PARTIAL MARKET LIBERALIZATION AND THE EFFICIENCY OF POLICY REFORM: THE CASE OF THE EUROPEAN DAIRY SECTOR

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This article analyzes the efficiency of partial market liberalization and policy reform with an application to the European dairy sector. In a second best world, partial moves toward market liberalization are not always efficiency improving. We develop a general equilibrium model to investigate the efficiency implications of discrete changes in government policy. The analysis covers price and quantity instruments used in both domestic and trade policy. We derive simple conditions under which partial market liberalization is efficiency improving. We apply the approach to agricultural policy reform in the European dairy sector and identify market liberalization scenarios that are "not" efficiency improving.

Key words: dairy, efficiency, European Union, market liberalization, policy reform.

Government policy has major impacts on agricultural markets. For example, in the United States, Canada, and Europe, agricultural policy has increased farm income through price support programs for grains and milk. Such policies are often complemented by import restrictions and export subsidies. Canada and Europe have also implemented production quotas (e.g., in the dairy sector). As a result, government pricing policy and trade policy have distorted agricultural markets (e.g., Wallace; Gardner, 1983, 1987; De Gorter and Meilke; Alston and Hurd; Bullock; Moschini and Sekokai; Salhofer). Starting in the 1990s, there has been a general move toward reductions in the role of price support programs in agriculture and a greater reliance on markets. This has been stimulated in part by the Uruguay Round of GATT negotiations that provided a multilateral agreement for partial market liberalization of the agricultural sector. It involved a reduction in export subsidies and increased import access commitments. This has been complemented by domestic agricultural policy reform. These changes have been motivated in part by the expected efficiency gains obtained from undistorted competitive markets. For example, reducing agricultural trade barriers is expected to generate significant agricultural productivity gains by stimulating regional specialization consistent with each region's comparative advantage.

Yet agricultural pricing and trade policy reform has typically been piecemeal. Even after recent policy reforms, agricultural markets are still significantly distorted by government policy. This creates significant challenges for the design of policy reform. The reason is that partial moves toward competitive markets are not always efficiency improving. For example, there are scenarios where imposing production quotas can reduce the distortionary effects of existing price subsidies and actually improve economic efficiency (e.g. Johnson, Gisser, Just, Bullock and Salhofer). This is a situation of "second best" where efficiency gains are more difficult to assess. This issue gains significance when both price and quantity instruments are used. Price instruments include price support, taxes, import tariffs, and export subsidies. Quantity instruments include production quotas and import or export quotas. In trade policy, even after the GATT-WTO agreements, both tariffs and quotas still impose significant
barriers to agricultural trade. This suggests a need to develop general guidelines to better understand the circumstances under which partial market liberalization is efficiency-enhancing. First, domestic policy instruments and trade policy instruments often interact with each other, meaning that the efficiency implications of partial market liberalization should consider their “joint” effects. Second, trade liberalization often involves multilateral negotiations (e.g., WTO negotiations), suggesting the need to present the arguments in the context of “many nations.” This would extend the previous research on the relative efficiency of agricultural policy instruments (e.g., Wallace; Gardner, 1983, 1987; DeGorter and Melike; Bullock; Moschini and Skokai; Alston, Carter and Smith; Gisser; Bullock and Salhofer; Bullock, Salhofer and Kola). Finally, while previous theoretical work on trade liberalization has often focused on infinitesimal changes in policy instruments (e.g., Vousden; Anderson and Neary, 1992, 1996; Neary; Turunen-Red and Woodland, 1991, 2000), it would be useful to extend such an analysis to cover the more realistic case of discrete changes in government policy.\footnote{Note that empirical studies generally deal with discrete changes in policy while theoretical ones deal with infinitesimal changes.}

The objective in this article is to analyze the efficiency of market liberalization and policy reform with an application to the dairy sector in the European Union (EU). As pointed out by Beghin and Sumner, the dairy industry is influenced heavily by government policy and is likely to be further reformed during the next WTO negotiation round. Thus, it represents a good case study to evaluate the efficiency impacts of reforming distortionary agricultural policy. This is done first by developing a general equilibrium model of resource allocation and markets in the presence of distortions from domestic and trade policy. The model considers multicommodities and multiagents and allows for transaction costs in trade. After characterizing the distorted market equilibrium, we investigate the efficiency implications of discrete changes in government policy involving price as well as quantity instruments used in both domestic and trade policy. We derive simple conditions under which partial market liberalization is efficiency improving. We apply our approach to the analysis of agricultural policy reform in the EU dairy sector and identify market liberalization scenarios that are not efficiency enhancing. We also analyze alternative policy reform scenarios that improve efficiency and discuss their implications for the distribution of welfare in the dairy sector.

The outline of the article is as follows. The next section provides a conceptual model of domestic and trade policy in a general equilibrium context under transaction cost. Both price and quantity instruments (representing domestic as well as trade policy) are introduced in the model to generate a distorted market equilibrium. We then investigate the efficiency implications of partial market liberalization using Luenberger’s benefit function. We derive sufficient conditions and necessary conditions for policy reform to be efficiency improving. The following section shows how these general equilibrium results can be adapted to a partial equilibrium context. Next we develop an empirical application to market liberalization and agricultural policy reform in the European dairy sector. This is followed by an analysis of alternative EU dairy policy scenarios, with a special focus on the relaxation of EU production quotas either singly or in combination with domestic or trade policy liberalization. This provides some evidence on the efficiency impacts and welfare trade-offs of alternative partial market liberalizations. Lastly, the final section provides a summary, conclusions and thoughts for further research in this area.

A Conceptual Model of Pricing and Trade Policy

Consider an economy consisting of firms and consumers involved in the allocation of $m$ commodities. Let $N_f$ be the set of firms, $N_c$ be the set of consumers, and $N = N_f \cup N_c$ the set of all agents. The $i$th consumer chooses a consumption bundle $x_i = (x_{i1},\ldots,x_{im}) \in X \subset \mathbb{R}^m$, and has preferences represented by the utility function $u_i(x_i), i \in N_c$. The $i$th firm chooses the netput vector $y_i = (y_{i1},\ldots,y_{im}) \in Y_i \subset \mathbb{R}^m$, where outputs are positive, inputs are negative, and $Y_i$ denotes the transformation set, $i \in N_f$. Finally, trade is denoted by $t = \{t_{ijk} : i, j \in N; k = 1,\ldots,m \geq 0\}$, where $t_{ijk}$ is the quantity of the $k$th commodity traded from the $i$th agent to the $j$th agent. When $i = j$, this includes the quantity of the $k$th commodity that the $i$th agent trades with itself. We consider the case where trade can be costly and involves the use of resources $z = \{z_t, i \in N\}$, where $z_t = (z_{t1},\ldots,z_{tm})$ is the vector of commodities used by the $i$th agent in trading.
activities (e.g., transportation). The trading technology is represented by the transformation set \( Z \), where \((z, t) \in Z \) denotes feasible trade. We make two assumptions:

A1. any agent can trade with itself costlessly; and

A2. the \( m \)th commodity is “money” that can be exchanged costlessly among agents.

Let \( x_i = 0 \) for \( i \in N_c \), \( x = \{x_i, i \in N \} \), \( y_i = 0 \) for \( i \in N_c \), and \( y = \{y_i, i \in N \} \). A “feasible allocation” \((x, y, z, t)\) satisfies \( x_i \in X_i \) for \( i \in N \), \( y_i \in Y_i \) for \( i \in N \), \((z, t) \in Z \), and

\[
\begin{align*}
(1a) & \quad \sum_{j \in N} t_{ij} \leq y_i - z_i, \quad i \in N \\
(1b) & \quad x_i \leq \sum_{j \in N} t_{ji}, \quad i \in N
\end{align*}
\]

where \( t_{ij} \) = \( \{t_{ijk}: k = 1, \ldots, m\} \). Equation (1a) indicates that the \( i \)th agent cannot export more than its production \( y_i \) net of resources used in trade \( z_i \), and equation (1b) states that the \( i \)th agent cannot consume more than it obtains either from itself \( x_i \), or from others \( \sum_{j \neq i} t_{ji} \).

Next we introduce various policy instruments into the model. They include tariffs and subsidies, as well as quotas. Let \( r_{ijk} \) be the unit “tariff” (unit “subsidy” if negative) imposed on the \( k \)th quantity \( t_{ijk} \) exchanged from agent \( i \) to agent \( j \). Partition the set of agents into two mutually exclusive groups: \( N = \{D, F\} \), where \( D \) is the set of “domestic agents,” while \( F \) is the set of agents constituting the “rest of the world.” When \( i \in F \) and \( j \in D \), then \( r_{ijk} \) is an import tariff on the \( k \)th commodity. When \( i \in D \) and \( j \in F \), then \(-r_{ijk}\) is the export subsidy on the \( k \)th commodity. Finally, when \((i, j) \in D \times D \) with \( i \in N_c \) and \( j \in N_c \), then \( r_{ijk} \) represents a domestic tax on the \( k \)th commodity which, if positive, increases the price paid by domestic consumers. The welfare implications of these tariffs and subsidies are discussed below.

