payments. The first order conditions of equations (13) and (14) are

$$P_1 \frac{\partial x_1}{\partial w_1} + x_i\left(\frac{\partial P_1}{\partial x_1} \frac{\partial x_1}{\partial w_1} + \frac{\partial P_1}{\partial x_2} \frac{\partial x_2}{\partial w_1} + \frac{\partial P_1}{\partial x_3} \frac{\partial x_3}{\partial w_1}\right) - c_c \frac{\partial x_1}{\partial w_1} = 0$$

$$P_2 \frac{\partial x_2}{\partial w_2} + x_2\left(\frac{\partial P_2}{\partial x_1} \frac{\partial x_1}{\partial w_2} + \frac{\partial P_2}{\partial x_2} \frac{\partial x_2}{\partial w_2} + \frac{\partial P_2}{\partial x_3} \frac{\partial x_3}{\partial w_2}\right) - c_a \frac{\partial x_2}{\partial w_2} = 0$$

Using backward induction from (7) and (8) and substituting $P_i + x_i P_{ii} = w_i (i=1, 2)$ into (15) and (16), the optimal upstream prices set by the STEs are:

$$w_1^* - c_c = -x_i\left(P_{12} \frac{\partial w_1}{\partial x_2} + P_{13} \frac{\partial w_1}{\partial x_1}\right)$$

$$w_2^* - c_a = -x_2\left(P_{21} \frac{\partial w_2}{\partial x_2} + P_{23} \frac{\partial w_2}{\partial x_2}\right)$$

where $\partial x_i/\partial w_j$ (i=1, 2, or 3; and j=1 or 2) may be derived by taking total differential of equations (7), (8), and (9).
\[
\begin{align*}
\frac{\partial x_1}{\partial w_2} &= (P_{13} + x_1 P_{113})(P_{32} + x_3 P_{332}) - (2P_{33} + x_3 P_{333})(P_{12} + x_1 P_{112}) \\
\frac{\partial x_2}{\partial w_2} &= (2P_{11} + x_1 P_{111})(2P_{33} + x_3 P_{333}) - (P_{13} + x_1 P_{113})(P_{31} + x_3 P_{331}) \\
\frac{\partial x_3}{\partial w_2} &= (P_{12} + x_1 P_{112})(P_{31} + x_3 P_{331}) - (2P_{11} + x_1 P_{111})(P_{32} + x_3 P_{332}) - (P_{13} + x_1 P_{113})(P_{31} + x_3 P_{331})
\end{align*}
\]

\[P_0\] is the derivative of \(P_i\) w.r.t. \(x_j\) (i, j=1, 2, 3, respectively). \(P_{ij}\) is the cross derivative of \(P_i\) w.r.t. \(x_j\) and \(x_k\) \((\partial^2 P_i/\partial x_j \partial x_k, k=1, 2, 3)\).

The profit-maximizing upstream transfer prices set by the STEs specify that domestic upstream producers sell the product at a price below marginal cost if \(w_i < c_i (i=1,2)\), which increases the market share in the international malting barley market in an analogous fashion as a domestic output subsidy.

The conjectural variations model arises by assuming that each firm views its rivals’ output as a function of its own output. It provides an index of the degree of market power, consistent with behavior from price-taking to perfect collusion by leading directly to the relevant first-order conditions for the various models in homogeneous markets. For example, in the Cournot model, each firm believes that the other firm’s choice is independent of its own and the conjecture is zero. In the collusive model, each firm believes that the other firm is collusive with its change and cooperates to maximize joint profits. In the competitive model, each firm believes that its opponent will react to its own (the firm’s) change in output and conjecture for each opponent is -1. As a result, the first order conditions reduce to: price equals marginal cost. It is common to interchange conjectural variation with reaction or best response. In this study, we extend the application of reaction of firms to a heterogeneous market. Incorporating the best response of firms into the model modifies equations (7), (8), and (9) to:

\[P_1 + \gamma_{12} P_{12} + \gamma_{13} P_{13} - w_1 = 0 \tag{19}\]
\[P_2 + \gamma_{21} P_{21} + \gamma_{22} P_{22} + \gamma_{23} P_{23} - w_2 = 0 \tag{20}\]
\[P_3 + \gamma_{31} P_{31} + \gamma_{32} P_{32} + \gamma_{33} P_{33} - c_3 = 0 \tag{21}\]

Next, define \(M_2/M_1 = \gamma_{12}, M_2/M_1 = \gamma_{13}, M_2/M_2 = \gamma_{21}, M_2/M_2 = \gamma_{23}, M_2/M_3 = \gamma_{31},\) and \(M_2/M_3 = \gamma_{32}.\) The \(\gamma_0\) (i, j=1, 2, 3, and i \(\neq\) j) indicates firm i’s expectations about the reaction of firm j to a change in its quantity, or firm j’s best response to the change of firm i’s quantity change. For example, \(\gamma_{12}\) indicates the CWB’s expectation about the response of the ABB to a change in the CWB’s export quantity, or the ABB’s best response to the output change of the CWB.

Equations (19)-(21) can now be written

\[P_1 + \gamma_{12} P_{12} + \gamma_{13} P_{13} - w_1 = 0 \tag{22}\]
\[P_2 + \gamma_{21} P_{21} + \gamma_{22} P_{22} + \gamma_{23} P_{23} - w_2 = 0 \tag{23}\]
\[P_3 + \gamma_{31} P_{31} + \gamma_{32} P_{32} + \gamma_{33} P_{33} - c_3 = 0 \tag{24}\]
When products are imperfect substitutes, the conditions for different market models are different from those under a homogeneous product scenario. They not only depend on the best response from other firms, but they also depend on the cross-price effects. This means that the potential impact of market power depends on product differentiation. For example, for the CWB, if the term in the parentheses in equation (22) is equal to zero (i.e. if \(P_{11} + \gamma_{12}P_{12} + \gamma_{13}P_{13} = 0\)), then the CWB is facing a competitive market. The value in the parentheses depends not only on the best response from other firms, but also on the cross-price effects. It is different from the homogeneous condition which only depends on the best response. For Cournot competition, \(\gamma_{ij} = 0\), each firm believes that the other firms' choice is independent from its own and the conjecture parameters are the same as those under the homogeneous scenario. Note that (22)-(24) collapses to (7), (8), and (9) under the Cournot assumption. For collusive behavior, conjectures are positive and under total collusion or a cartel, firms cooperate to maximize the joint profits by simultaneously choosing quantities. If malting barley are imperfect substitutes, all direct or cross-price effects in equations (19)-(21) are negative and the mark up under collusion is greater than that under the Cournot assumption, and furthermore, greater than that under competition. For the current analysis, we set profit maximization separately instead of considering a cartel to maximize joint profit. We make this choice because, as Varian (1992) analyzed, the cartel solution is not stable. If one firm believes that the other firms will stick to the agreed-upon cartel output, the one firm would find it beneficial to chisel other cartel members by increasing its own output in order to sell more at the high price. But if the firm does not believe that other firms will stick with the cartel agreement, then it will not be optimal for the firm to maintain the agreement. This strategic situation is similar to the Prisoner’s Dilemma and the final result will be a set of Nash equilibrium strategies, as long as the discount rate is not too high. Although Friedman (1971) showed that the cartel output is sustainable as a subgame perfect equilibrium in an infinitely repeated game as long as the discount rate is sufficiently small, the study is not limited by the separate maximizations of profits set up above. Instead, it is easy to tell if the firms are collusive by the estimated results from separate maximization of each firm’s profit. If in very few cases the firms are collusive, then the first order conditions for maximization of joint profit by simultaneously choosing outputs become

\[
P_1 + x_1P_{11} + x_2P_{21} + x_3P_{31} - w_1 = 0 \quad (25)
\]

\[
P_2 + x_1P_{12} + x_2P_{22} + x_3P_{32} - w_2 = 0 \quad (26)
\]

\[
P_3 + x_1P_{13} + x_2P_{23} + x_3P_{33} - c_3 = 0 \quad (27)
\]

