Competition and complementarity in Chinese and ASEAN manufacturing industries

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Abstract

The impact of China’s integration into the world market is likely to be experienced intensely by its labor-abundant ASEAN neighbors because they occupy similar trade niches. Of these, the electrical and electronics industries are of particular interest, as they constitute the “leading edge” of skill-intensive manufacturing industries in newly industrializing economies; their growth is thought to be a powerful stimulus to human capital accumulation in labor-abundant economies. By extension, changes in the trade patterns of the ASEAN-4 countries (Indonesia, Malaysia, Philippines and Thailand) caused by China’s growth could have crucial impacts on their long-term growth by affecting the rate of human capital accumulation. This paper uses the gravity model framework to test two empirical hypotheses: trade diversion—that expanded trade with China will reduce ASEAN-4 exports of electrical and electronic products to the world, and trade competition, that China and ASEAN-4 are competitors in global markets for these manufactures. Estimation results show that China’s growth increases the scale of production. However, we find a negative impact due to competition with China in third markets, especially where final products are concerned. The results imply benefits to ASEAN-4 from pursuit of the ASEAN-China FTA, since this will increase their access to the China market, but may also imply a need for policies to stimulate ASEAN-4’s human capital accumulation, in order to sustain their long-term comparative advantage.

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1. Introduction

Does the spectacular emergence of China as a producer and exporter of manufactures pose a threat or present an opportunity to its regional neighbors, the newly industrializing economies (NIEs) of Southeast Asia? On one hand, China’s growth increases the size of the market for ASEAN exports—and given the size of the Chinese economy and its sustained growth of 7% or more for many years, this effect is likely to be large so long as ASEAN retains comparative advantage, and increasing as trade barriers between China and the region are reduced. On the other hand, China’s increasingly sophisticated production structure has enabled it to begin commercially viable production of manufactures right across the skill-intensity spectrum. As China builds export capacity, could ASEAN NIEs’ skill-intensive industries go the way of their garment and footwear sectors, in essence swallowed whole by Pearl River Delta megafactories? According to endogenous growth theory, human capital accumulation plays an important role in helping a developing country sustain growth over the long term. Therefore, failure to accumulate human capital, caused by a loss of skill-intensive export industries, decreases the likelihood that the ASEAN-4 countries can sustain their climb up the industrial ladder from labor-abundant, resource-dependent economies into exporters of skill-intensive manufactures.

In this study, we use the gravity model as a framework to explain trade between China and ASEAN-4 in electrical and electronics products. The impacts of China’s integration into the world market can be thought of as causing changes in the scale and composition of ASEAN-4 production. The scale of production is expected to expand for products in which ASEAN-4 has comparative advantage over China, because of China’s size and rapid growth. The composition of ASEAN-4’s production is expected to change as the region’s comparative advantage and that of China evolve; production of goods in which ASEAN-4 has a comparative advantage over
China will stay in the region, while those in which China has comparative advantage over ASEAN-4 will move to China.

For reasons given above, our empirical study focuses on the electrical and electronics industries, which are important contributors to ASEAN-4 employment, exports, and growth. Our empirical investigation uses product-level data on bilateral trade in electrical and electronics products\(^1\) between ASEAN-4 and their seven major trade partners in electrical and electronics products in the most recent period available, from 1999 to 2003. We derive a modified gravity model in which the impacts on bilateral trade of China’s integration into the world economy consists of two phenomena: diverting exports to China (trade diversion to China), and competing with China in exports to third countries (trade competition with China).

The results support the prediction of expansion in the scale of production driven by exports to China, meaning that ASEAN-4’s export markets increase with the growth of the Chinese economy. However, we also find negative impacts from the growth of China’s export, primarily in final goods.

The paper is organized as follows. Section 2 presents the theoretical foundations of the gravity model and empirical evidence on China-ASEAN-4 trade. In section 3 we derive a modified gravity model, based on and extending the framework of Deardorff (1998). The model derived in this section has the advantage of having a firm basis in microeconomic theory, in contrast with the prevailing, more ad hoc approach to empirical gravity model estimation. Section 4 presents the data and methodology. Section 5 presents estimation results, and section 6 concludes.

\(^1\) HS-1996 Code 85, UN Commodity Trade Statistics Database (Comtrade)
2. Literature Review

2.1) Theoretical Foundations of the Gravity Model

The gravity model is one of the most commonly used empirical frameworks for the study of trade. It has been frequently and successfully used for nearly three decades to analyze bilateral trade flows across countries. The basic idea is that trade between two countries depends on their economic sizes and the distance which separates them. Economic size is usually measured by the GDP or GNP of the two countries. The distance is a measure of the cost of transporting goods between the two countries. It is usually found that greater economic size increases trade between countries, while greater distance between them decreases the volume of bilateral trade.

The simplest version of the gravity model takes the following form:\(^{2}\):

\[
X_{ij} = A \cdot \left( \frac{Y_i Y_j}{d_{ij}} \right)
\]

where \(X_{ij}\) is the value of exports from country \(i\) to country \(j\), \(Y_i\) and \(Y_j\) are the GDPs of \(i\) and \(j\), \(d_{ij}\) is a measure of distance between \(i\) and \(j\), and \(A\) is a constant of proportionality.

Of course, this highly stylized statement of the model cannot capture the richness of bilateral trade patterns. In addition to the primary variables described above, other variables, such as per capita GDP, population, land area, etc. are typically included in the gravity model as proxies for economic size. Dummy variables such as common language, adjacency, colonial relationship, trade blocs, etc. are also included to represent country-specific historical and cultural factors that are thought to affect bilateral trade.

The use of a gravity equation for describing trade flows first appeared in the empirical literature without theoretical foundations. Deardorff (1995) and Sohn (2005) provided useful

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\(^{2}\) Deardorff (1995) uses this equation as a standard gravity model.
literature reviews on the theoretical development of the gravity model; the following is a summary of their surveys. Tinbergen (1962) and Poyhonen (1963) performed the first econometric studies of trade flows based on the gravity equation, for which they gave only intuitive justification. Most gravity regressions fitted data very well, with $R^2$ values of 0.65-0.95. After that, many studies used variants of gravity equations as an empirical benchmark for the bilateral trade flows. Linnemann (1966) added more variables and went further toward a theoretical justification in terms of a Walrasian general equilibrium system, but the Walrasian model tends to include too many explanatory variables for each trade flow to be easily reduced to the gravity equation. Leamer and Stern (1970) followed Savage and Deutsch (1960) in deriving it from a probability model of transactions. Leamer (1974) used both the gravity equation and the H-O model to prompt explanatory variables in a regression analysis of trade flows, but he did not integrate the two approaches theoretically.

