FIRMS IN A GLOBAL ECONOMY

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ABSTRACT

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Chapter 1: Multiproduct Competition in the Global Economy

This paper presents a simple model of heterogeneous multiproduct firms to examine their strategic decisions on the product scope in the global economy. I find that there are several different types of equilibria depending on technological difference and relative cost advantage of domestic and foreign firms. When each firm has local cost advantage and technological difference between firms is sufficiently large, firms reallocate resources toward their more profitable products. By contrast, when there exists a small technological difference or global cost advantage, the more productive firm may expand the product line contrary to existing core competence literature. This is because a high-productivity firm can increase its market power by expanding its product range while its rival's product line expansion is limited by cost disadvantage.

Chapter 2: Production Sharing and Exchange Rate Pass-Through

This paper proposes a theoretical background for various possibilities of exchange pass-through and expenditure-switching by investigating the effect of different channels through which exchange rate shocks affect firms' decisions on pricing and entry and exit. I extend the model of exchange rate pass-through with endogenous markups built by Rodriguez-Lopez (2011) introducing the intermediate input sector: domestic and imported intermediate inputs. I show that the degrees of exchange rate pass-through and expenditure switching depend on the shares of imported inputs in total costs. According to the relative sizes of these shares, exchange rate movements might lead to different cost shocks to each trading nation. When the imported input shares are located within some range, a low but positive

rate of pass-through to aggregate import prices can be derived in the model. In addition, low levels of exchange rate pass-through to aggregate import prices can coexist with negligible movements in trade flows unlike Rodriguez-Lopez. The results of this paper also provide a potential explanation for the fact that the degree of pass-through varies across countries and industries.

Chapter 3: Exchange Rate Pass-Through in Korean Manufacturing Industries

This paper examines exchange rate pass-through into Korean export prices at the industry level using disaggreated trade data. Unlike traditional approaches, I construct a testable model in which both the intensive and extensive margins are operative. I find that more import-intensive industries in Korea have higher exchange rate pass-through into their export prices. This is because aggregate export prices are affected not only by changes in firms' marginal costs, but also by variations in the composition of exporters due to changes in the exporting cut-off. In addition, I show that the relative value of the destination market currency should be also considered when estimating exchange rate pass-through regardless of a high proportion of dollar invoicing of Korean exports and imports. Finally, I find that pass-through is increasing both in Korea's share in total import of the destination market and in Korea's comparative advantage industries.

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CHAPTER 1

Multiproduct Competition in the Global Economy

1.1 Introduction

Multiproduct firms dominate international trade in most developed countries. According to the study on US firms by Bernard et al. (2007), 57.8 percent of exporting firms produce multiple products, and multiproduct firms account for more than 99.6 percent of export value in the year 2000.[1] Despite this dominant role in the global economy, multiproduct firms have received comparatively little attention in the field of international trade so far. This is because traditional theoretical frameworks of international trade are based on single product firms only. However, trade economists have recently begun to take more interest in multiproduct firms and examine their activity.[2]

My paper is inspired by an interesting result of recent research on multiproduct firms. Trade liberalization induces firms to reallocate resources towards their relatively high-profit (i.e., core-competency) products. For instance, Bernard et al. (2011) model product-specific competencies as the strength of consumers' tastes for firm variety. The opening of trade intensifies product-market competition and so induces surviving firms to drop products with lower consumer tastes from the domestic market. Meanwhile, Eckel and Neary (2010) as-

[1] In this study, a *product* is defined at the ten-digit Harmonized System (HS) code level. Also Bernard et al. (2010) used five-digit Standard Industry Classification (SIC) code as a measure of *product*. Following their definition, multiproduct firms account for 87 percent of total output while they represent 39 percent of total firms in 1997.

[2] Besides articles introduced in the text, refer Eckel and Iacovone et al. (2010), Feenstra and Ma (2007), Mayer et al. (2009).

sume that firms typically own a core competence in the production of a particular variety. Yet, multiproduct firms are less efficient in the production of their varieties which are further away from the core product. They predict that globalization encourages multiproduct firms to focus on their core competence because greater competition hits those varieties produced at higher costs harder. In addition, Iacovone and Javorcik (2008) document empirical evidence for core competencies from the study of Mexican firms. They found the positive correlation between the rank of export varieties (in terms of their export values) and the rank of expansion of export varieties. Thus, exporters tend to expand their most important export products.

In spite of recent theoretical progress about the product scope for multiproduct firms, there remain some unexamined questions. First of all, multiproduct firms are generally big firms which have considerably large shares within the industry.[3] Thus, we need to examine strategic behaviors of multiproduct firms explicitly given the industry's market structure. In addition, multiproduct firms are likely to be heterogeneous in production technology. For example, multiproduct firms may have different firm-level productivity or product-level productivity. The different roles of multiproduct firms among countries also reflect heterogeneity. Iacovone and Javorcik (2008) observe that multiproduct exporters are much less prevalent in Mexico than in the US. Putting these facts together, both market structure and technological differences may have important roles in explaining the behaviors of multiproduct firms. In particular, globalization can cause considerable effects on multiproduct competition by increasing both market size and market competition. However, this idea has not been explored carefully in the existing literature. For instance, Bernard et al. (2011) extend the heterogeneous firm model of Melitz (2003) to multiproduct firms. In their model, market structure is an ex post equilibrium outcome of monopolistic competition with free entry and ex ante uncertainty. Eckel and Neary (2010) introduce a differentiated product oligopoly model and so they do not consider strategic behaviors such as predatory pricing.

[3] Multiproduct firms are larger than single product firms in the same industry in terms of both shipments and employment. See Bernard et al. (2010)

Furthermore, their analysis excludes the possibility that the degree of competition may vary across products produced by a multiproduct firm.

In this paper, I develop a simple multiproduct competition model in the global economy. The basic theoretical setup is similar to Eckel and Neary (2010). They introduce both demand and supply linkages, which make a clear distinction between multiproduct firms and single-product firms. First, on the demand side, there exists the "cannibalization effect" when multiproduct firms produce differentiated products. Because a larger output of one variety tends to crowd out demand for all other varieties, a multiproduct firm needs to restrict its output of each variety. Second, on the cost side, flexible manufacturing allows firms to expand their product lines, but this expansion is limited due to diseconomies of scope. Marginal production cost increases when firms produce varieties further from their core competence.

I follow this framework basically, but there are some noticeable differences in my paper. First, I formally consider the framework of a homogeneous product oligopoly model in which firms compete directly in the same product market. When products are homogeneous, the only source of market power is lack of competition.[4] Hence, multiproduct firms have more incentives to adjust their product scope strategically in response to changes in the market conditions. Next, I define the difference between firms' core products (or the gap between firms' feasible product lines) as technological difference. In general, firms can have their idiosyncratic advantages in producing a specific good by the exclusive patent right or cumulative experience in production process. For example, some automakers have comparative advantage in producing a compact car while others can produce a sports car or SUV more effectively. Finally, I assume that flexible manufacturing is imperfect because the physically feasible production lines may be different among multiproduct firms. Sometimes it may be impossible to enter the product market without original technology. For instance, every PC maker cannot produce a tablet computer like the iPad and sell it at competitive prices.

[4]In contrast, both lack of competition and product differentiation can create market power under a differentiated product oligopoly model.

The model yields several interesting predictions about the product scope for multiproduct firms in the global economy. Relative cost advantage as well as technological difference are main factors that affect the product line selection. There are several different types of equilibria as a result of strategic behaviors of heterogeneous multiproduct firms. When each firm has local cost advantage and technological difference between firms is sufficiently large, firms concentrate more on their core-competency products. This is similar to a traditional Ricardian model from the standpoint of specialization due to a gap between production technologies. Although each firm has its own segmented monopolized markets, intensified competition among differentiated goods induces firms to focus on their more profitable products. By contrast, when there exists a small technological difference or global cost advantage, the more productive firm may expand the product line while the less productive firm reduces its product scope in the global economy. This is because a high-productivity firm can create its monopolistic power in some varieties by expanding its product line. This result is a new finding contrary to the existing literature.[5] In reality, we can observe the product line changes occur with frequency. Consider, for example, the history of the automobile industry. Japanese and Korean automakers began to export compact cars in the initial phase and have gradually extended their product lines to mid-size, full-size and luxury class cars. In contrast, General Motors reduced its product mix by dropping some unprofitable brands such as Pontiac, Saturn and SAAB after its 2009 bankruptcy reorganization. Although a dynamic model is not presented, this paper can give us some insight into adjustments in the intra-firm extensive margin.

In conclusion, this paper suggests that we should consider various conditions in analyzing the optimal choice of product scope for multiproduct firms. In particular, firms are likely to have strategic incentives to adjust the number of products produced within a more concentrated industry. Thus, an empirical study on multiproduct firms needs to investigate both

[5] Bernard et al. (2011) also mention that trade liberalization might have an ambiguous effect on the product scope if they allow demand heterogeneity across countries. Exporters can add products with high consumer tastes in the foreign market.

competition intensity and firm heterogeneity.

The remainder of the paper is structured as follows. Section 1.2 introduces main assumptions about consumers and firms and examines an optimal choice of scale and scope by multiproduct firms. Section 1.3 illustrates a symmetric oligopoly model to emphasize the difference with our heterogeneous oligopoly model. In a symmetric oligopoly model, neither a rise in market size nor an increase in the number of firms affects the product line selection of multiproduct firms. Section 1.4 analyzes a heterogeneous oligopoly model in the global economy and shows the paper's key results. Section 1.5 concludes the paper.

1.2 Basic Model

We introduce the behavior of consumers and multiproduct firms in a single industry. We begin with a closed economy where L consumers exist.

1.2.1 Preferences and Demand

Following the specification of Melitz and Ottaviano (2008) as well as Eckel and Neary (2010), preferences are defined over a continuum of differentiated products indexed by $i \in \Omega$, and a homogeneous numeraire good. All consumers share the same utility function given by

$$U = q_0 + \alpha \int_{i\in\Omega} q(i)di - \frac{1}{2}\gamma \int_{i\in\Omega} q(i)^2 di - \frac{1}{2}\eta \left(\int_{i\in\Omega} q(i)di \right)^2 \tag{1.1}$$

where q_0 and $q(i)$ denote the individual consumption levels of the numeraire good and each variety i. The parameters α, γ and η are all positive. The parameters α and η represent the substitution pattern between the differentiated varieties and the numeraire: increases in α and decreases in η both raise the demand for the differentiated varieties relative to the numeraire. The parameter γ is a measure of product differentiation between the varieties. In the limit, when $\gamma = 0$, the goods are perfect substitutes. Since γ is positive, differentiated products are imperfect substitutes in demand. That is, a multiproduct firm produces multiple goods which are horizontally differentiated. For example, firms produce various types of cars in the automobile industry. The degree of product differentiation increases with γ as consumers prefer more balanced consumption across varieties.

Let $\Omega^* \subset \Omega$ be the subset of varieties that consumed ($q(i) > 0$). We assume that consumers have positive demands for the numeraire good. Then, the inverse demand for each variety i is given by

$$p(i) = \alpha - \gamma q(i) - \eta Q, \quad \text{where} \quad Q \equiv \int q(i)di, \quad i \in \Omega^* \tag{1.2}$$

The market demand for a particular good i, $x(i)$, is equal to $Lq(i)$. This allows equation (1.2) to be rewritten by

$$p(i) = \alpha - \frac{\gamma}{L}x(i) - \frac{\eta}{L}X \quad \text{where} \quad X \equiv \int x(i)di, \quad i \in \Omega^* \tag{1.3}$$

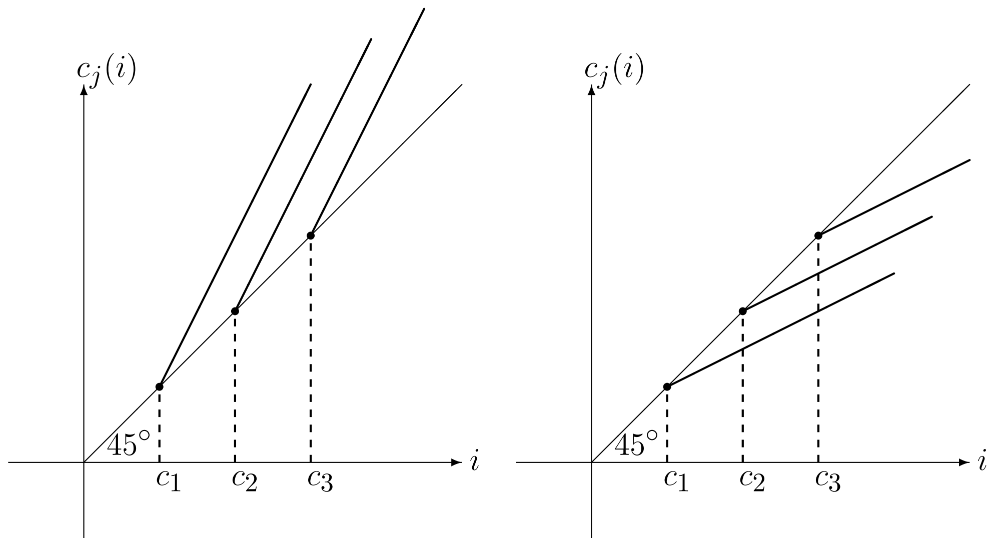
where X denotes the output of the entire industry.[6]

1.2.2 Production Technology

The technology of multiproduct firms is summarized by a core competence and flexible manufacturing. This is illustrated in Figure 1.1, where $c_j(i)$ indicates the marginal cost which a firm j incurs to produce good i. We set a firm j's core competence at c_j with $c_j(c_j) = c_j$.[7] This assumption implies two important facts. First, each firm has its own independent core product. As a firm's core competency product is closer to the origin, a firm can produce

[6]We assume that individual outputs of differentiated goods are measured in the same units. Thus, we can calculate the firm's total output or industry output easily by adding up the output of each variety. However, in general, measuring aggregate output of a multiproduct firm is more difficult because of the need for differential valuation of the outputs. See Bradley and Baron (1993) for details.

[7]Eckel and Neary (2010) arrange a firm's core competence at $i = 0$ with $c_j(0) = c_j^0$. In their model, there is no overlap in varieties produced among firms. Therefore, we should interpret that the origin denotes a representative firm's core competence, not a specific firm's core competence.



(a) $\beta > 1$ (b) $0 < \beta < 1$

Figure 1.1: Core Competency and Flexible Manufacturing

the more profitable variety. Second, multiproduct firms have different feasible product lines because the marginal cost is lowest for core competency variety by definition. A firm can expand its product line only towards the right-hand side from its core product. In other words, flexible manufacturing is imperfect.

Multiproduct firms must pay higher marginal production costs to produce additional varieties, but the marginal costs of existing products remain unchanged. In this paper, we assume that $c_j(i)$ is a linearly increasing function. Formally, the cost function is expressed by

$$c_j(i) = \begin{cases} c_j + \beta(i - c_j) & \text{if } i \geq c_j \\ \infty & \text{otherwise} \end{cases} \tag{1.4}$$

The slope β of the cost function represents the degree of flexibility in expanding product scope. The higher β implies that higher marginal costs incur in adding new products. We need to pay regard to two interesting cases. When $\beta > 1$, each firm has *local cost advantage* in producing some bounded varieties. When $0 < \beta < 1$, the most productive firm has *global cost advantage* in all varieties.

1.2.3 Optimal Scale and Scope

Profits for a multiproduct firm j are given by

$$\Pi_j = \int_{c_j}^{c_j+N_j} \left[p_j(i) - c_j(i)\right] x_j(i)di - F \tag{1.5}$$

where N_j is the scope of production of the firm j and the fixed cost F is independent of both scale and scope. So $c_j + N_j$ denotes the marginal variety which a firm j produces.

We assume that firms play a one-stage Cournot game. The first-order condition with respect to the scale of production of a particular good i is given by

$$\frac{\partial \Pi_j}{\partial x_j(i)} = p_j(i) - c_j(i) - \frac{\gamma}{L}x_j(i) - \frac{\eta}{L}X_j = 0 \tag{1.6}$$

where $X_j \equiv \int_{c_j}^{c_j+N_j} x_j(i)di$ denotes the firm's aggregate output.[8]

Let $M(i) = \{1, \cdots, m_i\}$ be the set of firms which produce product i. Notice that $p_j(i) = p(i)$ for all $j \in M(i)$ because firms belonging to $M(i)$ produce homogeneous good i.[9] From equations (1.3) and (1.6), we obtain the following equation.

$$\alpha - \frac{\gamma}{L}x(i) - \frac{\eta}{L}X = c_j(i) - \frac{\gamma}{L}x_j(i) - \frac{\eta}{L}X_j \tag{1.7}$$

[8]The second-order condition can be easily shown to hold: $\frac{\partial^2 \Pi_j}{\partial x_j(i)^2} = \frac{\partial p_j(i)}{\partial x_j(i)} - \frac{\gamma}{L} - \frac{\eta}{L}\frac{\partial X_j}{\partial x_j(i)} < 0$.

[9]Baldwin and Ottaviano (2001) categorize multiproduct competition into the following three types. The first, 'full symmetry', refers to the case where all varieties as equally good substitutes. In other words, this type is the standard Dixit-Stiglitz model of monopolistic competition. Eckel and Neary (2010) follow this framework. The second is, 'firm-wise symmetry (or market segmentation)', where a firm's own varieties are perceived by consumers to be closer substitutes to each other than to those of other firms. The third is, 'matching product lines (or market interlacing)', where a firm's own varieties are less good substitutes for each other than they are for the other firm's varieties. The approach described in this paper falls into the third category.

Summing both sides over $j \in M(i)$ gives the total output of a single variety.

$$x(i) = \sum_{j \in M(i)} x_j(i) = \frac{L}{\gamma} \cdot \frac{1}{m_i + 1} \left[m_i \left(\alpha - \frac{\eta}{L} X \right) - \sum_{j \in M(i)} c_j(i) - \frac{\eta}{L} \sum_{j \in M(i)} X_j \right] \tag{1.8}$$

Substituting (1.8) into (1.7), we can obtain a firm j's output with respect to a single variety.

$$\begin{aligned} x_j(i) = \frac{L}{\gamma} \Bigg[& \frac{1}{m_i + 1} \left(\alpha - \frac{\eta}{L} X \right) + \left(\frac{1}{m_i + 1} \sum_{k \in M(i)} c_k(i) - c_j(i) \right) \\ & + \frac{\eta}{L} \left(\frac{1}{m_i + 1} \sum_{k \in M(i)} X_k - X_j \right) \Bigg] \end{aligned} \tag{1.9}$$

The first term shows that industry output has a negative effect on the single product output. Next, we define the second term as the *relative cost advantage* in producing variety i. As the marginal costs of firm j are smaller than those of rival firms in producing the same variety, its output increases. Finally, we define the last term as the *relative cannibalization effect*. A firm j's aggregate output X_j has a more negative effect on the output of a variety when total firm output is relatively bigger than those of its rivals. That is, a firm with higher market share is hurt more from the cannibalization effect.

Next, consider the firm's choice of product line. The first-order condition with respect to the scope of production is

$$\frac{\partial \Pi_j}{\partial N_j} = \left[p_j\,(i) - c_j\,(i) \right] x_j\,(i) \Big|_{i = c_j + N_j} = 0 \tag{1.10}$$

From the FOC for scale, equation (1.6), the profit margin $p_j\,(i) - c_j\,(i) \Big|_{i = c_j + N_j}$ cannot be zero. Therefore, multiproduct firms choose their product ranges so that the output of the marginal variety is zero.

That is, $x_j(i)\Big|_{i=c_j+N_j} = 0.$[10]

1.3 Symmetric Oligopoly

1.3.1 Closed Economy

We consider a symmetric Cournot oligopoly model as a benchmark in order to stress the difference with our main heterogeneous model. We assume that there is an exogenously given number of multiproduct firms m in a closed economy. Let $x_o(i)$ and X_o denote the output of each firm in variety i and the total output of each firm, respectively. Then the industry output X is equal to mX_o. From equation (1.9), output per firm in variety i is given by

$$x_o(i) = \frac{L}{(m+1)\gamma}\left[\alpha - c_o(i) - \frac{(m+1)\eta}{L}X_o\right] \tag{1.11}$$

In addition, from the equation of the optimal scope $x_o(c_o + N_o) = 0$,

$$c_o(c_o + N_o) = \alpha - \frac{(m+1)\eta}{L}X_o \tag{1.12}$$

Thus,

$$x_o(i) = \frac{L}{(m+1)\gamma}\left[c_o(c_o + N_o) - c_o(i)\right] = \frac{L}{(m+1)\gamma}\left[\beta(c_o + N_o - i)\right] \tag{1.13}$$

Given c_o, multiproduct firms produce more of each variety the closer it is to its core competence. Also, given the demand structure, profit margins are lower for products that

[10]We can show that $\frac{\partial x_j(i)}{\partial N_j}\Big|_{i=c_j+N_j} < 0$ in the equilibrium illustrated in this paper because the marginal cost is increasing in i. Thus, second-order condition is verified: $\frac{\partial^2 \Pi_j}{\partial N_j^2} = \left[p_j(i) - c_j(i)\right]\frac{\partial x_j(i)}{\partial N_j}\Big|_{i=c_j+N_j} < 0.$

are further from firms' core competence.

$$p_o(i) - c_o(i) = \frac{1}{m+1}[\alpha - c_o(i)] \tag{1.14}$$

Now, let's calculate the total output of each identical multiproduct firm.

$$X_o = \int_{c_o}^{c_o+N_o} x_o(i)di = \frac{\beta L}{2(m+1)\gamma} N_o^2 \tag{1.15}$$

Substituting (1.15) into (1.12), we can get the optimal scope of production.

$$\beta\eta N_o^2 + 2\beta\gamma N_o - 2\gamma(\alpha - c_o) = 0 \Rightarrow N_o = \frac{-\beta\gamma + \sqrt{(\beta\gamma)^2 + 2\beta\gamma\eta(\alpha - c_o)}}{\beta\eta} \tag{1.16}$$

Note that there exists neither L nor m in (1.16). In other words, the optimal scope of production is independent of both market size and the number of firms in a symmetric oligopoly equilibrium.[11] This is because the change in L or m causes an equi-proportionate change in both output per firm in variety i (x_o) and total firm output (X_o).

Let's examine this prediction in more detail. First, equation (1.12) gives one negative relationship between the optimal output of each firm (X_o) and the optimal choice of product scope (N_o). This is illustrated by the downward-sloping straight line in Figure 1.2. This comes from the cannibalization effect. A firm desires to produce less variety as its total output increases. On the other hand, equation (1.15) shows another relationship between X_o and N_o. A rise in N_o raises total output. The curve passing through the origin in Figure 1.2 represents this relationship. For example, suppose that m increases. Then, both loci shift inward by the same proportion. As a result, the optimal choice of product range does not change while the output of each firm reduces.

I now compare my results with those of Eckel and Neary (2010). The market-size effect

[11] This result does not depend on our linear cost function assumption. For example, if the cost function is replaced by $c_o(i) = c_o + \beta\,(i - c_o)^2$, the optimal product scope is obtained by solving the following cubic equation: $\beta\eta N_o^3 + \beta\gamma N_o^2 - \gamma(\alpha - c_o) = 0$.

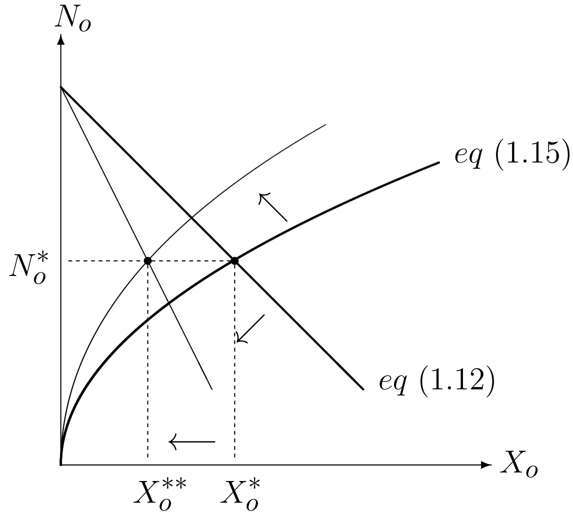


Figure 1.2: Competition Effect in a Symmetric Oligopoly Model

(an increase in L) is the same as that demonstrated by their model. Given a fixed number of firms, market expansion does not affect firm scope in both models. On the contrary, in the Eckel and Neary (2010) model, the competition effect (an increase in m) causes a fall in firm scope. This disparity results from different assumptions about the degree of product differentiation in oligopoly. In my current setup, all firms compete in the same product market with each firm sharing an identical core competence product. Thus, an increase in the number of firms causes an equi-proportionate increase in competition among all varieties already produced. As a result, firms have no incentive to adjust their product scope. By contrast, each firm produces a mutually exclusive set of products in Eckel and Neary (2010). As a result, intensified competition hits marginal varieties harder and encourages incumbent firms to prune their product lines.

Proposition 1 *In a symmetric oligopoly model under a closed economy, the market size effect of an increase in L is an equi-proportionate increase in the output of each variety and total firm output, but there is no change in firm scope. The competition effect of an increase in m is an equi-proportionate fall in both the output of each variety and total firm output, but there is a rise in industry output and no change in firm scope.*

Proof. All these results are clear from equations (1.13), (1.15) and (1.16). Because $X =$

mX_o and $\dfrac{m}{m+1}$ is increasing in m, the total industry output rises in response to an increase in the number of firms like a single product Cournot model. ■

Also note the following intuitively consistent results[12]:

$$\frac{\partial N_o}{\partial \beta} < 0, \quad \frac{\partial N_o}{\partial \alpha} > 0, \quad \frac{\partial N_o}{\partial \gamma} > 0, \quad \frac{\partial N_o}{\partial \eta} < 0, \quad \frac{\partial N_o}{\partial c_o} < 0$$

$$\frac{\partial X_o}{\partial \beta} < 0, \quad \frac{\partial X_o}{\partial \alpha} > 0, \quad \frac{\partial X_o}{\partial \gamma} < 0, \quad \frac{\partial X_o}{\partial \eta} < 0, \quad \frac{\partial X_o}{\partial c_o} < 0$$

Because higher β indicates less flexibility in expanding product lines, multiproduct firms will shrink their product ranges. Increases in α and decreases in η imply that consumers much prefer the differentiated varieties to the numeraire good. Thus, more preference for the differentiated goods raises both the number of varieties and the output of each variety. Since γ indexes the degree of product differentiation, multiproduct firms produce more varieties the higher γ is. Finally, multiproduct firms have narrower feasible product lines when c_o is greater.

1.3.2 Global Economy

We assume that there are L consumers with identical preferences located in each of $k \geq 2$ countries. In addition, we assume that the good markets of all countries are completely integrated in a single world market as a result of free trade, so the price of a given product is the same in every place.[13]

Because globalization leads to concurrent increases in both market size and the number of firms, $L' = kL$ and $m' = km$.[14] We already know that the optimal scope of production does not depend on L' and m', so $N_o^{'} = N_o$.

[12]See Appendix for proofs.

[13]In this model, when consumers buy a specific good, they are indifferent about which firm produces it.

[14]I will use prime superscript $'$ to denote variables in the global economy.

Also using $\dfrac{k}{km+1} = \dfrac{1}{m+(1/k)} > \dfrac{1}{m+1}$, we obtain the following results.

$$X_o' = \frac{\beta L'}{2(m'+1)\gamma} {N_o'}^2 = \frac{\beta L}{2\gamma} \frac{k}{(km+1)} {N_o}^2 > X_o$$

$$x_o'(i) = \frac{L'}{(m'+1)\gamma}\left[\alpha - c_o(i) - \frac{\beta\eta}{2\gamma}{N_o'}^2\right] = \frac{L}{\gamma}\frac{k}{(km+1)}\left[\alpha - c_o(i) - \frac{\beta\eta}{2\gamma}{N_o}^2\right] > x_o(i)$$

We summarize these results in the following proposition.