Let \( Q_M = \{q_{km}: k = 1, \ldots, m\} \), where \( q_{km} \) is the “import quota” imposing an upper bound on the quantity of the \( k \)th commodity imported on the domestic markets. And let \( Q_E = \{q_{ke}: k = 1, \ldots, m\} \), where \( q_{ke} \) is the “export quota” imposing an upper bound on the quantity of the \( k \)th commodity exported to the rest of the world. These import and export quotas are relevant in conjunction with minimum access commitments (increased import quotas) and maximum export subsidy commitments under the Uruguay Round GATT agreement. The trade quotas impose the following constraints on trade:

\[
\begin{align*}
(2a) & \quad \sum_{i \in F} \sum_{j \in D} t_{ij} \leq q_M \\
(2b) & \quad \sum_{i \in D} \sum_{j \in F} t_{ij} \leq q_E
\end{align*}
\]

Finally, consider the presence of production quotas on the domestic markets. Let \( \{D_1, D_2, \ldots, D_s\} \) be a partition of \( D \), where \( D_c \) is the set of domestic agents facing the “production quota” \( q_{ys} \). This imposes the production constraints

\[
(2c) \quad \sum_{i \in D_s} y_i \leq q_{ys}, \quad s = 1, \ldots, S.
\]

We expect quotas to generate quota rents to market participants. Denote by \( Q_M, Q_E, \) and \( Q_y = \{q_{ys}: s = 1, \ldots, S\} \) the quota rents per unit of imports, exports, and production associated with quotas \( q_{km}, q_{ke}, \) and \( q_{ys} = \{q_{ys}: s = 1, \ldots, S\} \), respectively. The effects of quotas and quota rents on resource allocation and welfare are discussed below.

In general, for the \( k \)th commodity, the tariff \( r_{ijk} > 0 \) imposes a price wedge between the \( i \)th and \( j \)th agent: it increases the price paid by the \( j \)th agent and generates revenue. Alternatively, the subsidy \( s_{ijk} < 0 \) decreases the price paid by the \( j \)th agent and involves budgetary cost. We consider a market equilibrium where the \( i \)th agent can face two prices for commodity \( k \): \( p^*_{ik} = \{p^*_{ijk}: k = 1, \ldots, m\} \) when commodities are sold, and \( p^*_{ik} = \{p^*_{ijk}: k = 1, \ldots, m\} \) when commodities are purchased. Although the case where \( p^*_{ik} = p^*_{ik} \) is an important special case, the distinction between these two prices becomes relevant under distortionary pricing policy. Let \( r_{ij} = \{r_{ijk}: k = 1, \ldots, m\}, r = \{r_{ij}: i, j \in N\}, p^* = \{p^*_{ik}: i \in N\}, \) and \( p^* = \{p^*_{ik}: i \in N\} \). In this context, we are interested in evaluating the effects of the policy instruments \( \alpha = (r, q_M, q_E, q_y) \) on resource allocation, trade, and prices.

**Distorted Market Equilibrium**

**DEFINITION 1.** An allocation \((x^*, y^*, z^*, t^*)\) along with market prices \((p^*_{ik}, p^*_{ik})\) and the quota rents \((Q^*_M, Q^*_E, Q^*_y)\) constitute a “distorted market equilibrium” if it is feasible and satisfies

(a) for each \( i \in N_c \) and all \( x_i \in X_i \),

\[
p^*_{ik} \cdot x_i \leq p^*_{ik} \cdot x^*_i \implies u_i(x_i) \leq u_i(x^*_i),
\]
(b) for each \( i \in N \), and all \( y_i \in Y_i \)
\[
(p_i^* - \sum_s \delta_{is} Q_{ys}^*) \cdot y_i^* 
\geq \left(p_i^* - \sum_s \delta_{is} Q_{ys}^* \right) \cdot y_i,
\]
where \( \delta_{is} = 1 \) if \( i \in D \), (=0 otherwise).

(c) for all \((z, t) \in Z\),
\[
\sum_{i \in N} \sum_{j \in N} (p_j^* - p_i^* - \delta_{ij} M Q_M^* - \delta_{ij} E Q_E^* - r_{ij}) \cdot t_{ij}^* - \sum_{i \in N} p_i^* \cdot z_i^* 
\geq \sum_{i \in N} \sum_{j \in N} (p_j^* - p_i^* - \delta_{ij} M Q_M^* - \delta_{ij} E Q_E^* - r_{ij}) \cdot t_{ij}^* - \sum_{i \in N} p_i^* \cdot z_i,
\]
where \( \delta_{ij} M = 1 \) if \( i \in F \) and \( j \in D \) (=0 otherwise), and \( \delta_{ij} E = 1 \) if \( i \in D \) and \( j \in F \) (=0 otherwise).

(d) for each \( i \in N \), \( p_i^* > 0 \), \( p_j^* > 0 \), with \( p_j^* \cdot (y_i^* - x_i^* - \sum_{j \in N} t_{ij}^*) = 0 \), and \( p_i^* \cdot \sum_{j \in N} t_{ji}^* = 0 \),
\[
\sum_{i \in E} \sum_{j \in D} t_{ij}^* \leq q_{M}, \quad Q_{i}^* \geq 0; \quad \sum_{i \in D} t_{ij}^* \leq q_{E}, \quad Q_{i}^* \geq 0; \quad \text{and} \quad \sum_{i \in D} t_{ij}^* \leq q_{ys}, \quad Q_{ys}^* \geq 0; \quad s = 1, \ldots, M; \quad \text{with} \quad Q_{i}^* \cdot [\sum_{i \in E} t_{ij}^* - q_{M}] = 0, \quad Q_{i}^* \cdot [\sum_{i \in D} t_{ij}^* - q_{E}] = 0, \quad \text{and} \quad Q_{ys}^* \cdot [\sum_{i \in D} y_i^* - q_{ys}] = 0, \quad s = 1, \ldots, S.
\]

Condition (a) represents economic rationality for consumers. Condition (b) represents profit maximization under production quotas. It shows that firms behave as if they were facing prices \((p_i^* - \delta_{is} Q_{ys}^*)\), and that quota rents \((Q_{ys}^* \geq 0)\) reduce the incentive to produce. Condition (c) states that trade activities maximize profit under policy distortions. The tariffs \( r \) as well as the trade quota rents \((Q_{M}, Q_{E})\) act as trade barriers that reduce the profitability of trade. Alternatively, subsidies \( r_{jk} < 0 \) stimulate exports of the \( k \)th commodity from agent \( i \) to agent \( j \). Condition (d) is the budget constraint for each agent. Finally, condition (e) imposes trade and production quotas, with the requirement that quota rents are nonnegative and become positive only if the corresponding quotas are binding.

Next, we present an alternative formulation of distorted market equilibrium relying on the concept of benefit function proposed by Luenberger (1992a). For the \( i \)th agent, Luenberger defines the “benefit function” as
\[
(b_i(x_i, u_i, g) = \max\{\beta : u_i(x_i - \beta g) \geq u_i\}
\]
for some \( g \in \mathbb{R}^n \), \( g \neq 0 \), \( i \in N \). The benefit function \( b_i(x_i, u_i, g) \) measures the largest amount of the commodity bundle \( g \) that the consumer facing \( x_i \) is willing to give up while maintaining the welfare level \( u_i \). Below, we will choose \( g = (0, \ldots, 0, 1) \), meaning that \( g \) is one unit of “money.” Then, \( b_i(x_i, u_i, g) \) measures the \( i \)th consumer’s willingness to pay to move from consuming \( x_i \) (with corresponding utility \( u_i(x_i) \)) to utility level \( u_i \).

Under a quasi-concave utility function \( u_i(x_i) \) and the convexity of \( X_i \), \( b_i(x_i, u_i, g) \) is concave in \( x_i \) and nonincreasing in \( u_i \) (Luenberger, 1992a, p. 464-66). Under differentiability, \( \partial b_i / \partial x_i \) is the price-dependent Hicksian demand for \( x \) from the \( i \)th consumer. Letting \( b_i = 0 \) for \( i \in N \), define the “aggregate benefit function” as
\[
B(x, u, g) = \sum_{i \in N} b_i(x_i, u_i, g)
\]
where \( u = \{u_i : i \in N\} \). Under the assumed convexity, \( B(x, u, g) \) is concave in \( x \).

**Definition 2.** Given \( g = (0, \ldots, 0, 1) \), a “maximal equilibrium” is an allocation \((x, y, z, t)\) satisfying
\[
V(\alpha, u) = \max_{x, y, z, t} \left\{ B(x, u, g) \right. \\
\sum_{i \in N} \sum_{j \in N} r_{ij} \cdot t_{ij}^* : \right. \\
\left. (x, y, z, t) \text{ is feasible} \right\}
\]
where \( \alpha = (r, q_M, q_E, q_y) \) are the policy instruments. Let
\[
W(\alpha, u) = V(\alpha, u) + \sum_{i \in N} \sum_{j \in N} r_{ij} \cdot t_{ij}^*
\]
where \( t_{ij}^* \) solves the optimization problem (4a). In addition to being a maximal equilibrium, \( u \) is chosen such that \( W(\alpha, u) = 0 \), then the allocation is “zero maximal.”
In the absence of distortions (where \( r = 0, q_M = \infty, q_E = \infty \) and \( q_v = \infty \)), Luenberger (1992b) has shown that a zero maximal equilibrium identifies a Pareto-efficient allocation (where no consumer can be made better off without making any other worse off). In this context, the Pareto utility frontier is given by the set of utilities \( u \) satisfying \( W(0, \infty, \infty, \infty, \infty, u) = 0 \). Definition 2 expands on these results by considering an economy distorted by the policy instruments \( \alpha \).