In the search for the theoretical background of the gravity model, Anderson (1979) and Bergstrand (1985) showed that it could be derived from a model of trade in products differentiated by country of origin, a structure known as the Armington assumption. Bergstrand (1989) derived a version of the gravity equation using a hybrid of the perfectly competitive Heckscher-Ohlin (H-O) model and the one-sector monopolistic competition of Krugman (1979). Helpman (1987) applied his test of data to the trade among OECD countries, where most would agree that monopolistic competition is plausibly present. Helpman interpreted the close fit of the gravity equation with bilateral data on trade as supportive empirical evidence for the monopolistic competition model. Hummels and Levinsohn (1995) performed some negative tests of the same proposition by looking for the same relationship in trade among a wider group of countries, including ones where monopolistic competition is less plausibly a factor. They
found that the test worked just as well for that group of countries, thus leading one to suspect that the relationship represented by the gravity equation is not unique to the monopolistic competition model. Feenstra et al. (1998) further derived a gravity equation from a reciprocal dumping model of trade with homogenous goods. This showed another kind of product differentiation model coming from factor endowment differences. Finally, Deardorff (1998) derived the gravity equation from the standard H-O model, both with frictionless and with impeded trade. His work showed that the H-O model, at least in some of the equilibria that it permits, easily admits interpretations consistent with the gravity equation. Due to the development of this theoretical foundation, it is generally accepted that a number of trade models are consistent with the empirical success of the gravity equation.

The gravity model is now one of the most commonly used bilateral trade frameworks in economics. Applications are widespread in such areas as studies of bilateral trade, regional trade blocs, home-market effects, etc. However, most econometric models use aggregate trade data; there is only a relatively small number of studies applying the gravity model at the level of product groups. Bergstrand (1989) and Fidrmuc (1998) present disaggregated models for one-digit SITC categories; Vittas and Mauro (1997) and Festoc (1997b) for two-digit SITC categories, and Schumacher (2003) for three-digit ISIC industries.

Our empirical study focuses on a specific sub-sector, the electrical and electronics industry, by applying the gravity model at a product level of this industry. The electrical and electronics industry is important not only because of its large contribution to ASEAN-4’s export earnings but also its linkages to human capital accumulation. The industries covered by our study form the “leading edge” of human capital intensive activities in NIEs. Their growth is

\[^{3}\text{4-digit HS-1996 Code 85}\]
thought to be a powerful stimulus for human capital accumulation in those countries. In particular, demand for skilled labor used in these production processes, and technology transferred via FDI into these industries, stimulate human capital accumulation processes. In most growth models, human capital plays a significant role in sustaining economic growth in the long term. Changes in patterns of trade in this industry, therefore, have potentially important implications not merely for human capital accumulation, but for long-term growth.

2.2) Empirical Evidence on China-ASEAN-4 trade

A number of previous studies have focused on the impacts of China’s integration into the world market and export competition with other Asian countries. Ahearne, Fernald, Loungani, and Schindler (2003) used a panel of annual data spanning 1981-2001 for four NIEs (Korea, Singapore, Taiwan, and Hong Kong) and ASEAN-4 members, thus considering the impact of China’s exports on the exports of these neighboring countries. They regressed the growth of these countries’ exports on the growth of foreign incomes and the change in the country’s real exchange rate, and then added China’s real export growth as an additional regressor to these export equations. While the coefficient on Chinese exports tended to be positive, suggesting complementarities between its exports and those of its Asian neighbors, it was not significant at standard confidence levels. On this basis, the authors concluded that there is little evidence that increases in China’s exports reduce the exports of other Asian economies.

Ianovichchina and Walmsley (2001) focused their study on China’s entry into the WTO, which they modeled as a liberalization of its trade regime that increased its propensity to import and export. They calibrated and simulated a multi-country, multi-sector model of international trade and found that China’s entry into the WTO had a positive impact on the exports of Japan
and the NIEs (Hong Kong, South Korea, Singapore and Taiwan), due mainly to the increase in their exports to China of high quality textile and electronics inputs (along with miscellaneous exports of processing industries). As important suppliers of materials to China, these countries will observe an improvement in their terms of trade and return to capital as well as an increase in production due to an expansion in exports to China. On the other hand, the simulations suggested a decline in exports (mainly of textiles and apparel) and a reduction in GDP relative to baseline levels in regional developing countries like Vietnam, the Philippines, Thailand, Indonesia, and Malaysia.

In the same way, Yang and Vines (2000) simulated a multi-country, multi-sector model with differentiated products as a way of analyzing the impact of China’s growth on exports from other Asian countries. They found that the exports of ASEAN countries dropped slightly, while those of Japan and the NIEs both increased. These overall effects are the sum of positive effects on exports to China itself and negative effects on exports to the third markets, which differ in magnitude depending on each Asian exporter.

The IMF (2004) used a computable general equilibrium model designed to capture the geographical and sectoral structure of trade flows. This analysis pointed to a small negative impact on the exports and output of all world regions. In terms of output, this negative effect (measured as the percentage deviation from values obtained in the slow-Chinese growth baseline) is largest for the Middle East and smallest for the advanced economies. The ASEAN economies suffer a somewhat larger than average impact, while the NIEs and South Asian economies experience a somewhat smaller than average impact. The precise effects vary by sector and country. For example, countries that rely heavily on exports of textiles and clothing,
labor-intensive manufacturing in which China also has a comparative advantage, tend to experience particularly large negative effects.

Chirathivat and Mallikamas (2005) simulated the effects of an ASEAN-China FTA using the model of the Global Trade Analysis Project (GTAP) as adapted in the Chulalongkorn and Monash General Equilibrium Model (CAMGEM). The model contains forty-five countries and fifty product sectors. They found that some sectors—notably rice, sugar, vegetable oils, textiles, chemicals, rubber and plastic products, and electronic equipment—would benefit from expanded trade with China. On the negative side, due to ASEAN’s lower trade barriers, imports from China would cause a decline in ASEAN’s output of vegetables and fruits. In addition, the FTA would create some trade diversion effects, such that intra-industry trade among ASEAN members would decline.