Although firms simultaneously choose outputs and conjectures are also zero, it is easy to tell from the estimation results under separate maximizations of each firm’s profit whether it is Cournot or collusive. The reason is that the mark-ups \((P_i - w_i)\) in (25)-(27), are bigger than the mark-ups in (22)-(24) with zero conjectures. Therefore, if firms are playing collusion instead of Cournot, the conjectures in (22)-(24) should be positive. Equations (25)-(27) cannot be reconstructed from the estimation results because they are derived from the maximization of joint profit. If the conjecture variations in (22)-(24) are positive, with the possibility of total collusive, We can set up the maximization of joint profit, derive the first order conditions, and test if it is total collusive. For simplification, this study first considers the maximization of profits only by figuring them separately.

Because the reaction of foreign marketing agents to a change in the quantity of domestic exports is endogenous in the pre-commitment stage, this implies that the conduct parameter associated with the domestic marketing agent is predetermined. Hence, the conduct of the domestic marketing agent could be estimated as a free parameter in the output stage. Expressing the optimal initial payments using conjectural variations yields:
\[
\begin{align*}
\frac{\partial x_2}{\partial w_1} &= \frac{(S_6 S_7 - S_4 S_8)}{|S|} = \frac{S_6 S_7 - S_4 S_8}{S_4 S_8 - S_6 S_8} \\
\frac{\partial x_3}{\partial w_1} &= \frac{(S_4 S_8 - S_4 S_7)}{|S|} = \frac{S_4 S_8 - S_4 S_7}{S_4 S_8 - S_6 S_8} \\
\frac{\partial w_1}{\partial x_2} &= \frac{(S_5 S_8 - S_5 S_7)}{|S|} = \frac{S_5 S_8 - S_5 S_7}{S_4 S_8 - S_6 S_8} \\
\frac{\partial w_1}{\partial x_3} &= \frac{(S_5 S_7 - S_5 S_7)}{|S|} = \frac{S_5 S_7 - S_5 S_7}{S_4 S_8 - S_6 S_8} \\
\frac{\partial w_2}{\partial x_2} &= \frac{(S_5 S_8 - S_5 S_7)}{|S|} = \frac{S_5 S_8 - S_5 S_7}{S_1 S_9 - S_7 S_7} \\
\frac{\partial w_2}{\partial x_3} &= \frac{(S_5 S_7 - S_5 S_7)}{|S|} = \frac{S_5 S_7 - S_5 S_7}{S_1 S_9 - S_7 S_7} \\
\frac{\partial w_2}{\partial x_3} &= \frac{(S_5 S_7 - S_5 S_7)}{|S|} = \frac{S_5 S_7 - S_5 S_7}{S_1 S_9 - S_7 S_7} \\
\end{align*}
\]

and \( S_i \)’s are the items in the matrix \( S \).

\[
S = \begin{pmatrix}
S_1 & S_2 & S_3 \\
S_4 & S_5 & S_6 \\
S_7 & S_8 & S_9
\end{pmatrix}
\]

In equations (22)-(24), the value of the \( \gamma_i \)’s combined with the cross price effects gives an illustration of the market structure and the degree of competition. Specifically, the departure of the \( \gamma_i \)’s from zero is a logically consistent test of whether the Cournot-Nash model provides an accurate description of the industry equilibrium. Under the Cournot hypothesis, the optimal initial payments of the CWB and the ABB in (28) and (29) will be in accordance with (17) and (18). The stability conditions from the second order conditions of (4)-(6) under the linear inverse demand functions are
To test the hypothesis that the CWB and the ABB strategically utilize their pre-payment systems and product differentiation to shift rents from other foreign firms, the following formulas need to be calculated.

\[
\frac{\partial \pi_j}{\partial w_j} = \sum_{i=1}^{3} \frac{\partial \pi_i}{\partial x_i} \frac{\partial x_i}{\partial w_j}
\]  

(33)

In equation (33), if \(i=1\), then the first term equals zero by the first order condition of profit maximization (if \(i=2\), then the second term cancels). Therefore, we can write (33) separately as follows:

\[
\frac{\partial \pi_2}{\partial w_1} = \frac{\partial \pi_2}{\partial x_1} \frac{\partial x_1}{\partial w_1} + \frac{\partial \pi_2}{\partial x_3} \frac{\partial x_3}{\partial w_1}
\]

(34)

\[
\frac{\partial \pi_3}{\partial w_1} = \frac{\partial \pi_3}{\partial x_1} \frac{\partial x_1}{\partial w_1} + \frac{\partial \pi_3}{\partial x_2} \frac{\partial x_2}{\partial w_1}
\]

(35)

\[
\frac{\partial \pi_1}{\partial w_2} = \frac{\partial \pi_1}{\partial x_2} \frac{\partial x_2}{\partial w_2} + \frac{\partial \pi_1}{\partial x_3} \frac{\partial x_3}{\partial w_2}
\]

(36)

\[
\frac{\partial \pi_3}{\partial w_2} = \frac{\partial \pi_3}{\partial x_1} \frac{\partial x_1}{\partial w_2} + \frac{\partial \pi_3}{\partial x_2} \frac{\partial x_2}{\partial w_2}
\]

(37)

\(\partial x_i/\partial w_j\) has been defined earlier and \(\partial \pi_i/\partial x_j\) is as follows:

\[
\frac{\partial \pi_1}{\partial x_2} = \gamma_{21}(P_1 - w_1) + x_1(\gamma_{21}P_{11} + P_{12} + \gamma_{23}P_{13})
\]

(38)

\[
\frac{\partial \pi_1}{\partial x_3} = \gamma_{31}(P_1 - w_1) + x_1(\gamma_{31}P_{11} + \gamma_{32}P_{12} + P_{13})
\]

(39)

\[
\frac{\partial \pi_2}{\partial x_1} = \gamma_{12}(P_2 - w_2) + x_2(P_{21} + \gamma_{12}P_{22} + \gamma_{13}P_{23})
\]

(40)

\[
\frac{\partial \pi_2}{\partial x_3} = \gamma_{32}(P_2 - w_2) + x_2(\gamma_{31}P_{21} + \gamma_{32}P_{22} + P_{23})
\]

(41)

\[
\frac{\partial \pi_3}{\partial x_1} = \frac{1}{n}[\gamma_{13}(P_3 - c_3) + x_3(P_{31} + \gamma_{12}P_{32} + \gamma_{13}P_{33})]
\]

(42)

\[
\frac{\partial \pi_3}{\partial x_2} = \frac{1}{n}[\gamma_{23}(P_3 - c_3) + x_3(\gamma_{21}P_{31} + P_{32} + \gamma_{23}P_{33})]
\]

(43)

If \(\partial \pi_i/\partial w_1<0\) and \(\partial \pi_i/\partial w_1>0\) (\(i=2\), or 3), then by lowering its initial payments, the CWB could increase its profit and decrease firm \(i\)'s profits. In this case, the CWB strategically utilizes its pre-
payment system to shift rents from country i. Similar analysis could be applied to the ABB. Unlike in the homogeneous product market, rent shifting in the product differentiated market not only depends on the market structure, but also on cross-price effects, which indicate the degree of product differentiation.