Proposition 2 *In a symmetric oligopoly model, globalization causes rises in both output of each variety and total firm output, but there is no change in firm scope.*

1.4 Heterogeneous Duopoly in the Global Economy

1.4.1 Closed Economy

In general, it is difficult to analyze the equilibrium in a heterogeneous oligopoly model because the market structure may be too complex. Instead, we consider the simplest case as a starting point. Before globalization, there are two countries with identical consumers. In each country, only one multiproduct firm monopolizes the industry.[15] Because most multiproduct firms are large firms, our model is not too unrealistic. In addition, despite its simplicity, we can obtain some meaningful intuition.

From equations (1.11) and (1.15),

$$x_j(i) = \frac{L}{2\gamma}\left[\alpha - c_j(i) - \frac{2\eta}{L}X_j\right], \quad j = d, f \tag{1.17}$$

$$X_j = \int_{c_j}^{c_j+N_j} x_j(i)di = \frac{\beta L}{4\gamma}N_j^2, \quad j = d, f \tag{1.18}$$

where d and j denote a domestic firm and a foreign firm, respectively.

[15] This is the special case that $m = 1$ in a symmetric model of section 1.3.

Also from equation (1.16), we obtain the following optimal scope of production.

$$\beta\eta N_j^2+2\beta\gamma N_j-2\gamma(\alpha-c_j)=0 \Rightarrow N_j=\frac{-\beta\gamma+\sqrt{(\beta\gamma)^2+2\beta\gamma\eta(\alpha-c_j)}}{\beta\eta}, \quad j=d,f \quad (1.19)$$

In the global economy, a domestic and a foreign firm compete with each other in the fully integrated market. Thus, the market size increases from L to $L'=2L$. Without loss of generality, suppose that $c_d < c_f$.

Before the analysis, we explain the equilibrium concept more clearly. A firm has its optimal output schedules of each variety through Cournot competition given a configuration of product ranges (N_d, N_f). These output schedules $\{x_j(i)\}_{j=d,f}$ are given by equation (1.9). Therefore, each firm selects the optimal product range to maximize its profit given the rival's product scope and output schedules. Then, we can derive multiproduct Cournot-Nash equilibria.[16] In this paper, we sketch out some possible equilibria instead of depicting all equilibria formally. For convenience, we analyze two different cases (1) $\beta > 1$, and (2) $0 < \beta < 1$ separately.

1.4.2 Global Economy: Local Cost Advantage

When $\beta > 1$, each firm has local cost advantage as depicted in Figure 1.1 (a). Above all, we can think of the situation where the difference between c_d and c_f is very large. Then, the domestic firm will not compete with the product line which the foreign firm produces because of the prohibitively high production costs as well as the cannibalization effect. This situation is illustrated in Figure 1.3.

Let's consider the sufficient condition for the segmented monopoly. Let $p^D(c_f)$ denote the price of variety c_f when both firms produce this product. If $p^D(c_f) - c_d(c_f) < 0$, the domestic firm will not enter the product line that the foreign firm produces.

[16] See Grossman (2007) for details.

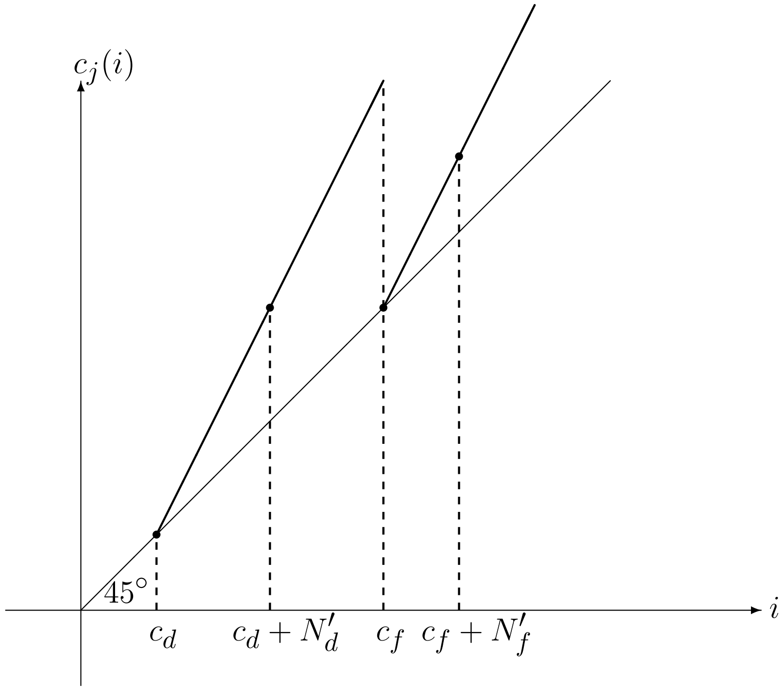


Figure 1.3: Segmented Monopoly ($\beta > 1$)

$$
\begin{aligned}
p^D(c_f) - c_d(c_f) &= \left[\alpha - \frac{\gamma}{L'}\left(x_d'(c_f) + x_f'(c_f)\right) - \frac{\eta}{L'}(X_d' + X_f')\right] - c_d(c_f) \\
&= \frac{1}{3}\left[\alpha + c_f(c_f) - 2c_d(c_f)\right] \\
&= \frac{1}{3}\left[(\alpha - c_f) + 2(1-\beta)\left(c_f - c_d\right)\right] < 0 \\
&\Rightarrow \quad c_f - c_d > \frac{\alpha - c_f}{2(\beta - 1)} \qquad (1.20)
\end{aligned}
$$

We define the difference between c_d and c_f as *technological difference*. This represents the difference between firms' core products and also denotes the gap between firms' physically feasible product ranges. The following proposition shows us the case of segmented monopoly in the global economy.

Proposition 3 *When each multiproduct firm has local cost advantage ($\beta > 1$) and technological difference between firms is sufficiently large ($c_f - c_d > \frac{\alpha - c_f}{2(\beta-1)}$), each firm has its own segmented monopolized markets in the global economy. While the product scopes of both firms decrease, total industry output increases.*

Proof. First, let's show that multiproduct firms shrink their product lines. The output of each firm in variety i is given by

$$x_d'(i) = \frac{L'}{2\gamma}\left[\alpha - c_d(i) - \frac{2\eta}{L'}X_d' - \frac{\eta}{L'}X_f'\right] \tag{1.21}$$

$$x_f'(i) = \frac{L'}{2\gamma}\left[\alpha - c_f(i) - \frac{2\eta}{L'}X_f' - \frac{\eta}{L'}X_d'\right] \tag{1.22}$$

By using equations (1.21), (1.22) and the optimal scope equations, we can get the following results. (See Section 1.3.1)

$$X_d' = \frac{\beta L'}{4\gamma}N_d'^{2}, \qquad X_f' = \frac{\beta L'}{4\gamma}N_f'^{2} \tag{1.23}$$

$$\begin{aligned} \beta\eta N_d'^{2} + 2\beta\gamma N_d' - 2\gamma(\alpha - c_d) + \frac{1}{2}\beta\eta N_f'^{2} = 0 \\ \beta\eta N_f'^{2} + 2\beta\gamma N_f' - 2\gamma(\alpha - c_f) + \frac{1}{2}\beta\eta N_d'^{2} = 0 \end{aligned} \tag{1.24}$$

Although we cannot obtain nice analytical solutions, it is easy to show that firm scopes decrease through globalization by comparing (1.24) with (1.19). Notice the last terms of the simultaneous equations (1.24) are positive and the other terms are equal to those of the equation (1.19) in a closed economy. This is illustrated in Figure 1.4. Globalization shifts the optimal choices of product scope from A to B.

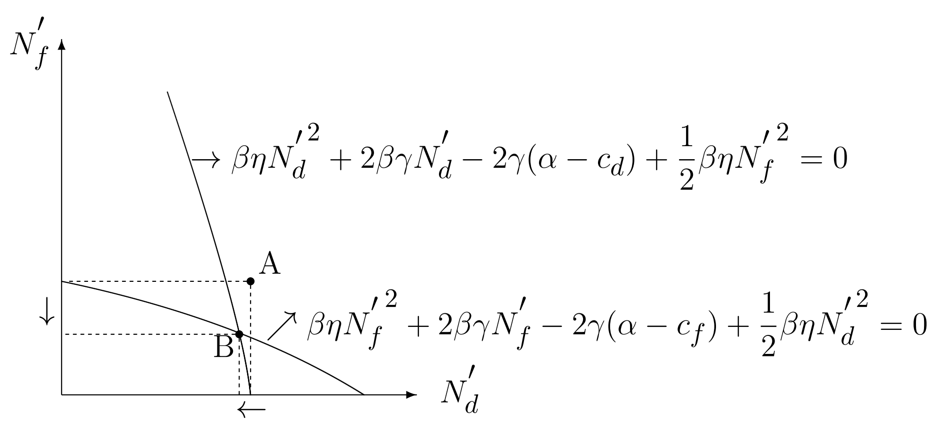


Figure 1.4: Segmented Monopoly and Reduction in the Product Scopes

Next, we can easily show that globalization leads to an increase in total industry output. From the optimal scope equations of closed economy and open economy,

$$\begin{aligned} X_d + X_f &= \frac{L}{2\eta}\left[2\alpha - (c_d + c_f) - \beta(N_d + N_f)\right] \\ X_d^{'} + X_f^{'} &= \frac{2L}{3\eta}\left[2\alpha - (c_d + c_f) - \beta(N_d^{'} + N_f^{'})\right] \end{aligned} \tag{1.25}$$

Since $N_d > N_d^{'}$ and $N_f > N_f^{'}$, the total industry output increases from globalization. ■

The segmented monopoly is similar to a traditional Ricardian model. Each firm specializes in the products in which it has comparative advantage. Also, we need to note that the foreign firm reduces its scope relatively further, as illustrated in Figure 1.4. Though the foreign firm has local cost advantage, its rival is more competitive in the entire industry. This may be one explanation for the empirical fact that multiproduct firms are more prevalent in advanced countries.

As another candidate of the equilibrium, we can think of the case that there exists partial duopoly due to a relatively small difference between c_d and c_f. This situation is illustrated in Figure 1.5. Assume that $N_f^{'}$ is given. The domestic firm will not produce in the range located at the right-hand from B on its cost function in equilibrium. It is because the domestic firm's production costs are higher than the foreign firm's costs in this range. So $c_f < c_d + N_d^{'} \leq c_f + N_f^{'}$.

Intuitively, the foreign firm may have a stronger incentive to expand its product scope since it has relatively lower production costs within its feasible product range. It may be possible that the foreign firm creates its monopolized markets by adding new products and this benefit outweighs the cannibalization effect. Point A in Figure 1.5 represents this situation. In other words, $c_f < c_d + N_d^{'} < c_f + N_f^{'}$. The following proposition verifies this equilibrium.

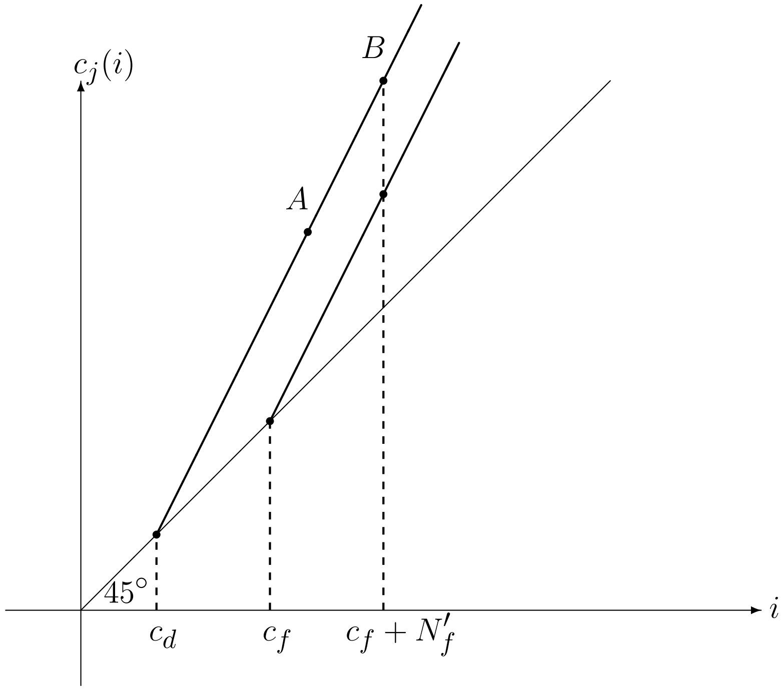


Figure 1.5: Partial Duopoly and Segmented Monopoly ($\beta > 1$)

Proposition 4 *When each multiproduct firm has local cost advantage ($\beta > 1$) and technological difference between firms is small, partial duopoly and segmented monopoly coexist in the global economy. While the more productive firm in duopoly markets increases its product scope, the less productive firm in duopoly markets will decrease its product scope.*

Proof. Suppose that $N_f^{'}$ is given. A domestic firm monopolizes the markets with $c_d \leq i < c_f$. In the region with $c_f \leq i \leq c_d + N_d^{'}$, there exists duopoly.[17]

$$x'_d(i) = \begin{cases} \dfrac{L'}{2\gamma}\left[\alpha - c_d(i) - \dfrac{2\eta}{L'}X'_d - \dfrac{\eta}{L'}X'_f\right] & \text{if } c_d \leq i < c_f \\ \\ \dfrac{L'}{3\gamma}\left[\alpha - 2c_d(i) + c_f(i) - \dfrac{3\eta}{L'}X'_d\right] & \text{if } c_f \leq i \leq c_d + N_d^{'} \end{cases} \tag{1.26}$$

By integrating (1.26) and substituting the result $X_d^{'}$ into the optimal product scope equation,

[17]Note that duopoly cannot exist when the sufficient condition for segmented monopoly above is satisfied:$\alpha - 2c_d(c_f) + c_f(c_f) < 0$

we can get the following equation.

$$\begin{aligned}\beta\eta N_d'^2 + 2\beta\gamma N_d' - 2\gamma(\alpha - c_d) + 2\gamma(\beta - 1)(c_f - c_d) + \frac{1}{2}\beta\eta(c_f - c_d)^2 \\ +\eta(c_f - c_d)\left[\alpha + (\beta - 2)c_f + (1 - \beta)c_d - \frac{3\eta}{L'}X_f'\right] = 0\end{aligned} \tag{1.27}$$

If the last term of the equation above is positive, it is sufficient to show $N_d' < N_d$.[18]

Note that a foreign firm produces a positive output for its core product.

$$x_f'(c_f) = \frac{L'}{3\gamma}\left[\alpha - 2c_f(c_f) + c_d(c_f) - \frac{3\eta}{L'}X_f'\right] = \frac{L'}{3\gamma}\left[\alpha + (\beta - 2)c_f + (1 - \beta)c_d - \frac{3\eta}{L'}X_f'\right] > 0 \tag{1.28}$$

Therefore, $N_d' < N_d$.

Next, assume that $c_d + N_d' = c_f + N_f^*$. Keep in mind that N_f^* is a possible candidate, not a solution. Then, the foreign firm will always produce in only duopoly markets.

$$X_f^* = \int_{c_f}^{c_f + N_f^*} x_f^*(i)di = \int_{c_f}^{c_f + N_f^*} \frac{L'}{3\gamma}\left[\alpha - 2c_f(i) + c_d(i) - \frac{3\eta}{L'}X_f^*\right] = \frac{\beta L'}{6\gamma}N_f^{*2} \tag{1.29}$$

Substituting (1.29) into the optimal product scope equation $x_f^*(c_f + N_f^*) = 0$, we can obtain the following equation.

$$\beta\eta N_f^{*2} + 2\beta\gamma N_f^* - 2\gamma(\alpha - c_f) - 2\gamma(\beta - 1)(c_f - c_d) = 0 \tag{1.30}$$

Because the last term is negative, $N_f^* > N_f$.

Finally, let's check if N_f^* is the solution. Using $N_f^* = N_d' - \big(c_f - c_d\big)$, we must get equation (1.27) from equation (1.30). However, this is not verified.

As a result, $c_d + N_d' < c_f + N_f'$. Therefore, $N_f' > N_f^* > N_f$. ■

On the other hand, it is not easy to compare the total industry output before and after

[18] In the equation, the first three terms are identical to those in the equation of a closed economy. The next two terms are always positive.

globalization. From the optimal scope equations,

$$(X_d'+X_f')-(X_d+X_f)=\frac{L}{3\eta}\left[\alpha-\frac{1}{2}(c_d+c_f)-\beta(c_f-c_d)+\frac{3}{2}\beta(N_d+N_f)-\beta(N_d'+3N_f')\right] \tag{1.31}$$

But we can guess that total industry will be more likely to increase when $c_f - c_d$ is smaller from equation (1.31). Remember the result in a symmetric oligopoly model.

1.4.3 Global Economy: Global Cost Advantage

Suppose that the domestic firm has global cost advantage ($0 < \beta < 1$). First of all, we can consider the equilibrium where the domestic firm monopolizes the entire industry. If the difference between c_d and c_f is sufficiently large, the foreign firm may exit the industry due to prohibitively high production costs compared with its rival. This situation is illustrated in Figure 1.6.

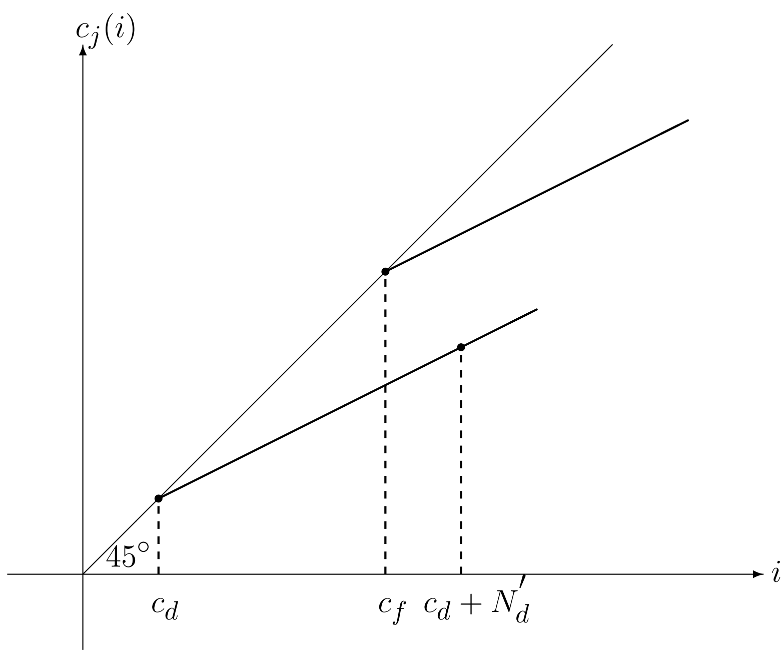


Figure 1.6: Pure Monopoly ($0 < \beta < 1$)

Let's think of the sufficient condition for the pure monopoly. Let $p^D(c_f)$ denote the price of variety c_f when both firms produce this product. If $p^D(c_f) - c_f(c_f) < 0$, the foreign firm will exit.

$$\begin{aligned} p^D(c_f) - c_f(c_f) &= \frac{1}{3}\left[\alpha + c_d(c_f) - 2c_f(c_f)\right] \\ &= \frac{1}{3}\left[\left(\alpha - c_f\right) + (\beta - 1)\left(c_f - c_d\right)\right] < 0 \\ &\Rightarrow \; c_f - c_d > \frac{\alpha - c_f}{1-\beta} \end{aligned} \tag{1.32}$$

Proposition 5 *When one multiproduct firm has global cost advantage ($0 < \beta < 1$) and technological difference between firms is sufficiently large ($c_f - c_d > \frac{\alpha - c_f}{1-\beta}$), the more productive firm will monopolize the industry in the global economy. While its product scope remains or increases, total industry output increases.*

Proof. First, consider the case $\frac{\alpha - c_f}{1-\beta} < c_f - c_d \leq N_d$. Then, it is obvious that the domestic firm (the more productive firm) does not change its product line. That is, $N_d' = N_d$.

Second, suppose that $c_f - c_d > N_d$. To deter a rival's entry, the domestic firm should expand its product line in the global economy. That is, $N_d' = c_f - c_d > N_d$. In conclusion, the domestic firm will not reduce its product range after globalization.

Now, let's consider total industry output. From the optimal scope equations of closed economy and global economy,

$$X_d' - \left(X_d + X_f\right) = \frac{\beta L'}{4\gamma} {N_d'}^2 - \frac{\beta L}{4\gamma}\left(N_d^2 + N_f^2\right) = \frac{\beta L}{4\gamma}\left(2{N_d'}^2 - N_d^2 - N_f^2\right) > 0 \tag{1.33}$$

Thus, total industry output increases in the global economy. ■

As another candidate of the equilibrium, we can think of the case that there exists partial duopoly due to a relatively small difference between c_d and c_f. This situation is illustrated in Figure 1.7. Assume that N_f' is given. In equilibrium, the domestic firm will not put its marginal product in the range located at the left-hand from A on its cost function. So $c_f + N_f^{'} \leq c_d + N_d^{'}$.

As mentioned before, the domestic firm is more likely to expand its product range. This is because it can expect more benefit by creating its market power in spite of the cannibalization effect. By contrast, the foreign firm may shrink its production scope because its competitiveness is further harmed by globalization. Point B in Figure 1.7 represents this situation. In other words, $c_f < c_f + N_f^{'} < c_d + N_d^{'}$. The following proposition proves this intuition.

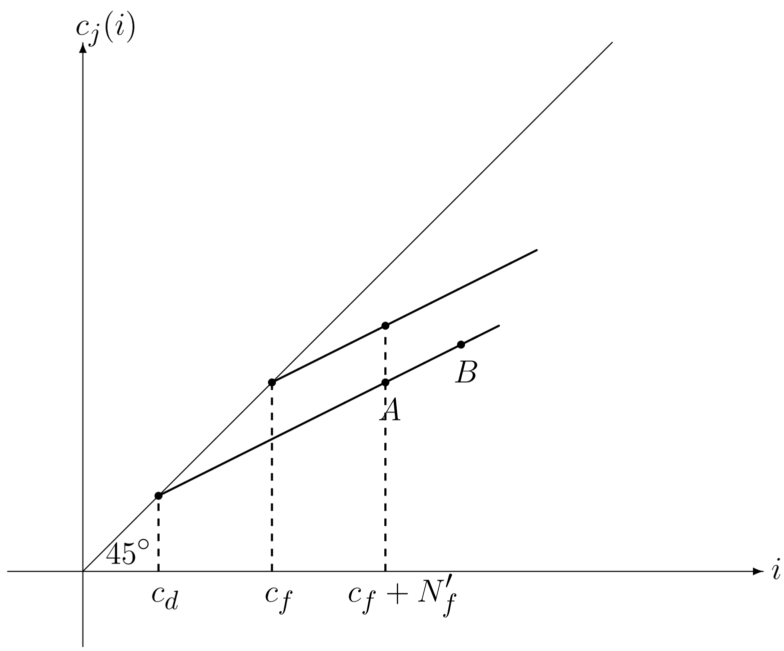


Figure 1.7: Partial Duopoly ($0 < \beta < 1$)

Proposition 6 *When one multiproduct firm has global cost advantage* ($0 < \beta < 1$) *and technological difference between firms is small, the less productive firm competes only in partial duopoly markets in the global economy. The more productive firm monopolizes the rest of the product markets. While the more productive firm increases its product scope, the less productive firm will decrease its product scope.*

Proof. Above all, note that the foreign firm will always produce in only duopoly markets.

Therefore, we can obtain the following equation just by substituting $N_f^{'}$ into N_f^* in equation (1.30) of proposition 4.

$$\beta\eta N_f^{'2} + 2\beta\gamma N_f^{'} - 2\gamma(\alpha - c_f) - 2\gamma(\beta - 1)(c_f - c_d) = 0 \tag{1.34}$$

Since $0 < \beta < 1$, the last term is always positive. Therefore, we can conclude that $N_f^{'} < N_f$.

Next, assume that $c_d + N_d^* = c_f + N_f^{'}$. Keep in mind that N_d^* is a possible candidate, not a solution. Substituting N_d^* into $N_d^{'}$ in equation (1.27) of proposition 4 and rearranging by using $x^{'}(c_f + N_f^{'}) = 0$ yields the following expression.

$$\begin{aligned} &\beta\eta N_d^{*2} + 2\beta\gamma N_d^* - 2\gamma(\alpha - c_d) = \\ &- \beta\eta(c_f - c_d)N_d^* + 2\gamma(1 - \beta)(c_f - c_d) + \frac{1}{2}\beta\eta(c_f - c_d)^2 \end{aligned} \tag{1.35}$$

Finally, let's check if N_d^* is the solution. Using $N_d^* = N_f^{'} + \big(c_f - c_d\big)$, we must obtain equation (1.34) from equation (1.35). However, it does not work. As a result, $c_f + N_f^{'} < c_d + N_d^{'}$.

We can obtain the following equation by considering the additional monopoly markets of the domestic firm between $c_f + N_f^{'}$ and $c_d + N_d^{'}$.

$$\begin{aligned} &\beta\eta N_d^{'2} + 2\beta\gamma N_d^{'} - 2\gamma(\alpha - c_d) \\ &+\frac{\eta}{3\gamma}N_f^{'}\left[\beta\eta N_f^{'2} + \beta\gamma N_f^{'} - 2\gamma(\alpha - c_f) - 2\gamma(\beta - 1)(c_f - c_d)\right] = 0 \\ &\Rightarrow \beta\eta N_d^{'2} + 2\beta\gamma N_d^{'} - 2\gamma(\alpha - c_d) - \frac{1}{3}\beta\eta N_f^{'2} = 0 \end{aligned} \tag{1.36}$$

The final equation is derived from the fact that the square bracket term of the first equation is equal to $-\beta\gamma N_f^{'}$ using equation (1.34). Therefore, we can conclude that $N_d^{'} > N_d$. ■

As expected, it is not simple to compare the total industry output before and after globalization. From the optimal scope equations,

$$
\begin{aligned}
&(X_d' + X_f') - (X_d + X_f) = \\
&\frac{L}{3\eta}\left[\alpha + \frac{1}{2}(7c_f - 9c_d) - 2(\beta - 1)(c_f - c_d) + \frac{3}{2}\beta(N_d + N_f) + 2\beta(N_f' - 3N_d')\right]
\end{aligned} \tag{1.37}
$$

1.5 Conclusion

Firm heterogeneity under monopolistic competition has become an essential part in modern trade theory. Although recently developed theories like Melitz (2003) explain some empirical findings well, there remain insufficiently examined areas. First of all, we often observe that some industries are dominated by a small number of big firms. Therefore, we cannot neglect firms' strategic behaviors within a given market structure. On the other hand, we should develop a new trade model for multiproduct firms in view of their huge roles in the global economy. The growing evidence tells us that many firms, and especially most large exporters, are multiproduct firms. This paper is inspired by these studies.

In the paper, I have developed a simple model of multiproduct firms, which highlights the strategic decision regarding their product scope. The model yields several interesting predictions about the product scope for multiproduct firms in the global economy. I find that there are several different types of equilibria according to technological difference and relative cost advantage. When each firm has local cost advantage and technological difference between firms is sufficiently large, firms have their own segmented monopolized markets after globalization. And each firm shrinks its product scope and concentrates on more profitable products. This result is consistent with existing core competence literature. By contrast, I show that the more productive firm can expand its product scope after globalization when there exists a small technological difference or global cost advantage. This is because it can obtain market power that offsets the cannibalization effect when its rival's product line expansion is limited by cost disadvantage. Therefore, this paper suggests that we should be more careful with the effects of globalization in more concentrated industries.