While most econometric models use aggregate trade data, CGE models use disaggregated data, but cannot be statistically verified. The limitation of this literature is that the results of simulation studies depend on how the models in question are calibrated. Econometric studies have not yielded precise estimates of the key effects, leading investigators either to draw inferences from coefficients that are not significantly different from zero or to suggest, on the basis of their failure to identify a significant effect, that one does not exist.

In a very recent contribution to the econometric side of this literature, Eichengreen et al. (2004) added China’s exports into the set of explanatory variables in the gravity framework. They found a tendency for China’s exports to the third markets to crowd out the exports of other Asian countries. However, this effect is felt mainly in markets for consumer goods, and hence is felt more by the less-developed Asian countries that export mainly final products. Crowding-out effects were small in markets for capital goods, and as a result China’s expansion tended to
benefit the more advanced Asian economies for which machinery and equipment comprise a significant fraction of total exports. At the same time, there has been a tendency for a rapidly growing China to suck up imports from its Asian neighbors. However, this direct effect of Chinese imports is also felt mainly in markets for capital goods, and thus by the more advanced Asian economies. This analysis of trade flows thus suggests that more and less developed Asian countries are affected differently by China’s growth.

Our study thus falls into a burgeoning tradition of using the gravity model to investigate the impacts of China’s integration into the world economy. In contrast to existing studies, in which the role for China’s exports is introduced into the modified gravity equation by the ad hoc process of simply adding variables into the estimating model, we develop a modified gravity model based on a microtheoretic framework.

3. **Modified Gravity Model**

In this section we derive the gravity model based on theoretical models of trade expounded in Mulapruk (2005). We start with the simplest case of frictionless trade. Distance plays no role in this case since there are no transport costs. Then, in the second case, we consider impeded trade by assuming the existence of barriers such as transport costs. To the extent that transport cost is related to distance, this immediately gives a result similar to the standard gravity equation, which includes distance. In the last two cases, we assume that a new country, i.e. China, enters into the world market, first under frictionless trade and then under impeded trade. In these models, the impacts of China’s integration into the world market on bilateral trade between pairs of countries $i$ and $j$ (exports from country $i$ to country $j$), are considered as i) trade diversion to China (exports from country $i$ divert to China), and ii) trade competition with China in third markets.
(exports from China compete with exports from country \(i\) in country \(j\)’s market). In the final case, we add the impact of China’s growth into the impeded trade model, and the resulting expression forms the basis of an econometric specification used in section 4.

3.1) Frictionless Trade

In this and the next subsection we adapt the framework presented in Deardorff (1998), which derived bilateral trade relationships for discrete goods from the standard Heckscher-Ohlin model, to derive a gravity model for a continuum of goods. We begin with two countries, home (\(H\)) and foreign (\(F\)), and assume existence of a set of intermediate goods \(z\), defined continuously over the range \([0,1]\). For simplicity, the preferences of consumers everywhere are assumed to be identical and homothetic. By comparing the unit costs of the two countries, we find that the home country specializes in the production of goods \(z \in [0,z^*]\), while the foreign country specializes in production of goods \(z \in [z^*,1]\). Let \(X_{HF}(z)\) be the value of exports of good \(z\) from \(H\) to \(F\). Let \(x_i\) be country \(i\)’s demand and \(y_i\) be its output in frictionless trade equilibrium with world price vector \(p\). Then, in the case of complete specialization, the value of \(H\)’s total exports to \(F\) can be written as:

\[
X_{HF} = \int_0^{z^*} p(z)x_F(z)dz
\]

\[
= \int_0^{z^*} p(z) \frac{\alpha(z)Y_F}{p(z)} dz
\]

\[
= \int_0^{z^*} p(z)x_w(z)Y_F Y_w^{-1} dz
\]
The first equality shows that the value of exports of good $z$ from $H$ to $F$ is equal to $F$’s total demand of goods $z \in [0, z^*]$. From the assumption of well-behaved and homothetic preferences, the share of income spent on every good $z$, $\alpha(z)$, is a function of commodity prices $p(z)$. Identical and homothetic preferences imply that the share of foreign income and the share of world income spent on the same good $z$ are equal, i.e. 

$$
\alpha(z) = \frac{x_F(z)p(z)}{Y_F} = \frac{x_W(z)p(z)}{Y_W}.
$$

Then we relate world demand for goods $z \in [0, z^*]$ to home’s total output and to home’s total revenue from production, $x_W(z)p(z) = y_X(z)p(z) = Y_H$.

Thus (paraphrasing Deardorff), with identical, homothetic preferences and frictionless trade, the standard gravity model in equation (1) can be derived, with a constant of $A = 1/Y_W$.

Bilateral trade between two countries is positively related to their incomes. Distance plays no role in this case since there are no transport costs.

Note that in the more general case in which there is no complete specialization, the derivation above still holds by defining $\gamma_H(z) = \frac{y_H(z)}{y_W(z)}$ to be the fraction of good $z$ supplied by $H$ and $y_W(z) = \sum_i y_i(z)$ to be the world output of good $z$. Then, the value of $H$’s total exports to $F$ can be written as:

$$
X_{HF} = \int_0^{z^*} \gamma_H(z)p(z)x_F(z)dz
$$
\[
= \int_0^{z^*} p(z) y_H(z) Y_F \frac{Y_F}{Y_W} \, dz
\]

\[
\therefore X_{HF} = \frac{Y_H Y_F}{Y_W}.
\] (3)

The standard gravity model still emerges with a constant of \( A = 1/Y_W \).