**Empirical Methods**

To evaluate the degree of market power, it is necessary to identify $\gamma_{ij}$'s. Equations (22)-(24) are expanded and rearranged as:

$$P_{1t} - w_{1t} = \lambda_{12}(P_{12}x_{1t}) + \lambda_{13}(P_{13}x_{1t}) - P_{11}x_{1t}$$  \hspace{1cm} (43)

$$P_{2t} - w_{2t} = \lambda_{21}(P_{21}x_{2t}) + \lambda_{23}(P_{23}x_{2t}) - P_{22}x_{2t}$$  \hspace{1cm} (44)

$$P_{3t} - c_{3t} = \lambda_{31}(P_{31}x_{3t}) + \lambda_{32}(P_{32}x_{3t}) - P_{33}x_{3t}$$  \hspace{1cm} (45)

The market power parameters in the above equations ($\lambda_{ij}$'s) are the negative counterparts of the conjectural variation parameters (i.e., $\gamma_{ij} = -\lambda_{ij}$). Much prior research has been done on market power and firm conduct using the conjectural variation approach. Commonly dubbed New Empirical Industrial Organization [NEIO] methodology, it infers market conduct and unknown cost parameters through the responsiveness of price to changes in demand elasticities and cost components (Genesove and Mullin, 1998). Based on the concept of conjectural variations, which was introduced by Bowley in 1924 (Perry, 1982) and extended by Iwata (1974), Bresnahan (1982) gave an outline of a methodology to identify econometrically the market power parameter by introducing an interaction term in the demand function. Love and Murniningtyas (1992) applied this method to the Japanese wheat market to measure the market power of an import STE, Japanese Food Agency (JFA), with the assumption that the rest of the world suppliers are competing. Deodhar and Sheldon (1997) applied the method to the world soymeal export market to estimate the degree of market power exerted by the exporters in developed countries. Another cornerstone of the NEIO methodology is to analyze firm or industry conduct through the estimation of conjectural elasticities, which is also based on conjectural variations. Representative papers include those by Appelbaum (1978) on the U.S. crude petroleum and natural gas industry, Appelbaum (1982) on the U.S. rubber, textile, electrical machinery and tobacco industries, Schroeter (1988), Stieger, Azzam, and Broersen (1993) on the beef packing industry, Schroeter and Azzam (1990) on the meat industry, Koontz, Garcia, and Hudson (1983) on fed cattle markets, Wann and Sexton (1992) on the California pear processing industry, Gollop and Roberts (1979) on the U.S. coffee roasting industry, and Genesove and Mullin (1998) on the sugar industry.

To estimate the parameters ($\lambda_{ij}$'s) in this system, we choose to estimate the derivatives of prices with respect to quantities, which are $P_{12}$, $P_{13}$, $P_{21}$, $P_{23}$, $P_{31}$, and $P_{32}$. It is here that we empirically allow for some degree of product heterogeneity (i.e. imperfect substitutes). To identify the quantity derivatives of prices, we specified an input distance function for malt production and derived the inverse demand equations. From the inverse demand equations, which resulted from applying Gorman’s Lemma to the distance function, the derivatives of prices with respect to quantities can be identified directly. The aggregate input distance function of imported malting barley is given by

$$D = D(Q,Y) = \max_d \{d : F(Q/d) \geq Y\}$$  \hspace{1cm} (46)

where $Q$ is a (n×1) vector of input quantities; $Y$ is a (1×1) scalar representing malt output; and $F(Q/d)$ is the production technology. The behavioral assumption is to rescale all the input levels that are consistent with a target output level. Specifically, $d$ is the largest scalar value that could be used to divide $Q$ and still produce $Y$. Similar to the analysis by Marsh and Featherstone (2003), the distance function is assumed to be weakly separable in inputs by partitioning inputs into two
subgroups of malting barley and other inputs. The properties of a distance function are: 1) homogeneous of degree one and concave in input quantities, 2) nondecreasing in input quantities, and 3) nonincreasing in output \( Y \). Given the homogeneity property in input quantities, inverse demand equations for malting barley may be obtained by applying Gorman’s Lemma to the distance function \( D \),

\[
\frac{\partial D(Q, Y)}{\partial Q} = P^*(Q, Y) = (P^*_1, P^*_2, P^*_3)
\]  

(47)

where \( P^*_i \) (i=1, 2, and 3) are cost normalized input prices, \( P^*_i = P_i / \sum_{j=1}^{3} P_j x_j \).

To complete the model specification, the distance function is assumed to take the form of a normalized quadratic distance function (Marsh and Featherstone, 2003; Holt and Bishop, 2002). The normalized quadratic distance function is a flexible functional form, able to estimate flexibilities and interactions between input and output quantity. The normalized quadratic distance function is given by

\[
d^*(Q^*, Y) = b_0 + \frac{1}{2} \left( \sum_{i=1}^{2} b_i x_i^* Y + \frac{1}{2} b_y Y^2 \right)
\]

(48)

where \( d^* \) and \( x_i^* \) are normalized distance and input quantities, \( d^* = D/x_3 \), and \( x_i^* = x_i/x_3 \), respectively. The normalized quadratic distance function is linear homogeneous and concave in inputs and continuously differentiable. The inverse demand functions are obtained using Gorman’s Lemma:

\[
P^*_1 = b_1 + b_{11} x_1^* + b_{12} x_2^* + b_{1y} Y
\]

(49)

\[
P^*_2 = b_2 + b_{22} x_2^* + b_{12} x_1^* + b_{2y} Y
\]

(50)

where \( P^*_i \) is normalized input prices by cost, \( P^*_i = P_i / \sum_{j=1}^{3} P_j x_j \). Consequently, the cost of producing the target level of output is unity. The third inverse demand function has been dropped to avoid singularity of the error covariance matrix. The derived inverse demand function is homogeneous of degree zero in inputs. Homogeneity is realized by the normalization process and symmetry is imposed by setting \( b_{ij} = b_{ji} \).

Input demand flexibilities are given by

\[
f_{ij} = \frac{b_{ij} x_j^*}{P^*_i}
\]

for \( i, j = 1, 2 \)  

(51)

using the estimated \( b_{ij} \) and predicted \( P^*_i \). The flexibilities for the third input is recovered from the homogeneity condition, which is \( \sum_{j=1}^{3} f_{ij} = 0 \).