The objective function in (4a) involves the aggregate benefit \( B(x, u, g) \) minus the tariff cost \( \sum_{i \in N} \sum_{j \in N} r_{ij} \cdot t_{ij} \). This can be interpreted as a “distorted aggregate benefit” where the tariffs \( r \) generate price distortions. The maximum equilibrium in (4a) thus involves maximizing this distorted aggregate benefit, \( B(x, u, g) - \sum_{i \in N} \sum_{j \in N} r_{ij} \cdot t_{ij} \), subject to feasibility constraints. And, the zero maximal equilibrium in (4b) implies choosing the utility levels \( u = \{ u_i : i \in N \} \) such that the aggregate benefit \( W(\alpha, u) \) equals zero. Note that the term \( \sum_{i \in N} \sum_{j \in N} r_{ij} \cdot t_{ij} \) in (4b) corresponds to the redistribution of the revenue generated by the tariffs.\(^3\) Interpreting \( W(\alpha, u) \) as the largest “aggregate surplus” that can be generated under policy distortions, zero maximality is then equivalent to the total redistribution of this surplus among consumers. In other words, having a nonnegative aggregate surplus, \( W(\alpha, u) \geq 0 \), can be interpreted as representing a feasible allocation, while \( W(\alpha, u) = 0 \) identifies the boundary of the feasible region under distortionary policy \( \alpha \). In this context, the values of \( u \) that satisfy \( W(\alpha, u) = 0 \) identify the “utility frontier” of the distorted economy.\(^4\)

The optimization problem (4a) can be expressed in terms of the Lagrangean

\[
L = B(x, u, g) - \sum_{i \in N} \sum_{j \in N} r_{ij} \cdot t_{ij} + \sum_{i \in N} p_i^f \cdot \left[ y_i - z_{ij} - \sum_j t_{ij} \right] + \sum_{i \in N} q_i^f \cdot \left[ \sum_j t_{ij} - x_i \right] + Q_M \cdot \left[ q_m - \sum_{i \in F} \sum_{j \in D} t_{ij} \right] + Q_E \cdot \left[ q_E - \sum_{i \in D} \sum_{j \in F} t_{ij} \right] + \sum_s Q_{ys} \cdot \left[ q_{ys} - \sum_{i \in D} y_i \right]
\]

where \( p_i^f, p_f^f, Q_M, Q_E \) and \( Q_{ys} \) are nonnegative Lagrange multipliers associated with the constraints (1a), (1b), (2a), (2b), and (2c), respectively. A key relationship between zero maximality and distorted market equilibrium is presented next (see the proof in the appendix).

**PROPOSITION 1.** Assume that \( u_i(x_i) \) is quasi-concave in \( x_i \) and strictly increasing in \( x_{im} \) for each \( i \in N_c \) that sets \( X_i, Y_i \), and \( Z \) are convex, and that \( p_i^f + g = p_i^{f*} + g = 1 \). Then, a zero maximal allocation \( (x^*, y^*, z^*, t^*) \) represents a distorted market equilibrium.

Note that \( p_i^{f*} + g = p_i^{f*} + g = 1 \) implies that \( p_i^{f*} = p_i^{f*} = p_i^{f*} \) for all \( i \in N \) (otherwise \( t_{jm}^{f*} \) or \( t_{jm}^{f*} \) would be unbounded, contradicting the existence of a saddle-point of \( L \) in (6)). Thus, the optimal choice of \( t_{jm} \) means that the price of the \( m \)th commodity (money) is the same for all agents. Without a loss of generality, it can always be normalized to 1 under the assumption that \( u_i(x_i) \) is strictly increasing in \( x_{im} \) for all \( i \in N_c \). This means that money is used as a basis for evaluating all welfare measures.

**Welfare Implications of Distorted Equilibrium**

Proposition 1 shows that the zero maximality provides a representation of distorted market equilibrium under some regularity conditions. We have seen that \( W(\alpha, u) = 0 \) identifies the utility frontier of the distorted economy (with \( W(0, \infty, \infty, \infty, \infty, \infty) = 0 \) identifying the Pareto utility frontier). This provides useful insights into the effects of the policy distortions \( \alpha \) as stated next (see the proof in the appendix).

**PROPOSITION 2.** Assume that \( u_i(x_i) \) is quasi-concave in \( x_i \) for each \( i \in N_c \) and the sets \( X_i, Y_i \) and \( Z \) are convex. Then, for any change in policy from \( \alpha \) to \( \alpha' \), a maximal allocation
satisfies

\[
\sum_{i \in N} \sum_{j \in N} r_{ij}' \cdot [N_{ij}^\alpha(\alpha', u) - N_{ij}^\alpha(\alpha, u)] + Q_M^\alpha(a', u) \cdot [q_M^\alpha - q_M]
\]

\[
+ Q_E\alpha(a', u) \cdot [q_E^\alpha - q_E]
\]

\[
+ \sum_s Q^{*\alpha}(a', u) \cdot [q_{ys} - q_{ys}]
\]

\[
\leq W(\alpha', u) - W(\alpha, u)
\]

\[
\leq \sum_{i \in N} \sum_{j \in N} r_{ij}' \cdot [N_{ij}^\alpha(\alpha', u) - N_{ij}^\alpha(\alpha, u)]
\]

\[
+ Q_M^\alpha(a, u) \cdot [q_M^\alpha - q_M]
\]

\[
+ Q_E\alpha(a, u) \cdot [q_E^\alpha - q_E]
\]

\[
+ \sum_s Q^{*\alpha}(a, u) \cdot [q_{ys} - q_{ys}].
\]

Proposition 2 provides a lower bound and an upper bound on the change in the aggregate surplus \([W(\alpha', u) - W(\alpha, u)]\) evaluated at \(u\). It is very general in the sense that it applies for endogenous treatment of markets, without differentiability assumptions, and it allows for discrete changes in the policy parameters \(\alpha\). With \(\alpha = (r, q_M, q_E, q_y)\), it includes the “joint” effects of price as well as quantity instruments used in both domestic and trade policy. These results generalize the previous trade policy analysis (e.g., Vousden; Turunen-Red and Woodland, 1991; Anderson and Neary, 1992, 1996; Neary). Also, proposition 2 includes some intuitive and well-known results as special cases. First, for a ceteris paribus change in \(r\), proposition 2 implies that \(\sum_{i \in N} \sum_{j \in N} r_{ij}' \cdot [N_{ij}^\alpha(\alpha', u) - N_{ij}^\alpha(\alpha, u)] \leq 0\). This gives the intuitive result that an increase in tariffs tends to decrease the corresponding quantity traded. Under differentiability, this implies that \(\partial N(\alpha, u) / \partial r\) is a symmetric, negative semi-definite matrix. Second, for a ceteris paribus change in \((q_M, q_E, q_y)\), proposition 2 implies that \([Q^{*\alpha}(\alpha', u) - Q^{*\alpha}(\alpha, u)] \cdot [q_M^\alpha - q_M] + \sum_s [Q^{*\alpha}(\alpha', u) - Q^{*\alpha}(\alpha, u)] \cdot [q_{ys} - q_{ys}] \leq 0\).

This gives the intuitive result that an increase in quotas tends to decrease the corresponding quota rents. Under differentiability, this means that \(\partial Q(\alpha, u) / \partial q\) is a symmetric, negative semi-definite matrix.

In general, with \(u : W(\alpha, u) = 0\) representing the utility frontier, the change in aggregate surplus, \(W(\alpha', u) - W(\alpha, u)\), provides a convenient monetary measure of the efficiency implications of a policy change from \(\alpha\) to \(\alpha'\). Indeed, \(W(\alpha', u) - W(\alpha, u) > 0(<0)\) identifies efficiency gains (losses) associated with an outward (inward) shift in the utility frontier. Two attractive choices for \(u\) are possible. If \(u\) is chosen such that \(W(\alpha, u) = 0\), then the change in surplus becomes \(W(\alpha', u)\), a “compensating variation” measure of the aggregate efficiency gains (losses if negative) due to the policy change from \(\alpha\) to \(\alpha'\). Alternatively, if \(u\) is chosen such that \(W(\alpha', u) = 0\), then the change in surplus becomes \(-W(\alpha, u)\), an “equivalent variation” measure of the aggregate efficiency losses (gains if negative) due to the policy change from \(\alpha\) to \(\alpha'\). With either choice, the term \([W(\alpha', u) - W(\alpha, u)]\) can be used to evaluate how the utility frontier shifts with a policy change from \(\alpha\) to \(\alpha'\). Figure 1 represents the efficiency gains generated by a move from \(\alpha = (r, q_M, q_E, q_y)\) to \(\alpha' = (r', q_M', q_E', q_y')\). Define a weak (strict) Pareto welfare improvement as a policy change associated with \(W(\alpha', u) - W(\alpha, u) > 0(<0)\). Then, proposition 2 implies that \(W(\alpha', u) - W(\alpha, u) \geq 0\) whenever \(\alpha' = (0, \infty, \infty, \infty, \infty)\). This gives the well-known result that complete market liberalization always generates nonnegative efficiency gains as it tends to shift up in the utility frontier (see Figure 1). Perhaps more importantly, proposition 2 identifies Pareto welfare improving moves under partial market liberalization, as stated next.