### 3.2) Impeded Trade

In the case of impeded trade, we assume the existence of barriers to trade such as transport costs for every product. Transport costs are assumed to take Samuelson’s iceberg form, with the transport factor (one plus the transport cost) between countries \( H \) and \( F \) being \( t_{HF} \). That is, a fraction \( t_{HF} - 1 \) of goods shipped from \( H \) is used up in transport to \( F \). The seller receives price \( p(z) \) and the buyer must pay the transport cost. Therefore, the buyers’ price in market \( F \) is \( t_{HF} p(z) \). Let \( y_H(z) \) be the output \( H \); then \( H \)’s income is

\[
Y_H = \int_0^{z^*} p(z) y_H(z) \, dz = \nu(z^*) Y_W,
\]

where \( \nu(z^*) = \frac{Y_H}{Y_W} \) is the relative size or output of \( H \) compared to the world. Trade can be valued as either exclusive of transport costs (f.o.b.) or inclusive of transport costs (c.i.f.). On a c.i.f. basis we get immediately\(^4\)

\[
X_{HF}^{cif} = \nu(z^*) Y_F = \frac{Y_H Y_F}{Y_W}.
\]

\(^4\) This derivation assumes Cobb-Douglas preferences; Deardorff develops the additional case of CES preferences.
On a c.i.f. basis, there is no role for transport costs or distance. On an f.o.b. basis, however, these flows must be reduced by the amount of the transport costs.

\[
X_{HF}^{fob} = \frac{Y_H Y_F}{t_{HF} Y_W}
\]

\[
\therefore X_{HF}^{fob} = \frac{Y_H Y_F}{d_{HF} Y_W}.
\]

(4)

To the extent that transport cost is related to distance, this immediately gives a result similar to the standard gravity equation, in which bilateral trade is positively related to the two countries’ incomes and negatively related to the distance between them, \(d_{HF}\).

### 3.3) Entrance of a Third Country: Frictionless Trade Case

We now assume that a third country \((T)\), analogous to China, joins the world market. This expands the market for home’s exports; now, \(H\) can export not only to \(F\) but also to \(T\). To \(H\), this is trade diversion to China. At the same time, \(F\) now can import either from \(H\) or from \(T\).

From the perspective of \(H\) this is competition with China.

Trade diversion to \(T\) may decrease bilateral trade between \(H\) and \(F\) if home’s output is limited and home’s exports to \(T\) crowd out its exports to \(F\). This constraint on supply growth is an important consideration in models of aggregate trade. However, our study focuses only on a subset of manufacturing goods, so it is reasonable to suppose that supply elasticities can be higher than might be expected for aggregate trade. In particular, it is possible that the entrance of \(T\) expands the scale of production in the home country. In this case, home’s exports to \(T\) will not crowd out its exports to \(F\), but will be positively related to them.
For trade competition, if $T$ has comparative advantage over $H$ in good $z$, we expect a negative impact of $T$’s expansion on $H$’s exports of that good; $H$’s exports to $F$ will lose market share. On the other hand, if $H$ has comparative advantage over $T$ in good $z$, we expect no competition with $T$ in that particular product. We first consider each phenomenon separately, and then combine them in a unified model later in this section.

i). **Trade Diversion to China**

We continue to assume frictionless trade and identical homothetic preferences. $H$’s total export of good $z$ is equal to its exports to $F$, $X_{HF}(z)$, and $T$, $X_{HT}(z)$. Let $s_F$ and $s_T$ be $F$ and $T$’s income relative to world income, i.e. $s_F = Y_F/Y_W$ and $s_T = Y_T/Y_W$. Each country consumes a fraction of $H$’s output according to their relative incomes. The modified version of the gravity model can be derived immediately:

$$X_H(z) = X_{HF}(z) + X_{HT}(z)$$

$$= \int_0^{z^*} s_F x_H(z)dz + \int_0^{z^*} s_T x_H(z)dz$$

$$= (s_F + s_T) \int_0^{z^*} x_H(z)dz$$

$$X_{HF}(z) = (s_F + s_T)Y_H - X_{HT}(z)$$

$$\therefore X_{HF}(z) = \frac{Y_F Y_H}{Y_W} + \frac{Y_T Y_H}{Y_W} - X_{HT}(z). \quad (5)$$

The first term in (5) is similar to that in a standard gravity model. The second term relates to the third country’s GDP, which captures the effect of access to $T$’s market on expansion of $H$’s export market. The last term capture trade diversion from $F$ to $T$. 
ii). Trade Competition with China

We now turn to competition with China. Let $M_F(z)$ be $F$’s imports. These are made up of exports of good $z$ from $H$ and $T$. $F$’s imports from each country are a function of $F$’s relative income and the outputs of $H$ and $T$. Then the modified gravity model is:

$$M_F(z) = X_{HF}(z) + X_{TF}(z)$$

$$= \int_0^z s_F x_H(z)dz + \int_0^z s_F x_T(z)dz$$

$$= s_F (Y_H + Y_T)$$

$$X_{HF}(z) = s_F (Y_H + Y_T) - X_{TF}(z)$$

$$\therefore X_{HF}(z) = \frac{Y_F Y_H}{Y_W} + \frac{Y_F Y_T}{Y_W} - X_{TF}(z). \quad (6)$$

Next, we combine the trade diversion trade competition by assuming that the total effect is a linear aggregation of these two effects with a weight parameter $\kappa$. That is:

$$(1 + \kappa)X_{HF}(z) = \frac{Y_F Y_H}{Y_W} + \frac{Y_F Y_H}{Y_W} - X_{HF}(z) + \kappa \left[ \frac{Y_F Y_H}{Y_W} + \frac{Y_F Y_T}{Y_W} - X_{TF}(z) \right]$$

$$\therefore X_{HF}(z) = \frac{Y_F Y_H}{Y_W} + \frac{Y_F Y_T}{Y_W} + \frac{1}{(1 + \kappa)} \left[ \frac{Y_F Y_H}{Y_W} \right] + \frac{\kappa}{(1 + \kappa)} \left[ \frac{Y_F Y_T}{Y_W} \right]$$

$$- \frac{1}{(1 + \kappa)} X_{HF}(z) - \frac{\kappa}{(1 + \kappa)} X_{TF}(z). \quad (7)$$