There are some areas in which my framework might be improved. First, we need to measure explicitly changes in product diversity and overall industry productivity in order to analyze gains from globalization. Second, multiproduct firms add and drop products with surprising intensity and frequency as indicated by Bernard et al (2010).[19] Thus, a dynamic optimization model may be more useful in analyzing multi-stage competition among multiproduct firms. Third, it will be important work to find empirical evidence that supports main predictions of this paper.

[19] On average, 54 percent of US manufacturing firms change their mix of five-digit (SIC) products every five years.

APPENDIX

Appendix

Proofs omitted in the text: page 13

For convenience, let $A \equiv (\beta\gamma)^2 + 2\beta\gamma\eta(\alpha - c_o)$.

$$\frac{\partial N_o}{\partial \beta} = -\frac{\gamma}{\beta} A^{-\frac{1}{2}}(\alpha - c_o) < 0$$

$$\frac{\partial N_o}{\partial \alpha} = \gamma A^{-\frac{1}{2}} > 0$$

$$\frac{\partial N_o}{\partial \gamma} = \frac{-1 + A^{-\frac{1}{2}}[\beta\gamma + \eta(\alpha - c_o)]}{\eta} > 0 \quad \because \beta\gamma + \eta(\alpha - c_o) > A^{\frac{1}{2}}$$

$$\frac{\partial N_o}{\partial \eta} = \frac{\gamma}{\eta^2}[1 - A^{-\frac{1}{2}}\{\beta\gamma + \eta(\alpha - c_o)\}] < 0$$

$$\frac{\partial N_o}{\partial c_o} = -\gamma A^{-\frac{1}{2}} < 0$$

Use $X_o = \frac{\beta L}{2(m+1)\gamma} N_o^2 = \frac{L}{(m+1)\eta^2}[\beta\gamma + \eta(\alpha - c_o) - A^{\frac{1}{2}}]$.

$$\frac{\partial X_o}{\partial \beta} = \frac{\gamma L}{(m+1)\eta^2}[1 - A^{-\frac{1}{2}}\{\beta\gamma + \eta(\alpha - c_o)\}] < 0$$

$$\frac{\partial X_o}{\partial \alpha} = \frac{L}{(m+1)\eta}[1 - A^{-\frac{1}{2}}\beta\gamma] > 0 \quad \because \beta\gamma < A^{\frac{1}{2}}$$

$$\frac{\partial X_o}{\partial \gamma} = \frac{\beta L}{(m+1)\eta^2}[1 - A^{-\frac{1}{2}}\{\beta\gamma + \eta(\alpha - c_o)\}] < 0$$

$$\frac{\partial X_o}{\partial \eta} = \frac{\beta L}{(m+1)\gamma} \frac{\partial N_o}{\partial \eta} < 0$$

$$\frac{\partial X_o}{\partial c_o} = -\frac{L}{(m+1)\eta}[1 - A^{-\frac{1}{2}}\beta\gamma] < 0$$

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CHAPTER 2

Production Sharing and Exchange Rate Pass-Through

2.1 Introduction

Price changes caused by exchange rate fluctuations can have a considerable impact on the profitability of domestic firms. The most traditional view is that exchange rate shocks change the price competitiveness of domestic firms against foreign firms. For example, an appreciation in the domestic currency makes the foreign export price of goods produced by domestic firms more expensive. However, some countries have continued to outperform their export competitors despite the massive appreciation (for instance, see Athukorala and Menon (1994) for a study on Japanese exporters). As a result, many economists have been motivated to analyze the relationship between exchange rates and prices of traded goods more clearly.

One remarkable outcome is now popularly known as the exchange rate pass-through (ERPT) relationship. The rate of exchange rate pass-through can be defined as the percent change in import prices in the importing nation's currency due to 1% change in the exchange rate between the two trading partners. A rate of 1 (less than 1) indicates a complete (incomplete) exchange rate pass-through. Empirical studies for industrialized countries consistently show a low pass-through of nominal exchange rate changes to import prices.[1] An implication of this empirical finding is that the "expenditure-switching" effect of exchange rate changes might be very small. If exchange rate movements have little effect on prices, there is lit-

[1] See Yang (1997), Engel (2002), Campa and Goldberg (2005).

tle change in the quantities traded. However, this interpretation has no micro foundation regarding firms' adjustment after exchange rate shocks as Rodriguez-Lopez (2011) points out.

There are various possible explanations about sources of incomplete pass-through. In this paper, I focus on two factors which Athukorala and Menon (1994) point out.[2] The first factor is "pricing to market (PTM)" behavior called by Krugman (1986). Exporting firms may take strategic pricing behavior which aims to protect market share during currency appreciation or to augment profit margins during currency depreciation. Let's introduce a stylized framework of exchange rate pass-through and pricing to market. Let P_H^* be the Home-currency import price of a Foreign good and P_F^* denote the Foreign-currency export price of a Foreign good. Also E indicates the bilateral exchange rate defined as the Home currency per unit of the Foreign currency. Assuming the law of one price holds, then

$$P_H^* = P_F^* \cdot E \Longrightarrow \underbrace{\frac{d\ln P_H^*}{d\ln E}}_{ERPT} = \underbrace{\frac{d\ln P_F^*}{d\ln E}}_{PTM} + 1 \tag{2.1}$$

If $\dfrac{d\ln P_F^*}{d\ln E} = 0$, there is no PTM by Foreign exporters into the Foreign-currency prices. Consequently, this implies full pass-through to Home import prices. By contrast, if $\dfrac{d\ln P_F^*}{d\ln E} = -1$, this implies full PTM by Foreign exporters and zero pass-through into Home import prices. Markup adjustment to exchange rate changes has strong empirical support. For example, Goldberg and Knetter (1997) conclude that destination-specific changes in markups are a very significant factor in incomplete exchange rate pass-through. Therefore, we need to allow endogenous markups in analyzing pass-through to firm-level prices.[3]

Secondly, incomplete pass-through may result from changes in the marginal cost due to changes in imported input costs. Recently, the role of imported intermediate inputs

[2] Current research points to other sources of incomplete pass-through: the importance of local nontraded costs in the total costs, the costs of nominal price adjustment and so on.

[3] Exogenous markups imply full exchange rate pass-through to firm-level import prices.

has received a lot of attention in explaining the effect of exchange rate shocks. One of the recent noticeable trends in world trade involves the increasing interconnectedness of production processes in a vertical trading chain across many countries (Hummels et. al (2001)[4]). With the growth of vertical specialization[5], we need to pay more attention to changes in input prices due to exchange rate movements. In an economy with intermediate goods trade, exchange rate changes will affect not only the relative price of final goods, but also the relative price of local inputs to imported inputs. Exchange rate appreciations have a negative effect on domestic firms through the traditional revenue channel, but a positive effect through the cost channel by lowering prices of imported inputs.

These different channels of exchange rate shocks have been examined more vigorously in the empirical area by the practical necessity of policy-makers. Athukorala and Menon (1994) conclude that the cost lowering effect of exchange rate changes seems to have provided Japanese exporters with considerable leverage in enduring the yen appreciation. Ahmed (2009) shows there is a significant negative effect on exports of Chinese Renminbi (RMB) appreciation against the currencies of China's advanced-economy trading partners, and there is a positive effect on processing exports of Chinese RMB appreciation against other emerging Asian currencies.[6] Greenway et al. (2010) find evidence of both a negative effect from appreciation and an offsetting effect through imported intermediate inputs for a sample of UK manufacturing firms between 1988 and 2004.

With production sharing the role of imported inputs in affecting pass-through becomes important. Existing literature suggests that pass-through is muted when firms use imported inputs. Goldberg and Knetter (1997) state that if changes in the value of the home cur-

[4]For their 14-country sample, the vertical specialization share grew by about 30% between 1970 and 1990, and growth in vertical specialization exports accounted for 30% of the growth in the overall export /GDP ratio.

[5]There exist various expressions with the same meaning in the trade literature: "slicing up the value chain", "disintegration of production", "international fragmentation" etc.

[6]China's exports include a substantial amount of intermediate inputs imported from other East Asian economies. Koopman, Wang, and Wei (2008) illustrate that this East Asian supply chain is particularly dominant in electronic products.

rency against the dollar influence exporters' marginal costs by inducing imported input price changes, pass-through to the U.S. could be muted relative to other markets. Yang (1997, 1998) shows that there is a negative relationship between the elasticities of marginal cost with respect to exchange rate and pass-through. Cost shocks offset the effect of the exchange rate change on the Foreign firm's export price in the importing nation's currency.

The aim of this paper is to investigate the effect of different channels through which exchange rate shocks affect firms' decisions on pricing and entry and exit. I extend the model of exchange rate pass-through with endogenous markups built by Rodriguez-Lopez (2011) introducing the intermediate input sector. In his paper, he assumes that exchange rate movements are exogenous and that wages are fixed.[7] Exchange rate movements generate reallocation of firms because firms are heterogeneous with respect to their levels of productivity. As a result, exchange rate movements affect the extensive margin of trade–the number of goods traded–by altering the cut-off productivity levels. In addition, I introduce two factors, domestic and imported intermediate inputs. Therefore, firms' exposure to exchange rates includes two aspects: exports of final goods and imports of intermediate inputs.

Rodriguez-Lopez shows that low levels of exchange rate pass-through to firm- and aggregate-level import prices coexist with large movements in trade flows. However, these results may not be reconciled with some empirical observations. First, the pass-through to the aggregate import price is always negative in his original model.[8] This consequence results mainly from a composition bias. In response to a Home currency depreciation, the least productive Foreign exporters leave the Home market as their competitiveness weakens. Under intensified competition with Home firms, the surviving Foreign exporters must decrease their markups. In the end, aggregate import prices are computed using only the survivors who are the most

[7]There exists strong evidence of nominal wage rigidities from many countries. See Akerlof (2007) for detail.

[8]To solve this problem, he proposes an extended model considering product quality. His quality model predicts that the pass-through to the aggregate unit import price can be positive.

productive.[9] Second, his model predicts large and unilateral expenditure-switching effects of exchange rate fluctuations. But some empirical studies show us that imports and exports are much less responsive to exchange rate movements.[10]

This paper proposes a theoretical background for various possibilities of exchange pass-through and expenditure-switching. The shares of imported inputs in total costs are important determinants.[11] According to the relative sizes of these shares, exchange rate movements might lead to different cost shocks to each trading nation. When the imported input shares are located within some range, a low but positive rate of pass-through to aggregate import prices can be derived in the model. In addition, both the size and the direction of expenditure-switching effects are ambiguous because they also depend on the imported input shares. Therefore, low levels of exchange rate pass-through to aggregate import prices can coexist with negligible movements in trade flows unlike Rodriguez-Lopez. Although I use a partial equilibrium model with fixed wages, we can investigate welfare implications of exchange rate changes briefly. Under the current model, the effect of exchange rate movements on welfare in each trading country is ambiguous. This is because a change in the overall competitive environment by exchange rate shocks may vary with the impact of cost shocks. In this paper, the overall competitive environment is captured by the number of competitors (or the number of product varieties) in each market.

[9] Rodriguez-Lopez indicates that aggregate prices can differ drastically from the average firm-level pass-through rate due to a sample selection problem related to changes in the extensive margin of trade.

[10] For example, Dong (2012) indicates that both U.S. imports and exports have become much less responsive to exchange rate movements in recent years.

[11] According to Campa and Goldberg (2006), the ratio of imported inputs to total costs differs significantly by country and industry. In general, larger countries have a lower share of imported inputs into production while smaller countries have a higher share. Within the manufacturing sector, chemicals has the largest share of imported inputs, 67 percent of total costs, followed by electrical machinery and medical and precision instruments, both with imported input shares above 50 percent. The industries within manufacturing with the lowest imported input shares are forestry and metal ores.

2.2 Basic Model

2.2.1 Preferences and Demand

We begin by considering an economy which imports intermediate inputs from a trading partner, but does not trade differentiated final goods. There are two countries, Home, Foreign. We use a star (*) to denote Foreign variables.

L identical consumers share the same utility function given by

$$U = z_0 + \alpha \int_{\omega\in\Omega} z(\omega)d\omega - \frac{1}{2}\gamma \int_{\omega\in\Omega} z(\omega)^2 d\omega - \frac{1}{2}\eta \left[\int_{\omega\in\Omega} z(\omega)d\omega\right]^2 \tag{2.2}$$

where z_0 and $z(\omega)$ are, respectively, the individual consumption of the numeraire good and quantity of variety ω in the differentiated sector. The demand parameters α, γ and η are all positive. The parameter α and η denote the substitution pattern between the numeraire and the differentiated varieties: both increases in α and decreases in η raise the demand for the differentiated varieties relative to the numeraire. The parameter γ represents the degree of product differentiation among the varieties.

Total expenditure of the representative consumer is given by

$$I = z_0 + \int_{\omega\in\Omega} p(\omega)z(\omega)d\omega \tag{2.3}$$

where $p(\omega)$ is the price that consumers pay for a specific variety ω.

We assume that consumers have positive demands for the numeraire good ($z_0 > 0$). The inverse demand for each variety ω is then given by

$$p(\omega) = \alpha - \gamma z(\omega) - \eta Z \tag{2.4}$$

where $Z \equiv \int_{\omega\in\Omega} z(\omega)d\omega$ denotes the consumption level over all varieties.

Let $\Omega^* \subset \Omega$ be the subset of varieties that are consumed ($z(\omega) > 0$). We can derive the following linear market demand system for these varieties.

$$y(\omega) \equiv Lz(\omega) = \frac{L}{\gamma}\left[\frac{\gamma\alpha}{\eta N + \gamma} - p(\omega) + \frac{\eta N}{\eta N + \gamma}\bar{p}\right], \qquad \forall \omega \in \Omega^* \tag{2.5}$$

where N is the measure of consumed varieties and $\bar{p} = \frac{1}{N}\int_{\omega \in \Omega^*} p(\omega) d\omega$ is their average price. The set Ω^* is the largest subset of Ω that satisfies

$$p(\omega) \leq \frac{1}{\eta N + \gamma}\left(\gamma\alpha + \eta N \bar{p}\right) \equiv \hat{p} \tag{2.6}$$

where $\hat{p}$ is the price-ceiling for all varieties, above which the demand for an individual variety will be zero.

Let's substitute (2.6) into (2.5). The quantity demanded for each variety is

$$y(\omega) = \frac{L}{\gamma}\left[\hat{p} - p(\omega)\right] \tag{2.7}$$

2.2.2 Production

Labor is the only factor of production and is assumed to be inelastically supplied in a competitive market. There are three sectors in each country. The final-good sector is monopolistically competitive while the intermediate-input sector and the numeraire good market are competitive.

Production of the final good requires two types of intermediate inputs: domestic (I_d) and imported (I_m). We assume that producing one unit of a domestic input requires one unit of labor and, given the nominal wage rate W, entails cost W. It will turn out that in equilibrium the price of each intermediate input equals the marginal cost of producing the input. The numeraire good is produced under constant to returns at unit cost. That is, one unit of the numeraire good is produced using $\frac{1}{W}$ units of labor. A parallel assumption holds for Foreign country. In the Foreign country, the marginal cost of producing the input is W^* and one unit of the numeraire good is produced using $\frac{1}{W^*}$ units of labor.

We adopt a CES production function that transforms intermediate inputs to final goods like Bas (2009).

$$y = \frac{1}{c}[(I_d)^{\frac{\sigma-1}{\sigma}} + (\phi I_m)^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{\sigma-1}} \tag{2.8}$$

where $\frac{1}{c}$ indexes firm productivity and is assumed to be different among heterogeneous firms. Each firm learns about c only after paying the entry cost.

σ is the elasticity of substitution between two inputs. We assume that domestic and imported inputs are imperfect substitutes: $1 < \sigma < \infty$. The parameter ϕ measures the imported inputs requirements in the production process. Higher ϕ indicates higher efficiency of imported inputs.

2.2.3 Firms' Optimization

First, we can consider the following cost minimization problem conditional y.

$$\begin{aligned} \min_{I_d, I_m} \quad & C(y) = W I_d + E W^* I_m \\ s.t.\ \ y &= \frac{1}{c}[(I_d)^{\frac{\sigma-1}{\sigma}} + (\phi I_m)^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{\sigma-1}} \end{aligned} \tag{2.9}$$

where E is the nominal exchange rate, measured as the Home currency per unit of the Foreign currency. Actually, E can be interpreted as the real exchange rate in this paper. This is because W and W^* denote labor productivity in Home and Foreign, respectively.[12]

Equation (2.9) yields the following relationship between factor demands and their relative

[12] $Q = \frac{EP^*}{P} = \frac{E\frac{W^*}{MPL^*}}{\frac{W}{MPL}} = E\frac{W^*}{W}\frac{MPL}{MPL^*} = E\frac{W^*}{W}\frac{W}{W^*} = E$ where Q is the real exchange rate, P and P^* are the price levels of Home and Foreign country. MPL and MPL^* are marginal products of labor in the non-tradable numeraire sector of the two countries, respectively.

prices.

$$\frac{I_m}{I_d} = \left(\frac{W}{EW^*}\right)^{\sigma} \phi^{\sigma-1} \tag{2.10}$$

From equation (2.10), exchange rate appreciations (a decrease in E) or higher imported input requirements raise the relative demand for imported intermediate inputs.

Substituting (2.10) into (2.8),

$$\begin{aligned} y =& \frac{1}{c}\left\{1+\left(\frac{W}{EW^*}\right)^{\sigma-1}\phi^{\sigma-1}\right\}^{\frac{\sigma}{\sigma-1}} I_d \\ =& \frac{A^{\sigma}}{c} I_d \end{aligned} \tag{2.11}$$

where $A \equiv \left\{1+\left(\frac{W}{EW^*}\right)^{\sigma-1}\phi^{\sigma-1}\right\}^{\frac{1}{\sigma-1}}$

Now let's calculate the effective marginal cost of producing one unit of final good, which is identical to the average cost.[13]

$$\frac{C(y)}{y} = \frac{WI_d + EW^* I_m}{y} = \frac{WA^{\sigma-1}I_d}{\frac{A^{\sigma}}{c}I_d} = \frac{Wc}{A} \tag{2.12}$$

Therefore, the effective marginal cost is the product of two terms, $\frac{W}{A}$ and c. For our better understanding, suppose that we can split production process of a final good into two stages. At the first stage, firms produce virtual intermediate inputs I_V using domestic and imported inputs. $I_V = [(I_d)^{\frac{\sigma-1}{\sigma}} + (\phi I_m)^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{\sigma-1}}$. In the second stage, a final good is produced using these virtual inputs, that is $y = \frac{I_V}{c}$. Then c can be interpreted as unit virtual input requirement for a final good. The price of a virtual input is given by $\frac{W}{A}$. In other words, $\frac{W}{A}$ represents the effective input prices of Home firms. If Home firms do not use imported inputs at all ($\phi = 0$), the effective input price would be W. Access to foreign inputs lowers the effective input price from the existence of an additional term $A > 1$ in

[13] As we see in equation (2.12), the marginal cost is not given directly and is computed indirectly. Thus, I use the term "effective marginal cost".

the denominator. Therefore, we can interpret A as the coefficient of productivity growth due to imported inputs. Note that exchange rate movements cause marginal cost shocks by changing A.

Given the technology, the Home firms' profit function is

$$\begin{aligned}\pi(c) =& p(c)y(c) - WI_d - EW^*I_m \\ =& \left[p(c) - \frac{Wc}{A}\right] y(c) \\ =& \left[p(c) - \frac{Wc}{A}\right] \frac{L}{\gamma} \left[\hat{p} - p(c)\right]\end{aligned} \tag{2.13}$$

The pricing rule is derived by maximizing profits with respect to the price. Given the continuum of competitors, each individual firm regards itself as quite small relative to the market as a whole and treats $\bar{p}$ and N as unaffected by its own choices. Therefore, a firm takes $\hat{p}$ as given.

$$p(c) = \frac{1}{2}\left(\hat{p} + \frac{Wc}{A}\right) \tag{2.14}$$

Let $\mu(c)$ and $\pi(c)$ denote the (absolute) mark-up and profit.

$$\mu(c) = \frac{1}{2}\left(\hat{p} - \frac{Wc}{A}\right) \tag{2.15}$$

$$y(c) = \frac{L}{2\gamma}\left(\hat{p} - \frac{Wc}{A}\right) \tag{2.16}$$

$$\pi(c) = \mu(c)y(c) = \frac{L}{4\gamma}\left(\hat{p} - \frac{Wc}{A}\right)^2 \tag{2.17}$$

As expected, lower cost firms (high productivity firms) set lower prices and higher mark-ups and earn higher profits.[14]

[14] In this paper, c is basically a physical unit which is not measured in terms of money value. Because we assume fixed wages, c is expressed as cost draws by abuse of notation.

2.2.4 Trade in Final Goods

Home and Foreign countries have respectively L and L^* identical consumers who share the same preferences. The final goods markets in the two counties are segmented, but firms can produce in one market and sell in the other, incurring a per-unit trade cost. Let $\tau > 1$ be the iceberg cost for Home firms. In the same way, τ^* accounts for the iceberg cost for Foreign firms.

Let $p_D(c)$ and $p_X(c)$ denote the nominal domestic and export prices of a Home firm with cost c. These prices are set in the currency of the destination country.

Following equation (2.14), we can write the pricing equations for a Home firm with cost c as

$$p_D(c) = \frac{1}{2}\left(\hat{p} + \frac{Wc}{A}\right), \quad p_X(c) = \frac{1}{2}\left(\hat{p}^* + \frac{\tau}{E} \cdot \frac{Wc}{A}\right)$$

Mark-ups are given by

$$\mu_D(c) = \frac{1}{2}\left(\hat{p} - \frac{Wc}{A}\right), \quad \mu_X(c) = \frac{1}{2}\left(\hat{p}^* - \frac{\tau}{E} \cdot \frac{Wc}{A}\right)$$

Also we can get the following profit functions.

$$\pi_D(c) = \frac{L}{4\gamma}\left(\hat{p} - \frac{Wc}{A}\right)^2, \quad \pi_X(c) = \frac{L^*}{4\gamma}\left(\hat{p}^* - \frac{\tau}{E} \cdot \frac{Wc}{A}\right)^2$$

Let A^* be the the coefficient of productivity growth due to imported inputs by Foreign firms.

$$A^* = \left\{1 + \left(\frac{EW^*}{W}\right)^{\sigma-1} (\phi^*)^{\sigma-1}\right\}^{\frac{1}{\sigma-1}}$$

Analogously, prices, mark-ups and profits by a Foreign firm are given by

$$p_D^*(c) = \frac{1}{2}\left(\hat{p}^* + \frac{W^*c}{A^*}\right), \quad p_X^*(c) = \frac{1}{2}\left(\hat{p} + \tau^* E \cdot \frac{W^*c}{A^*}\right)$$

$$\mu_D^*(c) = \frac{1}{2}\left(\hat{p}^* - \frac{W^*c}{A^*}\right), \quad \mu_X^*(c) = \frac{1}{2}\left(\hat{p} - \tau^* E \cdot \frac{W^*c}{A^*}\right)$$

$$\pi_D^*(c) = \frac{L^*}{4\gamma}\left(\hat{p}^* - \frac{W^*c}{A^*}\right)^2, \quad \pi_X^*(c) = \frac{L}{4\gamma}\left(\hat{p} - \tau^* E \cdot \frac{W^*c}{A^*}\right)^2$$

2.2.5 Cut-off Productivity Levels

We define the cut-off rules as $c_r = \sup\{c : \pi_r(c) > 0\}$ and $c_r^* = \sup\{c : \pi_r^*(c) > 0\}$ for $r \in \{D, X\}$.

$$c_D = \frac{A\hat{p}}{W}, \quad c_X = \frac{AE\hat{p}^*}{\tau W}$$

$$c_D^* = \frac{A^*\hat{p}^*}{W^*}, \quad c_X^* = \frac{A^*\hat{p}}{\tau^* EW^*}$$

Then, we derive the following relationships between cut-off levels.

$$c_X^* = \left(\frac{A^*W}{A\tau^*EW^*}\right)c_D \tag{2.18}$$

$$c_X = \left(\frac{AEW^*}{A^*\tau W}\right)c_D^* \tag{2.19}$$

where the term in parentheses in each equation is the relative variable cost.

We assume that cost draws c are Pareto distributed in the interval $[0, c_M]$ in both countries. The cumulative distribution function of costs is given by $G(c) = \left(\frac{c}{c_M}\right)^k$, where $k > 1$ indexes the dispersion of cost draws. As k increases, the ratio of high-cost firms increases and the cost distribution is more clustered near the upper bound.

Entry is unrestricted in both countries. Firms will enter in each country as long as their expected profits are no less than the sunk entry cost. Let f_E and f_E^* be the entry cost in units of effective labor of the Home and Foreign country, respectively. Consequently, the sunk cost in each country is represented by Wf_E and $W^*f_E^*$ in nominal terms.

Free entry conditions for both countries are given by

$$\int_0^{c_D} \pi_D(c)dG(c) + E\int_0^{c_X} \pi_X(c)dG(c) = Wf_E \tag{2.20}$$

$$\int_0^{c_D^*} \pi_D^*(c)dG(c) + \frac{1}{E}\int_0^{c_X^*} \pi_X^*(c)dG(c) = W^* f_E^* \tag{2.21}$$

Using the Pareto parametrization for the cost draws, the free entry conditions can be re-written as follows.

$$L\left(\frac{W}{A}\right)^2 (c_D)^{k+2} + EL^*\left(\frac{\tau W}{AE}\right)^2 (c_X)^{k+2} = \varphi W f_E \tag{2.22}$$

$$L^*\left(\frac{W^*}{A^*}\right)^2 \left(c_D^*\right)^{k+2} + \frac{1}{E}L\left(\frac{\tau^* E W^*}{A^*}\right)^2 \left(c_X^*\right)^{k+2} = \varphi W^* f_E^* \tag{2.23}$$

where $\varphi \equiv 2\gamma(k+1)(k+2)\left(c_M\right)^k$

We now solve for the equilibrium cut-off levels.

$$c_D = \left[\frac{A^2\varphi W f_E}{LW^2}\cdot\frac{(\tau^*)^k\left\{\tau^k - \psi\right\}}{(\tau\tau^*)^k - 1}\right]^{\frac{1}{k+2}} \tag{2.24}$$

$$c_X = \left[\frac{A^2 E\varphi W f_E}{L^*\left(\tau W\right)^2}\cdot\frac{(\tau^*)^k\,\psi - 1}{(\tau\tau^*)^k - 1}\right]^{\frac{1}{k+2}} \tag{2.25}$$

$$c_D^* = \left[\frac{\left(A^*\right)^2\varphi W^* f_E^*}{L^*\left(W^*\right)^2}\cdot\frac{\tau^k\left\{(\tau^*)^k - \frac{1}{\psi}\right\}}{(\tau\tau^*)^k - 1}\right]^{\frac{1}{k+2}} \tag{2.26}$$

$$c_X^* = \left[\frac{\left(A^*\right)^2\varphi W^* f_E^*}{LE\left(\tau^* W^*\right)^2}\cdot\frac{\frac{\tau^k}{\psi} - 1}{(\tau\tau^*)^k - 1}\right]^{\frac{1}{k+2}} \tag{2.27}$$

where $\psi \equiv \dfrac{EW^* f_E^*}{W f_E}\left(\dfrac{EW^*/A^*}{W/A}\right)^k$ is a combined measure of the entry cost and the variable cost of Foreign country relative to Home country. Therefore, ψ can be defined as the index describing relative competitiveness of Home firms.

We see that ψ must range between $\frac{1}{(\tau^*)^k}$ and τ^k in order to obtain positive equilibrium cut-off levels.[15] Because we treat all the variables except exchange rates as fixed, this condition consequently limits exchange rate fluctuations. Throughout this paper, we will assume this necessary condition holds.