The derivatives of prices with respect to quantities (\( dP_i/dx_j \)) could be expressed by normalized input quantities and parameters in (49) and (50). Then equations (43)-(45) could be expressed as follows:

\[
P^*_1 - w_1^* = (\lambda_{12} b_{12} - \lambda_{13} b_{11} x_1^* - \lambda_{13} b_{12} x_2^* - b_{11}) x_1^*
\]

(52)

\[
P^*_2 - w_2^* = (\lambda_{21} b_{12} - \lambda_{23} b_{12} x_1^* - \lambda_{22} b_{22} x_2^* - b_{22}) x_2^*
\]

(53)

\[
P^*_3 - c_3 = -\lambda_{31} (b_{11} x_1^* + b_{12} x_2^*) - \lambda_{32} (b_{12} x_1^* + b_{22} x_2^*) - (b_{11} x_1^* + b_{12} x_2^*) x_1^* - (b_{12} x_1^* + b_{22} x_2^*) x_2^*
\]

(54)

where \( w_i^* \) is the normalized initial payments by cost (See Appendix for derivation).
Data

Evaluating the international market for malting barley has been a challenge in much of the past research primarily because of rather severe data limitations. Unfortunately, international statistics, such as the FAO Yearbook and World Grain Statistics, report barley trade aggregately instead of separating it into feed and malting barley. Consistent data for malting barley export quantities and prices were only available for Canada and Australia.

From August 1975, as authorized by Order-in-Council, barley selected and accepted from producers for use in malting, pot or pearling, is set into a separate pool account by the CWB, which is labeled “Designated Barley.” Prior data were not available. The CWB reports its initial payments, operating cost and final payments per ton for each account and indicates its export quantity of malting barley in its annual reports. Realized prices of the CWB malting barley used in the study were recovered by adding operating costs to total payments to producers. The production cost of malting barley in 1991 was obtained from Chudleigh et al. (1998). The production cost for other years was derived from the production cost in 1991 and the farm input price index, which was obtained from Annual Statistics and Agricultural Statistics Profile. The ABB reports its initial payments and final realized prices for different grades of barley received from producers in its annual report. Initial payments and final realized prices for malting barley were weighted by quantities of different grades of malting barley received by the ABB from South Australia and Victoria. The ABB does not consistently report its barley exports in the separate categories of feed barley and malting barley. The Commodity Statistical Bulletin, which started in 1985, reports data on exports of malting barley by the ABB and Australia from 1980/81. Since 1995, the Commodity Statistical Bulletin has become the Australian Commodity Statistics. However, Australian Commodity Statistics 1997 does not report barley exports for the ABB. Nor does the Australian Commodity Statistics 1999 report barley exports for either Australia or the ABB. The ABB data of malting barley exports data from 1980/81 to 1991/92 were obtained from Commodity Statistical Bulletin; data from 1992/93 to 1994/95 were obtained from CIE, and data for 1995/96 to 1997/98 were obtained from ABB annual reports. Australian malting barley exports data from 1980/81 to 1996/97 were obtained from Commodity Statistical Bulletin and Australian Commodity Statistics. Australian malting barley export data for 1997/98 were obtained from Australian Food Statistics 2000.

Because malting barley export data for the ABB and Australia between 1975/76 and 1980/81 were not directly available, we estimated these levels using a straightforward set of assumptions. By referring to the ABB annual reports, Commodity Statistical Bulletin, which lists the destinations of Australian malting barley export between 1983/84 and 1991/92, and many other publications and research (Center for International Economics (CIE), Schmitz and Koo (1996), Agriculture and Agri-Food Canada, etc), the analysis and estimations were developed along several lines.

West Asia is a major barley importing region that includes Saudi Arabia, Iraq, and Kuwait. This region, especially Saudi Arabia, imports very large quantities of barley from the U.S., Canada, the EU, and Australia. North Africa, which includes Algeria, Libya, and Morocco, also imports a little barley from the U.S. and Europe. Due to religious and legal constraints on alcohol consumption, all barley imported into these regions was assumed to be feed barley.

Data from the Commodity Statistical Bulletin indicate that no malting barley was exported to Muslim countries between 1983/84 and 1991/92. Export data for ABB before 1980/81 were estimated from the information provided in ABB annual reports and Commodity Statistical Bulletin. Australia mostly exported malting barley to China, the EU, South America, South Africa, South Korea, Taiwan and Japan. Occasionally, it would have exported malting barley to the former Soviet Union. By referring to Commodity Statistical Bulletin, which lists Australian malting barley exports’ destinations between 1983/84 and 1991/92, it was found that
Australia only exported malting barley to the Soviet Union in two years. Based on the information obtained from ABB annual reports and Commodity Statistical Bulletin, it was assumed that exports of barley to China were totally malting barley.

One hundred percent of barley exports to South America, South Africa and the EU were malting barley. In addition to this, 4.62% (the average percentage of malting barley imports from Australia by Japan from 1983/84 to 1991/92) of barley exports to Japan and 28.13% (average percentage of malting barley imports from Australia by Taiwan from 1983/84 to 1991/92) of barley exports to Taiwan were malting barley.

Those rules were applied to both Australia and the ABB for the years between 1975/76 and 1980/81. Explicitly, the exports of malting barley by ABB were calculated by

\[ X_{ABB} = X_{China} + X_{SA} + X_{EU} + 0.462 \times X_{Japan} + 0.2813 \times X_{Taiwan} \]

Table 1 contains summary statistics of export quantities, realized prices, initial payments, and the differences between realized prices and initial payments for the CWB and the ABB as well as of export quantity and realized prices for the rest of the world (ROW).

Total malting barley exports from the other exporting countries were the sum of malting barley exports from the U.S, E.U., South America and the residual exports from Australia not under ABB authority. World malting barley export data for 1996/97 and 1997/98 were obtained from Bi-weekly Bulletin, and for 1990/91 to 1994/95, data were obtained from Schmitz and Furtan (2000). Prior to 1990/91, and for the year 1995/96, the aggregate data for the rest of the world were derived by calculating the sum of exports from each country and were estimated using several assumption similar to those used for Australia.

All exports to Muslim countries were assumed to be feed barley.

The malting barley export data after 1989/90 for the U.S. is available from the USDA. For the rest of the years, U.S. malting barley exports were approximated in the following fashion referred to in Schmitz and Koo (1996): all barley sold to China, South America, and Central America was assumed to be malting barley. Three percent of exports to Japan and 27 percent of exports to Taiwan were assumed to be malting barley. All exports to Europe before 1985 were assumed to be feed barley and after 1985 were assumed to be malt quality. All other exports were assumed to be feed barley.

Intra-EU malting barley trade was excluded. EU trade always included the current 15 countries for each year, even though the number of countries in the European Union changed over the period. EU barley exports were assumed to contain malting grade barley in the following proportion: 1) 2% as malting barley to Switzerland; 2) 3.5% to the former USSR; 3) 75% to the former Czech-Slovakia; 4) 18% to Turkey (Schmitz and Koo, 1996); 4) 100% to East Asia, which includes China (including Hong Kong and Taiwan), Japan, and South Korea; and 5) 100% to South America and Central America.

It was necessary to choose a price series for other exporting malting barley. Only the U.S. was an active exporter to Asia, South America, and Europe in most study years. Along with the issue of data availability, prices of malting barley in a principal US market (Minneapolis) were used as a substitute of that for other countries. They were obtained from the USDA (Figure 6.6). Malting barley exporting countries in South America only exported barley to the countries within South America. It was assumed that all barley trade within South America was for malting barley. Barley exports by each country from 1976 to 1990 were obtained from the USDA website and for 1995/96 were obtained from the Statistical Handbook, Canada.