3.4) Entrance of the Third Country: Impeded Trade Case

In this section, we consider the entrance of China in impeded trade with a positive iceberg-type transport cost. The derivation in this section is similar to those already undertaken. Trade diversion to China and trade competition with China can be found as follows:
i). **Trade Diversion to China**

\[ X_{HF}^{\text{cif}} (z) = X_{HF}^{\text{cif}} (z, p(z) t_{HF} ) + X_{HT}^{\text{cif}} (z, p(z) t_{HT} ) \]

\[ = \int_{0}^{z^*} s_F p_H (z) t_{HF} x_H (z) dz + \int_{0}^{z^*} s_T p_H (z) t_{HT} x_H (z) dz \]

\[ = (s_F + s_T) \int_{0}^{z^*} x_H (z) dz \]

\[ X_{HF}^{\text{cif}} (z) = s_F Y_H + s_T Y_H - X_{HT}^{\text{cif}} (z) \]

\[ X_{HF}^{\text{fob}} (z) = \frac{s_F Y_H}{t_{HF}} + \frac{s_T Y_H}{t_{HT}} - \frac{X_{HT}^{\text{fob}} (z)}{t_{HT}} \]

\[ \therefore X_{HF}^{\text{fob}} (z) = \frac{Y_F Y_H}{Y_w t_{HF}} + \frac{Y_T Y_H}{Y_w t_{HT}} - \frac{X_{HT}^{\text{fob}} (z)}{t_{HT}}. \] (8)

ii). **Trade Competition with China**

\[ M_{HF}^{\text{cif}} (z) = X_{HF}^{\text{cif}} (z, p(z) t_{HF} ) + X_{TF}^{\text{cif}} (z, p(z) t_{TF} ) \]

\[ = \int_{0}^{z^*} s_F p_H (z) t_{HF} x_H (z) dz + \int_{0}^{z^*} s_T p_H (z) t_{TF} x_T (z) dz \]

\[ = s_F (Y_H + Y_T) \]

\[ X_{HF}^{\text{cif}} (z) = s_F Y_H + s_T Y_T - X_{TF}^{\text{cif}} (z) \]

\[ \therefore X_{HF}^{\text{fob}} (z) = \frac{s_F Y_H}{t_{HF}} + \frac{s_T Y_T}{t_{TF}} - \frac{X_{TF}^{\text{fob}} (z)}{t_{TF}} \]

\[ \therefore X_{HF}^{\text{fob}} (z) = \frac{Y_F Y_H}{Y_w t_{HF}} + \frac{Y_T Y_T}{Y_w t_{TF}} - \frac{X_{TF}^{\text{fob}} (z)}{t_{TF}}. \] (9)

Then we combine the two effects to obtain:

\[ (1 + \kappa) X_{HF}^{\text{fob}} (z) = \frac{Y_F Y_H}{Y_w t_{HF}} + \frac{Y_T Y_T}{Y_w t_{TF}} - \frac{X_{HT}^{\text{fob}} (z)}{t_{HT}} + \kappa \left[ \frac{Y_F Y_H}{Y_w t_{HF}} + \frac{Y_F Y_T}{Y_w t_{TF}} - \frac{X_{TF}^{\text{fob}} (z)}{t_{TF}} \right] \]
\[
X_{HF}(z) = \frac{Y_F Y_H}{Y_W d_{HF}} + \frac{1}{(1 + \kappa)} \left[ \frac{Y_T Y_H}{Y_W d_{HT}} \right] + \frac{\kappa}{(1 + \kappa)} \left[ \frac{Y_F Y_T}{Y_W d_{FT}} \right]
- \frac{1}{(1 + \kappa)} \left[ \frac{X_{HT}(z)}{d_{HT}} \right] - \frac{\kappa}{(1 + \kappa)} \left[ \frac{X_{TF}(z)}{d_{FT}} \right].
\]

(10)

The modified gravity equation is similar to that obtained in the previous case. The difference is only that all the terms are divided by related transport costs. To the extent that transport cost is related to distance, we get the modified gravity equation as follows:

\[
X_{HF}(z) = \frac{Y_F Y_H}{Y_W d_{HF}} + \frac{1}{(1 + \kappa)} \left[ \frac{Y_T Y_H}{Y_W d_{HT}} \right] + \frac{\kappa}{(1 + \kappa)} \left[ \frac{Y_F Y_T}{Y_W d_{FT}} \right]
- \frac{1}{(1 + \kappa)} \left[ \frac{X_{HT}(z)}{d_{HT}} \right] - \frac{\kappa}{(1 + \kappa)} \left[ \frac{X_{TF}(z)}{d_{FT}} \right].
\]

(11)

As a final step, we rearrange this expression, making substitutions using \( Y_T = Y_W - Y_F - Y_H \) to eliminate terms involving China’s GDP. The resulting equation, shown as (12) below, is the basis for econometric estimation.

4. Data and Methodology

In this study, we use 4-digit level data of bilateral trade in electrical and electronics products\(^5\) of ASEAN-4, China, and seven ASEAN-4’s major trade partners from 1999-2003. These countries accounted for about 73-82% of total exports from ASEAN-4 (See Table 3). A list of all twelve countries and forty-eight product categories used in this study can be found in Table 1. Our data on bilateral trade flows are from the UN Commodity Trade Statistics Database (UN Comtrade). GDP in current U.S. dollars are obtained from the World Bank’s World Development Indicators.

\(^5\) HS-1996 Code 85, UN Commodity Trade Statistics Database (Comtrade).
The U.S. GDP deflators from the Bureau of Economic Analysis (BEA\textsuperscript{6}) were used to obtain the real value of both exports and GDP. The distance between two countries is the distance between their capital cities, measured in miles.\textsuperscript{7}

Since there are eleven countries, excluding China, in the sample and this is a study of bilateral trade in forty-eight products, there should be 5,280 observations for each year -- a total of 26,400 observations. Data on some products in some years and in some countries, however, are unavailable. Hence, the effective sample is smaller at 16,558 observations.

We estimate the log linear form, as is common practice in existing studies. A log linear-form of equation (11) for estimation purposes is as follows:

\[
\ln X_{ij}(z) = \alpha + \beta_1 \ln Y_i + \beta_2 \ln Y_j + \beta_3 \ln N_i + \beta_4 \ln N_j + \beta_5 \ln d_{ij} \\
+ \beta_6 \ln d_{CH,j} + \beta_7 \ln X_{i,CH} + \beta_8 \ln X_{CH,j} + \varepsilon_{ij},
\]

where subscript \(w\) denotes world, \(i\) and \(j\) are countries (other than China) included in the study, \(Y_i\) and \(N_i\) are the GDP and population of country \(i\), \(d_{i,j}\) is the distance between country \(i\) and \(j\), and \(X_{i,j}\) is exports from \(i\) to \(j\).