**PROPOSITION 3.** For any change from \(\alpha\) to \(\alpha'\), a sufficient condition for a weak (strict) Pareto welfare improvement is

\[
\sum_{i \in N} \sum_{j \in N} r_{ij}' \cdot [N_{ij}^\alpha(\alpha', u) - N_{ij}^\alpha(\alpha, u)]
\]

\[
+ Q_M^\alpha(a', u) \cdot [q_M^\alpha - q_M]
\]

\[
+ Q_E^\alpha(a', u) \cdot [q_E^\alpha - q_E]
\]

\[
+ \sum_s Q^{*\alpha}(\alpha', u) \cdot [q_{ys} - q_{ys}] \geq 0
\]

and a necessary condition for a weak (strict) Pareto welfare improvement is

\[
\sum_{i \in N} \sum_{j \in N} r_{ij}' \cdot [N_{ij}^\alpha(\alpha', u) - N_{ij}^\alpha(\alpha, u)]
\]

\[
+ Q_M^\alpha(a, u) \cdot [q_M^\alpha - q_M]
\]

\[
+ Q_E^\alpha(a, u) \cdot [q_E^\alpha - q_E]
\]

\[
+ \sum_s Q^{*\alpha}(\alpha, u) \cdot [q_{ys} - q_{ys}] \geq 0.
\]
Efficiency of Market Liberalization

It is worth emphasizing that these results apply under very general conditions: they allow for both price and quantity distortions on domestic as well as trade policy; they apply to multilateral policy reform involving many commodities and many countries; they allow for transaction costs (which can also provide disincentives to trade); they do not require differentiability assumptions; and they allow for discrete changes in policy instruments $a$.

As such, proposition 3 generalizes previous research on trade liberalization policies (e.g., Woodland; Vousden; Turunen-Red and Woodland, 1991; Anderson and Neary, 1992, 1996; Neary) or domestic policy analysis (e.g., Gisser; Gardner, 1983; Bullock and Salhofer; Bullock, Salhofer and Kola). Note that the terms $Q_M^* \cdot (q_M - q_m)$, $Q_E^* \cdot (q_E - q_e)$, and $\sum_y Q_{ys}^* \cdot (q_{ys} - q_{ys})$ are always non-negative when quotas are relaxed. From proposition 3, the conditions for partial market liberalization to be efficiency improving thus depend on the terms: $\sum_{i \in N} \sum_{j \in N} r_{ij} \cdot [t_{ij}^*(\alpha', u) - t_{ij}^*(\alpha, u)]$ and $\sum_{i \in N} \sum_{j \in N} r_{ij} \cdot [t_{ij}^*(\alpha', u) - t_{ij}^*(\alpha, u)]$. When the first term is positive, proposition 3 shows that partial market liberalization is always welfare improving. Alternatively, when the second term becomes negative, market liberalization could reduce efficiency.

From proposition 3, efficiency reduction would occur if $\sum_{i \in N} \sum_{j \in N} r_{ij} \cdot [t_{ij}^*(\alpha', u) - t_{ij}^*(\alpha, u)] + Q_M^* \cdot (q_M - q_m) + Q_E^* \cdot (\alpha, u) \cdot (q_E - q_e) + \sum_y Q_{ys}^* \cdot (\alpha, u) \cdot (q_{ys} - q_{ys}) < 0$. This would require that $\sum_{i \in N} \sum_{j \in N} r_{ij} \cdot [t_{ij}^*(\alpha', u) - t_{ij}^*(\alpha, u)]$ is negative and sufficiently large. Applying to both domestic and trade policies, this result appears quite useful. In a second best world, it warns us against policy reform (especially quota reform) that exacerbates pricing policy by stimulating exports that are subsidized and reducing imports that are taxed. Proposition 3 also includes as a special case the result that production quota “and” price support can be Pareto superior to a price support alone (e.g., as argued by Johnson, Gisser, Just, Alston and Hurd or Bullock and Salhofer in a partial equilibrium context).

To relate proposition 3 to previous literature, consider the special case where all functions are differentiable and policy changes involve only “small changes” in $a$. Then proposition 3 becomes:

**COROLLARY 1.** For a “small change” from $a$ to $a'$, $[W(\alpha', u) - W(\alpha, u)] \geq (>) 0$ if and only if

$$r \cdot \left[ \frac{\partial t^* (\alpha, u)}{\partial r} \right] \cdot (r' - r) + r \cdot \left[ \frac{\partial t^* (\alpha, u)}{\partial q_M} \right] \cdot (q_M' - q_M)$$
The corollary shows conditions under which policy changes generate aggregate efficiency gains. It generates as special cases a number of well-known results (e.g., Vousden; Turunen-Red and Woodland, 1991, 2000). First, in the absence of quotas ($q = 0$), proportional reductions in tariffs/subsidies (where $(r - r')$ is proportional to $r$) are always welfare improving. This follows directly from the corollary and the negative semi-definiteness of $[\partial t^*(\alpha, u)/\partial r]$. Second, in the absence of tariffs (where $r = 0$), the corollary implies that any relaxation of production or trade quotas is always efficiency improving. Note that these results are obtained without requiring additional assumptions (such as the “rank condition” used in Turunen-Red and Woodland (1991, 2000)). The corollary also shows that partial and nonproportional tariff reductions are not always welfare improving. In particular, it shows that, under constant quotas $q$, this would occur if: $r \cdot [\partial t^*(\alpha, u)/\partial r] \cdot [r' - r] < 0$. This is a second best situation where partial market liberalization would be immiserizing. Finally, the corollary shows how quotas and tariffs/taxes imposed by both domestic and trade policies can interact with each other to affect welfare. Here, new results are obtained that apply to the joint effects of domestic and trade policy reform. In the presence of tariffs and quotas, the corollary states conditions under which relaxing quotas are efficiency enhancing. But it also shows that these conditions are not always satisfied under partial market liberalization. Indeed, the term $r \cdot [\partial t^*(\alpha, u)/\partial q^M] \cdot [q^M' - q^M] + r \cdot [\partial t^*(\alpha, u)/\partial q^E] \cdot [q^E' - q^E] + r \cdot [\partial t^*(\alpha, u)/\partial q^y] \cdot [q^y' - q^y]$ cannot be signed a priori as it depends on the effects of quotas on trade: $\partial t^*(\alpha, u)/\partial q^M$, $\partial t^*(\alpha, u)/\partial q^E$, and $\partial t^*(\alpha, u)/\partial q^y$. As a result, there are scenarios where relaxing quotas in the presence of tariffs and/or subsidies does not satisfy the condition stated in the corollary. An example of this result involves partial market liberalization where relaxing quotas would stimulate the distorting effects of existing taxes/subsidies. Such scenarios are investigated below in an application to market liberalization and policy reform in the EU dairy sector.

Partial Equilibrium Analysis

The model just discussed applies in a policy distorted general equilibrium framework, allowing complex interactions across policy instruments and commodity markets as well as agents. These interactions raise frequent difficulties in the empirical modeling of detailed policy instruments and market characteristics which are relevant in policy analysis. Often, the analysis focuses on a particular sector. Then, the presence of linkages across sectors can make the empirical investigation of domestic and trade policy effects difficult. However, under some circumstances, the model can still generate useful guidelines for policy analysis. In this section, we explore the assumptions that can make the above analysis relevant for partial equilibrium analysis.