The GDP deflator for each country was used to deflate the nominal variables for each country and was collected from the International Monetary Fund publication, International Financial Statistics. All price variables were subsequently converted to a U.S dollar equivalent. Malt production is a necessary data requirement in the distance model. Malt production was determined using the following accounting: (Domestic Malt Consumption) + (Malt exports)-
Malt import and export data were obtained from FAO. Domestic malt consumption was derived from beer production. Normally, to produce 1000 hectoliters of beer, the process requires about 147.7 kilograms of malt, and to produce 1 kilogram malt, the process requires 1.2 to 1.3 kilograms of malting barley. Data on beer production for those malting barley importing countries were obtained from FAO.

For the purpose of comparison, realized prices for the CWB, the ABB and the rest of the world were deflated with the GDP deflator where 1995=100. There is a general downward trend on the barley price in export markets. Summary statistics of deflated data are reported in Table 2.

Estimation Results and Discussion

The empirical estimation procedures were carried out according to the two distinct game theoretic stages described in figure 1. The global malting barley output stage estimation was conducted using a Bayesian inference framework with flexibility to allow parametric restrictions and imposition of general demand conditions (Geweke, 1986). The simulation approach was based on the Markov Chain Monte Carlo (MCMC) method and the Metropolis-Hastings algorithm, discussed by Griffiths et al (2000). This is followed by an empirical evaluation of the precommitment stage in which both STEs endogenously control the input price of the principal raw commodity. In particular, we used two methods: a bootstrap approach and the Wilcoxon signed rank test to test the null hypothesis that the optimal initial payment is not different from the observed initial payment. The bootstrap approach was also used to test the null hypothesis that STEs could not shift rent by using their prepayment systems.

Bayesian Approach

The Bayesian approach provides a formal framework for including the prior information. The process of estimating parameters is not to estimate the values of fixed parameters, but rather to continually update and sharpen the subjective beliefs about the “state of the world” (Greene, 2003). With the Bayesian approach, information about a parameter is expressed in terms of the posterior p.d.f. The posterior p.d.f. is a direct statement of the subjective probability of the parameter taking on particular values (Judge et al, 1988). In this study, we applied the Bayesian approach because of its advantage in drawing finite sample inferences concerning nonlinear functions of parameters and imposing economic restrictions.

The core of the Bayesian methodology is Bayes’ Theorem: for events A and B, the conditional probability of event A given that B has occurred is

\[
P(A | B) = \frac{P(B | A)P(A)}{P(B)}
\]

(55)

Applying this theorem to parameter estimation and viewing data as a fixed set of additional information in updating beliefs about the unknown parameters and covariance, the theorem becomes

\[
f(\beta, \Sigma | Y, X) \propto L(Y, X | \beta, \Sigma) p(\beta, \Sigma)
\]

(56)

where \( \propto \) means “is proportional to,” \( \beta \) is a vector of model parameters, \( \Sigma \) denotes the covariance matrix, and \( Y, X \) represent data observations. The posterior joint density function is \( f(\beta, \Sigma | Y, X) \) for \( \beta \) and \( \Sigma \), given observed random variables \( Y \) and \( X \), or revised beliefs about the distribution of \( \beta \) and \( \Sigma \) after observing the data; \( L(Y, X | \beta, \Sigma) \) is the likelihood function summarizing all the sample information; \( p(\beta, \Sigma) \) is the prior density function for \( \beta \) and \( \Sigma \) that summarizes the nonsample information about \( \beta \) and \( \Sigma \). Once the data are drawn, the joint posterior density is obtained and then it becomes the prior density function for drawing next data. This principle is one of continual accretion of knowledge about the parameters.

Under the assumption of multivariate normal residuals, the likelihood function is
\[ L(Y, X \mid \beta, \Sigma) \propto |\Sigma|^{-N/2} \exp[-0.5tr(R^*\Sigma^{-1})] \]  
(57)

where \( tr \) denotes trace, which is the sum of the diagonals of a square matrix; \( R \) is a symmetric estimated covariance matrix by substituting \( \beta \) into the function; and \( N \) is the number of observations.

The noninformative prior is chosen because it allows for better comparison of results with Nonlinear SUR results later on, although there is information available such as on concavity, symmetry, and theoretic bound. In addition, see Judge et al., 1998, the algebraic form of the prior density function is unchanged by the availability of this information, even though the region over which it is defined changes. This is also true of the posterior density. The non-informative prior used is given by:

\[ p(\beta, \Sigma) = p(\beta)p(\Sigma)I(\beta \in h_s) \]  
(58)

where \( h_s \) is the set of permissible parameter values when constraint information is \( (s=2) \) and is not \( (s=1) \) available. \( I(.) \) is an indicator function that takes the value 1 if the argument is true.

Then the posterior density under the assumption of noninformative prior is

\[ f(\beta, \Sigma \mid Y, X) \propto \left[ |\Sigma|^{(N+I+1)/2} \exp(-0.5tr(R^*\Sigma^{-1}))I(\beta \in h_s) \right] \]

(59)

Techniques of Markov Chain Monte Carlo (MCMC) simulation estimation and Metropolis-Hastings algorithm make the Bayesian estimation remarkably simple. The Metropolis-Hastings algorithm can draw samples from a marginal probability density indirectly without having to derive the density itself (Griffiths et al., 2000). The Metropolis-Hastings algorithm allows the imposition of curvature, stability, and bounds on market power parameters during the sample drawing process. After considering the characteristics of data generation process by the Bayesian method, we imposed constraints on each point-estimated price that they be positive. Unlike the method involving the Cholesky decomposition, which imposes curvature globally and forces some flexible functional forms to exhibit undesired properties by economic theory (Griffiths et al., 2000), the Metropolis-Hastings algorithm imposes curvature restrictions locally with computational advantages over importance sampling.

The empirical model linked to the theory consists of a system of 5 equations: two inverse demand equations (49) and (50), and three equations for estimating market power parameters (52), (53), and (54). The Metropolis-Hastings algorithm described by Griffiths et al. (2000) is carried out according to:

Step 1: Specify an arbitrary starting value \( k^0 \) that satisfies the constraints of stability, curvature, and bounds on market power parameters and set iteration \( i=0 \).

Step 2: Given the current value \( k^i \), use a symmetric transition density \( q(k^i, k^c) \) to generate a value as the next candidate in the sequence.

Step 3: Use the candidate value \( k^c \) to evaluate the stability, curvature, and bounds as well as positive estimated prices on market power parameter constraints. If any constraints are violated, then set \( u(k^i, k^c)=0 \) and go to step 5.

Step 4: let \( u(k^i, k^c)=\min(g(k^c)/g(k^i), 1) \), where \( g(k) \) is the kernel of the marginal density \( f(k \mid Y, X) \). \( g(k) \) can be obtained by integrating \( \Sigma \) out of the posterior function (Judge et al., 2000):

\[ f(k \mid Y, X) \propto |R|^{-N/2} I(k \in h_2) = g(k) \]

Step 5: Generate an independent uniform random variable \( U \) from the interval \([0,1]\).

Step 6: set \( i=i+1 \) and go to step 2.

The above iteration process generates a chain, \( k^1, k^2, \ldots, \) with the property that, for large \( i \), \( k^{(i)} \) is an effective sample from \( f(k \mid Y, X) \). \( f(k \mid Y, X) \) is the posterior joint density for \( k \) given \( Y \) and \( X \). The posterior density gives all the information about \( k \) after the sample \( Y \) and \( X \) has been observed. Consequently, the sequence \( k^{(i)} \), \( i=1, \ldots, i^{(m)} \) can be regarded as a sample from \( f(k \mid Y, X) \) that satisfies the constraints of stability, curvature, bounds, and positive price estimates on market.
power parameters. In Step 3, the concavity constraint is evaluated by using the maximum eigenvalue of the estimated Hessian matrix. The burn-in period, i, is set at 300,000, which is big enough to ensure the elimination of the influence of the starting value and the convergence of the MCMC chain. How many sample observations are needed for accurate estimation is not certain. The sample size m is set as large as 300,000.