We consider bilateral trade flows between eleven countries, the ASEAN-4 and their seven major trade partners, excluding China. The dependent variable is the real value of exports of good \(z\) from country \(i\) to \(j\). The two most important explanatory variables for our purposes are exports from country \(i\) to China, with coefficient \(\beta_7\), and exports from China to \(j\), with coefficient \(\beta_8\). These tell us what will happen to trade flows between pairs of non-China economies, as China increases its import demand and export supply; as such, they provide an indication of the effects on other countries of trade liberalization in China, other things equal. If

\textsuperscript{6} U.S. Department of Commerce
\textsuperscript{7} Source: http://www.wcrl.ars.usda.gov/cec/java/capitals.htm
an increase in exports from $i$ to China crowds out exports from $i$ to $j$, we expect our estimate of $\beta_7 < 0$; conversely, if an increase in exports from $i$ to China has a positive impact on exports from $i$ to $j$, we expect $\beta_7 > 0$. For exports from China to $j$, the variable with coefficient $\beta_8$ relates to the comparative advantage of China and $i$. If China has a comparative advantage over $i$ in any good $z$, we will find a negative impact of exports from China to $j$ on exports from $i$ to $j$, and $\beta_8 < 0$. In contrast, if $i$ has a comparative advantage over China in that good $z$, the exports from China to $j$ will have no impact on exports from $i$ to $j$ and $\beta_8 = 0$.

As pointed out by Eichengreen et al. (2004), it is important to recognize the potential endogeneity of exports from $i$ to China (China’s imports), and exports from China to $j$ (China’s exports). Unobserved omitted variables (for example, an improvement in sentiment worldwide) that increase Thailand’s exports to Germany will also in general increase China’s exports to Germany, creating a correlation between the error term and the key explanatory variable. An analogous example can also be found for China’s imports. Therefore, we performed a test for endogeneity, the Durbin-Wu-Hausman (DWH) test, and found that both China’s exports and imports have such a problem. The standard treatment for this type of problem is instrumental variables. In the present context, the gravity model suggests instruments that are both plausibly exogenous and strongly correlated with Chinese exports and imports. As in Eichengreen et al. (2004), we choose China’s GDP and the distance between China and $j$ to serve as instruments for exports from China to $j$. The instrument for the exports from $i$ to China is its own lagged value. In addition, the omitted variables also give us individual-specific effects; that is, they are
attributes specific to each pair of countries, but stay fairly constant over time. In this situation, a fixed-effects analysis is appropriate.

We now consider other explanatory variables in the equation. The first independent variables are trading partners’ GDPs. These serve as proxies for countries’ economic sizes, both in terms of production capacity and size of market. Larger countries, with greater production capacity, are more likely to achieve economies of scale and increase their exports based on comparative advantage. They also possess large domestic markets able to absorb more imports. Therefore, an increase in trading partners’ GDPs is expected to increase bilateral trade volumes. Thus, we expect that the estimated coefficient of $\beta_1, \beta_2 > 0$.

Note that while country $i$’s GDP is strongly correlated with its exports, questions can be raised about its exogeneity. However, the dependent variable is country $i$’s exports in a specific good to a particular market -- for example, exports of integrated circuits to Malaysia -- not its aggregate exports. While there are convincing reasons for thinking that the causality runs from aggregate exports to GDP in addition to the other way around, it is less plausible that GDP is significantly affected by its exports of a particular good to a particular market.

Many gravity model studies use per capita GDP as an explanatory variable. Per capita GDP serves as a proxy for the income level and/or purchasing power of a country. More precisely, it is whether we express the explanatory variables as GDP and per capita GDP, or as GDP and population. Frankel (1997) provided a useful example. To be consistent with the modified gravity equation, we add a population variable ($N$) into the list of explanatory variables and let it enter into the equation in a similar form to GDP. When controlling for GDP, the coefficient on population is generally negative. This captures the well-known phenomenon
whereby larger countries tend to be relatively less open to trade, measured as a percentage of GDP.

5. Estimation Results

Consider the observations for all bilateral trade flows between eleven countries, excluding the observations for China’s exports and imports, which are treated as explanatory variables. The first column of Table 4 shows the results of the log-linear model using observations for bilateral trade flows, of which the exporters are the ASEAN-4 economies. Then in columns 2-4, results are shown for estimates obtained by dividing the dataset into three product groups: final goods, intermediate goods, and a limited set of intermediate goods, respectively. The impacts of China’s growth on products with different skill-intensity vary due to the comparative advantage of China and ASEAN-4. With a presumption that intermediate products have a higher skill-intensity as compared to final products, if the degree of ASEAN’s comparative advantage over China differs between intermediate and final products, then pooling the two groups of data could yield incorrect results. Moreover, ASEAN’s exports of integrated circuits (IC, HS-1996 code 8542) to China are enormous compared to other products (see Figures 1-4). Therefore we consider separately the estimates for a limited set of intermediate goods, meaning intermediate goods excluding IC; otherwise, the impacts of trade in IC may dominate the impacts on other intermediate goods. The appendix provides a list of goods included in each group. As mentioned above, exports from $i$ to China are instrumented by their own lagged values; China’s GDP and the distance between China and $j$ are used as instruments for exports from China to $j$.

There is also potential heterogeneity among the countries of ASEAN-4, and to the extent that the data allow it, we want to examine this. The Malaysian economy is clearly more
advanced in terms of industrialization, and especially in the manufacture of electrical and electronics goods, than its neighbors. Table 5 shows the results of estimating the model using observations for all bilateral trade flows when the exporters are ASEAN-3, i.e. ASEAN-4 excluding Malaysia.\(^8\)

The results in both sets of estimates are broadly consistent. The coefficients of exports from \(i\) to China are positive and significant in all models, meaning that an increase in exports from \(i\) to China does not crowd out exports from \(i\) to \(j\). Rather, these imply an expansion in the scale of production in \(i\) due to China’s integration into the world market, which increases the size of \(i\)’s export market. By contrast, the coefficients of exports from China to third-country \(j\) are found to be negative and significant in each aggregate product category. Growth of China’s exports reduces ASEAN countries’ exports to third markets. This effect, as the estimates show, is much larger for final goods, and larger still when relatively-advanced Malaysia is excluded from the sample. ASEAN’s producers of final goods within HS85 face a significant threat to their export markets from China, whereas producers of intermediates can expect to grow along with the Chinese economy—at least while the structure of production and trade shown in these data continues to prevail. These findings indicate that the more advanced ASEAN economies will produce narrower ranges of goods, but in greater quantity: they will specialize and occupy niche markets within the electrical and electronics sectors.