2.2.6 Prices, Product Varieties and Welfare

Let $g(c|c \leq c_r)$ denote the probability density function for costs of Home firms that actually sell in market $r \in \{D, X\}$. Given the Pareto distribution assumption, we obtain

$$g(c|c \leq c_r) = \begin{cases} \dfrac{g(c)}{G(c_r)} = \dfrac{kc^{k-1}}{(c_r)^k} & \text{if } c \leq c_r \\ 0 & \text{otherwise} \end{cases}$$

A parallel conditional distribution holds for Foreign firms.

Let $\bar{p}_r$ and $\bar{p}_r^*$ denote the average price of Home goods and Foreign goods available in market r, for $r \in \{D, X\}$. Also, let $\bar{p}$ and $\bar{p}^*$ represent the average price of all goods at Home and at Foreign, respectively. We obtain the following proposition.

Proposition 7

The average prices of domestic and imported goods are equal:

$$\bar{p} = \bar{p}_D = \bar{p}_X^* = \left(\frac{k+\frac{1}{2}}{k+1}\right)\frac{W}{A}c_D \text{ and } \bar{p}^* = \bar{p}_D^* = \bar{p}_X = \left(\frac{k+\frac{1}{2}}{k+1}\right)\frac{W^*}{A^*}c_D^*$$

The equivalence of average prices of domestic and imported goods results from the identical price distribution faced by all firms competing in the same market. From pricing equations, (2.18) and (2.19), we can check this fact easily.

[15] To ensure an interior solution, we also need the equilibrium cut-off levels to be smaller than or equal to c_M.

From equation (2.6) and Proposition 7, the number of firms selling in each country is given by equation (2.28).[16]

$$
\begin{aligned}
N &= \frac{2(k+1)\gamma}{\eta} \cdot \frac{\alpha - \frac{W}{A}c_D}{\frac{W}{A}c_D} = \frac{2(k+1)\gamma}{\eta}\left(\frac{A}{Wc_D}\alpha - 1\right) \\
N^* &= \frac{2(k+1)\gamma}{\eta} \cdot \frac{\alpha - \frac{W^*}{A^*}c_D^*}{\frac{W^*}{A^*}c_D^*} = \frac{2(k+1)\gamma}{\eta}\left(\frac{A^*}{W^*c_D^*}\alpha - 1\right)
\end{aligned}
\tag{2.28}
$$

With Meltiz-Ottaviano (2008) utility function, the overall competitive environment is characterized by the number of competing varieties and average prices. When the domestic cut-offs decrease, average prices decline and product variety increases. That is, the competition environment becomes tougher. The following corollary shows us that welfare increases with decreases in the domestic cut-offs.

Corollary 1 *Welfare can be evaluated using the following indirect utility functions.*

$$
\begin{aligned}
U &= W + \frac{1}{2\eta}\left(\alpha - \frac{W}{A}c_D\right)\left(\alpha - \frac{k+1}{k+2}\frac{W}{A}c_D\right) \\
U^* &= W^* + \frac{1}{2\eta}\left(\alpha - \frac{W^*}{A^*}c_D^*\right)\left(\alpha - \frac{k+1}{k+2}\frac{W^*}{A^*}c_D^*\right)
\end{aligned}
$$

2.2.7 Entrants, Producers and Exporters

Let N_e (N_e^*) denote the mass of entrants at Home (Foreign). Also let N_D and N_X be the mass of Home firms selling at Home and at Foreign, respectively. With similar expressions for Foreign firms, for $r \in \{D, X\}$ we have

$$
N_r = G(c_r)N_e = \left(\frac{c_r}{c_M}\right)^k N_e \tag{2.29}
$$

[16]In Rodriguez-Lopez (2011), N and N^* are constant due to the use of translog preferences instead of a quadratic utility. However, the composition of domestic and imported goods in each market may change in response to exchange rate fluctuations.

$$N_r^* = G(c_r^*)N_e^* = \left(\frac{c_r^*}{c_M}\right)^k N_e^* \tag{2.30}$$

Because $N = N_D + N_X^*$ and $N^* = N_D^* + N_X$, we can solve the number of entrants in each country.

$$N_e = \frac{2(k+1)\gamma\,(c_M)^k}{\eta\left[(\tau\tau^*)^k - 1\right]}\left[\frac{(\tau\tau^*)^k}{(c_D)^k}\left(\frac{A}{Wc_D}\alpha - 1\right) - \frac{1}{(c_X)^k}\left(\frac{A}{Wc_X}\frac{E}{\tau}\alpha - 1\right)\right] \tag{2.31}$$

$$N_e^* = \frac{2(k+1)\gamma\,(c_M)^k}{\eta\left[(\tau\tau^*)^k - 1\right]}\left[\frac{(\tau\tau^*)^k}{(c_D^*)^k}\left(\frac{A^*}{W^*c_D^*}\alpha - 1\right) - \frac{1}{(c_X^*)^k}\left(\frac{A^*}{W^*c_X^*}\frac{1}{E\tau^*}\alpha - 1\right)\right] \tag{2.32}$$

Both N_e and N_e^* must be non-negative. The following corollary shows that if trade costs are sufficiently high, exporters always are more productive than non-exporters. Empirical studies find that exporting firms tend, on average, to be more productive.[17] Therefore, I assume that Corollary 2 holds throughout this paper.[18]

Corollary 2 *If* $\frac{1}{\tau^*} \leq E \leq \tau$, $c_D \geq c_X$ *and* $c_D^* \geq c_X^*$.

2.3 The Effect of Exchange Rates in Partial Equilibrium

2.3.1 The Cut-off Levels and the Exchange Rate

To understand how exchange rate shocks are reflected in prices, we begin by analyzing their impact on the cut-off levels.

[17] Bernard and Jensen (1999), Clerides, Lach and Tybout (1998) and Aw, Chung and Roberts (2000) are frequently cited empirical papers which support a positive correlation between exporting and productivity.

[18] Purchasing power parity states that the real exchange rate is equal to 1. Therefore, assuming this parity holds, the sufficient condition of Corollary 2 is also satisfied.

Taking the natural logarithm of equation (2.24), we obtain

$$\ln c_D = \frac{1}{k+2}\left[\ln \nu_D + 2\ln A + \ln(\tau^k - \psi)\right] \quad \text{where} \quad \nu_D \equiv \frac{\varphi f_E}{LW} \cdot \frac{(\tau^*)^k}{(\tau\tau^*)^k - 1}$$

Let $\epsilon_{c_D,E}$ be the elasticity of c_D with respect to the exchange rate.

$$\epsilon_{c_D,E} = \frac{\partial \ln c_D}{\partial \ln E} = \frac{1}{k+2}\left[2 \cdot \frac{\partial \ln A}{\partial \ln E} - \frac{\psi}{\tau^k - \psi} \cdot \frac{\partial \ln \psi}{\partial \ln E}\right] \tag{2.33}$$

Thus, $\epsilon_{c_D,E}$ is comprised with combination of two different effects. From the bracket in equation (2.33), the first term indicates a negative cost shock due to higher prices of imported inputs. With a depreciation in the Home currency, Home firms experience a rise in imported input prices because the coefficient A decreases. All other things being equal, Home firms' cut-offs must decrease to compensate for higher input prices.

Next, the second term indicates the competitiveness effect. As defined, an increase in ψ implies that Home firms become more competitive. A depreciation of the Home currency affects relative competitiveness in two opposite directions. To begin with, a Home currency depreciation directly raises both the variable cost and entry cost of Foreign firms expressed in the Home currency. On the other hand, with a depreciation in the Home currency, Home firms experience a negative cost shock while Foreign firms face a positive cost shock. This indirect channel makes Home firms less competitive contrary to the former direct channel. As a result, the net effect of these two forces, namely the sign of $\frac{\partial \ln \psi}{\partial \ln E}$, is unclear. Suppose first that a depreciation of the Home currency makes Home firms more competitive $\left(\frac{\partial \ln \psi}{\partial \ln E} > 0\right)$ in the Foreign market. Then, an increase in the ex ante expected profit from exporting gives rise to downward pressure on the domestic cut-off for Home firms taking into account the free-entry condition. Reversely, the weakened competitiveness of Home firms due to a depreciated domestic currency $\left(\frac{\partial \ln \psi}{\partial \ln E} < 0\right)$ tends to put upward pressure on c_D.

From the definition of A and A^*,

$$\frac{\partial \ln A}{\partial \ln E} = -\frac{\left(\frac{W}{EW^*}\right)^{\sigma-1} \phi^{\sigma-1}}{1 + \left(\frac{W}{EW^*}\right)^{\sigma-1} \phi^{\sigma-1}} = -\epsilon_A \tag{2.34}$$

$$\frac{\partial \ln A^*}{\partial \ln E} = \frac{\left(\frac{EW^*}{W}\right)^{\sigma-1} (\phi^*)^{\sigma-1}}{1 + \left(\frac{EW^*}{W}\right)^{\sigma-1} (\phi^*)^{\sigma-1}} = \epsilon_{A^*} \tag{2.35}$$

These elasticities (in absolute value) range between 0 and 1. We can interpret the economic meaning of ϵ_A and ϵ_{A^*} easily. From equation (2.10),

$$\frac{EW^* I_m}{W I_d} = \left(\frac{W}{EW^*}\right)^{\sigma-1} \phi^{\sigma-1} \Longrightarrow \epsilon_A = \frac{\left(\frac{W}{EW^*}\right)^{\sigma-1} \phi^{\sigma-1}}{1 + \left(\frac{W}{EW^*}\right)^{\sigma-1} \phi^{\sigma-1}} = \frac{EW^* I_m}{W I_d + EW^* I_m} \tag{2.36}$$

Therefore, ϵ_A represents the share of imported inputs in total variable costs of Home firms and ϵ_{A^*} denotes the corresponding imported input share of Foreign firms.

From the definition of ψ,

$$\frac{\partial \ln \psi}{\partial \ln E} = (k+1) - k\left(\epsilon_A + \epsilon_{A^*}\right) \tag{2.37}$$

Substituting (2.34) and (2.37) into (2.33), we obtain the following expression.

$$\epsilon_{c_D,E} = \frac{1}{(k+2)(\tau^k - \psi)} \left[\left\{k\psi - 2(\tau^k - \psi)\right\} \epsilon_A + k\psi\epsilon_{A^*} - \psi(k+1)\right] \tag{2.38}$$

Therefore, we see that the impact of exchange rate shocks on the cut-off level depends on some parameters.

Proposition 8

1. *(a) If* $\tau^k \geq \left(\frac{k+1}{2}\right)\psi$, $\epsilon_{c_D,E} < 0$.

   (b) If $\psi < \tau^k < \left(\frac{k+1}{2}\right)\psi$, $\epsilon_{c_D,E} \geq 0$ *only when* $\epsilon_{A^*} \geq \left[\frac{2(\tau^k - \psi)}{k\psi} - 1\right]\epsilon_A + 1 + \frac{1}{k}$.
   Otherwise, $\epsilon_{c_D,E} < 0$.

2. *(a) If* $(\tau^*)^k \geq \left(\frac{k+1}{2}\right)\frac{1}{\psi}$, $\epsilon_{c^*_D,E} > 0$.

   (b) If $\frac{1}{\psi} < (\tau^*)^k < \left(\frac{k+1}{2}\right)\frac{1}{\psi}$, $\epsilon_{c_{D^*},E} \leq 0$ *only when* $\epsilon_{A^*} \geq \frac{k\epsilon_A - (k+1)}{2[(\tau^*)^k\psi - 1] - k}$.
   Otherwise, $\epsilon_{c^*_D,E} > 0$.

Consider first the impact of a depreciation of the Home currency on c_D, the cut-off level for domestic producers at Home. Equation (2.33) tells us that the competitiveness effect is very slight when trade costs are sufficiently large. In this case, the cut-off for Home firms selling in their domestic market always decreases to make up for higher prices of imported inputs as shown in Proposition 8-1 (a). Unless trade costs are large enough to incapacitate the competitiveness effect, the sign of $\epsilon_{c_D,E}$ is determined by the relative size of a directly-induced negative cost shock and the competitiveness effect. Figure 2.1 (a) illustrates how the sign of $\epsilon_{c_D,E}$ is determined within ϵ_A ϵ_{A^*} range. Note that $\epsilon_{c_D,E} < 0$ holds in most areas.

For $\epsilon_{c_D,E}$ to be positive, a currency devaluation must weaken the competitiveness of Home firms considerably. Then, pre-entry expected profit from exporting decreases for Home producers. In order to satisfy the free-entry condition, the pre-entry expected profit from domestic sales increases for Home firms. This occurs if and only if c_D increases. To obtain this result, ϵ_{A^*} needs to be sufficiently large and so Foreign firms enjoy the huge benefit from cheaper prices of imported inputs after a Home currency depreciation. On the contrary, ϵ_A may affect $\epsilon_{c_D,E}$ through both a directly-induced cost shock effect and the competitiveness effect in the opposite direction.

Analogously, we can obtain the cut-off rule for Foreign firms selling domestically as the second part of Proposition 8. From Figure 2.1, a depreciation of Home currency is likely to

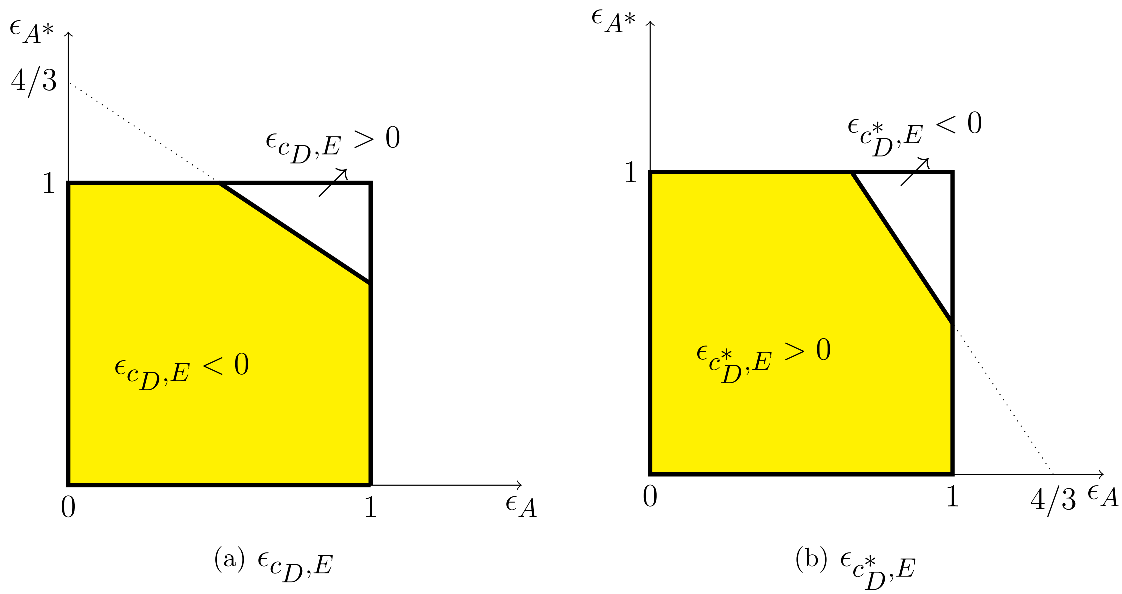


Figure 2.1: The Impact of Exchange Rate Movements on the Cut-off Level ($k = 3, \psi = 1, \tau = \tau^* = (1.5)^{1/3}$)

For interpretation of the references to color in this and all other figures, the reader is referred to the electronic version of this dissertation.

lead a decline in the cut-off for Home domestic producers and a rise in the cut-off for Foreign domestic producers. This is because Home firms' competitiveness generally improves ($\frac{\partial \ln \psi}{\partial \ln E}$ is positive) or weakens mildly ($\frac{\partial \ln \psi}{\partial \ln E}$ is negative but relatively small in absolute value) due to a depreciation of Home currency. For example, suppose that a Home-currency depreciation leads to the improvement of competitiveness of Home firms. Then, the entry at Home increases while the entry at Foreign declines. Assuming the trade cost is sufficiently large, increased competition among local firms dominates in the Home market. c_D decreases by the intensified competition at Home combined with higher imported input costs.

Given the relationships established in equations (2.18) and (2.19),

$$\epsilon_{c^*_X,E} = \epsilon_{c_D,E} + \epsilon_A + \epsilon_{A^*} - 1 \tag{2.39}$$

$$\epsilon_{c_X,E} = \epsilon_{c^*_D,E} + 1 - \epsilon_A - \epsilon_{A^*} \tag{2.40}$$

From Proposition 8, if $\epsilon_{c_D,E} \geq 0$, $\epsilon_{c^*_X,E} \geq 0$. Also, if $\epsilon_{c^*_D,E} \leq 0$, $\epsilon_{c_X,E} \leq 0$. But with $\epsilon_{c_D,E} < 0$ ($\epsilon_{c^*_D,E} > 0$), we cannot determine the sign of $\epsilon_{c^*_X,E}$ ($\epsilon_{c_X,E}$).

In conclusion, the effect of exchange rate movements on the cut-off levels is not unilateral when we include a tradable intermediate input sector. This property yields distinguishing features of this model.

2.3.2 Welfare

According to the results in Section 2.2.6, we must analyze the change in the effective marginal cost cut-off to investigate the impact of exchange rate fluctuations on average prices, product varieties and welfare. For simplicity of notation, we define the effective marginal cost cut-off as the product of the effective input price and cost cut-off. That is, $\lambda_r = \dfrac{W}{A} c_r$ and $\lambda^*_r = \dfrac{W^*}{A^*} c^*_r$ for $r \in \{D, X\}$. And the elasticities of these cut-offs with respect to the exchange rate are defined as $\epsilon_{\lambda_r,E}$ and $\epsilon_{\lambda^*_r,E}$ for $r \in \{D, X\}$. Then, the following equations are readily obtained.

$$\epsilon_{\lambda_D,E} = \epsilon_A + \epsilon_{c_D,E} \tag{2.41}$$

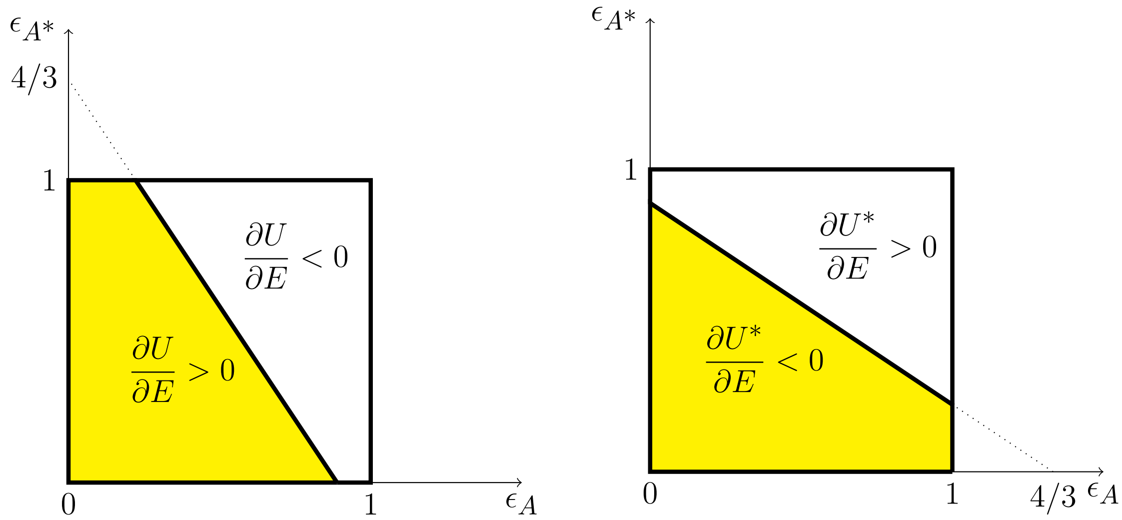
$$\epsilon_{\lambda^*_D,E} = -\epsilon_{A^*} + \epsilon_{c^*_D,E} \tag{2.42}$$

Therefore, $\epsilon_{\lambda_D,E} < 0$ ($\epsilon_{\lambda^*_D,E} < 0$) is the sufficient condition for Home welfare (Foreign welfare) to increase due to a Home currency depreciation. Proposition 9 tells us that the impact of exchange rate shocks on each country's welfare is ambiguous.

Proposition 9

1. *If* $\epsilon_{A^*} < -\dfrac{\tau^k}{\psi}\epsilon_A + 1 + \dfrac{1}{k}$, *a depreciation of the Home currency raises Home welfare. Otherwise, Home welfare decreases or remains unchanged due to a depreciation of the Home currency.*

2. If $\epsilon_{A^*} > -\frac{1}{(\tau^*)^k \psi}\epsilon_A + \frac{k+1}{k\psi(\tau^*)^k}$*, a depreciation of the Home currency raises Foreign welfare. Otherwise, Foreign welfare decreases or remains unchanged due to a depreciation of the Home currency.*



(a) $\epsilon_{\lambda_D,E}$

(b) $\epsilon_{\lambda_D^*,E}$

Figure 2.2: The Impact of Exchange Rate Movements on Welfare ($k = 3, \psi = 1, \tau = \tau^* = (1.5)^{1/3}$)

Figure 2.2 illustrates the impact of a Home currency depreciation on welfare in each country. In comparison with Figure 2.1, the welfare implication of exchange rate changes is more ambiguous. Again, the effective marginal cost cut-off is the product of the effective input price and cost cut-off. In the case of λ_D, the cost cut-off c_D is likely to decrease in response to a Home currency depreciation as shown in Figure 2.1 (a). However, there exits a negative cost shock represented by an increase in $\frac{W}{A}$, which is a factor for the rise in λ_D.

We need to note that a rise in $\frac{W}{A}$ causes a decrease in N_e and a decline in $\frac{W^*}{A^*}$ leads to an increase in N_e^* from equation (2.31) and (2.32) when the cost cut-offs remain unchanged. In other words, a negative cost shock due to a Home-currency depreciation reduces the number of entrants at Home and a positive cost shock increases the number of entrants at Foreign. We have to consider the effects of cost shocks on entry decision together with the changes in cut-off levels to investigate the changes in the overall competitive environment determining welfare changes.

However, we must keep in mind that proposition 9 is derived from a restricted model. Consequently, there are definite limitations of this welfare analysis. First, most economists believe a significant depreciation of a country's currency always reduces its consumption and welfare. This is because a depreciation of the country causes a deterioration in its terms of trade. With our current partial equilibrium model, we cannot investigate the effect of exchange rate shocks on terms of trade effectively. Secondly, exchange rate changes may lead to substantial valuation effects in the form of capital gains or losses. Given a country's international investment position, asset channel can offset some or all of the effects of the trade channel.[19]

2.3.3 Exchange Rate Pass-Through

Firm-level Prices and Trade Flows

The Home-currency import price of a good produced by a Foreign firm with cost c is given by

$$p_X^*(c) = \frac{1}{2}\tau^* E \frac{W^*}{A^*}\left(c_X^* + c\right) \tag{2.43}$$

Therefore, the pass-through rate defined as the elasticity of $p_X^*(c)$ with respect to the exchange rate is given by

$$\xi_X^*(c) = \frac{\partial \ln p_X^*(c)}{\partial \ln E} = 1 - \epsilon_{A^*} + \frac{c_X^*}{c_X^* + c} \cdot \epsilon_{c_X^*,E} \quad \text{for } \; c \leq c_X^* \tag{2.44}$$

where note that $\dfrac{c_X^*}{c_X^* + c} \in [1/2, 1)$.

From equation (2.44), we can sort out three forces when the exchange rate changes: (1) the direct effect on the firm's variable cost $(1 - \epsilon_{A^*})$, (2) the change in the competitive

[19] See Tilte (2005) for valuation effect of exchange rate movements.

environment of Foreign exporters ($\epsilon_{c_X^*,E}$), (3) firm-specific effect reflecting a Foreign firm's relative position with respect to the cut-off level ($\frac{c_X^*}{c_X^*+c}$). The following proposition states exchange rate pass-through to firm-level import prices.

Proposition 10

1. *If* $\epsilon_{c_X^*,E} > 0$, $1-\epsilon_{A^*} < \xi_X^*(c) < \epsilon_{\lambda_D,E}$. *More productive firms have higher pass-through rates.*

2. *If* $\epsilon_{c_X^*,E} \leq 0$, $\epsilon_{\lambda_D,E} \leq \xi_X^*(c) \leq 1-\epsilon_{A^*}$. *More productive firms have lower pass-through rates.*

First, suppose that $\epsilon_{c_X^*,E} > 0$. This implies that Foreign exporters face a weaker competitive environment at Home due to a depreciation of the Home currency. We can also show that $\epsilon_{\lambda_D,E} > 0$ whenever $\epsilon_{c_X^*,E} > 0$. So N decreases. Because the number of competitors in the Home market declines, Foreign exporters can increase their mark-ups. That is, they raise their product prices by more than the percentage increase in variable costs $(1-\epsilon_{A^*})$. From the point of view of more productive Foreign firms, they have a bigger incentive to raise prices because less competitors exist and they are weaker than before. The area (a) of Figure 2.3 represents this situation.

By contrast, if $\epsilon_{c_X^*,E} < 0$, a depreciation of the Home currency gives Foreign exporters tougher competition. As a result, more productive Foreign firms absorb a higher proportion of an exchange rate shock to remain competitive in the Home market. The rate of pass-through $\xi_X^*(c)$ is incomplete (less than 1) and less than $1-\epsilon_{A^*}$. When $\epsilon_{\lambda_D,E} > 0$, $\xi_X^*(c)$ is always positive. The area (b) in Figure 2.3 represents this situation. When $\epsilon_{\lambda_D,E} < 0$ (and so N increases), $\xi_X^*(c)$ can be negative. Foreign exporters must compete with more and stronger competitors. Thus, some high productivity Foreign firms may lower their product prices. This corresponds to the area (c) in Figure 2.3.

There are some interesting implications related to Proposition 10. First, when we introduce a tradable intermediate-input sector, the Foreign exporter's variable cost increases

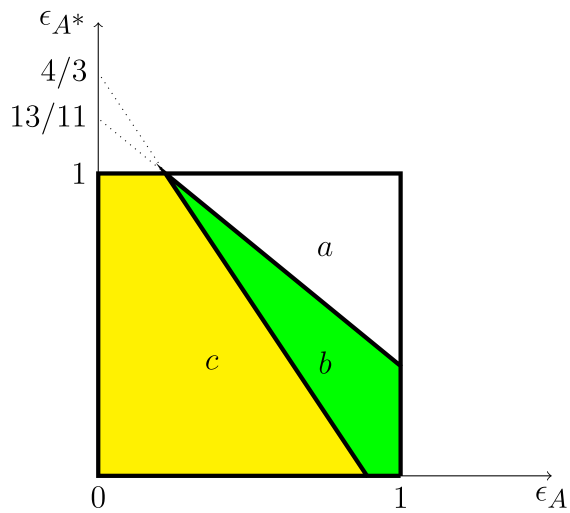


Figure 2.3: Exchange Rate Pass-Through and Export Quantity at the Firm Level ($k = 3, \psi = 1, \tau = \tau^* = (1.5)^{1/3}$)

by $1 - \epsilon_{A^*}$ percent with 1 percent depreciation of the Home currency. This fact is consistent with the existing literature which suggests that pass-through is muted using imported inputs in production.[20] Second, we cannot guarantee that exchange rate pass-through to firm-level import prices is incomplete contrary to Rodriguez-Lopez (2011). In his model, Foreign exporters are always in tougher competition due to a Home currency depreciation. On the contrary, Foreign exporters may face a different competitive environment after an exchange rate shock in the current model. For instance, it is possible that Foreign exporters are in weaker competition at Home in spite of a Home currency depreciation shown as (a) in Figure 2.3. This case happens because the opposite cost effects between the two countries are considerably large. Next, Rodriguez-Lopez shows that the firm productivity associated with exchange rate pass-through is sensitive to the choice of the utility function.[21] Furthermore, the current model tells us that the change in the competitive environment driven by $\epsilon_{c^*_X, E}$ is

[20]See Ghosh (2009) for details.