The starting values were chosen arbitrarily, but within the prescribed economic constraints. The choice of transition density \( q(k_i, k_c) \) is arbitrary. It is commonplace to use a multivariate normal distribution with mean \( k_i \) and covariance matrix equal to unrestricted nonlinear Seemingly Unrelated Regression (SUR) estimators. In order to manipulate the rate at which the candidate \( k_c \) is accepted as the next value in the sequence, a tuning constant was used to multiply the covariance matrix. A smaller tuning constant increases the acceptance rate, but at the same time, a smaller tuning constant makes new draws more like old ones, so this slows down the process (Greene, 2003). The tuning constant is set at 0.01 to make the acceptance rate of approximately 0.40. This constant is chosen by trial and error.

The bootstrapped confidence intervals for parameter estimates are constructed after the burn-in period. The 90% confidence interval for each parameter was constructed by the percentile method, which requires ranking the estimated parameters and then selecting the 15000th (5% of total iterations) outcome as the lower critical value and the 285000th (95% of total iterations) outcome as the upper critical value. If the bootstrapped confidence interval for a parameter estimate contains zero, then the parameter value is not considered significant from zero at the 10% level.

The bootstrapped parameter estimates, along with the upper and lower bounds of the 90% confidence intervals for the Bayesian system, are reported in Table 3. Both \( b_{11} \) and \( b_{22} \) are significant at the 10% level and negative due to the curvature constraint set during the data generation process. Both output parameters (\( b_{1y} \) and \( b_{2y} \)) are negative and only \( b_{1y} \) is significant. This shows that output of malt has significant effect on the price of malting barley from the CWB and has insignificant effect on the price of malting barley from the ABB. However, the significant effect is very small.

As discussed above, market power parameters lie between -1 and 1. When the market power parameter (\( \lambda_{ij} \)'s) is equal to 1 or conjectural variation (\( \gamma_{ij} \)) is equal to -1, the firm believes that other firms will reduce their output by exactly 1 unit if it increases its output by 1 unit. However, in this study malting barley is modeled as an imperfect substitute across exporters, thus firms have some degree of market power and we should not observe the perfectly competitive outcome. When the market power parameter is negative or conjectural variation (\( \gamma_{ij} \)) is positive, STEs are found to be collusive.

Significance or insignificance of conjectural variation parameters describes the conduct of STEs and firms in the world malting barley market. If the conjectural variation \( \lambda_{ij} \) is not significant, then country \( i \) does not consider country \( j \)'s output change when \( i \) makes its decision. If both \( \lambda_{ij} \) and \( \lambda_{ji} \) are not significant, then the two countries are in Cournot competition. The results show that all market power parameters are not significant, which suggests that CWB, the ABB, and the other exporting countries are in Cournot competition with each other. This outcome does not imply that the single stage Cournot equilibrium has been identified. However, the single stage result can be supported unless there is some compelling evidence for a precommitment mechanism that may shift the equilibrium to favor one exporter over the others.

The bootstrapped confidence intervals for flexibility estimates are also constructed after the burn-in period. Table 4 contains the bootstrapped flexibility estimates, along with the 90% confidence intervals for the Bayesian system. All own price flexibilities are negative (imposed by concavity in the data generation process), inflexible, statistically significant. An inflexible price is consistent with an elastic demand. Cross-price flexibilities between the ABB and the
other exporting countries were insignificant, which suggests a low level of substitutability and possibly a high level of product differentiation. Cross-price flexibilities between the CWB and the ABB, and those between the CWB and other exporting countries, were significant and positive, which indicates a complimentary effects were present across parts of the export market.

One possibility for the complimentary effects is the effect of geography. The distance between Canada and Australia is great. Each exporter has its own regular customers (e.g., U.S only imports malting barley from Canada). The purchases from these regular customers may disguise the substitution relationship of malting barley from the CWB and the ABB, which may be presented by non-regular and off-switching customers (like China, which imports malting barley from both markets). The other possibility is that in some crop years, production of a STE was very low due to bad weather, causing a decrease in world total supplies and a consequent price increase. But decreased supply from one STE resulted in increased demand for the other STE. Therefore, all world prices increased while demand for imports from one STE also increased.

Using equations (28) and (29), we tested each STE to see if they had set their initial payments at optimal levels. With linear inverse demand functions, all second derivatives of prices with respect to quantities are zero, which greatly simplifies the matrix $S$. By testing whether the optimal mark downs (right hand sides of equations (28) and (29) were equal to the true values of the mark downs, $w_i - c_i$, it could be determined statistically whether the CWB and the ABB set their initial payments at optimal levels. Table 5 contains the bootstrapped estimates of the differences between optimal initial payments and actual payments, along with the upper and lower bounds of the 90% confidence interval for the Bayesian system. Both the CWB and the ABB set their initial payments considerably higher than optimal levels. This implies that while some rent shifting was possible, it does not generate much support that the prepayment system is operating as an effective strategic tool.

A test of rent-shifting based on equations (40)-(43) was also conducted by the bootstrap method. Table 6 shows the test results of rent shifting. All values are insignificant. Therefore the hypothesis that STEs could not utilize their initial payments to shift rent cannot be rejected. Combined with the bootstrapped results from above, a fairly strong conclusion emerges. It does not appear that the prepayment system can be used to shift rent and even if it could, it is currently being heavily underutilized.

To see if the findings from the bootstrap procedures hold up to additional testing, the Wilcoxon signed rank test was conducted. The Wilcoxon signed rank test is a nonparametric method of testing whether two populations have equal locations. To perform the test, we first calculated the difference between the optimal and observed initial payments, $w_i - W_i$. Means of optimal initial payments were estimated by substituting the estimated parameters from the Bayesian method into (28) and (29). Then, we ranked the absolute values of the differences and calculated the sum of the ranks from the positive differences. When the null hypothesis that no difference in distributions is true, the mean and standard deviation of the Wilcoxon signed rank statistic, $W$, are given by $n(n+1)/4$ and $\sqrt{n(n+1)(2n+1)/24}$, respectively. For $n>12$, the distribution of $W - n(n+1)/4 / \sqrt{n(n+1)(2n+1)/24}$ can be adequately approximated by the standard normal. With 23 pairs of observations of the ranked data, the Wilcoxon signed rank statistic were -4.19726 for both the CWB and the ABB. Therefore, the null hypothesis that there were no differences between optimal and observed initial payments should be rejected. Consequently, the left tail alternative that observed initial payments were higher than optimal levels could be accepted.
Therefore, the Wicoxon signed rank test suggested that both STEs set their initial payments at higher than optimal levels.