6. Conclusion

\(^8\) In an earlier version of this paper we examine several other model specifications, including estimation on the full sample of bilateral trade flows with and without dummy variables for ASEAN-4 and ASEAN-3; differential treatment of the Indonesian data, and experiments with different lag lengths for the \(X_{i,CH}\) instrumental variable. Results are available on request.
China’s entrance into the world market has been one of the most important recent developments affecting the structure and evolution of the world economy. The strong impact of China’s growth is particularly likely to be felt in the labor-abundant ASEAN-4 countries, because they occupy trade niches similar to China’s, i.e. exporting mainly labor-intensive products. It is of particular interest to ask what effects China’s expansion has had on exports of electrical and electronics products from these countries, since production of these goods uses both ‘raw’ and skilled labor. After low-skill, labor-intensive industries such as garments, footwear and furniture, exploitation of comparative advantage in production of electrical and electronic goods appears to be an important step on the industrialization ladder. In addition—and arguably in contrast to the first-generation sectors—expansion of electrical and electronics industries provides a powerful stimulus to investments in human capital, which then pay dividends both for aggregate economic growth and for continued structural change.

In this study we derived a modified gravity model in which the impacts of China’s integration into the world market on bilateral trade between pairs of countries consist of two phenomena: trade diversion to China, and trade competition with China. Unlike most preceding studies, which aggregate across much broader product categories, our empirical investigation focused solely on the electrical and electronics industry. Again unlike most such studies, the modification of the gravity model used in our analysis is built upon explicit microtheoretic foundations. To maximize our chances of “learning about what’s ahead by looking in the rearview mirror”, we restricted our analysis to product level data of bilateral trade between ASEAN-4 and their major trade partners in this industry from 1999 to 2003.

The results support the prediction of expansion in the scale of production in electrical and electronics industry, meaning that ASEAN-4’s export markets increase with the growth of China.
On the other hand, China’s exports have negative impacts on ASEAN-4’s exports to the rest of the world. It seems that the future for ASEAN-4’s electrical and electronics industries is to specialize, becoming suppliers of intermediates to Chinese producers of final goods. This is not such a bad prospect, and may indeed be in line with the long-run comparative advantage of such economies. But sectors and countries specialized in final goods within these industries have lost ground as China expands, and could reasonably be expected to continue to do so in the future.

Because the industries covered by this analysis are those which form the “leading edge” of human capital intensive activities in NIEs and their growth is thought to be a powerful stimulus to human capital accumulation in those countries, the prospect of lower overall output growth rates due to competition with China should be troubling. On one hand, our results suggest the desirability of the China-ASEAN FTA, which allows ASEAN-4 to gain more benefits from China’s market growth. On the other hand, government policies that help stimulate ASEAN-4’s human capital accumulation may be desirable in order to sustain long-term comparative advantage over a broader range of goods.

Finally, there is the question of whether China’s dominance of regional and global markets for manufactures will permit the later-developing ASEAN nations (notably Vietnam, Cambodia and Laos) any chance of breaking into the industrialization race. As Pack and Saggi (2005:44) point out, this may depend less on national policies than on their capacity to integrate with international networks based on multinational producers or global buyers, rather than on more conventional measures of comparative advantage.
Note: For Table 1 and Table 3 see separate data appendix

Table 2: Statistics of variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1999</td>
<td>2000</td>
</tr>
<tr>
<td>Yi (billion US$)(^1)</td>
<td>1,571.0</td>
<td>1,632.7</td>
</tr>
<tr>
<td>Popi (million)(^1)</td>
<td>83.8</td>
<td>84.7</td>
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<tr>
<td>Xi,j (million US$)(^2)</td>
<td>40.63</td>
<td>63.62</td>
</tr>
<tr>
<td>Xi, ch (million US$)(^2)</td>
<td>0.05</td>
<td>0.06</td>
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<tr>
<td>Xch,j (million US$)(^2)</td>
<td>0.02</td>
<td>0.04</td>
</tr>
<tr>
<td>di,j (miles)(^3)</td>
<td>4,027.29</td>
<td></td>
</tr>
<tr>
<td>di, ch (miles)(^3)</td>
<td>2,910.59</td>
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</tr>
<tr>
<td>Yi (billion US$)(^1)</td>
<td>2,738.9</td>
<td>2,900.7</td>
</tr>
<tr>
<td>Popi (million)(^1)</td>
<td>83.7</td>
<td>84.6</td>
</tr>
<tr>
<td>Xi,j (million US$)(^2)</td>
<td>213.17</td>
<td>319.92</td>
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<tr>
<td>Xi, ch (million US$)(^2)</td>
<td>0.18</td>
<td>0.26</td>
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<tr>
<td>Xch,j (million US$)(^2)</td>
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<td>di,j (miles)(^3)</td>
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<td>di, ch (miles)(^3)</td>
<td>1,800.95</td>
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Source: \(^1\)World Bank, World Development Indicators  
\(^2\)UN Comtrade  
\(^3\)http://www.wcrl.ars.usda.gov/cec/java/capitals.htm
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<thead>
<tr>
<th>Variable</th>
<th>All Goods</th>
<th>Final Goods</th>
<th>Intermediate goods</th>
<th>Intermediate excl. IC</th>
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<tbody>
<tr>
<td>ln($Y_i$)</td>
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<td>.731</td>
<td>1.237</td>
<td>1.464</td>
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<tr>
<td></td>
<td>.253***</td>
<td>.430*</td>
<td>.276***</td>
<td>.279***</td>
</tr>
<tr>
<td>ln($Y_j$)</td>
<td>1.934</td>
<td>2.374</td>
<td>1.423</td>
<td>1.435</td>
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<td>.111***</td>
<td>.282***</td>
<td>.093***</td>
<td>.094***</td>
</tr>
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<td>-.290</td>
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<td>.075***</td>
<td>.128***</td>
<td>.081***</td>
<td>.082***</td>
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<td>.173***</td>
<td>.057***</td>
<td>.056***</td>
</tr>
<tr>
<td>ln($d_{ij}$)</td>
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<td>-1.477</td>
<td>-1.828</td>
<td>-1.872</td>
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<tr>
<td></td>
<td>.079***</td>
<td>.117***</td>
<td>.089***</td>
<td>.092***</td>
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<td>ln($d_{i,ch}$)</td>
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<td>2.119</td>
<td>-.067</td>
<td>.006</td>
</tr>
<tr>
<td></td>
<td>.250***</td>
<td>.427***</td>
<td>.273***</td>
<td>.275</td>
</tr>
<tr>
<td>ln($X_{i,ch}$) lag 1</td>
<td>.296</td>
<td>.176</td>
<td>.355</td>
<td>.322</td>
</tr>
<tr>
<td></td>
<td>.022***</td>
<td>.038***</td>
<td>.023***</td>
<td>.024***</td>
</tr>
<tr>
<td>ln($X_{ch,j}$)</td>
<td>-.863</td>
<td>-1.059</td>
<td>-.460</td>
<td>-.474</td>
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<tr>
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<td>.109***</td>
<td>.267***</td>
<td>.091***</td>
<td>.092***</td>
</tr>
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<td>-20.246</td>
<td>-24.466</td>
<td>-30.098</td>
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<tr>
<td></td>
<td>4.309***</td>
<td>7.421***</td>
<td>4.66***</td>
<td>4.732***</td>
</tr>
</tbody>
</table>