[21]He shows that more productive firms have higher pass-through rates with the translog expenditure function. But he obtains the opposite result with the quasilinear-quadratic utility function: lower pass-through rates for high productivity firms.

an important factor in determining the relationship between firm-specific productivity and exchange pass-through.

The quantity that a Foreign firm with $c \leq c_X^*$ sells in the Home market is given by

$$y_X^*(c) = \frac{L}{2\gamma}\tau^* E \frac{W^*}{A^*}\left(c_X^* - c\right) \tag{2.45}$$

The export sales in terms of the Home currency are given by

$$p_X^*(c) y_X^*(c) = \frac{L}{4\gamma}\left[\tau^* E \frac{W^*}{A^*}\right]^2 \left[\left(c_X^*\right)^2 - c^2\right] \tag{2.46}$$

The impact of exchange rates on firm-level traded quantities may be relatively substantial compared with the exchange pass through effect, but it does not always hold unlike Rodriguez-Lopez (2011). The following proposition presents the results regarding exchange rates and firm-level quantity adjustments.

Proposition 11

1. *If $\epsilon_{c_X^*,E} \geq 0$, the export quantity and export sales are increasing with respect to the exchange rate:* $\frac{\partial \ln y_X^*(c)}{\partial \ln E} > \xi_X^*(c) > 0$.
2. *If $\epsilon_{c_X^*,E} < 0$ and $\epsilon_{\lambda_D,E} > 0$, some high productivity Foreign firms may increase their export quantities and export sales while the other Foreign firms decrease their export quantities and export sales:* $\frac{\partial \ln y_X^*(c)}{\partial \ln E} < \xi_X^*(c)$.
3. *If $\epsilon_{c_X^*,E} < 0$ and $\epsilon_{\lambda_D,E} \leq 0$, the export quantity and export sales are decreasing with respect to the exchange rate:* $\frac{\partial \ln y_X^*(c)}{\partial \ln E} < \xi_X^*(c)$ *and* $\frac{\partial \ln y_X^*(c)}{\partial \ln E} < 0$.

Each item 1, 2, 3 of Proposition 11 corresponds to each area (a), (b), (c) in Figure 2.3: (a) When Foreign exporters face a weaker competitive environment at Home, they increase their export quantities. (b) With less and stronger competitors, some more productive Foreign exporters increase their export quantities, but the other Foreign firms decrease their export quantities. (c) With more and stronger competitors, Foreign firms decrease their export quantities.

Therefore, at the intensive margin, quantities adjust in a variety of ways after an exchange rate shock. Roughly speaking, when the role of imported inputs in production is not large, low levels of exchange rate pass-through coexist with relatively larger movements in trade flows at the firm level like Rodriguez-Lopez (2011). On the contrary, if the shares of imported inputs in total costs are sufficiently large, the impact of exchange rates on firm-level trade flows occurs differently at both the extensive and intensive margin.[22]

Aggregate Prices and Trade Flows

The aggregate import price is a weighted average of prices of imported goods. The market share of a Foreign firm with c is given by

$$s_X^*(c) = \frac{y_X^*(c)}{Y_X^*} = \frac{y_X^*(c)}{\displaystyle\int_0^{c_X^*} y_X^*(c)dc} = \frac{\frac{L}{2\gamma}\tau^* E\frac{W^*}{A^*}\left(c_X^* - c\right)}{\frac{L}{4\gamma}\tau^* E\frac{W^*}{A^*}\left(c_X^*\right)^2} = \frac{2(c_X^* - c)}{\left(c_X^*\right)^2} \tag{2.47}$$

where Y_X^* denotes the quantity of Foreign exports. Therefore, the aggregate import price is

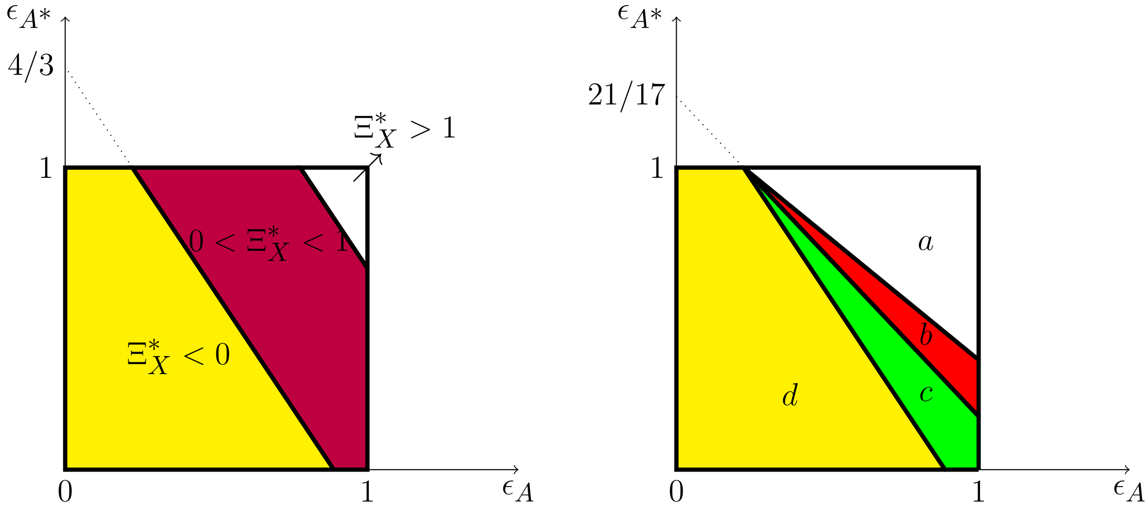
$$P_X^* = \int_0^{c_X^*} p_X^*(c)s_X^*(c)dc = \frac{2}{3}\tau^* E\frac{W^*}{A^*}c_X^* = \frac{2}{3}\frac{W}{A}c_D \tag{2.48}$$

The following proposition presents the result regarding exchange rate pass-through to the aggregate import price.

Proposition 12

The pass-through rate of exchange rate to the aggregate import price is $\Xi_X^* = \dfrac{\partial \ln P_X^*}{\partial \ln E} = \epsilon_{\lambda_D,E}$.

[22] At the extensive margin, the cut-off levels and mass of entrants change. At the intensive margin, the original or surviving firms adjust their export quantities.



(a) Ξ_X^*

(b) $\dfrac{\partial \ln Y_X^*}{\partial \ln E}$

Figure 2.4: Exchange Rate Pass-Through and Export Quantity at the Aggregate Level ($k = 3, \psi = 1, \tau = \tau^* = (1.5)^{1/3}$)

Figure 2.4 (a) illustrates how Ξ_X^* is determined within ϵ_A ϵ_{A^*} range. Let's examine the difference between Rodriguez-Lopez (2011) and the current model. In a basic model of Rodriguez-Lopez, the exchange rate pass-through to the aggregate import price is always negative. That is, a depreciation of the Home currency always lowers the aggregate import price. This surprising result is the consequence of a composition bias due to changes in the extensive margin of trade. With a Home-currency depreciation, the least productive Foreign firms exit the Home market. The new aggregate import price is computed taking into account only the surviving Foreign exporters, who are the most productive and so charged lower prices before the exchange rate shock. Furthermore, these surviving Foreign firms must reduce their markups in response to intensified competition at Home. In contrast, there are two important differences in this paper. First, the change in competitive environment (related to the extensive margin) due to an exchange rate shock is not unilateral. For example, the least productive Foreign exporters may enter the Home market after a Home currency depreciation due to relative cost advantage caused by lower imported input prices. Second, as we see in section 2.3.2, the number of competing varieties in the Home market (N) may decrease in response to the depreciation of the Home currency. Then, original or surviving Foreign exporters can raise their mark-ups or reduce their mark-ups by a smaller margin. Taken together, various adjustments occur on not only the extensive but also the intensive margin in my model.

The empirical evidence supports small but positive pass-through rates to aggregate import prices. To reconcile the theoretical model with the empirical evidence, Rodriguez-Lopez (2011) develops an extended model that includes product quality.[23] On the other hand, this model tells us that exchange rate pass-through rates depend on shares of imported inputs in total costs of the two countries. Based on the current model, the empirical evidence thus suggests that a pair of shares of imported inputs is likely to be located within some middle range.

Now let us look into the expenditure-switching effect of exchange rates. We can calculate the response of an aggregate export quantity to an exchange rate movement.

$$\frac{\partial \ln Y_X^*}{\partial \ln E} = 1 - \epsilon_{A^*} + 2\epsilon_{c_X^*,E} = 1 + \epsilon_{\lambda_X^*,E} + \epsilon_{c_X^*,E} = \epsilon_{\lambda_D,E} + \epsilon_{c_X^*,E} = \Xi_X^* + \epsilon_{c_X^*,E} \tag{2.49}$$

In addition, the value of Foreign exports in terms of the Home currency is given by

$$V_X^* = \int_0^{c_X^*} p_X^*(c) y_X^*(c) dc = \int_0^{c_X^*} \frac{L}{4\gamma} \left[\tau^* E \frac{W^*}{A^*}\right]^2 \left[\left(c_X^*\right)^2 - c^2\right] dc = \frac{L}{6\gamma} \left[\tau^* E \frac{W^*}{A^*}\right]^2 \left(c_X^*\right)^3 \tag{2.50}$$

Therefore,

$$\frac{\partial \ln V_X^*}{\partial \ln E} = 2\left(1 - \epsilon_{A^*}\right) + 3\epsilon_{c_X^*,E} = 2\epsilon_{\lambda_D,E} + \epsilon_{c_X^*,E} = \Xi_X^* + \frac{\partial \ln Y_X^*}{\partial \ln E} \tag{2.51}$$

[23] He assumes that higher productivity (or capability) is related to higher quality. If product quality is sufficiently positively related to firm productivity, the unit price increases with productivity while quality-adjusted price decreases with productivity. As a result, a positive pass-through rate to the aggregate unit import price can be obtained.

The following proposition states our result regarding the expenditure switching effect of an exchange rate movement.

Proposition 13

1. *If* $\epsilon_{c^*_X,E} \geq 0$*, the quantity and value of Foreign exports are increasing with respect to the exchange rate and their elasticities are greater than exchange rate pass-through rate;* $\frac{\partial \ln V^*_X}{\partial \ln E} > \frac{\partial \ln Y^*_X}{\partial \ln E} > \Xi^*_X > 0$

2. *If* $-\epsilon_{\lambda_D,E} < \epsilon_{c^*_X,E} < 0$*, the quantity and value of Foreign exports are increasing with respect to the exchange rate. The exchange rate pass-through rate is between the two exchange rate elasticities;* $0 < \frac{\partial \ln Y^*_X}{\partial \ln E} < \Xi^*_X < \frac{\partial \ln V^*_X}{\partial \ln E}$

3. *If* $\epsilon_{c^*_X,E} < -\epsilon_{\lambda_D,E} < 0$*, the quantity of Foreign exports is decreasing with respect to the exchange rate. The exchange rate elasticity of Foreign export value is positive or negative but smaller in absolute value than that of Foreign export quantity;* $\frac{\partial \ln Y^*_X}{\partial \ln E} < 0 < \Xi^*_X$ *and* $\frac{\partial \ln Y^*_X}{\partial \ln E} < \frac{\partial \ln V^*_X}{\partial \ln E}$

4. *If* $\epsilon_{c^*_X,E} < 0$ *and* $\epsilon_{\lambda_D,E} \leq 0$*, the quantity and value of Foreign exports are decreasing with respect to the exchange rate and their elasticities are greater in absolute values than exchange rate pass-through rate;* $\frac{\partial \ln V^*_X}{\partial \ln E} < \frac{\partial \ln Y^*_X}{\partial \ln E} < \Xi^*_X < 0$

Figure 2.4 (b) presents a graphical illustration about the response of Foreign's export volume to an exchange rate movement. Each area (a), (b), (c), (d) corresponds to each item 1, 2, 3, 4 of Proposition 13. The last part of Proposition 13 is similar to the prediction of Rodriguez-Lopez model, namely large and unambiguous expenditure-switching effect of exchange rate fluctuations. However, the current model suggests there might be various cases regarding the expenditure-switching effect. For example, the trade flows move in the unexpected direction as described in the first two parts of Proposition 13. If a Home-currency depreciation causes a less competitive environment for Foreign exporters in the Home market, both the quantity and value of Foreign exports can increase. Another possibility is that the expenditure-switching effect may be trivial or ambiguous like the third case of Proposition 13. One important implication of Proposition 13 is that a depreciation of the domestic currency may lead to a negligible effect or even a negative impact on the current account considering global production sharing.

2.4 Conclusion

The issue of exchange rate pass-through has been extensively studied in international economics, but relatively less attention has been paid to imported input prices in the literature. To examine this issue, I present a partial equilibrium model of production sharing and exchange pass-through with monopolistic competition among heterogeneous firms, endogenous markups and sticky wages. Exchange rate fluctuations has two distinct effects. First, a Home-currency depreciation improves directly the Home firms' competitive position through a rise in the production costs of Foreign final goods, in terms of the Home currency. Second, a depreciation causes an indirect effect by increasing imported input prices, which leads to a rise in the production costs of Home final goods. Consequently, the domestic and foreign firms' competitive positions depend on the relative importance of these two effects. In the end, the degrees of exchange rate pass-through and expenditure switching depend on adjustments in firms' prices and quantities due to altered competitive positions caused by an exchange rate shock.

With production sharing involving two trading partners, the model derives some interesting results. Both exchange rate pass-through and expenditure-switching effect are ambiguous unlike the prediction of a standard model built by Rodriguez-Lopez (2011). While the pass-through to the aggregate import price is always negative in his original model, a low but positive rate of pass-through can be derived assuming the shares of imported inputs in total costs are located within some range. In addition, a depreciation of the domestic currency may lead to a negligible effect or even a negative impact on the current account contrary to popular belief.

The results of this paper also provide a potential explanation for the fact that the degree of pass-through varies across countries and industries. This is because the ratio of imported inputs to total costs differs significantly by country and industry. Future research might explore the implications of these findings for exchange rate pass-through patterns across countries with different industry mixes and thus verify roles of imported inputs in production.

APPENDIX

Appendix

Proof of Proposition 7.

$$\begin{aligned}
\bar{p}_D &= \int_0^{c_D} \frac{1}{2}\frac{W}{A}\left(c_D + c\right)\frac{kc^{k-1}}{\left(c_D\right)^k}dc \qquad \text{(A.1)} \\
&= \frac{1}{2}\frac{W}{A}k\left(c_D\right)^{-k}\int_0^{c_D}\left(c_D c^{k-1} + c^k\right)dc \\
&= \frac{1}{2}\frac{W}{A}k\left(c_D\right)^{-k}\left[\frac{2k+1}{k(k+1)}\left(c_D\right)^{k+1}\right] \\
&= \left(\frac{k+\frac{1}{2}}{k+1}\right)\frac{W}{A}c_D
\end{aligned}$$

$$\begin{aligned}
\bar{p}_X^* &= \int_0^{c_X^*} \frac{1}{2}\tau^* E\frac{W^*}{A^*}\left(c_X^* + c\right)\frac{kc^{k-1}}{\left(c_X^*\right)^k}dc \qquad \text{(A.2)} \\
&= \left(\frac{k+\frac{1}{2}}{k+1}\right)\tau^* E\frac{W^*}{A^*}c_X^* \\
&= \left(\frac{k+\frac{1}{2}}{k+1}\right)\tau^* E\frac{W^*}{A^*}\left[\frac{A^*W}{A\tau^*EW^*}\cdot c_D\right] \\
&= \left(\frac{k+\frac{1}{2}}{k+1}\right)\frac{W}{A}c_D
\end{aligned}$$

Analogously, $\bar{p}^* = \bar{p}_D^* = \bar{p}_X = \left(\frac{k+\frac{1}{2}}{k+1}\right)\frac{W^*}{A^*}c_D^*$.

Proof of Corollary 1.

From equation (2.5), $z(c) = \frac{1}{\gamma}\left[\frac{\gamma}{\eta N + \gamma}(\alpha - \bar{p}) - (p(c) - \bar{p})\right]$ for $c \leq c_D$,

$$\int_0^{c_D} z(c)dc = \frac{N}{\eta N + \gamma}(\alpha - \bar{p}) \qquad \text{(A.3)}$$

$$\int_0^{c_D} z(c)^2 dc = \left(\frac{N}{\eta N + \gamma}\right)^2(\alpha - \bar{p})^2 + \frac{1}{\gamma^2}\int_0^{c_D}\left(p(c) - \bar{p}\right)^2 dc \qquad \text{(A.4)}$$

$$\int_0^{c_D} p(c)z(c)dc = \frac{N}{\eta N + \gamma}(\alpha - \bar{p})\bar{p} - \frac{1}{\gamma}\int_0^{c_D} (p(c) - \bar{p})^2 \, dc \tag{A.5}$$

Substituting (2.3), (A.3), (A.4) and (A.5) into (2.2),

$$\begin{aligned} U &= W + \frac{1}{2}\frac{N}{\eta N + \gamma}(\alpha - \bar{p})^2 + \frac{1}{2}\frac{N}{\gamma}\left[\frac{1}{N}\int_0^{c_D} (p(c) - \bar{p})^2 \, dc\right] \qquad (A.6) \\ &= W + \frac{1}{2\eta}\left(\frac{\alpha - \frac{W}{A}c_D}{\alpha - \bar{p}}\right)(\alpha - \bar{p})^2 + \frac{1}{2\eta}\left[\frac{k}{2(k+1)(k+2)}\right]\left(\alpha - \frac{W}{A}c_D\right)\left(\frac{W}{A}c_D\right) \\ &= W + \frac{1}{2\eta}\left(\alpha - \frac{W}{A}c_D\right)\left(\alpha - \frac{k+1}{k+2}\frac{W}{A}c_D\right) \end{aligned}$$

where we use $\frac{1}{N}\int_0^{c_D} (p(c) - \bar{p})^2 \, dc = \int_0^{c_D} (p(c) - \bar{p})^2 \, g(c|c \le c_D)dc$.

Analogously, we can derive the indirect utility function of Foreign country.

Proof of Corollary 2.

Using (2.18) and (2.19), we can re-write equation (2.31) in a different way

$$N_e = \frac{2(k+1)\gamma\,(c_M)^k}{\eta\left[(\tau\tau^*)^k - 1\right]}\left(\frac{c_D^*}{c_X}\right)^k\left[\frac{1}{\left(c_X^*\right)^k}\left(\frac{A^*}{W^* c_X^*}\frac{1}{\tau^* E}\alpha - 1\right) - \frac{1}{\left(c_D^*\right)^k}\left(\frac{A^*}{W^* c_D^*}\alpha - 1\right)\right] \tag{A.7}$$

$$N_e \ge 0 \Longleftrightarrow \left(\frac{c_D^*}{c_X^*}\right)^k \cdot \frac{\frac{A^*}{W^* c_X^*}\frac{1}{\tau^* E}\alpha - 1}{\frac{A^*}{W^* c_D^*}\alpha - 1} \ge 1$$

which is incompatible with $c_D^* < c_X^*$ since $\frac{1}{\tau^* E} \le 1$. Therefore, $c_D^* \ge c_X^*$.

We also re-write equation (2.32) as the following expression

$$N_e^* = \frac{2(k+1)\gamma\,(c_M)^k}{\eta\left[(\tau\tau^*)^k - 1\right]}\left(\frac{c_D}{c_X^*}\right)^k\left[\frac{1}{(c_X)^k}\left(\frac{A}{W c_X}\frac{E}{\tau}\alpha - 1\right) - \frac{1}{(c_D)^k}\left(\frac{A}{W c_D}\alpha - 1\right)\right] \tag{A.8}$$

$$N_e^* \ge 0 \Longleftrightarrow \left(\frac{c_D}{c_X}\right)^k \cdot \frac{\frac{A}{W c_X}\frac{E}{\tau}\alpha - 1}{\frac{A}{W c_D}\alpha - 1} \ge 1$$

which is incompatible with $c_D < c_X$ since $\dfrac{E}{\tau} \leq 1$. Therefore, $c_D \geq c_X$.

Proof of Proposition 8.

From equation (2.38), for $\epsilon_{c_D,E}$ to be negative

$$\epsilon_{A^*} < \left[\frac{2(\tau^k - \psi)}{k\psi} - 1\right]\epsilon_A + 1 + \frac{1}{k} \tag{A.9}$$

However, if $\dfrac{2(\tau^k - \psi)}{k\psi} - 1 \geq -\dfrac{1}{k}$, this condition is satisfied for $\forall \epsilon_A \in (0,1)$ and $\forall \epsilon_{A^*} \in (0,1)$.
We can check that $\dfrac{2(\tau^k - \psi)}{k\psi} - 1 \geq -\dfrac{1}{k} \Longleftrightarrow \tau^k \geq \left(\dfrac{k+1}{2}\right)\psi$.
Now let's prove part 2. From equation (2.26),

$$\epsilon_{c^*_D,E} = \frac{1}{(k+2)\{(\tau^*)^k\,\psi - 1\}}\left[\{2[(\tau^*)^k\,\psi - 1] - k\}\epsilon_{A^*} - k\epsilon_A + k + 1\right] \tag{A.10}$$

For $\epsilon_{c^*_D,E}$ to be positive

$$\{2[(\tau^*)^k\,\psi - 1] - k\}\epsilon_{A^*} - k\epsilon_A + k + 1 > 0 \tag{A.11}$$

First, if $2[(\tau^*)^k\,\psi - 1] - k \geq 0 \Longleftrightarrow (\tau^*)^k \geq \left(\dfrac{k+2}{2}\right)\dfrac{1}{\psi}$, the condition above is obviously satisfied.

Now suppose that $2[(\tau^*)^k\,\psi - 1] - k < 0$.
Because $\epsilon_A \in (0,1)$ and $\epsilon_{A^*} \in (0,1)$, $\{2[(\tau^*)^k\,\psi - 1] - k\}\epsilon_{A^*} - k\epsilon_A + k + 1 > 2\,(\tau^*)^k\,\psi - k - 1$.
Therefore, if $2\,(\tau^*)^k\,\psi - k - 1 \geq 0 \Longleftrightarrow (\tau^*)^k \geq \left(\dfrac{k+1}{2}\right)\dfrac{1}{\psi}$, (A.11) is always satisfied.

Proof of Proposition 9.

If we derive $\epsilon_{\lambda_D,E}$ and $\epsilon_{\lambda^*_D,E}$, the result then follows by determining their signs.

$$\epsilon_{\lambda_D,E} = \frac{1}{(k+2)(\tau^k - \psi)}\left[k\tau^k\epsilon_A + k\psi\epsilon_{A^*} - \psi(k+1)\right] \tag{A.12}$$

$$\epsilon_{\lambda_D^*,E} = \frac{1}{(k+2)\{(\tau^*)^k \psi - 1\}} \left[-k\psi (\tau^*)^k \epsilon_{A^*} - k\epsilon_A + k + 1 \right] \tag{A.13}$$

Proof of Proposition 10.

Suppose $\epsilon_{c_X^*,E} > 0$. $\frac{c_X^*}{c_X^* + c} \cdot \epsilon_{c_X^*,E}$ is a positive value and approaches to $\epsilon_{c_X^*,E}$ as $c \to 0$. Hence, $1 - \epsilon_{A^*} < \xi_X^*(c) < 1 - \epsilon_{A^*} + \epsilon_{c_X^*,E}$. In addition, $1 - \epsilon_{A^*} + \epsilon_{c_X^*,E} = 1 + \epsilon_{\lambda_X^*,E} = \epsilon_{\lambda_D,E}$ by definition. Therefore, $1 - \epsilon_{A^*} < \xi_X^*(c) < \epsilon_{\lambda_D,E}$. Actually, $\epsilon_{c_X^*,E} > 0 \iff \epsilon_{\lambda_D,E} > 1 - \epsilon_{A^*}$.

To show that more productive Foreign firms have higher pass-through rates,

$$\frac{\partial \xi_X^*(c)}{\partial c} = -\frac{c_X^*}{\left(c_X^* + c\right)^2} \cdot \epsilon_{c_X^*,E} < 0 \tag{A.14}$$

Analogously, we can prove the second part when we assume $\epsilon_{c_X^*,E} \leq 0$

Proof of Proposition 11.

From equation (2.45),

$$\frac{\partial \ln y_X^*(c)}{\partial \ln E} = 1 - \epsilon_{A^*} + \frac{c_X^*}{c_X^* - c} \cdot \epsilon_{c_X^*,E} \tag{A.15}$$

Note $\frac{c_X^*}{c_X^* - c} \in (1, \infty)$.

First, if $\epsilon_{c_X^*,E} \geq 0$, $\frac{\partial \ln y_X^*(c)}{\partial \ln E} \geq 1 - \epsilon_{A^*} + \epsilon_{c_X^*,E} = \epsilon_{\lambda_D,E} > 0$.

Next, suppose that $\epsilon_{c_X^*,E} < 0$. Then, $\frac{\partial \ln y_X^*(c)}{\partial \ln E} < \epsilon_{\lambda_D,E}$. Hence, if we add the condition $\epsilon_{\lambda_D,E} \leq 0$, $\frac{\partial \ln y_X^*(c)}{\partial \ln E}$ is always negative. With $\epsilon_{\lambda_D,E} > 0$, some high productivity Foreign firms may increase their export quantities since $\frac{\partial \ln y_X^*(c)}{\partial \ln E}$ is decreasing in c and its upper bound is positive.

Now let's examine the relationship between exchange rates and firm-level export sales.

$$\frac{\partial \ln[p_X^* y_X^*(c)]}{\partial \ln E} = 2\left[1 - \epsilon_{A^*} + \frac{\left(c_X^*\right)^2}{\left(c_X^*\right)^2 - c^2} \cdot \epsilon_{c_X^*, E}\right] \tag{A.16}$$

Therefore, we can apply the same argument to the value of exports.

Proof of Proposition 12.

From equation (2.48), $P_X^* = \frac{2}{3}\lambda_D$. Hence, it is obvious that $\Xi_X^* = \frac{\partial \ln P_X^*}{\partial \ln E} = \epsilon_{\lambda_D, E}$.

Proof of Proposition 13.

Given the equations (2.49) and (2.51), all the results are obtained easily.

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CHAPTER 3

Exchange Rate Pass-Through in Korean Manufacturing Industries

3.1 Introduction

The exchange rate pass-through has substantial economic effects. From a macroeconomic perspective, the extent of exchange rate pass-through has an important implication for monetary policy as it affects domestic inflation and foreign transactions. From a microeconomic perspective, the degree of pass-through helps us examine the response of firms' export and price setting decisions to exchange rate shocks. Therefore, the empirical literature on the exchange rate pass-through is extensive.

Current trade literature has highlighted the role of both the intensive margin (markup adjustments) and extensive margin (entry and exit decision) in explaining firm export behaviour. However, most empirical works on exchange rate pass-through have focused mainly on the intensive margin and have paid little attention to the extensive margin.[1] That is, most articles have concentrated on the heterogeneity in the responses to exchange rate shocks by exporters and hence they do not model entry and exit into exporting (Berman et al. (2012), Amiti et al. (2012)[2], Fauceglia et al. (2012)).

[1]Many firm-level studies condition their analysis on exporting firms' pricing strategies related to exchange rate shocks (Amiti et al. (2012), Berman et al. (2012), Li et al. (2012)). On the other hand, the extensive margin has been vigorously examined in investigating the relationship between exchange rates and trade flows. See Berman et al. (2012), Colacelli (2010), Tang and Zhang (2012) for example.