The Bayesian output results show that all conjecture variations are insignificant and the world malting barley market can be characterized by a Cournot equilibrium. From the precommitment stage results, there is little, if any, support for the notion that the prepayment system is effective in shifting rent. Thus, it does appear the Cournot equilibrium we found is consistent with a single-stage Cournot outcome. The structure of the malting barley market for STEs is quite similar in nature to the model by Brander and Spencer (1985), in which governments are able to act first and set export subsidies (lowering the initial payments has the same effect as export subsidies), with the understanding of how these subsidies influence the output equilibrium. Then firms take the subsidy levels set by governments as well as the output levels set by rivals as given. The optimal export subsidy moves the industry equilibrium to what would, in the absence of the subsidy, be the Stackelberg leader-follower position in output space with the firm that has an export subsidy as the leader and the firm without an export subsidy as the follower.

The world malting barley market mostly diverges from Brander and Spencer’s in the nature of the product. In particular, Brander and Spencer assumed that products were perfect substitutes. In a product differentiated environment, the realization of rent shifting depends not only on the presupposition of Cournot competition, but also on the degree of product differentiation. The empirical results showed that all the rent shifting effects were insignificant. Thus, contrary to the results from a homogeneous product market, we cannot conclude that STEs were capable of shifting rents. However, with possible positive values occurring in rent shifting tests, there are signals to suggest that the two STEs could utilize their initial payment system as a pre-commitment strategy to shift rent from others. Although due to the degree of substitution, geographic and other effects (such as the influence of weather on supply), as well as competition in the precommitment phase, much of the benefits are lost, leaving only the possibility of a much smaller distortionary presence.

Summary and Conclusions

Under the Agreement on Agriculture in the Uruguay Round of multilateral trade negotiations completed in 1994, participating countries agreed to convert quotas and other quantitative import restrictions to tariffs and thus base agricultural protection on tariffs. Countries also committed to reducing tariffs and consequently reducing their support to agricultural producers. As a means to achieve policy objectives such as domestic price support, efficiency in agricultural marketing, a low-cost food supply, and stable farm prices, the existence of STEs makes the distortions implicit. Concerns are aroused by the lack of transparency, exclusive export/import rights, and some financial benefits for STEs. Critics of state trading argue that the lack of price transparency or financial benefits from the government could be used to mask export subsidies or import tariffs, and that exclusive purchasing/selling rights in the domestic or on the world markets may be used by an STE as a reason to act as a monopsonist/monopolist.

State trading will likely continue as a contentious issue for many years. It is important for trade and policy researchers to make clear STEs’ trade effects and consequently to strengthen WTO rules governing STEs that will impose the necessary discipline on STEs. Although there have been many studies examining the distortionary effects of STEs, such as price discrimination, economic efficiency, welfare redistribution efficiency, or market leadership exerted by STEs, the results are contradictory. Most studies examining the market power of STEs always separate one STE from other STEs. Furthermore, in most empirical work the important distinctions between homogeneous and differentiated goods are typically ignored.
The purpose of this dissertation was to examine whether a dual STE-structure generates Stackelberg leadership capabilities in a differentiated product market. We focused on exclusive procuring and pricing policies, and whether STEs could utilize these as strategies to shift rent from other exporting countries. A conceptual two-stage model and an empirical framework were developed to evaluate these market possibilities. In addition, the model provides a framework to test if STEs set their initial payments at optimal levels.

The theoretical model in the research of this dissertation proposed endogenous control of an upstream supply in that STEs chose the initial prices of their raw commodities given that they competed in a downstream market of imperfect substitutes. The decision sequence consisted of a precommitment stage in which STEs chose initial prices followed by an output stage that determines prices, quantities and trade flows for the two STEs and a group of other exporters. We estimated the output stage by considering STE trade policy as a given shift parameter in the domestic marginal cost function. In the precommitment stage, we employed a subset of the output stage results to characterize the value of the trade policy parameter. Under the assumption of Cournot competition, we developed the model to feature the optimal initial payment levels. Then, we extended it to a conjectural variations model to capture the reaction of firms to the quantity changes of other firms. Besides the construction of a framework to examine the optimal initial payment levels, we also set up a framework to test whether STEs could utilize their initial payments to shift rent from other firms under a product differentiated scenario.

A normalized quadratic distance function was used to derive inverse demand relationships to identify the derivatives necessary for the estimation of market power parameters in the conjectural variations models. We applied a Bayesian approach to jointly estimate the inverse demand and conjectural variation relationships. The data for this study were from 1976/7 to 1997/8. Because of the difficulty of obtaining f.o.b. prices for both the CWB and the ABB, the average pooled prices were used as substitutes. World malting barley export data were not directly available from any source and had to be constructed through a series of steps involving feed barley trade flows, assumptions about various importing regions, and other factors. Results from the Bayesian approach indicated that all market power parameters were not significant, suggesting that the CWB, the ABB, and the other exporting countries did not consider the output changes of their rivals. Because the output stage results could be consistent with a static Cournot equilibrium with or without a precommitment, it was important to examine further the precommitment stage for any evidence of rent shifting activity. Two independent analyses were conducted. First, the bootstrap test results showed that both the CWB and the ABB set their initial payments higher than the optimal levels. Second, using a Wilcoxon signed rank test of the optimal initial prices and the observed ones, we rejected the hypothesis for both STEs that the paired data were similar. Thus, a consistent conclusion emerges. It appears that while support for an imperfectly competitive market was found, there is no causal evidence linking the market structure to the prepayment systems in Canada or Australia.

To test robustness of the Bayesian results, a nonlinear SUR model was also estimated. Nonlinear SUR and the Bayesian results are similar in the sense that all conjecture variations are insignificant, optimal initial payments are lower than observed values, and rent shifting effects are insignificant. However, they differ in magnitudes and significance of some parameter estimates. As O'Donnell, Rambaldi, and Doran discussed about the similarity and differences between the results of least squares and Bayesian method, the similarity between the nonlinear SUR results and Bayesian results is due to the use of a non-informative prior, while the differences are due to the fact that the variance of the marginal posterior p.d.f.s is large and subsequently, the variance of the MCMC sample mean is also large.

To provide additional verification of Cournot competition, a normalized likelihood ratio (LR) test for non-nested models was conducted. The test results showed that the Cournot model
was significantly better than the CWB leading model. The test results also showed that the data did not enable me to discriminate among the Cournot model, the ABB leading model, and the CWB and the ABB collusive model. This result provided a support to the specification of market structure by both the Bayesian and nonlinear SUR methods.

In this study, a conceptual two-stage model and an empirical framework was developed to evaluate if a dual STE-structure generates Stackelberg leadership capabilities in a differentiated product market or if STEs use exclusive procuring and pricing policies as strategies to shift rent from other exporting countries. Parametric and semi-nonparametric methods provide consistent conclusions in the sense of providing the same economic findings on market structure, optimal initial payment tests, and rent shifting test. Consistency between the parametric and semi-nonparametric methods, as well as a myriad of other hypothesis tests, demonstrated robustness.

Based on the conceptual model framework, data, and subsequent empirical results, important conclusions were reached. First, the STEs did not have market leadership in the differentiated global malting barley market. Both STEs and other exporting countries were in Cournot competition. Hamilton and Stiegert (2002) also found that the CWB was in Cournot competition with the other export sector in a homogeneous market. But unlike this study, they found support for rent-shifting and leadership outcomes for the STE. With product differentiation, firms rationally ignore rival behavior more than when products are the same and we would naturally tend to observe the Cournot –Nash equilibrium in such cases. This result is also consistent with Varian’s game theory model that the unique subgame perfect equilibrium in the finitely-repeated quantity-setting game is the repeated one-shot Cournot.