Consider focusing on a particular sector of the economy producing a set of commodities. Partition the consumption vector $x$ into two groups: a and b, where “group a” is the set of commodities generated by the sector of interest, “group b” denotes all other goods. A simple way to conduct partial equilibrium analysis on sector a would be to consider the maximization problem (4a), taking $(x_a, y_b, z_b, t_b)$ as given. This would amount to choosing the allocation $(x_a, y_a, z_a, t_a)$ in (4a) conditional on $(x_b, y_b, z_b, t_b)$. The advantage of this approach is that it would apply in general, without imposing restrictions on preferences or technology. Its main disadvantage is that it would neglect linkages and induced adjustments in sector b. An alternative approach to partial equilibrium analysis is to assume that the benefit function $b_i$ defined in (3a) can be written as $b_i(x_i, u_i, g) = b_{i1}(x^*_i) + b_{i2}(x^*_i, u_i)$. Then, we can decompose the optimization problem in (4a) into two stages: in a first stage, choose $D_1 = (x^*_b, y^*_b, z^*_b, t^*_b)$, conditional on $(x^*_a, y^*_a, z^*_a, t^*_a)$; in a second stage,
choose \( D_2 = (x^a, y^a, z^a, t^a) \). Consider the trade indirect cost function \( C(x^a, y^a, t^a, \cdot) = \min \{ \sum \{ i \in N | p_i^t \cdot z_i : (z, t) \in Z \} \} \). Then, equation (4a) can be written as:

\[
\begin{align*}
(4a') \quad V(\alpha, u) &= \max_{D_2} \left\{ \sum_{i \in N} b_{ai} (x^a_i) \
- C(x^a, y^a, t^a, \cdot) \
- \sum_{i \in N} \sum_{j \in N} r^a_i \cdot t^a_j : \text{equations (1) and (2) for group "a";} \quad D_2 \text{ is feasible} \right\}
\end{align*}
\]

where the first stage is:

\[
(4a'') \quad C(x^a, y^a, t^a, \cdot) = - \max_{D_1} \left\{ \sum_{i \in N} b_{bi} (x^b_i, u_i) \
- \sum_{i \in N} \sum_{j \in N} r^b_i \cdot t^b_j : \text{equations (1) and (2) for group "b";} \quad D_1 \text{ is feasible} \right\}
\]

Note that, when the benefit function \( b(\cdot) \) is strongly separable in \( x^a_i \) and \( (x^b_i, u_i) \), the demand for commodities \( x^a \) exhibits zero income effects. The outcome of the first stage optimization (4a'') generates the function \( C(x^a, y^a, t^a, \cdot) \) that measures the opportunity cost of producing \( y^a \) and generating consumption \( x^a \). This cost function is subtracted from the benefit function \( b_{ai} (x^a_i) \) in the second stage optimization (4a').

Equation (4a') is in fact the formulation commonly found in partial equilibrium models. In particular, marginal benefit being given by the price-dependent demand function, it follows that \( b_{ai} (x^a_i) \) can be measured as the area under the price-dependent curve. This is a standard benefit measure used in partial equilibrium welfare analysis (e.g., see Wallace, Gardner, 1987 or Bullock in the analysis of the social cost of agricultural programs). Equation (4a') also corresponds to the optimization formulation proposed by Samuelson, and Takayama and Judge in the context of spatial resource allocation, and by Chavas, Cox, and Jesse in the context of a spatially distributed vertical sector. \( C(x^a, y^a, t^a) \) in (4a') measures aggregate transaction cost (including transportation cost) for commodities in “group a,” plus aggregate production cost for \( y^a \) (e.g., as measured by the area below the aggregate supply curves for \( y^a \)). Then \[ \sum_{i \in N} b_{ai} (x^a_i) - C(x^a, y^a, t^a) \] in (4a') is the sum of producer and Marshallian consumer surplus across all agents, net of aggregate transaction cost.

Note that the effects of distortionary government policy show up in both (4a') and (4a''). Production and trade quotas affect first stage decisions as well as second stage decisions through the quota constraints (2). The effects of taxes and tariffs \( t \) tend to increase the cost of economic decisions in (4a') as well as (4a''). This means that, in a partial equilibrium model, distortionary government policies (including both domestic and trade policy) have two adverse effects on resource allocation. First, they have direct effects on the sector of interest. This can be seen in (4a') through the term \[- \sum_{i \in N} \sum_{j \in N} r^a_i \cdot t^a_j \] reflecting distorted price signals, and through the quota constraints (2) restricting desired economic adjustments in the sector. Second, it has indirect effects that are captured by the term \( C(x^a, y^a, t^a, \cdot) \) in (4a''). Indeed, from (4a''), this term can reflect economy-wide distortions (e.g., due to taxation) affecting the cost of production and trade (Alston and Hurst, Moschini and Sckokai).

By focusing only on resource allocation in a single sector, equation (4a') provides a convenient framework to conduct partial equilibrium analysis. We want to emphasize that it is fully consistent with the general equilibrium model presented above, meaning that all our earlier welfare results remain valid in this context. However, the convenience of (4a') is obtained only under some restrictive assumptions. They involve strong separability of the benefit function \( b(\cdot) \) in \( x^a \) and \( (x^b, u_i) \). This assumption implies zero income effects for \( x^a \). This means that formulation (4a') strictly holds only in the absence of income effects for \( x^a \). However, there are circumstances where (4a') can provide an approximate measure in the presence of income effects. As shown by Randall and Stoll, the approximation is good when the income flexibility of prices for \( x^a \) is small and the budget share for \( x^a \) is small. This suggests that, under such conditions, (4a') can be used “without an apology” in partial equilibrium economic and welfare analysis. Such arguments have been commonly used in applied analysis (e.g., Wallace; Gardner, 1987; Bullock).
Application to EU Dairy Policy

In this section we apply the theoretical results discussed in the previous sections by analyzing the impact of milk production quota removal in the EU. As shown above, quota removal in the presence of price distortions (tariffs and/or subsidies) may not lead to a Pareto welfare improvement. In this section we explore empirically some partial liberalization scenarios in the context of EU dairy policy and investigate conditions under which they can be efficiency improving. To accomplish this, a spatial model of the European dairy sector is developed based on our conceptual framework (see Bouamra-Mechemache). Dairy products represent a small expenditure share of the total budget of EU consumers and exhibit low to moderate income effects. Following Randall and Stoll, this suggests that the partial equilibrium model (4a') can provide a good approximation to the distorted dairy markets. The empirical model considers the dairy industry as a vertical sector where two agricultural products (cow milk and non-cow milk) are transformed into ten final products (butter, skim milk powder (SMP), whole milk powder (WMP), condensed milk, hard and semi-hard cheese, processed cheese, other cheeses, fluid milk, fresh products, and casein). Following Chavas, Cox and Jesse, the dairy processing technology is consistent with the allocation of two milk components (fat and proteins). The analysis covers nine EU regions (Belgium and Luxembourg; Denmark; Finland and Sweden; France; Germany and Austria; Ireland and United Kingdom; Italy and Greece; Netherlands; Spain and Portugal), plus the rest of the world (ROW).

The model integrates the following EU dairy policy instruments: (i) regional milk supply is subject to a regional production quota; (ii) intervention prices act as floor prices for butter and SMP domestic markets; (iii) domestic subsidies apply to industrial uses of butter and SMP; (iv) there is a production subsidy on casein; (v) export subsidies and import tariffs are imposed for each final dairy product. Moreover, GATT import and export commitments are explicitly modeled. On the export side, constraints are introduced for the four categories of dairy products defined by the GATT agreement. These constraints define an upper bound to the volume and to the value of subsidized exports. Nonsubsidized exports can occur in the model. On the import side, we define three regimes of imports (current access, minimum access and over-quota) with different tariff rates. This model extends the previous models of the dairy sector that have investigated the economic and welfare effects of EU dairy policy reform (e.g., Benjamin, Gohin, and Guyomard; Bouamra-Mechemache and Réguillart, 1999, 2000).

The model is based on the optimization problem in (4a'), where consumer benefit is measured as the area under the regional price-dependent demand curves and producer cost as the area under the regional supply curves. For a given set of policy instruments (a scenario), the model determines the regional milk prices paid to farmers, the regional milk productions, the regional shadow prices for milk components, the regional prices of dairy commodities, the regional productions and consumptions of final commodities, intra-EU trade and trade with ROW countries for each final dairy product. Finally, the surplus and welfare implications of policy scenarios can be computed from the model results.

Model Calibration with 1995 Data

The model is calibrated using 1995 EU and country specific data on prices, production, consumption, and trade. In the absence of strong prior information on their functional form, the supply and demand functions are assumed to be linear. For each region, their intercepts and slopes are set to be consistent with 1995 EU dairy market (i.e., price and quantity) conditions.

Special attention is devoted to cow milk supply due to the existence of production quotas. The model includes regional aggregated milk supply functions. The regional supply curves depend on the level of the regional quota rent. The regional quotas are implemented as upper bound production constraints at the regional level. Under this policy, observed regional milk prices are not equal to the regional marginal cost of production: they exceed marginal cost by the value of the corresponding quota rent. We estimate quota rents using data from quota lease markets when such markets exist. We calculate marginal cost in each region as the observed market price minus the estimated quota rent. These quota rent...
Table 1. EU Dairy Price Calibration Errors as Percentage of 1995 Data