[2]Instead, they rather focus on the import decisions of the firms. In equilibrium, the more productive firms choose to source a greater share of their inputs internationally with fixed costs of importing.

In addition, a single bilateral exchange rate does not move around separately as Hummels et al. (2010) point out. Other things being equal, a depreciation of the Korean won against the US dollar would make dollar-denominated Korean export products more attractive in the importing country. But if other currencies are also depreciating against the US dollar, then the net effect on prices of Korean goods sold abroad will also depend on the extent of exchange rate pass-through by competing countries. Therefore, we need to pay attention to shocks on multiple exchange rates in estimating pass-through.[3]

In this paper, I attempt to empirically analyze the role that imported inputs and adjustments in the extensive margin play in exchange rate pass-through at the industry level using disaggregated Korean data. I develop further a quadratic utility model introduced in the second chapter to guide the empirical analysis. I find that more import-intensive industries in South Korea (hereafter simply "Korea") have higher exchange rate pass-through into their export prices. This result cannot be explained by previous firm-level studies, but it is consistent with my theoretical model including the extensive margin of trade. This is because aggregate export prices are affected not only by changes in firms' marginal costs, but also by variations in the composition of exporters due to changes in the exporting cut-off. For example, suppose that the exporting cost cut-off declines owing to a competitive disadvantage caused by higher imported input prices following a depreciation of the Korean won. The new aggregate export price is then computed taking into account only the surviving Korean firms who are the most productive and had lower prices before the exchange rate shock. Next, I show that the relative value of the destination market currency should be also considered when estimating exchange rate pass-through regardless of an astonishingly high proportion of dollar invoicing of Korean exports and imports. Finally, I find that pass-through is increasing both in Korea's share in total import of the destination market and in

[3]Hummels et al. (2010) document that a depreciation of currency of the competing country shifts the residual demand curve inward and reduces the exchange rate pass-through elasticity. They also suggest that cross-currency exchange rate shocks become more crucial when an exporting country is relatively small.

Korea's comparative advantage industries.

This paper is related to two strands of recent literature. First, it relates to the existing literature emphasizing the importance of firm heterogeneity and the extensive margin of trade. Bernard et al. (2009) find that short-run changes in US exports are largely accounted for by the intensive margin. By contrast, the extensive margins, which are decomposed into firm entry and exit and continuing firms' adding and dropping of country-products, play an important role in explaining long-run changes in US exports.[4] Using a bilateral trade sample of 136 countries, Colacelli (2010) shows that the extensive margin of trade plays a significant role in export adjustments response to real exchange rate fluctuations at the yearly frequency. Berman et al. (2012) find that a 10% real depreciation increases the exporting probability by around 1.8 percentage point from a French firm-level data set. Tang and Zhang (2012) find that a 10% real appreciation of the renminbi is associated with a 1 percentage point decline in the probability of entry, and a 0.2 percentage point increase in the probability of exit using Chinese firm-level data.

Second, this paper is related to the recent empirical work on the role of imported inputs in exchange rate adjustments of exports. The rationale for studying this area is that a currency depreciation not just lowers the foreign currency prices of exports, but also raises the prices of imported inputs. Campa and Goldberg (2010) document that integrated production (through cost variation from imported input use in goods production) has become large enough to dominate the direct consumption of imported goods as the channel for transmission of exchange rates into the CPI. Berman et al. (2012) show that firms that are more dependent on imports increase their export price expressed in home currency more than others (that is, lower exchange rate pass-through) because they see their input costs rise when the euro depreciates. Using detailed Belgium micro data, Amiti et al. (2012) find that more import-intensive exporters have significantly lower exchange rate pass-through into their export

[4]This evidence is consistent with interpretation by Eaton et al. (2008). Conditional on survival, entering exporters and recently added product-countries grow more rapidly than incumbent exporters and product-countries.

prices. They also provide a second channel that limits the effect of exchange rate shocks on export prices. This channel is based on the fact that import intensive firms have higher market shares and hence actively move their markups in response to changes in marginal costs. On the other hand, Fauceglia et al. (2012) document that Swiss exporters optimally choose to absorb changes of the imported input prices in their markups and hence imported input price changes do not significantly change exchange rate pass-through behavior.

Korea is a small open economy that depends highly on foreign trade[5] and has a relatively high share of imported inputs intro production.[6] Thus, estimating the size of exchange rate pass-through has received considerable attention in empirical studies for Korea. Before turning to my study, I briefly review the empirical literature. Athukorala (1991) finds an average pass-through into foreign prices for the nominal effective exchange rate to be around 28 per cent. Yang and Hwang (1994) estimate pass-through from real sectoral exchange rate shocks into Korean export prices in six manufacturing sectors. They have documented that Korean exporters absorb 70% of a given exchange rate change in their margin and pass through the remaining 30%. Lee (1995) estimates the response of Korean manufactured-export prices to nominal effective exchange rate changes for 16 industries. He shows that pricing-to-market behaviour is prevalent in Korean export industries and explains this result by the market power asymmetry between home and export markets. Lee (1997) estimates exchange rate pass-through of industry specific real exchange rate changes into Korean import prices. The average pass-through elasticity for all manufacturing imports was 0.62 and market concentration systematically reduced the pass-through. Choi and Kim (2001)[7] and Kim and Lee (2009)[8] show that Korean export prices have become less responsive to the

[5]The proportion of Korea's trade to its gross national income (GNI) stood at 112.7 percent in 2012.

[6]See Section 3.2.2 for details.

[7]The pass-through elasticities before the financial crisis (1981:1Q $\sim$ 1997:3Q) and in the whole sample period (1981:1Q $\sim$ 2000:4Q) were 0.61 and 0.39, respectively.

[8]The long run elasticities of pass-through before and after the financial crisis were 0.61 and 0.24, respectively.

won/dollar exchange rate since the financial crisis in 1997. Decline in prices of major export products and increased competition with China have been suggested as the main reasons for the decline in exchange rate pass-through. Cho (2010) estimates exchange rate pass-through into export prices for 13 manufacturing industries. He suggests that industries with smaller destination market share or more competitive in the foreign market have lower exchange rate pass-through.

3.2 Background

3.2.1 Exchange Rate and Export Price Movements

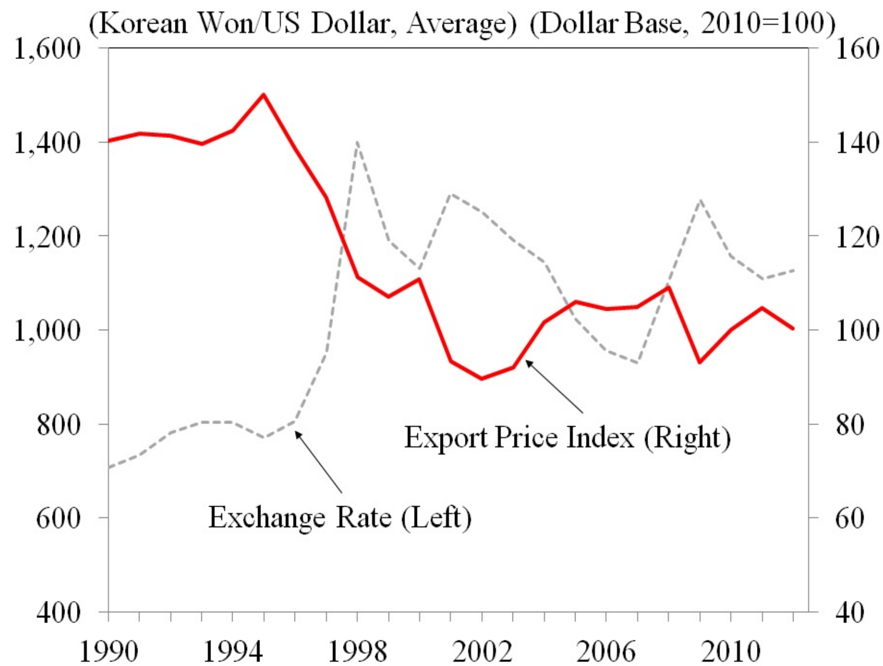
As Pollard and Coughlin (2006) pointed out, pass-through estimates are sensitive to the exchange rate index. Therefore, it is important to choose a proper exchange rate index to examine the relationship between exchange rate and export price. Empirical pass-through studies on Korea can be divided into two groups. The first group usually uses bilateral exchange rate, most notably the Korean won/US dollar exchange rate (Yang and Hwang (1994), Choi and Kim (2001), Kim and Lee (2009), Cho (2010)). The second group of studies uses a composite exchange rate which are constructed according to trade weights (Athukorala (1991), Lee (1995, 1997)). Because Korea uses the US dollar for more than 80% of trade transactions[9], the nominal won/dollar exchange rate is thought be the preferred index in examining exchange rate pass-through.

Figure 3.1 depicts the evolution of the nominal won/dollar exchange rate and the export price[10] in dollar terms over the period 1990-2012. With a few exceptions, there has been a negative correlation between the won/dollar exchange rate and the export price index.

[9]Appendix Table A1 shows the dollar share in the invoicing of exports and imports. As shown in Table A1, the extent to which the US dollar is used in trade invoicing varies substantially across countries.

[10]The Export Price Index is based, as a principle, on the FOB (free on board) price, that is the price at the time of shipping off the export goods from Korea. The index is computed on the won basis, the dollar basis and the contract currency basis.

Between 1996 and 1998, the Korean won depreciated greatly against the US dollar and the export price index (in dollar terms) declined. Over the period 2002-2005, the export price index increased gradually along with the appreciation of the Korean won.



Data Source: The Bank of Korea

Figure 3.1: Exchange Rate and Export Price Index

3.2.2 Imported Inputs into Production

The shares of imported inputs are calculated from the Input-Output Table. Define a vector of share of import content in final demand for domestically produced products by IM.[11]

$$IM = uA^M[I - A^D]^{-1} \tag{3.1}$$

where u is a $1 \times n$ vector of 1's, A^M is the $n \times n$ imported coefficient matrix, I is the identity matrix, A^D is the $n \times n$ domestic coefficient matrix and n is the number of sectors.

For industry s, IM_s is the column sum of the coefficient matrix for total intermediate

[11] See Koopman et al. (2012) for the derivation of equation (3.1).

import requirement. We can know that the concept of vertical specialization by Hummels et al. (2001) and that of import content in total exports are identical.[12]

Since 2000, the Korean Input-Output tables have been compiled with 404, 168, 77 and 28 industrial sectors in basic, small, medium and large classifications, respectively. I use 168 sector classification as a benchmark to measure shares of imported inputs into production. This classification is not only appropriately disaggregated but also consistent with sectoral categories of other independent variables such as producer price index. Again, I focus on 100 manufacturing industries out of 168 sectors.

I have calculated the share of imported inputs by manufacturing industry using the Korean Input-Output tables for 1990, 1995, 2000, 2005, 2010. These shares are reported in Appendix Table A2. As shown in Table A2, imported input shares of given the industry tend to increase but are relatively stable over time while there is considerable variation across industries at a specific time.[13]

We see the distribution of imported input shares in production among 100 Korean manufacturing industries in Table 3.1 (as of 2010). For the majority of industries, the share of imported inputs in production ranges between 30% and 60%. At the same time, nearly 80% of (manufacturing) export sales are generated by the industries belonging to that interval. The export-value-weighted median of imported input shares is 41%. The industry with the highest share is naphtha (88%) while cereal husking has the lowest share (11%).

In addition, we need to notice that the dispersion of imported inputs into production also differs significantly by country (Campa and Goldberg (2010)). Appendix Table A3 reports the import content of exports for manufacturing industries across countries. In general, larger countries (Brazil, Russia, United States) have a lower share of imported inputs while smaller countries (Belgium, Hungary, Ireland, Singapore, Taiwan) have a higher share. Ko-

[12] Vertical specialization share of total exports for country k is calculated by $VSX_k = uA^M[I - A^D]^{-1}X/X_k$, where X is an $n \times 1$ vector of exports and X_k is total country export. The result is also called the import content of exports.

[13] Over the period 1990-2010, between standard deviation is 0.14 while within standard deviation is 0.06.

rea has a relatively high share of 42% and is expected to be more sensitive to cost shocks due to exchange rate movements.

Table 3.1: Distribution of Imported Input Shares in 2010

	# Industries	Fraction of Industries	Fraction of Export Value
$0 < IM_s \leq 0.3$	10	10.0%	0.9%
$0.3 < IM_s \leq 0.4$	38	38.0%	30.4%
$0.4 < IM_s \leq 0.5$	16	16.0%	31.5%
$0.5 < IM_s \leq 0.6$	20	20.0%	17.5%
$0.6 < IM_s \leq 0.7$	7	7.0%	13.4%
$IM_s > 0.7$	9	9.0%	6.3%
Total	100	100.0%	100.0%

3.3 Theoretical Framework

In this section, I construct a theoretical framework linking an industry's exchange rate pass-through to its import intensity. In order to do that, I extend the two-country model introduced in the second chapter (Production Sharing and Exchange Rate Pass-Through) to three-country model which would be more appropriate for empirical analysis. That is, I divide the global economy into three categories; Korea (K), an export destination country (D) and other competing countries (R).

International trade transactions can be invoiced in the producer currency, in the destination currency, or in a third currency, that is, vehicle currency. Both the US dollar and the euro are widely used for invoicing and settling international trade around the world. In particular, the U.S. dollar has been the dominant vehicle currency in Korea. Consequently, most empirical research articles focus on the Korean won-U.S. dollar nominal exchange rates in analyzing exchange rate pass-through into export price. For simplicity, I suppose that the US dollar is the only currency in the invoicing and payment of international trade. In particular, this assumption plays a crucial role in examining the impact of imported inputs on marginal costs in response to exchange rate shocks. It seems to be an oversimplification of the real world but would be a benchmark which provides necessary insights to help us understand the mechanism. More will be said on this assumption later.

3.3.1 Demand and Production

Each economy has identical consumers denoted by L_K, L_D and L_R, respectively. These consumers are assumed to share the quasilinear-quadratic utility function proposed by Melitz and Ottaviano (2008). Let the source country be indexed by i and the destination country by j for $i, j \in \{K, D, R\}$. Also let E_{iU} (E_{jU}) be the exchange rate defined as units of country i (j) currency per unit of the US dollar for $i, j \in \{K, D, R\}$. The quantity demanded for a variety imported from country i and consumed by country j is

$$y_{ij}(\omega) = \frac{L_j}{\gamma}\left[\widehat{p_j} - E_{jU} \cdot p_{ij}^{U}(\omega)\right] \tag{3.2}$$

where $\widehat{p_j}$ denotes the price-ceiling for all varieties sold in country j and p_{ij}^{U} represents the US dollar-denominated export price of country i to country j. The parameter γ stands for the degree of product differentiation among the varieties.

I adopt the same assumptions for production process as those used in the second chapter. Then, $\frac{W_i}{A_i}c$ represents the effective marginal cost for a firm with productivity $\frac{1}{c}$ located in country i, where W_i is the nominal wage rate in country i and A_i denotes the coefficient of productivity growth due to imported inputs.

To be more specific, A_i is given by

$$A_i = \left\{1 + \left(\frac{W_i}{E_{iU} \cdot W_{-i}^{U}}\right)^{\sigma_i - 1} \phi_i^{\sigma_i - 1}\right\}^{\frac{1}{\sigma_i - 1}} \tag{3.3}$$

where W_{-i}^{U} indexes the average US dollar-denominated wage rate of the rest of the world except country i, σ_i indexes the elasticity of substitution between domestic and imported inputs in country i and ϕ_i measures the relative efficiency of imported inputs in country i.

For simplicity, assume that per-unit trade costs are identical across countries ($\tau_K = \tau_D = \tau_R = \tau$). Then, we can obtain the following price and profit functions in US dollar terms for $i \neq j$.

$$p_{ij}^U(c) = \frac{1}{2}\left(\frac{\widehat{p_j}}{E_{jU}} + \frac{\tau}{E_{iU}} \cdot \frac{W_i}{A_i}c\right) \tag{3.4}$$

$$\pi_{ij}^U(c) = \frac{L_j}{4\gamma}E_{jU}\left(\frac{\widehat{p_j}}{E_{jU}} - \frac{\tau}{E_{iU}} \cdot \frac{W_i}{A_i}c\right)^2 \tag{3.5}$$

3.3.2 Cut-off Levels

We define the cut-off rules as $c_{ij} = \sup\{c : \pi_{ij}(c) > 0\}$ for $i, j \in \{K, D, R\}$.[14] For notational convenience, let $w_i = \dfrac{W_i}{A_i}$. Then, we derive the following relationships between cut-off levels.

$$\begin{aligned} c_{DD} &= \left(\frac{\tau w_K}{w_D} \cdot \frac{E_{DU}}{E_{KU}}\right) c_{KD}, \quad c_{DK} = \left(\frac{w_K}{\tau w_D} \cdot \frac{E_{DU}}{E_{KU}}\right) c_{KK}, \quad c_{DR} = \left(\frac{w_K}{w_D} \cdot \frac{E_{DU}}{E_{KU}}\right) c_{KR} \\ c_{RD} &= \left(\frac{w_K}{w_R} \cdot \frac{E_{RU}}{E_{KU}}\right) c_{KD}, \quad c_{RK} = \left(\frac{w_K}{\tau w_R} \cdot \frac{E_{RU}}{E_{KU}}\right) c_{KK}, \quad c_{RR} = \left(\frac{\tau w_K}{w_R} \cdot \frac{E_{RU}}{E_{KU}}\right) c_{KR} \end{aligned} \tag{3.6}$$

In addition, I assume that the sunk entry costs are identical across countries ($f_K = f_D = f_R = f$) for simplicity. Free entry conditions for all countries are given by

$$\int_0^{c_{KK}} \pi_{KK}(c)dG(c) + E_{KU}\int_0^{c_{KD}} \pi_{KD}^U(c)dG(c) + E_{KU}\int_0^{c_{KR}} \pi_{KR}^U(c)dG(c) = W_K f \tag{3.7}$$

$$\int_0^{c_{DD}} \pi_{DD}(c)dG(c) + E_{DU}\int_0^{c_{DK}} \pi_{DK}^U(c)dG(c) + E_{DU}\int_0^{c_{DR}} \pi_{DR}^U(c)dG(c) = W_D f \tag{3.8}$$

$$\int_0^{c_{RR}} \pi_{RR}(c)dG(c) + E_{RU}\int_0^{c_{RK}} \pi_{RK}^U(c)dG(c) + E_{RU}\int_0^{c_{RD}} \pi_{RD}^U(c)dG(c) = W_R f \tag{3.9}$$

[14] Note that $\pi_{ij}(c) = E_{iU} \cdot \pi_{ij}^U(c)$

Using the Pareto parametrization for the cost draws (c)[15] and equations (3.6)-(3.9), we can solve the equilibrium cut-off levels for Korean firms.

$$c_{KK} = \left[\frac{\varphi W_K}{L_K (w_K)^2} \cdot \frac{\tau^k\{(\tau^k+1) - \psi_D - \psi_R\}}{(\tau^k+2)(\tau^k-1)} \right]^{\frac{1}{k+2}} \tag{3.10}$$

$$c_{KD} = \left[\frac{\varphi W_K}{L_D (\tau w_K)^2} \cdot \frac{E_{KU}}{E_{DU}} \cdot \frac{(\tau^k+1)\psi_D - \psi_R - 1}{(\tau^k+2)(\tau^k-1)} \right]^{\frac{1}{k+2}} \tag{3.11}$$

$$c_{KR} = \left[\frac{\varphi W_K}{L_R (\tau w_K)^2} \cdot \frac{E_{KU}}{E_{RU}} \cdot \frac{(\tau^k+1)\psi_R - \psi_D - 1}{(\tau^k+2)(\tau^k-1)} \right]^{\frac{1}{k+2}} \tag{3.12}$$

where $\varphi = 2\gamma f(k+1)(k+2)c_M^k$, $\psi_D = \frac{W_D}{W_K}\left(\frac{w_D}{w_K}\right)^k \left(\frac{E_{KU}}{E_{DU}}\right)^{k+1}$ and $\psi_R = \frac{W_R}{W_K}\left(\frac{w_R}{w_K}\right)^k \left(\frac{E_{KU}}{E_{RU}}\right)^{k+1}$. Because $\frac{E_{KU}}{E_{DU}} = E_{KD}$ and $\frac{E_{KU}}{E_{RU}} = E_{KR}$, ψ_D and ψ_R measure relative competitiveness of Korean firms against the destination country D and the rest of the world R, respectively.[16]

3.3.3 Aggregate Export Prices and Exchange Rates

The aggregate export price set in the US dollar from Korea to the destination D is

$$P_{KD}^U = \int_0^{c_{KD}} p_{KD}^U(c) s_{KD}(c) dc = \frac{2}{3}\frac{\tau}{E_{KD}} w_K c_{KD} \tag{3.13}$$

[15] The cumulative distribution function of costs is given by $G(c) = \left(\frac{c}{c_M}\right)^k$, where $k > 1$ indexes the dispersion of cost draws. As k increases, the ratio of high-cost firms increases and the cost distribution is more clustered near the upper bound.

[16] To obtain positive cut-offs, both ψ_D and ψ_R must lie within some bounds. Graphical illustration shows us the condition is stricter than that of two-country model. That is, $\frac{1}{\tau^k} < \psi_D \ (\psi_R) < \tau^k$ cannot guarantee the existence of positive equilibrium cut-offs.

where $s_{KD}(c)$ denotes the market share of a Korean firm with cost c in total exports from Korea to country D.[17]

From equation (3.3), $d\ln A_i = -\epsilon_i \cdot d\ln E_{iU}$, where ϵ_i is the imported input share in total costs for firms located in country i. Taking logarithms and differentiating totally of both sides of equation (3.13) yield the following relationship.

$$d\ln P_{KD}^U = -d\ln E_{KU} - d\ln A_K + d\ln c_{KD} = -(1-\epsilon_K)d\ln E_{KU} + d\ln c_{KD} \qquad (3.14)$$

As shown in equation (3.11), c_{KD} is the function of three bilateral exchange rates E_{KU}, E_{DU} and E_{RU}. As a result, the aggregate Korean export price is affected by these various exchange rate shocks.

Let's obtain $d\ln c_{KD}$ from equation (3.11) and substitute it into equation (3.14), then

$$\begin{aligned}
d\ln P_{KD}^U &= -(1-\epsilon_K)d\ln E_{KU} \\
d\ln c_{KD} \longrightarrow &\begin{cases} +\dfrac{1}{(k+2)\{(\tau^k+1)\psi_D-\psi_R-1)\}}\Big[\{(\tau^k+1)\psi_D-\psi_R-1)\}\times \\ \{(1-2\epsilon_K)d\ln E_{KU} - d\ln E_{DU}\} \\ +(\tau^k+1)\psi_D\{(k+1-k\epsilon_K)\cdot d\ln E_{KU} - (k+1-k\epsilon_D)\cdot d\ln E_{DU}\} \\ -\psi_R\{(k+1-k\epsilon_K)\cdot d\ln E_{KU} - (k+1-k\epsilon_R)\cdot d\ln E_{RU}\}\Big] \end{cases} \\
&= \frac{1}{(k+2)\{(\tau^k+1)\psi_D-\psi_R-1\}}\Big[(k+1-k\epsilon_K)\cdot d\ln E_{KU}\cdot \\
&\quad -\{(\tau^k+1)\psi_D-\psi_R-1+(k+1-k\epsilon_D)\}\cdot d\ln E_{DU} \\
&\quad -(k+1-k\epsilon_R)\cdot d\ln E_{RU}\Big] \qquad (3.15)
\end{aligned}$$

Equation (3.15) carries several implications. First, we need to be cautious about empirical work on exchange rate pass-through because export prices in principle can be affected by movements of all exchange rates. The equation can be rewritten in the following simple

[17] For derivation, see the subsection 'Aggregate Prices and Trade Flows' of the second chapter.

form.

$$\frac{d\ln P_{KD}^{U}}{d\ln E_{KU}} = \underset{(+)}{\beta_K} \;+\; \underset{(-)}{\beta_D} \cdot \frac{d\ln E_{DU}}{d\ln E_{KU}} \;+\; \underset{(-)}{\beta_R} \cdot \frac{d\ln E_{RU}}{d\ln E_{KU}} \tag{3.16}$$

Consider first two other bilateral exchange rates have negative correlation with the won/dollar exchange rate $\left(\frac{d\ln E_{DU}}{d\ln E_{KU}} < 0 \text{ and } \frac{d\ln E_{RU}}{d\ln E_{KU}} < 0\right)$. For instance, suppose that the Korean won depreciates against the US dollar in spite of global weakness of the US dollar. Then, Korea's export price at the aggregate level would rise because new Korean entrants have lower productivity and charge higher prices than existing Korean exporters. If so, traditional estimation (using a single bilateral exchange rate) may find a pass-through estimate whose sign is opposite to that based on existing theoretical frameworks.

To take an extreme example, consider two other exchange rates have perfect positive correlation with the won/dollar exchange rate $\left(\frac{d\ln E_{DU}}{d\ln E_{KU}} = \frac{d\ln E_{RU}}{d\ln E_{KU}} = 1\right)$. It is reasonable to assume $\epsilon_D > \epsilon_R$ when we take two economies' sizes into consideration. Then, we can see that the aggregate Korean export price in dollar terms declines in response to a depreciation of the Korean won against the US dollar.[18]

Figure 3.2 depicts movements in the Korean won/US dollar exchange rates and nominal effective exchange rates of the US dollar.[19] Two series display considerable co-movement and the correlation coefficient is 0.692, which is significant at the 1% level. From equation (3.16), if exchange rates of the US dollar against the Korean won and against other currencies have a strong positive correlation, we can expect the same sign of pass-through as that of estimates obtained from traditional methods. That is, Korea's dollar-nominated export prices decrease along with a depreciation of the won against the US dollar.

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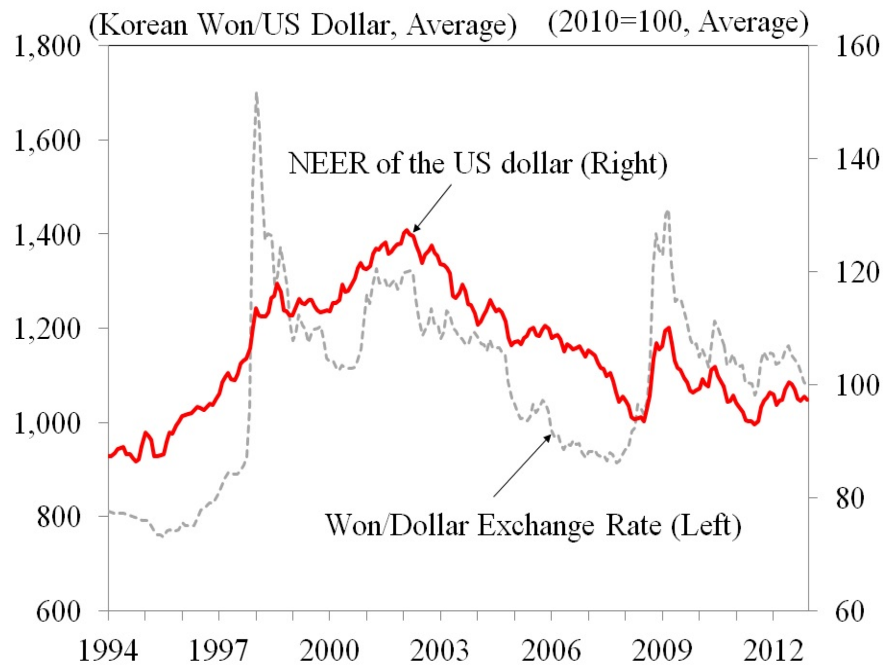
[18]

$$\begin{aligned}\frac{d\ln P_{KD}^{U}}{d\ln E_{KU}} &= -\frac{1}{(k+2)\{(\tau^k+1)\psi_D - \psi_R - 1\}}\Big[\{(\tau^k+1)\psi_D - \psi_R - 1\} \\ &\quad + k\{(1-\epsilon_K) + (\epsilon_D - \epsilon_R)\} + 1\Big] < 0\end{aligned}$$

[19]By definition, an increase in both series indicates an appreciation of the US dollar.