Second, both STEs were not setting their initial payments at optimal levels and did not shift rent from other exporting countries by utilizing a prepayment system as a precommitment. Both STEs set their initial payments higher than profit maximization levels. In addition, the effect of rent shifting by lowering initial payments was not significant. This is different from results under the assumption of product homogeneity. In Cournot competition, under product differentiation, rent shifting effects also depends on cross-price effects. In the world malting barley market, due to product differentiation, geographic effect, and output shocks from weather condition, etc, the rent shifting effects by using initial payment as a precommitment tool were dampened. Therefore, there is no urgent need to impose disciplines on STEs’ prepayment system.

**Figure 1: Two-Stage Structure Used by STEs**

![Two-Stage Structure Used by STEs](image)
Table 1: Summary Statistics of Data

<table>
<thead>
<tr>
<th></th>
<th>CWB</th>
<th>ABB</th>
<th>ROW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Max</td>
<td>Min</td>
</tr>
<tr>
<td>Exports (000 tonnes)</td>
<td>551.4</td>
<td>1423.0</td>
<td>52.8</td>
</tr>
<tr>
<td></td>
<td>(435.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Realized Prices</td>
<td>169.1(^2)</td>
<td>243.2</td>
<td>106.6</td>
</tr>
<tr>
<td></td>
<td>(34.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial Payments</td>
<td>143.5(^a)</td>
<td>225.3</td>
<td>88.1</td>
</tr>
<tr>
<td></td>
<td>(32.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differences between Realized Prices and Initial Payments</td>
<td>25.6(^a)</td>
<td>64.8</td>
<td>-16</td>
</tr>
</tbody>
</table>

\(^{a}\) CNDS/tonne  
\(^{b}\) AUS/tonne  
\(^{c}\) US$/tonne  
\(^{d}\) US$/tonne
Table 2: Summary Statistics of Deflated Data

<table>
<thead>
<tr>
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<th></th>
<th>ROW</th>
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<td></td>
<td>Mean</td>
<td>Max</td>
<td>Min</td>
<td>Mean</td>
<td>Max</td>
<td>Min</td>
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<td>Exports (000 tonnes)</td>
<td>551.4</td>
<td>1423.0</td>
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<td>1072.3</td>
<td>17.6</td>
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<tr>
<td></td>
<td>(435.7)</td>
<td></td>
<td>(299.2)</td>
<td></td>
<td>(498.9)</td>
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</tr>
<tr>
<td>Realized Prices ($/ton)</td>
<td>168.5</td>
<td>276.8</td>
<td>98.9</td>
<td>181.3</td>
<td>246.6</td>
<td>122.9</td>
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<tr>
<td></td>
<td>(45.6)</td>
<td></td>
<td>(38.0)</td>
<td></td>
<td>(71.7)</td>
<td></td>
</tr>
<tr>
<td>Initial Payments ($/ton)</td>
<td>140.7</td>
<td>197.1</td>
<td>80.9</td>
<td>125.9</td>
<td>179.4</td>
<td>67.5</td>
</tr>
<tr>
<td></td>
<td>(30.2)</td>
<td></td>
<td>(27.1)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Differences between Realized Prices and Initial Payments ($/ton)</td>
<td>27.8</td>
<td>117.3</td>
<td>-14.7</td>
<td>55.3</td>
<td>95.9</td>
<td>26.1</td>
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<tr>
<td></td>
<td>(24.8)</td>
<td></td>
<td>(19.5)</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

5 Standard deviations are in parenthesis
6 1995 US dollar
<table>
<thead>
<tr>
<th>Estimations</th>
<th>90% Confidence Interval</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Upper Critical Value</td>
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<tr>
<td>$b_1$</td>
<td>0.002497</td>
</tr>
<tr>
<td>$b_2$</td>
<td>0.001855</td>
</tr>
<tr>
<td>$b_{11}$</td>
<td>-0.000271</td>
</tr>
<tr>
<td>$b_{12}$</td>
<td>0.000104</td>
</tr>
<tr>
<td>$b_{22}$</td>
<td>-0.000151</td>
</tr>
<tr>
<td>$b_{1y}$</td>
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<tr>
<td>$b_{2y}$</td>
<td>-0.000084</td>
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<tr>
<td>$\lambda_{12}$</td>
<td>0.079667</td>
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<tr>
<td>$\lambda_{13}$</td>
<td>0.243644</td>
</tr>
<tr>
<td>$\lambda_{21}$</td>
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</tr>
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<td>$\lambda_{23}$</td>
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<td>$\lambda_{31}$</td>
<td>0.310498</td>
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<tr>
<td>$\lambda_{32}$</td>
<td>0.210307</td>
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</tbody>
</table>

Burn in period=300000. Sample size=300000.
Table 4 Flexibility Estimates for the Normalized Quadratic System with Bootstrapped 90% Percentile Confidence Intervals by Baysian Method

<table>
<thead>
<tr>
<th>Price Flexibilities</th>
<th>CWB</th>
<th>ABB</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>CWB</td>
<td>-0.375654</td>
<td>0.184540</td>
<td>0.128277</td>
</tr>
<tr>
<td>ABB</td>
<td>0.117519</td>
<td>-0.223369</td>
<td>0.015279</td>
</tr>
<tr>
<td>Others</td>
<td>0.258135</td>
<td>0.038829</td>
<td>-0.143556</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>90% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Critical Value</td>
</tr>
<tr>
<td>CWB</td>
</tr>
<tr>
<td>ABB</td>
</tr>
<tr>
<td>Others</td>
</tr>
</tbody>
</table>

| Lower Critical Value    |
| CWB                     | -0.525619 | 0.005347 | 0.062732 |
| ABB                     | 0.005328 | -0.405804 | -0.004123 |
| Others                  | 0.139781 | -0.017990 | -0.224788 |
Table 5: Estimates for Hypothesis Test $H_0: w_1^*-w_1=0$.

<table>
<thead>
<tr>
<th></th>
<th>Mean ($/1,000$ tonnes)</th>
<th>90% Confidence Interval</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Upper Critical Value</td>
<td>Lower Critical Value</td>
<td></td>
</tr>
<tr>
<td>$w_1^*-w_1$</td>
<td>-986.20073</td>
<td>-520.834028</td>
<td>-1559.972451</td>
</tr>
<tr>
<td>$w_2^*-w_2$</td>
<td>-911.60901</td>
<td>-677.651146</td>
<td>-1238.587726</td>
</tr>
</tbody>
</table>

Table 6: Hypothesis Test that STEs Could Shift Rents from Other Exporting Countries

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>90% Confidence Interval</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Upper Critical Value</td>
<td>Lower Critical Value</td>
<td></td>
</tr>
<tr>
<td>$\partial \pi_2 / \partial w_1$</td>
<td>-136.598382</td>
<td>529.959885</td>
<td>-772.610211</td>
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<tr>
<td>$\partial \pi_3 / \partial w_1$</td>
<td>-367.176858</td>
<td>413.266564</td>
<td>-1220.533833</td>
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<tr>
<td>$\partial \pi_1 / \partial w_2$</td>
<td>-256.966471</td>
<td>1266.988685</td>
<td>-1385.945852</td>
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<tr>
<td>$\partial \pi_3 / \partial w_2$</td>
<td>-174.590446</td>
<td>1202.522449</td>
<td>-1614.541864</td>
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</tbody>
</table>

References


U.S. Department of Agriculture (USDA).