<table>
<thead>
<tr>
<th></th>
<th>France</th>
<th>Belgium</th>
<th>Netherlands</th>
<th>Germany</th>
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<th>Italy</th>
<th>Greece</th>
<th>UK</th>
<th>Ireland</th>
<th>Denmark</th>
<th>Spain</th>
<th>Portugal</th>
<th>Sweden</th>
<th>Finland</th>
<th>EU</th>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Fluid milk</td>
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<td>2.8</td>
<td>-1.0</td>
<td>-2.8</td>
<td>6.0</td>
<td>-0.3</td>
<td>1.8</td>
<td>1.3</td>
<td>2.6</td>
<td>2.9</td>
<td>-12.6</td>
<td>0.2</td>
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<td></td>
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<td>0.3</td>
<td>-2.8</td>
<td>8.9</td>
<td>9.3</td>
<td>4.9</td>
<td>-1.2</td>
<td>12.6</td>
<td>-0.5</td>
<td></td>
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</tr>
<tr>
<td>SMP</td>
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<td>0.7</td>
<td>-0.5</td>
<td>1.9</td>
<td>2.2</td>
<td>1.2</td>
<td>-1.2</td>
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<td>-0.5</td>
<td>0.4</td>
<td>-0.1</td>
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<td></td>
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</tr>
<tr>
<td>WMP</td>
<td>1.5</td>
<td>1.6</td>
<td>1.8</td>
<td>1.2</td>
<td>1.8</td>
<td>1.5</td>
<td>1.8</td>
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<tr>
<td>Condensed milk</td>
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<td>0.3</td>
<td>1.1</td>
<td>-0.3</td>
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<td></td>
<td></td>
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<tr>
<td>Casein</td>
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<tr>
<td>Hard/semi hard cheese</td>
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<td>0.7</td>
<td>1.5</td>
<td>0.7</td>
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<tr>
<td>Processed cheese</td>
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<td>0.0</td>
<td>0.2</td>
<td>-0.3</td>
<td>0.4</td>
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<tr>
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<td>0.4</td>
<td>0.6</td>
<td>1.3</td>
<td>0.7</td>
<td>-0.4</td>
<td>0.8</td>
<td>1.0</td>
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rents are modelled as region specific and can be affected through transfers by lease or sales within regions. It is well known that nontransferable production quotas can generate cost inefficiencies (e.g., Burrell). Implementing a market for quota or removing the quota system is expected to improve production efficiency. Our regional model analyses the economic and welfare effects of quota removals, allowing for a reallocation of milk production across EU regions. However, it does not consider the current inefficiencies generated by nontransferable production quotas. We use long-term elasticities in order to analyse the long-term implications of policy changes. Depending on the countries, cow milk supply elasticities range between 1 and 1.5.

Tables 1 and 2 report the percentage difference between model simulation results and the 1995 data for aggregate EU and regional prices and consumptions. As shown in table 1, the model calibration errors for the weighted average EU prices (last column of table 1) are less than 1.5%. Regional raw milk prices are calibrated to exactly replicate the 1995 data. All regional commodity price calibration errors are less than 3% with some exceptions. As shown in table 2, the associated aggregate and regional consumption calibrations are equally robust, with calibration errors generally less than 2%. We conclude that the empirical model provides a reasonably good representation of the 1995 EU dairy sector.

Policy Simulation Results

To compare the impact of alternative policy scenarios on market equilibrium and welfare, we define a BASE scenario that represents a “2000 year” reference (“BASE2000”) by shifting domestic demand according to consumption trends while regional milk quotas are adjusted to their 2000 level. We also assume that the last year (2000) of the GATT commitments on imports and exports are implemented. We then apply different sets of partial EU policy reforms and compare the results of these scenarios with those of the “BASE2000” scenario.

To illustrate the implications of the conceptual model presented above, we focus attention on the removal of milk production quotas in the EU dairy sector. As a result, all scenarios investigated include elimination of milk production quotas. Each scenario differs by the other policy instruments that remain active. Four scenarios are analysed. In
Table 2. EU Dairy Consumption Calibration Errors as Percentage of 1995 Data

<table>
<thead>
<tr>
<th></th>
<th>France</th>
<th>Belgium</th>
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<td>Fluid milk</td>
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<td>2.5</td>
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<tr>
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<td>-0.5</td>
<td>-0.2</td>
<td>0.3</td>
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<tr>
<td>Fresh products</td>
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<tr>
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<tr>
<td>Hard/semi hard cheese</td>
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<td>-0.0</td>
<td>-0.4</td>
<td>-0.9</td>
<td>-0.4</td>
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<td>Processed cheese</td>
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<td>-0.2</td>
<td>-0.3</td>
<td>-0.4</td>
<td>-0.7</td>
<td>-0.4</td>
<td>0.2</td>
<td>-0.5</td>
<td>-0.6</td>
<td>-0.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

the first scenario (No Quota), regional milk production quotas are removed while keeping unchanged the other EU dairy policy instruments. In the second scenario (No Quota/No Cons/Prod Subsidies), quota removal is accompanied by the removal of EU consumption and production subsidies. In the third scenario (No Quota/50% Export Subsidies), quota removal is accompanied by a 50% decrease in unit export subsidies. Finally in the fourth scenario (No Quota/No Prod/Cons/Export Subsidies), we totally remove consumption subsidies, production subsidies as well as export subsidies. Import quotas and tariffs are maintained at GATT 2000 levels in all four scenarios.

**Impacts on Market Equilibrium**

A summary of the aggregate/average EU simulation results is presented in Table 3. All results compare each policy scenario with the “BASE 2000” scenario. We first analyse the impacts of these reforms on both domestic and world milk and dairy markets. Table 3 shows that, in response to the quota removal under all scenarios, EU milk production increases. This suggests that even though current EU prices are significantly higher than world prices, the marginal production cost of milk would allow the EU to be competitive in a more liberalized market with the removal of milk production quota. In other words, current EU milk prices are high in large part because they include a large quota rent, meaning that the elimination of production quotas would significantly reduce farm milk price. In all scenarios, milk prices decrease by more than 24% (see Table 3). Comparisons of scenarios 2, 3, and 4 with scenario 1 show that removing the non-quota policy instruments have smaller additional effects on milk price. As the removal of the other policy instruments tends to decrease demand for EU dairy commodities, these additional price effects are limited in part by some significant reduction in supply. Production level now reacts to the demand shift thus limiting the impact on prices by changes in production.

Markets for basic commodities (butter, SMP, and WMP) are greatly affected by quota removal. Demands for these products significantly depend on domestic as well as export subsidies (see Table 4). Thus, when subsidies are decreased or removed (scenarios 2, 3 and 4), prices and productions of butter, SMP and WMP are greatly affected. The magnitude of the impact on prices or production, however, depends on the scenario. In scenario 2, SMP price drops by more than 29% and its production decreases by 2.4% while EU milk production increases. Butter price decreases less because the share of subsidized consumption is smaller and because exports can still expand relative to the base scenario export level of butter. The same reasoning applies to the WMP market.

When export subsidies are decreased (scenario 3), the prices of butter, SMP and WMP decrease in roughly identical proportion. Finally, when domestic as well as export subsidies are removed (scenario 4), SMP and WMP production decrease significantly because they heavily depend on subsidized markets.
## Table 3. Impacts on Market Equilibrium (in Percentage Change Relative to the BASE 2000 Scenario)