Data Source: BIS, The Bank of Korea

Figure 3.2: Won/US Dollar Rates and Nominal Effective Exchange Rates of the US Dollar

Another implication of equation (3.15) is that industries with higher import intensity have higher pass-through rates: the coefficient on the interaction term ($\epsilon_K \cdot d \ln E_{KU}$) is negative. This result depends basically on the assumption of the given model. In this paper, the import intensity is the same for all firms in an industry regardless of how productive they are. As shown in the second chapter, the relative demand for imported inputs to domestic inputs is determined by an corresponding exchange rate, imported input requirement (ϕ) and the elasticity of substitution between these two inputs (σ). On the contrary, Amiti et al. (2012) suggest that the more productive firms source a greater share of their inputs from abroad, which in turn lead to a further increase in their productivity using the endogenous choice of importing at the firm level. They also find that import intensive exporters are more productive and greater market shares from detailed Belgium data. Given that both import intensity and market share distributions are skewed toward the largest exporters, they conclude that their findings help explain the observed low rate of pass-through at the aggregate level.

But there is an inherent limitation in the use of firm-level import intensity to analyze exchange rate pass-through at the industry level. This is because firms producing multiple products are prevalent in manufacturing (Bernard et al. (2010))[20] while all firms are assumed to be basically single-product firms in Amiti et al (2012). For instance, if firms produce several products across different industries, import intensity data constructed at the individual firm level would be inappropriate to examine industry-level pass-through. Furthermore, if import-intensive exporters have much larger market share, heterogeneity within exporting firms plays relatively little role in examining import intensity at the industry level. This is because a few larger exporters may determine industry import intensity.

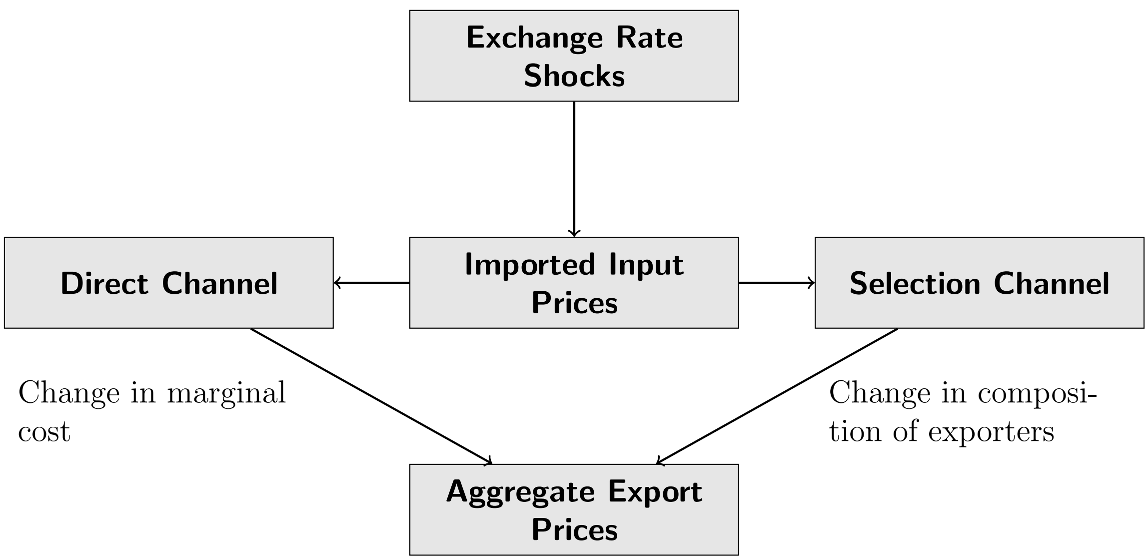


Figure 3.3: Import Intensity and Exchange Rate Pass-Through

Coming back to equation (3.15), the imported input share (ϵ_K) affects Korea's export price through two channels following exchange rate changes as shown in Figure 3.3. To begin with, exchange rate shocks have a direct effect on the marginal cost by making changes in imported input prices. Korean firms may thus absorb some of exchange rate variations through imported inputs, which act as a natural means for hedging exchange rate risks.

[20] Bernard et al. (2010) find that firms that produce multiple products represent 87 percent of output in 1997, while firms present in multiple industries and sectors are responsible for 81 percent and 66 percent of output, respectively.

Next, aggregate export prices are affected by variations in the composition of exporters due to changes in the exporting cut-off (c_{KD}). Suppose that the cut-off declines owing to a competitive disadvantage caused by higher imported input prices following a depreciation of the won. The new aggregate export price is then computed taking into account only the surviving Korean firms who are the most productive and had lower prices before the exchange rate shock. Equation (3.15) shows that the direct channel is dominated by the selection channel.

3.3.4 An Alternative Approach Without Selection Channel

Now I introduce an alternative model which includes only the intensive margin of trade in order to emphasize the outstanding feature of my model. That is, the approach here involves the subset of exporting firms, and hence does not model entry and exit decision. Because we now condition our analysis on exporters, there is no selection channel unlike my theoretical model.

Following Yun (2002), I investigate the extent of exchange rate pass-through when imported intermediate inputs are settled in the US dollar. Consider a Korean firm which exports its product to n foreign markets. The US dollar is assumed to be the only settlement and invoicing currency in trade.

The firm's profit maximization problem can then be written as follows.

$$\max_{p_j^U} \sum_{j=1}^{n} E_{KU} \cdot p_j^U y_j \left(p_j^U \cdot E_{jU}\right) - C(E_{KU}) \sum_{j=1}^{n} y_j \tag{3.17}$$

where p_j^U denotes price of exports to country j in US dollar terms and y_j is demand for import from the Korean firm to country j. Let E_{KU} be the exchange rate defined as Korean won per unit of US dollar and E_{jU} be the exchange rate defined as units of country j currency per unit of US dollar. C denotes the marginal cost set in the Korean won. For simplicity, we assume that marginal costs are constant and increase due to higher imported input prices when the Korean won depreciates.[21]

Notice that p_j destination-currency price of exports equals to $p_j^U \cdot E_{jU}$. Even if a Korean firm sets its export price in US dollar terms, import demand depends upon the price of imports in destination currency. As a result, we can expect that export prices in Korea will be affected not only by the won-dollar exchange rate but also by the destination currency-dollar exchange rate.

From the first order condition,

$$p_j^U = \frac{C(E_{KU})}{E_{KU}} \cdot \frac{\eta_j}{\eta_j - 1} \tag{3.18}$$

where $\eta_j = -\frac{\partial y_j}{\partial p_j}\frac{p_j}{y_j}$ is the price elasticity of demand in country j.

Take natural logarithms of both sides in equation (3.18) and differentiate, then

$$\frac{dp_j^U}{p_j^U} = -\left[1 - \frac{C'(E_{KU})}{C(E_{KU})}E_{KU}\right]\frac{dE_{KU}}{E_{KU}} - \frac{\frac{d\eta_j}{dp_j}\left(E_{jU}dp_j^U + p_j^U dE_{jU}\right)}{\eta_j(\eta_j - 1)} \tag{3.19}$$

Let $\theta_j = \frac{1}{\eta_j - 1}\frac{d\ln\eta_j}{d\ln p_j}$. Then, equation (3.19) can be re-written as

$$\frac{dp_j^U}{p_j^U} = -\left[1 - \frac{C'(E_{KU})}{C(E_{KU})}E_{KU}\right]\frac{dE_{KU}}{E_{KU}} - \theta_j\left[\frac{dp_j^U}{p_j^U} + \frac{dE_{jU}}{E_{jU}}\right] \tag{3.20}$$

Notice that $\epsilon_K = \frac{C'(E_{KU})}{C(E_{KU})}E_{KU}$ is the share of imported inputs in total costs of the Korean firm.

$$\frac{dp_j^U}{p_j^U} = -\frac{1}{1+\theta_j}\left(1 - \epsilon_K\right)\frac{dE_{KU}}{E_{KU}} - \frac{\theta_j}{1+\theta_j}\frac{dE_{jU}}{E_{jU}} \tag{3.21}$$

Equation (3.21) has the following implications. First, firms with higher import shares have

[21] This implies a relatively low elasticity of substitution between domestic and foreign intermediate inputs.

lower exchange rate pass-through as they face offsetting exchange rate effects on their marginal costs. This prediction is consistent with the firm level studies like Amiti et al. (2012) and Berman et al. (2012). Korean firms which are more dependent on imported inputs in production will experience their input costs rise when the Korean won depreciates against the US dollar and therefore lower their export prices in dollar terms less than others. This conflicting result is based on the fact that there is no selection channel caused by variations in the composition of exporters. Consequently, the alternative model suggests that prediction of firm-level may be valid at the industry level. That is, industries with higher import intensity also exhibit lower exchange rate pass-through. Second, a depreciation of the destination currency against the US dollar increases prices of Korean products sold in the importing country. Hence, Korean exporters need to reduce their export prices in US dollar terms. Third, the size of exchange rate pass-through depends on the price elasticity of demand.

3.4 Empirical Evidence

3.4.1 Data

The annual data in this analysis covers the period from 2002 to 2012. I use data on export unit values from the World Integrated Trade Solution (WITS), classified up to 6 digits by the Harmonized System (HS) Combined.[22]. Export prices in US dollar terms are proxied by product-level unit values computed as the ratio of export values to export quantities. Because export unit value is built using a free-on-board (FOB) price, we need to note that it is different from a final retail price of a traded good. In particular, it does not include transport or distribution costs.

Unit values may suffer from measurement errors due to compositional changes in quan-

[22] HS Combined combines all revisions of HS (HS88/92, HS96, HS2002 and HS2012). For more details on the nomenclature confer `http://wits.worldbank.org/WITS/WITS/WITSHELP/WITSHelp.htm`

tities and quality mix or to errors in measuring quantities.[23] Even if the use of highly disaggregated data limits this problem, we need to implement some additional measures in order to improve the reliability of unit values as proxies for prices. First, I drop annual changes in unit values (expressed in absolute value) that are more than 200% to remove unusual price changes.[24] Second, I adopt fixed effects to control for unobserved measurement errors.[25]

The shares of imported inputs in production at the industry level are obtained using the method introduced in section 3.2. In the regression, I use the time-averaged shares of imported inputs IM_s (2000, 2005 and 2010) by industry. Basically, we cannot obtain observable annual data on imported input shares using Input-Output tables. However, the average shares over the period might be justified by the fact that within-industry variation is quite small relative to between-industry variation and they can help to avoid the endogeneity and causation problems.[26] These average shares by industry are listed in Appendix Table A2. To link these shares to export unit values at the product level, I map each HS 6-digit production code to the corresponding Korean sector classification. To begin with, I employ the concordance between 10-digit HS codes and the 5-digit Standard Industrial Classification (SIC) product classes used to classify US manufacturing production.[27] I take the first 6-digits of the 10-digits HS code, and I include only the corresponding SIC code when it is a unique mapping. Some HS 6-digit codes map to several SIC codes, so that I exclude these

[23] See Silver (2007) for the concerns about unit value indices.

[24] Although improved deletion routines are certainly advocated by the IMF Manual, there is the arbitrary nature of the cut-off values often used in practice for deletion. See for example Amiti et al. (2012) and Gaulier et al. (2008).

[25] In particular, Gaulier et al. (2008) document that the importer-specific effect should control for trends in the evolution of the demand for quality. This is because country growth is often accompanied by an improvement in the quality of imports.

[26] Firms may adjust their imported input shares in response to exchange rate movements. As a result, the shares at a specific time cannot be regarded as exogenous variables.

[27] See Pierce and Schott (2009) for more detailed information. The concordance data are downloadable from Schott's website (http://faculty.som.yale.edu/peterschott/sub_international.htm).

codes. Next, I match 5-digit SIC codes to 100 manufacturing sectors in small classification of the Korean Input-Output table.

Due to the nature of the model, each country in the sample should be a Korea's major competitor in the world market. Thus, I limit the set of destination countries according to their shares in global trade. Another evidence supporting the use of a set of major countries is that the non-major currencies have little help in explaining import price changes (Pollard and Coughlin (2006)[28]). Specifically, I rank countries based on their averaged merchandise trade volumes (exports plus imports) for the period 2002 to 2012.[29] And I focus on 25 countries, whose shares in world trade are more than 1%, except Korea itself and two oil-exporting countries (Saudi Arabia, United Arab Emirates): United States, China, Germany, Japan, France, United Kingdom, Netherlands, Italy, Belgium, Canada, Hong Kong, Spain, Singapore, Mexico, Russia, Taiwan, India, Switzerland, Australia, Malaysia, Thailand, Brazil, Austria, Sweden, Poland, accounting for 78% of global trade. I will also report a robust test with other sets of countries later.

Data on bilateral exchange rates come from the International Financial Statistics of the International Monetary Fund. To compute the US dollar exchange rate against the rest of the world except Korea and country d, I consider product-specific exchange rates using the following formula.

$$\ln ERRU_{i,d,t} = \sum_{j \in J_d} \beta_{i,j,t} \ln ERDU_{j,t} \tag{3.22}$$

where J_d denotes all countries in the sample except Korea and country d, and $\beta_{i,j,t}$ is the trade-based weight of country j for product i in the basket.[30] There are two logical rea-

[28] They examined exchange rate pass-through into US import prices for 29 manufacturing industries using eight exchange rate indexes. They showed that major currency indexes perform better than their broad currency counterparts.

[29] Appendix Table A4 lists the top 50 countries with their averages trade volumes and the corresponding shares in world trade.

[30] To be more concrete, $\beta_{i,j,t} = 0.5 \times \frac{X^j_{i,t}}{\sum_{j \in J_d} X^j_{i,t}} + 0.5 \times \frac{M^j_{i,t}}{\sum_{j \in J_d} M^j_{i,t}}$ where $X^j_{i,t}$ and $M^j_{i,t}$ denote total export and total import of product i by country j, respectively.

sons for me to adopt product-specific exchange rates instead of aggregate trade-weighted exchange rates. First, the importance of each country as a competitor within a product can differ substantially from its importance in the aggregated world trade. As a consequence, product-specific exchange rates may be more effective than aggregate trade-weighted exchange rates in capturing changes in the competitive environment at the product level caused by exchange rate movements.[31] Second, product-specific exchange rates can help to reduce multi-collinearity problem among multiple exchange rates. Indeed, we can observe reductions in correlation with other exchange rates when using product-specific exchange rates as shown in Table 3.2.

Table 3.2: Correlation Coefficient Among Exchange Rates

	$\Delta \ln ERKU_t$	$\Delta \ln ERDU_{d,t}$
$\Delta \ln ERRU_{d,t}$	0.086^{***}	0.356^{***}
	(0.002)	(0.002)
$\Delta \ln ERRU_{i,d,t}$	0.066^{***}	0.209^{***}
	(0.002)	(0.002)

Note: Asymptotic standard errors are reported in parentheses with *** denoting significance at 1%.

3.4.2 Empirical Specification

According to the discussion in the previous theoretical framework, I estimate the following specification, where products are indexed by i, industries (or sectors) by s, destinations by d and Δ is the first difference operator.

$$\begin{aligned} \Delta \ln UV_{i,s,d,t} = \; & \alpha_1 \Delta \ln ERKU_t + \alpha_2 \Delta \ln ERKU_t \cdot IM_s + \alpha_3 \Delta \ln ERDU_{d,t} \\ & + \alpha_4 \Delta \ln ERRU_{i,d,t} + \lambda_t + \mu_{s,d} + \upsilon_{i,s,d,t} \end{aligned} \tag{3.23}$$

[31] From a similar perspective, Pollard and Coughlin (2006) conclude that industry-specific exchange rate indexes are preferred to aggregate indexes.

where $UV_{i,s,d,t}$ denotes the unit value of exports set in US dollars, used as a proxy for export prices, $ERKU_t$ is the Korean won/US dollar rate, $ERDU_{d,t}$ is the exchange rate defined as units of country d currency per unit of the US dollar and $ERRU_{i,d,t}$ is the US dollar exchange rate against the rest of the world except Korea and country d for product i. λ_t denotes year dummies and $\mu_{s,d}$ represents industry-destination fixed effects to capture the time-invariant characteristics that vary by industry, by destination or by industry-destination.

From equation (3.15), we expect a positive sign on α_1 and a negative sign on α_2, α_3 and α_4. In particular, the second coefficient α_2 captures the heterogeneity of pass-through rates, that is, the fact that high import intensity increases industry-level pass-through rate following a depreciation of the Korean won. In contrast, it is worth noting that the alternative model in Section 3.3.4 predicts a positive sign on the coefficient on the interaction term (α_2).

3.4.3 Estimation Results

To examine the relationship between pass-through, multiple exchange rate movements and import intensity, I start with a simple specification and build up to the benchmark empirical specification in equation (3.23). Table 3.3 reports the results. First, column 1 shows that the unweighted average exchange rate pass-through elasticity in the sample is 0.61 when we use only the won/dollar exchange rate. In column 2, I include an interaction between the won/dollar exchange rates and an industry's import intensity. We see that import intensity has a crucial characteristic to explain different pass-through rates between industries. Industries with a high share of imported inputs exhibit higher pass-through: a 1 percentage point higher import intensity leads to a 1.1 percentage higher pass-through. For example, tobacco industry with a 9% import content has a pass-through of 30%, while semiconductor industry with a 49% import content has a pass-through of 75%.

In column 3, I include a bilateral exchange rate between the currency of destination d and the US dollar. All coefficients corresponding to exchange rate shocks are of the expected sign and these are also highly significant except for the coefficient on won/dollar exchange rate.

Table 3.3: Baseline Results

	(1)	(2)	(3)	(4)
$\Delta \ln ERKU_t$	-0.610^{***}	-0.199	0.008	0.010
	(0.134)	(0.163)	(0.176)	(0.186)
$\Delta \ln ERKU_t \times IM_s$		-1.131^{***}	-1.142^{***}	-1.136^{***}
		(0.256)	(0.257)	(0.256)
$\Delta \ln ERDU_{d,t}$			-0.136^{***}	-0.140^{***}
			(0.039)	(0.040)
$\Delta \ln ERRU_{i,d,t}$				0.001
				(0.015)
Observations	283,722	283,722	283,722	278,252

Note: All regressions include country-industry fixed effects and yearly dummies. Standard errors are clustered at the country-year level, reported in parenthesis with *, ** and *** denoting significance at 10%, 5% and 1%, respectively.

We see that Korean exporters lower their export prices in US dollar terms in response to a depreciation of the destination currency against the US dollar. A depreciation of the destination market's currency against the US dollar not only raises the prices of Korean products sold in the importing country directly, but also lowers the exporting cut-off of Korean firms due to intensified competition and so causes a decrease in aggregate export price. In column 4, I estimate the main empirical specification in equation (3.23) by adding product-specific exchange rates between the other competitors' currencies and US dollar. We see that the coefficients both on the import intensity interaction and on the destination currency/US dollar exchange rates remain almost unchanged and strongly significant. However, contrary to expectations, the estimated coefficient on the trade-weighted exchange rates ($ERRU$), which I will refer to as third-country exchange rates, has the negligible positive sign and is not statistically significant.

There are several possible explanations for why third-country exchange rates do not have a significant impact on export prices. First, we need to re-examine the assumption about the invoice currency of international trade. In this paper, I assume that every country invoices its trade in the US dollar. The US dollar is still the primary invoice currency in international transactions, but the extent to which the dollar is used differs substantially across countries as shown in Appendix Table A1. As a result, my model might not fully capture the effect of exchange rate shocks on firms' pricing behavior. Furthermore, there exists some empirical evidence to support that exchange rate pass-through varies considerably with the choice of invoicing currency.[32] Another possible explanation is that Korean exporters in practice do not care too much about the other competitors' exchange rates in setting their prices to each destination. If we assume that prices are set conditional on the available information before the realization of exchange rates, it would be difficult or costly for firms to gather sufficient information to forecast multiple exchange rates.

3.4.4 Robustness

In this section, I provide different sets of robustness checks. First, I control for some other industry characteristics that could generate heterogeneity in the pass-through rates. Second, I test how robust my results are to alternative non-parametric specification. Third, I check that my results are robust to the use of real exchange rates. Fourth, I further check the robustness of my results within alternative samples of the dataset. Finally, I use the export price index as an alternative price indicator instead of unit value.

Additional Controls Although I focus on import intensity, the empirical work undertaken so far has been related the degree of exchange rate pass-through to other industry characteristics. Dornbusch (1987) suggests that the extent of the pass-through depends on the degree of product substitution, the relative number of domestic and foreign firms, and market structure. Yang (1997) documents that the degree of pass-through is found to be positively correlated to product differentiation and negatively to the elasticity of marginal cost. In addition, Choi and Kim (2001) note the share of Korean exporters in the foreign

[32]For instance, Gopinath et al. (2010) find that there is a large difference in the exchange rate pass-through of the average US import good priced in dollars (25 percent) versus non-dollars (95 percent).

market. Unfortunately, most variables mentioned above are not directly observable, but I employ some observable variables available to control product or industry heterogeneity.

To begin with, I define the product-specific Korea's share in total import of country d in product i[33] as follows.

$$MS_{i,d,t} = \frac{M^d_{i,K,t}}{M^d_{i,t}} \tag{3.24}$$

where $M^d_{i,K,t}$ is total import of product i from Korea to country d in period t and $M^d_{i,t}$ is total import of product i by country d in period t.

The elasticity of the exporter price also depends on the degree of competition in the sector. As a measure of the extent of product differentiation, I use the elasticity of substitution ($\sigma_{s,d}$) estimated by Broda and Weinstein (2006). They provide their estimates at the HS 3-digit level. Thus, I match them with product codes in the HS 6-digit classification.

Lastly, the revealed comparative advantage index ($RCAI_{i,t}$) is widely used to measure comparative advantages of nations in international trade. This index measures a country's relative export performance in a specific product category compared to its overall export performance in the following manner.

$$RCAI_{i,t} = \frac{X^K_{i,t}/X^W_{i,t}}{X^K_t/X^W_t} \tag{3.25}$$

Here, $X^K_{i,t}$ is total export of product i by Korea in period t and $X^W_{i,t}$ is total export of product i by world in period t. X^K_t is total export of Korea in period t and X^W_t is total export of world in period t. If $RCAI_{i,t} > 1$, it is assumed that Korea has comparative advantage in product i in period t.

Table 3.4 re-estimates the main empirical specification in column 4 of Table 3.3 with

[33] As Feenstra et al. (1996), it would be more appropriate to employ Korea's share in total destination sales which also covers competition with destination firms. But constructing product-specific market shares in this way could be very time consuming. Instead, I select an alternative measure which easily be built by customs data.

additional controls. We find that pass-through is increasing in Korea's share in total import of the destination market in column 1. It contrasts with the previous firm-level studies such as Berman et al. (2012) and Amiti et al. (2012), which document that large firms absorb more exchange rate movements in their markups. However, this result is similar to that reported by Auer et al. (2012) who find that the rate of pass-through into import prices following trade-partner currency movements is increasing in the trade partner's sector-specific market share.[34] In column 2, the coefficient on the elasticity of substitution interaction is insignificant.[35] One possibility is that there might be a considerable amount of heterogeneity among more detailed products (HS 6-digit) within a broad product classification (HS 3-digit). Next, column 3 suggests that exporters pass exchange rate shocks through their prices more in comparative advantage industries. It is likely that revealed comparative advantage indexes are systematically associated with market shares in the destination market. In that regard, this result is compliant with the outcome in column 1. Indeed, we observe that the coefficients on both the market share and the revealed comparative advantage index interaction terms drop slightly in size in column 4 when we include both variables.

Finally, I include all the variables in column 4. Once again, variations in import intensity, market shares and comparative advantage are the effective tools for explaining differences in pass-through across industries. The inclusion of other control variables does not modify substantially the size and statistical significance of the coefficients both on the import intensity interaction and on the destination currency/US dollar exchange rates.

Nonparametric Specification I interact the won/dollar exchange rates with different bins built from percentiles of industries' import intensity to examine the robustness of alternative non-parametric specifications. First, I construct dummy variables for industries

[34]Meanwhile, Feenstra et al. (1996) develop a Bertrand differentiated products model and show that the relationship between pass-through and market share is significantly nonlinear in the global automobile industry.

[35]Broda and Weinstein (2006) do not provide their estimates regarding four countries; Belgium, Russia, Taiwan and Singapore. Hence, these countries were excluded from regression. I re-estimated column 2 without country-industry fixed effects, but the result remain unchanged.

Table 3.4: Robustness: Additional Controls

	(1)	(2)	(3)	(4)
$\Delta \ln ERKU_t$	0.127	−0.017	0.133	0.203
	(0.192)	(0.220)	(0.185)	(0.221)
$\Delta \ln ERKU_t \times IM_s$	−1.143***	−1.111***	−1.072***	−1.094***
	(0.249)	(0.292)	(0.250)	(0.288)
$\Delta \ln ERDU_{d,t}$	−0.126***	−0.150***	−0.130***	−0.132***
	(0.040)	(0.041)	(0.039)	(0.039)
$\Delta \ln ERRU_{i,d,t}$	−0.012	−0.004	−0.007	−0.025
	(0.015)	(0.018)	(0.015)	(0.017)
$\Delta \ln ERKU_t \times MS_{i,d,t}$	−0.875**			−0.779**
	(0.344)			(0.381)
$MS_{i,d,t}$	0.561***			0.353***
	(0.034)			(0.040)
$\Delta \ln ERKU_t \times \sigma_{s,d}$		−0.001		0.000
		(0.001)		(0.001)
$\sigma_{s,d}$		−0.000		0.000
		(0.000)		(0.000)
$\Delta \ln ERKU_t \times RCAI_{i,t}$			−0.033***	−0.021**
			(0.008)	(0.008)
$RCAI_{i,t}$			0.024***	0.018***
			(0.001)	(0.001)
Observations	246,362	203,525	278,252	180,162

Note: All regressions include country-industry fixed effects and yearly dummies. Standard errors are clustered at the country-year level, reported in parenthesis with *, ** and *** denoting significance at 10%, 5% and 1%, respectively.

pertaining to each category, based on the median, quintiles and deciles of import intensity. And I replace the import intensity with those dummy variables and also interact them with the won/dollar exchange rates. In table 3.5, I replicate column 4 of Table 3.3 and column 4 of Table 3.4.