N         4517  1805   2712    2602
Groups    48     22     26     25
R² Within  0.0214  0.2403  0.1994
Between   0.3716  0.4883  0.0234  0.1208
Overall  0.0015  0.0001  0.1107  0.0878

Notes:
Fixed-effects IV estimator (Stata v.9); standard errors in parentheses
$X_{ch,j}$ instrumented by $Y_{ch}$ and $d_{ch,j}$
$X_{i,ch}$ instrumented by own lagged value
Significance: *** at 1 percent; ** at 5 percent; * at 10 percent
### Table 5: Bilateral trade flows ASEAN-3 (excl. Malaysia: modified gravity eq. estimates)

<table>
<thead>
<tr>
<th>Variable</th>
<th>All Goods 1</th>
<th>Final Goods 2</th>
<th>Intermediate goods 3</th>
<th>Intermediate excl. IC 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln(Y_i)</td>
<td>1.224</td>
<td>.999</td>
<td>.536</td>
<td>0.607</td>
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<tr>
<td></td>
<td>.618**</td>
<td>1.26</td>
<td>.587</td>
<td>.590</td>
</tr>
<tr>
<td>ln(Y_j)</td>
<td>2.734</td>
<td>3.043</td>
<td>1.851</td>
<td>1.841</td>
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<tr>
<td></td>
<td>.255***</td>
<td>.799***</td>
<td>.181***</td>
<td>.182***</td>
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<tr>
<td>ln(N_i)</td>
<td>-.053</td>
<td>-.479</td>
<td>-.609</td>
<td>-.820</td>
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<tr>
<td></td>
<td>.491</td>
<td>1.14</td>
<td>.445</td>
<td>.449**</td>
</tr>
<tr>
<td>ln(N_j)</td>
<td>-1.207</td>
<td>-1.571</td>
<td>-.660</td>
<td>-.611</td>
</tr>
<tr>
<td></td>
<td>.140***</td>
<td>.465***</td>
<td>.100***</td>
<td>.096***</td>
</tr>
<tr>
<td>ln(d_ij)</td>
<td>-2.831</td>
<td>-2.194</td>
<td>-2.561</td>
<td>-2.594</td>
</tr>
<tr>
<td></td>
<td>.206***</td>
<td>.356***</td>
<td>.189***</td>
<td>.194***</td>
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<tr>
<td>ln(d_i, ch)</td>
<td>.067</td>
<td>.979</td>
<td>1.594</td>
<td>2.159</td>
</tr>
<tr>
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<td>1.53</td>
<td>5.547</td>
<td>1.406</td>
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<tr>
<td>ln(X_i, ch) lag 1</td>
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<td>.156</td>
<td>.340</td>
<td>.302</td>
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<tr>
<td></td>
<td>.030***</td>
<td>.061**</td>
<td>.029***</td>
<td>.029***</td>
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<tr>
<td>ln(X_ch,j)</td>
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<td>-1.544</td>
<td>-.750</td>
<td>-.741</td>
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<td>.239***</td>
<td>.735**</td>
<td>.169***</td>
<td>.170***</td>
</tr>
<tr>
<td>Constant</td>
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<td>-10.687</td>
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<tr>
<td></td>
<td>11.506**</td>
<td>23.839</td>
<td>10.995</td>
<td>11.067</td>
</tr>
</tbody>
</table>

| N                         | 2922        | 1115          | 1807                 | 1727                    |
| Groups                    | 47          | 21            | 26                   | 25                      |
| R^2 Within                | 0.0214      | 0.0829        | 0.0896               |                         |
|   Between                 | 0.4199      | 0.4571        | 0.2827               | 0.3497                  |
|   Overall                 | 0.0207      | 0.0227        | 0.0217               | 0.0197                  |

Notes:
Fixed-effects IV estimator (Stata v.9); standard errors in parentheses
X_{ch,j} instrumented by Y_{ch} and d_{ch,j}
X_{i,ch} instrumented by own lagged value
Significance: *** at 1 percent; ** at 5 percent; * at 10 percent
Figure 1: ASEAN-4 exports to seven major trade partners
in electrical and electronics industry

Figure 2: Seven trade partners export to ASEAN4
in electrical and electronics industry
Table 3: ASEAN4 exports to China in electronical and electronics industry

![Diagram of ASEAN4 exports to China in electronical and electronics industry]

Figure 4: China exports to ASEAN4 in electrical and electronics industry

![Diagram of China exports to ASEAN4 in electrical and electronics industry]
References