<table>
<thead>
<tr>
<th></th>
<th>Scenario 1 No Quota</th>
<th>Scenario 2 No Quota/No Prod/Cons</th>
<th>Scenario 3 No Quota/50% Export Subsidies</th>
<th>Scenario 4 No Quota/No Prod/Cons/Export Subsidies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Milk</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production</td>
<td>7.4%</td>
<td>5.5%</td>
<td>5.0%</td>
<td>1.1%</td>
</tr>
<tr>
<td>Price</td>
<td>-24.6%</td>
<td>-25.7%</td>
<td>-26.0%</td>
<td>-28.2%</td>
</tr>
<tr>
<td>Price of fat</td>
<td>-12.3%</td>
<td>-8.1%</td>
<td>-23.9%</td>
<td>-21.0%</td>
</tr>
<tr>
<td>Price of protein</td>
<td>-29.9%</td>
<td>-34.6%</td>
<td>-24.1%</td>
<td>-29.6%</td>
</tr>
<tr>
<td><strong>Butter</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>-10.0%</td>
<td>-8.0%</td>
<td>-21.5%</td>
<td>-21.1%</td>
</tr>
<tr>
<td>Production</td>
<td>12.8%</td>
<td>5.3%</td>
<td>8.2%</td>
<td>-2.8%</td>
</tr>
<tr>
<td>Total consumption</td>
<td>6.9%</td>
<td>0.4%</td>
<td>14.7%</td>
<td>9.3%</td>
</tr>
<tr>
<td>Subsidized consumption</td>
<td>16.5%</td>
<td>-5.2%</td>
<td>35.4%</td>
<td>16.2%</td>
</tr>
<tr>
<td>Exports</td>
<td>52.0%</td>
<td>41.2%</td>
<td>-51.8%</td>
<td>-100.0%</td>
</tr>
<tr>
<td>World price</td>
<td>-24.8%</td>
<td>-19.7%</td>
<td>24.7%</td>
<td>47.7%</td>
</tr>
<tr>
<td><strong>Skim milk powder</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>-19.6%</td>
<td>-29.7%</td>
<td>-17.0%</td>
<td>-30.3%</td>
</tr>
<tr>
<td>Production</td>
<td>15.7%</td>
<td>-2.4%</td>
<td>9.6%</td>
<td>-15.1%</td>
</tr>
<tr>
<td>Total consumption</td>
<td>17.5%</td>
<td>-2.7%</td>
<td>15.1%</td>
<td>-2.3%</td>
</tr>
<tr>
<td>Subsidized consumption</td>
<td>24.6%</td>
<td>-7.3%</td>
<td>21.3%</td>
<td>-6.6%</td>
</tr>
<tr>
<td>Exports</td>
<td>0.1%</td>
<td>0.1%</td>
<td>-15.9%</td>
<td>-51.5%</td>
</tr>
<tr>
<td>World price</td>
<td>-0.0%</td>
<td>-0.0%</td>
<td>4.8%</td>
<td>15.6%</td>
</tr>
<tr>
<td><strong>Whole milk powder</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>-10.9%</td>
<td>-12.1%</td>
<td>-19.3%</td>
<td>-29.6%</td>
</tr>
<tr>
<td>Production</td>
<td>24.6%</td>
<td>26.6%</td>
<td>4.1%</td>
<td>-13.6%</td>
</tr>
<tr>
<td>Total consumption</td>
<td>3.7%</td>
<td>4.1%</td>
<td>6.5%</td>
<td>9.9%</td>
</tr>
<tr>
<td>Exports</td>
<td>39.2%</td>
<td>42.3%</td>
<td>1.5%</td>
<td>-31.6%</td>
</tr>
<tr>
<td>World price</td>
<td>-14.3%</td>
<td>-15.4%</td>
<td>-0.6%</td>
<td>11.5%</td>
</tr>
<tr>
<td><strong>Hard and semi-hard cheese</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>-12.6%</td>
<td>-13.3%</td>
<td>-12.8%</td>
<td>-14.0%</td>
</tr>
<tr>
<td>Production</td>
<td>6.2%</td>
<td>6.6%</td>
<td>6.3%</td>
<td>7.1%</td>
</tr>
<tr>
<td>Total consumption</td>
<td>6.7%</td>
<td>7.0%</td>
<td>6.8%</td>
<td>7.4%</td>
</tr>
<tr>
<td>Exports</td>
<td>0.0%</td>
<td>0.8%</td>
<td>0.0%</td>
<td>2.4%</td>
</tr>
<tr>
<td><strong>Fluid milk</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>-11.2%</td>
<td>-12.3%</td>
<td>-10.9%</td>
<td>-12.4%</td>
</tr>
<tr>
<td>Production</td>
<td>1.6%</td>
<td>1.7%</td>
<td>1.5%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Total consumption</td>
<td>1.3%</td>
<td>1.4%</td>
<td>1.3%</td>
<td>1.4%</td>
</tr>
<tr>
<td><strong>Unsubsidized exports of cheese</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Processed cheese</td>
<td>15.1%</td>
<td>14.9%</td>
<td>18.5%</td>
<td>18.9%</td>
</tr>
<tr>
<td>Other cheese</td>
<td>17.9%</td>
<td>19.5%</td>
<td>18.8%</td>
<td>21.4%</td>
</tr>
<tr>
<td><strong>Shadow value of GATT export constraints (Euro/kg)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Butter</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Skim milk powder</td>
<td>0.395</td>
<td>0.597</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Cheese</td>
<td>1.036</td>
<td>1.050</td>
<td>0.519</td>
<td>0.000</td>
</tr>
<tr>
<td>Other products</td>
<td>0.196</td>
<td>0.210</td>
<td>0.084</td>
<td>0.000</td>
</tr>
<tr>
<td><strong>Welfare (10^6 Euros)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EU Producers</td>
<td>-7,636</td>
<td>-8,012</td>
<td>-8,112</td>
<td>-8,847</td>
</tr>
<tr>
<td>EU Consumers</td>
<td>5,926</td>
<td>5,676</td>
<td>6,677</td>
<td>6,906</td>
</tr>
<tr>
<td>EU Taxpayers</td>
<td>-280</td>
<td>646</td>
<td>665</td>
<td>1,988</td>
</tr>
<tr>
<td>Total EU welfare</td>
<td>-918</td>
<td>-668</td>
<td>42</td>
<td>697</td>
</tr>
<tr>
<td>Total ROW welfare</td>
<td>172</td>
<td>174</td>
<td>-140</td>
<td>-291</td>
</tr>
<tr>
<td>Total World welfare</td>
<td>-746</td>
<td>-494</td>
<td>-98</td>
<td>407</td>
</tr>
</tbody>
</table>

**Table 4. Utilization of Dairy Products**

<table>
<thead>
<tr>
<th></th>
<th>Share of the Different Uses in 1998 in percentage</th>
<th>Subsidy percentage of EU Price</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unsubsidized Consumption</td>
<td>Subsidized Consumption</td>
</tr>
<tr>
<td>Butter</td>
<td>64</td>
<td>27</td>
</tr>
<tr>
<td>SMP</td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td>WMP</td>
<td>36</td>
<td>0</td>
</tr>
<tr>
<td>Condensed milk</td>
<td>73</td>
<td>0</td>
</tr>
<tr>
<td>Cheese</td>
<td>94</td>
<td>0</td>
</tr>
<tr>
<td>Fluid milk</td>
<td>99</td>
<td>0</td>
</tr>
</tbody>
</table>

\(^a\) On average.

Source: Zentrale Markt-und Preisberichtstelle (ZMP), Germany.

Butter production is less affected because its consumption is less dependent on subsidies. Note that the exports of these undifferentiated products drops heavily in this case. This suggests that EU has little comparative advantage in the production of such products.

On the other hand, when milk represents a smaller share of the total product value (e.g., fluid milk and cheeses), prices of these “high value-added” products decrease less than the prices of basic commodities (butter, SMP, and WMP) (see table 3). Because demand for “high value-added” products is mainly an unsubsidized domestic demand, the four scenarios have roughly identical impacts on prices and production of these products. A larger decrease in milk price leads to a larger decrease in the price of “high value added” products as well as a larger increase in their production at a rate that largely depends on the elasticity of domestic demand.

The results presented in table 3 show the impact of the removal of subsidy instruments on exports. While EU exports of undifferentiated products decrease (butter, SMP, and WMP), this is not the case for more differentiated products. These results suggest that the EU would be competitive on the world market for differentiated dairy products under market liberalizations.

**Impacts on Welfare**

The impact of policy reform on EU welfare is measured by changes in EU producer surplus, EU consumer surplus and cost to the EU taxpayers. The welfare changes reported in table 3 are expressed in million euros. Distributional impacts of the scenarios are large. Producer surplus decreases by 7.6 to 8.8 billion euros, while consumer surplus increases by 5.7 to 6.9 billion euros. Note that consumer gains do no fully offset producer losses. Taxpayers are also greatly affected, with gains that vary between 0 and 2.0 billion euros.

As an illustration of the conceptual arguments presented above, the results reported in table 3 indicate that partial liberalizations involving quota removal in the presence of price (tariff and subsidy) distortions do not automatically lead to an increase in aggregate “EU” welfare or “world” welfare (see proposition 3 and its corollary). If consumption, production and export subsidies remain at their initial level (scenario 1), then EU welfare decreases by 918 million euros. This result warns us against the removal of a production quota in the presence of a support price and export subsidies. It indicates that a production quota can reduce the distortions generated by existing price subsidies. Apparently, this helped motivate the EU milk production quota system introduced in 1984, when dairy subsidies and price support generated a high cost to the EU taxpayers. Moreover, in this scenario, “world” welfare is also negatively affected. This illustrates that, in a second best world, quota removal can have ambiguous impacts when other policy (especially price) instruments distort markets. This includes as a special case the situation discussed by Just, Alston and Hurd and Bullock and Salhofer, where combining a target price with a production quota can be more efficient than a target price alone.

When domestic subsidies are removed in addition to the milk production quotas (scenario 2), impacts on aggregate EU as well as world welfare remains negative but the loss in EU as well as world welfare are lower than in the first scenario. The removal of domestic subsidies has a small positive impact that does not offset the negative impact of quota removal. Rather it has redistribution effects from producers to consumers. The
net impact on aggregate EU welfare due to the removal of domestic subsidies is positive because it decreases deadweight losses due to price distortion both on the production side and on the consumption side. This net effect is small because price changes remain small when comparing scenario 2 with scenario 1. When export subsidies are partially removed in addition to production quotas (scenario 3), the impact on EU welfare is positive while the impact on world welfare is negative. Comparing scenarios 1 and 3 shows that cuts in EU export subsidies have a significant positive impact on EU welfare where consumer and taxpayer gains dominate producer losses. This is essentially due to a large country effect. Because EU is the major exporter on most world dairy markets, a decrease in its exports has a positive impact on world market prices that generates a net EU welfare gain. The ROW welfare is negatively affected because of the changes in world prices and EU net trade. We find that lowering export subsidies tends to increase world prices for butter and SMP, thus generated losses for ROW consumers (scenarios 3 and 4). In addition, binding import quotas for these commodities means that EU imports remain constant while the associated import quota rents decrease. Comparison between scenario 2 and 3 suggests that it is a better policy for the EU to cut export subsidies rather than to cut domestic subsidies (see table 3). Indeed, for an equivalent impact on producers and taxpayers, the second policy has a greater positive impact on EU consumers than the first.

When most instruments are removed (scenario 4), the impact on EU welfare is significantly positive and significantly greater than the negative impact on the rest of the world. As in scenario 3, the ROW welfare is reduced when the EU decreases its export subsidies. In this scenario, total world welfare increases by 410 million euros. The associated policy reform is thus identified as being efficiency improving. These results illustrate that it is only to the extent that price distortions are removed that one can expect production quota removal to improve aggregate welfare. As suggested in proposition 3, this is an example where relaxing domestic quotas can increase subsidized exports and exacerbate the adverse effects of current pricing policy on efficiency. Alternatively stated, we find that, in a second best world, production quotas can contribute to reducing the distorting effects of other policy instruments on the efficiency of the EU and world dairy sector.

While our empirical analysis ignores the distortionary effects of domestic taxation, we can get some insights on how such effects would influence our findings. Taking into account the opportunity cost of public funds, a reduction (increase) in the cost to EU taxpayers would generate additional welfare gains (losses) not accounted for in table 3. Such effects would further reduce EU and world welfare in scenario 1, and they would further increase EU and world welfare in scenario 4. Thus, at least for these two scenarios, our qualitative welfare results would remain valid under distorting EU taxation: (i) removing production quota while keeping other policy instruments unchanged (scenario 1) leads to a lower EU and world welfare; and (ii) eliminating both quotas and domestic and export subsidies (scenario 4) increases welfare even more.

**Concluding Remarks**

This article investigates the economic and welfare implications of domestic and trade policy distortions. A general equilibrium model based on Luenberger’s benefit function is used to integrate previous literature and provide an analytical structure to identify the welfare impacts of policy reform involving partial market liberalization. This conceptual model considers the distorted market equilibrium of an economy constituted of multi-commodities and multi-agents. It allows for both domestic and trade policies including both price instruments (import tariffs, export and production/consumption subsidies) and quantity instruments (production, import and export quotas). We know that, in a second best world, partial market liberalization is not always efficiency improving. This is particularly true of quota liberalization in the presence of price (tariff and subsidy) distortions. We generalize previous results indicating conditions under which policy

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9 As shown in optimal taxation theory, a large country exporter may have incentives to tax its exports. Here we analyze reduction in export subsidies; we therefore go in the right direction. See Moschini and Sckokai for an analysis of optimal choice of instruments.

10 Snow and Warren estimated that the welfare cost of 1 unit of public funds is in the range of -0.09 to 0.25.

11 For example, assuming that the opportunity cost of 1 unit of public funds equals 0.2, then EU total welfare would decrease by 56 million euros in scenario 1, and increase respectively by 129, 133, and 398 million euros in scenarios 2, 3, and 4.
reform is (or is not) efficiency enhancing. This provides a better theoretical support to empirical spatial partial equilibrium models.

We illustrate these results with an empirical application to EU dairy policy reform. Given the complexity of domestic and trade policy instruments currently used in the EU dairy policy, we develop an interregional partial equilibrium analysis of the EU dairy sector, where income and sectoral price effects from the EU dairy sector to the rest of the EU economy are assumed negligible. The empirical model provides a refined representation of the EU dairy sector, involving milk and the production, trade and consumption of ten dairy products among nine EU regions plus the rest of the world. The model is used to simulate the impacts of eliminating production quotas under four alternative partial market liberalization schemes: (i) quota elimination only; (ii) quota removal with elimination of production/consumption subsidies; (iii) quota removal with 50% reduction in export subsidies; and (iv) quota removal with both export subsidy reduction and elimination of production/consumption subsidies. These simulation results provide evidence concerning the relative interregional welfare impacts and policy trade-offs of alternative partial market liberalizations. For example, it is found that, from the EU viewpoint, it is more efficient to cut export subsidies than to cut domestic subsidies.

We show that the removal of the EU milk production quotas is welfare improving both at the EU and at the world level only with substantial liberalization of trade. Market liberalization always implies some welfare redistribution between producers, consumers and taxpayers. However, removing production quota is found to be efficiency improving only with the lowering or removal of subsidies. Indeed, in a second best situation, production quotas contribute to reducing the distorting effects of current EU pricing instruments on the efficiency of the EU and world dairy sector. Alternatively stated, production quota removal by itself is not a desirable policy alternative for either the EU or the world. Rather, policy reform should involve the joint consideration of domestic and trade policy instruments. This result would be relevant in further EU policy reform discussion as well as future WTO negotiations.

The analysis points to the importance of both efficiency improving policy reform and of welfare redistribution between producers, consumers and taxpayers, and across countries. Several issues remain worth exploring. The endogenous policy response by the rest of the world to large changes in EU dairy policy is not addressed. Given the "large country" attributes of the EU dairy sector, potential spillovers on the rest of the world and induced policy adjustments need to be investigated in further research. As well, we do not evaluate liberalization trade-offs involving agricultural (e.g., grains, oilseeds, and livestock) and other sectors. These linkages and tradeoffs are likely to be important part of the broader EU policy reform and trade liberalization discussions. Also, the issue of possible income redistribution needs to be addressed in more direct way. Building on previous literature (e.g., Gardner, 1983; Moschini and Sckokai), the analysis of the efficiency of redistribution in a multicommodity and multicountry framework needs to be refined. Finally, the possible role of imperfect competition and its interaction with policy reform need to be addressed. These appear to be good topics for further research.

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References


De Gorter, H., and K.D. Meilke. “Efficiency of Al-
Bullock, D.S., and K. Salhofer, “Measuring the So-
Bullock, D.S. “Redistributing Income Back to
Bouamra-Mechemache, Z., and V. Requillart. “Pol-
Bouamra-Mechemache, Z. “Modélisation des In-
Boots, M., A.O. Lansink, and J. Peerlings. “Effi-
Benjamin, C., A. Gohin, and H. Guyomard. “The
Beghin, J.C., and D.A. Sumner. “Dairy Policy and
Bouamra-Mechemache et aL
Gisser, M. “Price Support, Acreage Controls,
Gardner, B.L. “Efficient Redistribution through
Colman D., M.P. Burton, D.S. Rigby, and J.R.
Chavas, J.-P., T.L. Cox, and E. Jesse. “Spatial Alloca-
Franks. “Economic Evaluation of the UK Milk
Bois, D.S. “Disappearing Support, Acreage Controls,
Bouamra-Mechemache, Z., and V. Réguillart. “Pol-
Bouamra-Mechemache, Z., and V. Réguillart. “Pol-
Bouamra-Mechemache, Z. “Modélisation des In-
Gisser, M. “Price Support, Acreage Controls,
Bouamra-Mechemache, Z. “Modélisation des In-
Gardner, B.L. “Efficient Redistribution through
Gisser, M. “Price Support, Acreage Controls,

Appendix

PROOF OF PROPOSITION 1. Under the quasi-concavity of \( u_i(x_i) \) and the convexity of the sets \( X_i, Y_i, \) and \( Z \), the maximum equilibrium (4a) is equivalent to finding a saddle-point of the Lagrangean (6) where \( L \) is maximized with respect to \((x, y, t, z)\) and minimized with respect to \((p^T, p^c, Q_M, Q_E, Q_M)\) (see Takayama, p. 75). The maximization of \( L \) with respect to \( x_i \) implies that

\[
x_i^* \in \text{argmax}_x \left\{ b_i(x_i, u_i, g) - p_i^c \cdot x_i : x_i \in X_i \right\}
\]

for \( i \in \mathbb{N} \).

Given \( p_i^c \cdot g = p_i^c \cdot g = 1 \), Luenberger (1992a, pp. 272–3) has shown that \( \inf \{p_i^c \cdot x_i - b_i(x_i, u_i, g) : x_i \in X_i\} = \inf \{p_i^c \cdot x_i - b_i(x_i) \geq u_i, x_i \in X_i\} \), implying that \( p_i^c \cdot x_i^* \leq p_i^c \cdot x_i \) for all \( x_i \in X_i \) satisfying \( u_i(x_i) \geq u_i \). This yields condition (a) in definition 1.

The maximization of \( L \) with respect to \( y_i, z \) and \( t \) gives conditions (b) and (c) in definition 1. Finally, from the saddle-point theorem (Takayama, p. 74), the saddle-point of \( L \) implies the complementary slackness conditions stated in (d) and (e) of definition 1.

PROOF OF PROPOSITION 2. Under the quasi-concavity of \( u_i(x_i) \) and the convexity of the sets \( X_i, Y_i, \) and \( Z \), a maximal allocation satisfies a saddle-point of the Lagrangean \( L \) in (6). Let \( V(\alpha, u) \) denote the saddle value of \( L \). From Anderson and Takayama (p. 499), for any change from \( \alpha \) to \( \alpha' \), the saddle-point of \( L \) implies

\[
- \sum_{i \in \mathbb{N}} \sum_{j \in \mathbb{N}} (r_{ij}^* - r_{ij}) \cdot t_{ij}(\alpha, u) + Q_M(\alpha', u) \cdot [q_M' - q_M] + Q_E(\alpha', u) \cdot [q_E' - q_E] + \sum_s Q_{ys}(\alpha', u) \cdot [q_{ys}' - q_{ys}] \leq V(\alpha', u) - V(\alpha, u) - \sum_{i \in \mathbb{N}} \sum_{j \in \mathbb{N}} (r_{ij}^* - r_{ij}) \cdot t_{ij}(\alpha', u) + Q_M(\alpha, u) \cdot [q_M' - q_M] + Q_E(\alpha, u) \cdot [q_E' - q_E] + \sum_s Q_{ys}(\alpha, u) \cdot [q_{ys}' - q_{ys}].
\]

But \( W(\alpha, u) = V(\alpha, u) + \sum_{i \in \mathbb{N}} \sum_{j \in \mathbb{N}} r_{ij} \cdot t_{ij}(\alpha, u) \) from (4b). Substituting this into the above expression gives the desired results.