The interaction terms are always negative and statistically significant. The difference in the pass-through between industries with the highest import intensity and the other

Table 3.5: Robustness: Non-parametric Specification

	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \ln ERKU_t$	-0.339^{**}	-0.362^{**}	-0.392^{**}	-0.121	-0.150	-0.164
	(0.163)	(0.162)	(0.162)	(0.191)	(0.189)	(0.189)
$\Delta \ln ERKU_t \times IM_{Top50\%}$	-0.155^{***}			-0.158^{***}		
	(0.042)			(0.045)		
$\Delta \ln ERKU_t \times IM_{Top20\%}$		-0.404^{***}			-0.421^{***}	
		(0.079)			(0.087)	
$\Delta \ln ERKU_t \times IM_{Top10\%}$			-0.407^{***}			-0.510^{***}
			(0.122)			(0.156)
$\Delta \ln ERDU_{d,t}$	-0.138^{***}	-0.140^{***}	-0.139^{***}	-0.131^{***}	-0.132^{***}	-0.131^{***}
	(0.040)	(0.040)	(0.040)	(0.039)	(0.039)	(0.039)
$\Delta \ln ERRU_{i,d,t}$	-0.000	-0.000	-0.001	-0.026	-0.025	-0.027
	(0.015)	(0.015)	(0.015)	(0.017)	(0.017)	(0.017)
$\Delta \ln ERKU_t \times MS_{i,d,t}$				-0.932^{**}	-0.858^{**}	-0.942^{**}
				(0.402)	(0.389)	(0.395)
$MS_{i,d,t}$				0.350^{***}	0.352^{***}	0.351^{***}
				(0.040)	(0.040)	(0.040)
$\Delta \ln ERKU_t \times \sigma_{s,d}$				0.000	0.000	0.000
				(0.001)	(0.001)	(0.001)
$\sigma_{s,d}$				0.000	0.000	0.000
				(0.000)	(0.000)	(0.000)
$\Delta \ln ERKU_t \times RCAI_{i,t}$				-0.025^{***}	-0.021^{**}	-0.032^{***}
				(0.009)	(0.008)	(0.009)
$RCAI_{i,t}$				0.018^{***}	0.018^{***}	0.018^{***}
				(0.001)	(0.001)	(0.001)
Observations	278,252	278,252	278,252	180,162	180,162	180,162

Note: All regressions include country-industry fixed effects and yearly dummies. Standard errors are clustered at the country-year level, reported in parenthesis with *, ** and *** denoting significance at 10%, 5% and 1%, respectively.

industries is strongly significant: For example, as shown in column 1, export industries below the median decrease their prices by 0.3% following a 1 % depreciation of the won against the US dollar while export industries above the median decrease their prices by 0.5%. The pass-through rates of industries with much higher import intensity are even higher. Column 3 shows us that export industries below the top decile decrease their prices by 0.4% following a 1 % depreciation of the won against the US dollar while export industries above the top decile decrease their prices by 0.8%.

I now present graphically the fragmented set of non-parametric interaction terms using 20 bins (20 percentiles) classified by industry's import intensity in Figure 3.4, together with 90% confidence intervals and a lowess smoother[36]. On the whole, we can see that the pass-through elasticity (in absolute value) increases with import intensity. However, Figure 3.4 also suggests the possibility of nonlinear relationships between exchange rate pass-through rates and imported input shares. In particular, for industries with smaller imported input shares, the negative trend is not clear or a modest positive trend is detected.

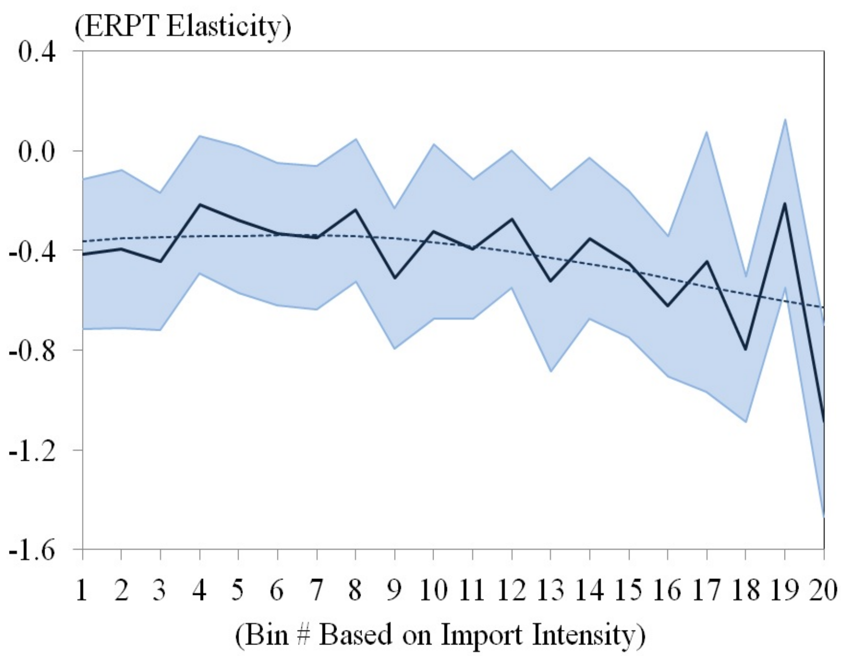


Figure 3.4: Exchange Rate Pass-Through Elasticity by Import Intensity (20 Bins)

Real Exchange Rates In table 3.6, I replicate the last columns of Table 3.3 and Table

[36]The default bandwidth of 0.8 in STATA is used for smoothing. This means that 80% of the data are used for calculating smoothed values for each point in the data except for the end points. The greater the bandwidth, the greater the smoothing.

3.4 by replacing nominal exchange rates with real exchange rates.[37] Real exchange rates are computed from the Penn World Table.[38] Due to data limitations, the analysis period is curtailed to 2002-2010. One interesting feature is the coefficient on the won/dollar real exchange rates is positive as expected from the theoretical model. We also observe that the key result related to import intensity is strengthened. On the other hand, the coefficient on third-country exchange rates have the opposite sign or statistically insignificant.

Alternative Samples I further investigate the robustness of the baseline results using alternative samples of the dataset. Table 3.7 provides the results of the main specification from column 4 of table 3.3 in eight alternative samples.

First, I add 28 countries including oil-exporting countries to the baseline sample, whose shares in world trade (2002-2012) are more than 0.3%.[39] A total of 53 countries account for 93% of global trade. Column 1-5 of Table 3.7 report the results for five alternative sets of destination countries based on the extended sample– all sample countries, the US only, all sample countries excluding the US, all Euro countries, non-Euro countries.[40] Column 1 reveals the same patterns we find in the baseline sample. It is remarkable that Korean exporters pass won/dollar exchange rate shocks through their prices to the US less than to other countries as shown in column 2 and 3. This is consistent with previous studies on low pass-through into the US. Interestingly, we see a huge difference between the coefficients on the bilateral exchange rates between destination currency and US dollar in column 4 and 5. Although both coefficients are not significant, the (absolute) pass-through elasticity for Euro countries is about four times larger than that for non-Euro countries. It suggests that

[37]In the second chapter, I mention that exchange rates can be interpreted as real exchange rates because each country's nominal wage reflects productivity by assumption.

[38]See Rodrick (2008) for more detailed calculation.

[39]The list of countries to be added is as follows: Saudi Arabia, United Arab Emirates, Turkey, Indonesia, Czech, Norway, Ireland, Denmark, Hungary, South Africa, Finland, Iran, Vietnam, Portugal, Israel, Slovakia, Chile, Venezuela, Philippines, Nigeria, Ukraine, Argentina, Romania, Greece, Algeria, Kuwait, Kazakhstan, Qatar. Iraq was ruled out due to data unavailability regardless of its share (0.3%) in global trade.

[40]Slovakia joined the Euro Zone in 2009. Considering its late joining, I exclude Slovakia from EU countries.

Table 3.6: Robustness: Real Exchange Rates

	(1)	(2)
$\Delta \ln RERKU_t$	0.728^{***}	0.315
	(0.233)	(0.278)
$\Delta \ln RERKU_t \times IM_s$	-1.170^{***}	-1.173^{***}
	(0.283)	(0.320)
$\Delta \ln RERDU_{d,t}$	-0.161^{***}	-0.170^{***}
	(0.046)	(0.042)
$\Delta \ln RERRU_{i,d,t}$	0.130^{**}	-0.010
	(0.063)	(0.074)
$\Delta \ln RERKU_t \times MS_{i,d,t}$		-0.866^{**}
		(0.426)
$MS_{i,d,t}$		0.374^{***}
		(0.042)
$\Delta \ln RERKU_t \times \sigma_{s,d}$		0.000
		(0.001)
$\sigma_{s,d}$		-0.000
		(0.000)
$\Delta \ln RERKU_t \times RCAI_{i,t}$		-0.017^{*}
		(0.009)
$RCAI_{i,t}$		0.018^{***}
		(0.001)
Observations	218,955	141,477

All regressions include country-industry fixed effects and yearly dummies. Standard errors are clustered at the country-year level, reported in parenthesis with *, ** and *** denoting significance at 10%, 5% and 1%, respectively.

differences in pass-through might be related to the currency of invoicing.

Table 3.7: Robustness: Alternative Samples

	Countries (Extended Sample)					Products (Deletion of Outlier)		
	All (1)	Only US (2)	W/O US (3)	Only Euro (4)	W/O Euro (5)	All Products (6)	$\Delta Price \leq$ 100% (7)	$\lvert\Delta Price\rvert \leq$ 50% (8)
$\Delta \ln ERKU_t$	-0.120	0.699^{***}	-0.202	-0.073	-0.117	0.075	0.040	0.212^{**}
	(0.156)	(0.107)	(0.161)	(0.418)	(0.168)	(0.241)	(0.183)	(0.090)
$\Delta \ln ERKU_t \times IM$	-1.107^{***}	-0.865^{**}	-1.117^{***}	-1.076^{***}	-1.102^{***}	-0.785^{**}	-1.180^{***}	-1.233^{***}
	(0.215)	(0.344)	(0.227)	(0.377)	(0.244)	(0.316)	(0.251)	(0.171)
$\Delta \ln ERDU_{d,t}$	-0.082^{***}		-0.066^{**}	-0.136	-0.036	-0.103^{**}	-0.138^{***}	-0.101^{***}
	(0.029)		(0.029)	(0.102)	(0.030)	(0.052)	(0.040)	(0.013)
$\Delta \ln ERRU_{i,d,t}$	0.001	-0.014	0.002	-0.001	0.001	0.036^{**}	-0.006	-0.003
	(0.001)	(0.055)	(0.008)	(0.019)	(0.009)	(0.018)	(0.016)	(0.005)
Observations	383,145	20,584	362,561	68,156	314,989	302,740	262,639	206,032

Note: All regressions include country-industry fixed effects and yearly dummies. Standard errors are clustered at the country-year level, reported in parenthesis with *, ** and *** denoting significance at 10%, 5% and 1%, respectively.

Next, I check the robustness against outliers. As IMF (2010) points out, unit value indices rely to a large extent on outlier detection and deletion. Therefore, I provide the results for three alternative sets in column 6-8 within the previous baseline country sample– all products (no outlier exclusion), dropping yearly unit value changes of over 100 percent and dropping changes of plus or minus over 50 percent. In column 6-8, we see that the results are insensitive to outliers.

Alternative Measure of Prices Unit value indices are widely used as measures of price changes of traded goods for economic analysis due to the relatively low cost of such data. However, they are exposed to well-recognized bias as mentioned in Section 3.4.1.[41] Therefore, I examine whether my results are robust to replacing unit values with export price indexes.

The quarterly data in this analysis covers the period from 1994 to 2012.[42] Export prices used here are export price indexes on the US dollar basis obtained from the Bank of Korea. I select 42 industries that encompass a broad spectrum of manufacturing industries using mapping between product classification of export prices and sector classification of the Korean Input-Output table.[43] In the regression, I use the time-averaged shares of imported inputs IM_s (1990, 1995, 2000, 2005 and 2010) by industry. These average shares by industry are listed in Appendix Table A5.

[41] United Nations (1981) provided an international guideline on choosing price measurement in external trade. Well-endowed countries were advised to conduct a comprehensive price survey in order to complement unit value indices. Countries under tight budgetary conditions were advised to use unit value indices but define each item in the narrowest sense possible.

[42] When selecting the analysis period, two main factors are considered. First, the existing empirical studies have concluded that the pass-through into export prices has declined since the financial crisis in 1997 (Kim and Choi (2001), Kim and Lee (2009)). Thus, I estimate pass-through coefficients using recent time series. Second, the nominal effective exchange rates for the US dollar are obtained from BIS broad indices comprising 61 economies (2010=100) with data from 1994. With drastic changes in global trade over recent decades, the broad indices are more appropriate than the narrow indices comprising 27 economies with data from 1967.

[43] 42 industries are comprised of 1 large (Food), 3 medium (Apparel, Pulp & Paper, Other Manufacturing) and 38 small industries.

Following Kim and Choi (2001), I estimate the following specification.

$$\begin{aligned}\Delta \ln XP_{s,t} = \ & \alpha_1 \Delta \ln ERKU_t + \alpha_2 \Delta \ln ERKU_t \cdot IM_s + \alpha_3 \Delta \ln EERUSD_t \\ & + \alpha_4 \Delta \ln PP_{s,t} + \alpha_5 \Delta \ln MO_{s,t-1} + \epsilon_{s,t}\end{aligned} \tag{3.26}$$

where $XP_{s,t}$ is the export price index for industry s (set in the US dollar), $ERKU_t$ is the exchange rate for the Korean won per US dollar, $EERUSD_t$ is the US dollar effective exchange rate obtained from BIS broad indices, $PP_{s,t}$ is the producer price index for industry s reflecting changes in production costs, $MO_{s,t-1}$ is the manufacturing operation ratio index for industry s measuring demand-side pressures. IM_s is the share of imported inputs in domestic production for industry s as defined earlier.

Because export price indexes are not computed on the destination basis, I use the US dollar effective exchange rate to capture changes in the value of the dollar versus other currencies.[44] An increase in $EERUSD_t$ indicates an appreciation of the US dollar.

I estimate equation (3.26) with quarterly dummies in order to correct for seasonal factors. The literature generally assumes pass-through to occur over time after the initial exchange rate shock. So I also estimate the long-run pass through, which are the sum of the coefficients on the contemporaneous exchange rates and two lags of exchange rates. The number of lag terms is chosen using the standard "general-to-specific" modeling.

Table 3.8 reports the results of the estimations of short-run and long-run exchange rate pass-through. All the coefficients associated with exchange rates have the expected sign and are strongly significant. Industries with a high share of imported inputs exhibit higher pass-through into US dollar export prices. Korean firms lower their dollar-denominated export prices in response to the worldwide US dollar appreciation. This result is consistent with

[44]Similarly, Kim and Lee (2009) added the dollar's effective exchange rate provided by FRB to their regression equation. They did not derive a specific relationship among exchange rates, but considered that other competitors' export prices might be affected by changes in the exchange rates between their currencies and US dollar. Meanwhile, Kim and Choi (2001) estimated the exchange rate pass-through by including the bilateral exchange rates between the Japanese yen and the US dollar.

the predicted negative sign of the coefficients on $\Delta \ln ERDU_{d,t}$ and $\Delta \ln ERRU_{i,d,t}$ in the baseline model. Moreover, the coefficients on the control variables have the expected positive sign: Both higher production costs and increased global demand put upward pressure on export price.

Table 3.8: Robustness: Alternative Measure of Prices

	Short-run	Long-run
$\Delta \ln ERKU_t$	0.510^{***}	0.424^{***}
	(0.089)	(0.125)
$\Delta \ln ERKU_t \times IM_s$	-1.803^{***}	-1.977^{***}
	(0.246)	(0.306)
$\Delta \ln EERUSD_t$	-0.550^{***}	-0.621^{***}
	(0.076)	(0.153)
$\Delta \ln PP_{s,t}$	0.761^{***}	0.577^{***}
	(0.055)	(0.051)
$\Delta \ln MO_{s,t-1}$	0.035^{***}	0.077^{***}
	(0.011)	(0.025)
Observations	3,150	3,066

Note: Both regressions include industry fixed effects and quarterly dummies. Standard errors are clustered at the industry level, reported in parenthesis with *** denoting significance at 1%.

3.5 Conclusion

I find that Korean manufacturing industries with higher import intensity have higher exchange rate pass-through elasticities. This result is consistent with predictions of the theoretical model developed in this paper. My work suggests that the extensive margin of trade may play an important role in determining the degree of aggregate exchange rate pass-through. Higher imported input prices following a depreciation not only have a direct effect on the marginal cost, but also affect the exporting cut-off due to changes in the competitive environment. Consequently, aggregate export prices are affected by variations in the composition of exporters due to changes in the exporting cut-off.

This paper relates industries' import intensities to pass-through rates, but does not mention about the relationship between firm-specific import intensity and pass-through. In future research I want to analyze more the puzzling difference in the current industry-level study and previous firm-level studies. For instance, Amiti et al. (2012) find that firms with high import shares have low exchange rate pass-through and import intensity is heavily skewed toward the largest exporters. Therefore, they suggest that their findings help explain low aggregate pass-through elasticities. In my opinion, there are two limitations in linking their results to aggregate pass-through. First, they do not consider the extensive margin of trade at all. Second, firm-level data may suffer from serious measurement errors due to the prevalence of multiproduct firms.

Finally, we need to develop a more realistic model to examine in detail the role of imported inputs in exchange rate pass-through. I assume full exchange rate pass-through into imported input prices like most researchers, but it seems to be a rather strong assumption given the empirical evidence of partial exchange rate pass-through into import prices. In addition, the invoice currency in trade is very important in capturing precisely changes in imported input prices in response to exchange rate shocks.

APPENDIX

Appendix

Table A1: US Dollar Use in the Export and Import Invoicing

	Observation[2]	US Dollar Share in Export	US Dollar Share in Import
United States	2003	99.8	92.8
Asia			
Japan	2001	52.4	70.7
Korea	2012	85.1	83.9
Thailand	1996	83.9	83.9
Australia	2002	67.9	50.1
EU			
France[1]	2002	34.2	43.2
Germany[1]	2002	32.3	37.9
Italy	2002	20.5	30.8
United Kingdom	2002	26.0	37.0
EU accession			
Bulgaria	2002	44.5	37.1
Czech	2002	14.7	19.5
Poland	2002	29.9	28.6
Slovenia	2002	9.6	13.3

[1] Invoicing data refer only to the invoicing of "extra euro-area" trade.
[2] Latest Observations are annual except for: Japan-January 2001, Germany-2002 Q3, United States-2003 Q1. Thailand is for overall trade and is not broken down by imports.
Source: Goldberg and Tille (2008) except for Korea – Korea Customs Service (January 2013)

Table A2: Share of Imported Inputs by Manufacturing Industry

	1990	1995	2000	2005	2010	Average[1]
Naphtha	0.93	0.77	0.94	0.87	0.88	0.89
Coal	0.39	0.64	0.67	0.78	0.86	0.77
Non-ferrous Metal Ingot	0.60	0.58	0.68	0.72	0.78	0.72
Basic Organic Chemical	0.67	0.48	0.68	0.70	0.78	0.72
Leather and Fur	0.48	0.54	0.60	0.67	0.80	0.69
Sugar	0.65	0.64	0.57	0.57	0.81	0.65
Cereal Milling	0.73	0.63	0.60	0.57	0.76	0.65
Other Petroleum	0.48	0.48	0.49	0.71	0.73	0.64
Fuel	0.78	0.54	0.58	0.60	0.68	0.62
Computer	0.45	0.54	0.55	0.61	0.69	0.62
Pig Iron and Ferrous-Alloy	0.45	0.54	0.60	0.53	0.71	0.61
Non-ferrous Metal	0.57	0.55	0.53	0.59	0.62	0.58
Synthetic Rubber	0.48	0.31	0.45	0.62	0.63	0.57
Man-made Fiber	0.51	0.51	0.52	0.55	0.62	0.56
Synthetic Resin	0.52	0.41	0.51	0.55	0.62	0.56
Aircraft	0.48	0.47	0.57	0.53	0.58	0.56
Crude Steel	0.45	0.48	0.54	0.54	0.59	0.56
Watch	0.44	0.37	0.46	0.55	0.63	0.55
Leather and Fur Garment	..	0.57	0.55	0.48	0.55	0.53
Animal Feed	0.47	0.49	0.46	0.54	0.57	0.53
Fertilizer and Agricultural Chemical	0.48	0.44	0.47	0.53	0.54	0.51
Electronic Video and Audio	..	0.38	0.48	0.51	0.54	0.51
Telecommunication and Broadcasting	0.34	0.36	0.49	0.49	0.54	0.50

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Table A2 (cont'd)

	1990	1995	2000	2005	2010	Average[1]
Cold Rolled Iron	0.37	0.39	0.40	0.52	0.58	0.50
Fiber	0.48	0.56	0.42	0.48	0.57	0.49
Wood	0.63	0.50	0.47	0.49	0.51	0.49
Semiconductor	0.61	0.33	0.50	0.48	0.48	0.49
Vegetable and Animal Oil	0.31	0.38	0.46	0.49	0.51	0.48
Other Basic Organic Chemical	0.42	0.35	0.40	0.49	0.54	0.48
Other Chemical	0.40	0.41	0.40	0.48	0.54	0.48
Electronic Display	0.27	0.30	0.46	0.44	0.47	0.45
Paper	0.46	0.44	0.42	0.43	0.51	0.45
Dye and Paint	0.42	0.41	0.41	0.43	0.51	0.45
Starche and Glucose	0.42	0.39	0.44	0.40	0.51	0.45
Railway Locomotive	0.29	0.41	0.47	0.39	0.46	0.44
Cast and Forged Steel	0.27	0.31	0.36	0.37	0.57	0.44
Pulp	0.44	0.38	0.39	0.49	0.44	0.44
Inorganic Chemical	0.32	0.24	0.34	0.43	0.51	0.43
Hot Rolled Iron	0.36	0.36	0.40	0.40	0.48	0.43
Office Machinery	0.34	0.31	0.37	0.42	0.47	0.42
Other Transport Equipment	0.28	0.27	0.33	0.34	0.51	0.39
Tire and Tube	0.38	0.35	0.33	0.39	0.46	0.39
Texile	0.38	0.37	0.34	0.37	0.45	0.39
Electronic Component	0.31	0.30	0.35	0.35	0.43	0.38
Ship	0.33	0.33	0.32	0.40	0.41	0.37
Plastic	0.35	0.30	0.33	0.35	0.44	0.37
Optical Instrument	0.30	0.17	0.34	0.36	0.42	0.37

Continued on next page

Table A2 (cont'd)

	1990	1995	2000	2005	2010	Average[1]
Other Leather	..	0.31	0.31	0.36	0.43	0.37
Other Electrical Equipment	0.36	0.31	0.34	0.35	0.41	0.37
Wood Product	0.33	0.35	0.37	0.34	0.39	0.37
Cement	0.26	0.19	0.21	0.32	0.56	0.36
Footwear	0.31	0.33	0.35	0.32	0.42	0.36
Other Steel	0.39	0.29	0.26	0.39	0.44	0.36
Engine and Turbine	0.27	0.41	0.36	0.34	0.34	0.35
Textile Dyeing	0.28	0.23	0.34	0.31	0.36	0.34
Agricultural and Construction Machinery	..	0.34	0.34	0.32	0.36	0.34
Domestic Electric Appliance	0.34	0.24	0.28	0.33	0.40	0.34
Trailer and Container	..	0.37	0.41	0.29	0.29	0.33
Metal Container	..	0.30	0.29	0.31	0.38	0.33
Paper Product	0.32	0.30	0.32	0.29	0.36	0.33
Other Manufacturing	0.27	0.28	0.33	0.30	0.34	0.32
Medical and Precision Instrument	0.28	0.23	0.31	0.31	0.35	0.32
Other Rubber	0.33	0.29	0.27	0.31	0.38	0.32
Glass	0.27	0.26	0.24	0.32	0.38	0.32
Other Texile	0.30	0.27	0.29	0.29	0.37	0.31
Knitted Apparel	..	0.28	0.26	0.29	0.40	0.31
Motor Vehicle Component	0.25	0.25	0.27	0.31	0.36	0.31
Electric Motor and Generator	0.31	0.28	0.29	0.30	0.34	0.31
Structural Metal	0.27	0.25	0.30	0.29	0.34	0.31
Other Special Purpose Machinery	0.30	0.26	0.28	0.28	0.36	0.31
Motor Vehicle	0.23	0.25	0.27	0.31	0.34	0.31

Continued on next page

Table A2 (cont'd)

	1990	1995	2000	2005	2010	Average[1]
Furniture	0.36	0.28	0.28	0.29	0.34	0.30
Toy and Athletic Good	0.24	0.22	0.27	0.28	0.35	0.30
Other Non-metallic Mineral	0.20	0.17	0.24	0.29	0.36	0.30
Clay	0.20	0.22	0.27	0.29	0.33	0.30
Refrigerator and Air Conditioning	..	0.25	0.26	0.29	0.33	0.29
Condiment	0.26	0.28	0.27	0.28	0.34	0.29
Bakery and Noodle	0.33	0.28	0.27	0.26	0.35	0.29
Other General Machinery	0.31	0.25	0.28	0.27	0.33	0.29
Industrial Conveying	..	0.29	0.29	0.25	0.33	0.29
Fish	0.22	0.26	0.29	0.28	0.30	0.29
Hand Tool and Metal Wire	..	0.26	0.25	0.26	0.35	0.29
Pharmaceutical	0.20	0.24	0.26	0.27	0.33	0.29
Meat	0.24	0.25	0.26	0.26	0.34	0.29
Cosmetic and Soap	0.29	0.24	0.26	0.25	0.33	0.28
General Machinery Component	0.21	0.22	0.24	0.27	0.33	0.28
Luggage and Handbag	..	0.23	0.27	0.25	0.30	0.27
Fabric Apparel	..	0.32	0.32	0.23	0.28	0.27
Machine Tool	0.25	0.26	0.26	0.24	0.31	0.27
Other Metal	0.29	0.23	0.25	0.25	0.31	0.27
Other Food	0.21	0.25	0.23	0.24	0.31	0.26
Non-alcoholic Beverage	0.19	0.17	0.22	0.24	0.30	0.25
Dairy	0.24	0.23	0.24	0.22	0.29	0.25
Ceramic	0.20	0.17	0.23	0.21	0.29	0.24
Printing and Reproduction	0.23	0.21	0.23	0.19	0.25	0.22

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Table A2 (cont'd)

	1990	1995	2000	2005	2010	Average[1]
Concrete	0.15	0.13	0.16	0.21	0.30	0.22
Fruit and Vegetable	0.12	0.10	0.14	0.17	0.20	0.17
Alcoholic Beverage	0.12	0.12	0.12	0.11	0.15	0.13
Tobacco	0.06	0.06	0.07	0.09	0.12	0.09
Cereal Husking	0.05	0.04	0.05	0.09	0.11	0.08

[1] The time-averaged shares during 2000-2010 used in the main empirical analysis. Descriptive statistics are as follows: Min=0.08, Max=0.89, Mean=0.40, Median=0.36, Standard Deviation=0.15.

Table A3: Imported Input Shares by Country

Country	IO Year	Import Content of Exports	Country	IO Year	Import Content of Exports
Australia	2004/05	0.202	Japan	2005	0.176
Belgium	2005	0.540	Korea	2005	0.417
Brazil	2005	0.177	Mexico	2003	0.475
Canada	2005	0.377	Netherlands	2005	0.478
China	2005	0.304	Norway	2005	0.318
Denmark	2005	0.370	Poland	2005	0.386
Finland	2005	0.409	Russia	2000	0.152
France	2005	0.333	Singapore	2000	0.698
Germany	2005	0.309	Spain	2005	0.426
Greece	2005	0.351	Sweden	2005	0.393
Hungary	2005	0.630	Switzerland	2005	0.291
India	2003/04	0.267	Taiwan	2006	0.545
Indonesia	2005	0.232	Turkey	2002	0.292
Ireland	2005	0.582	United Kingdom	2005	0.318
Israel	2005	0.507	United States	2005	0.164
Italy	2004	0.341	Vietnam	2000	0.463

Source: OECD, STAN Database for Structural Analysis (`www.oecd.org/sti/stan`)

Table A4: Top 50 Countries in World Merchandise Trade (2002-2012)

Rank	Country	Trading Volume[1] ($US Billion)	Share
1	United States	2,910	11.2%
2	China	2,110	8.1%
3	Germany	2,050	7.9%
4	Japan	1,260	4.9%
5	France	1,060	4.1%
6	United Kingdom	961	3.7%
7	Netherlands	924	3.6%
8	Italy	852	3.3%
9	Belgium	727	2.8%
10	Canada	727	2.8%
11	Hong Kong	698	2.7%
12	Korea	696	2.7%
13	Spain	534	2.1%
14	Singapore	528	2.0%
15	Mexico	521	2.0%
16	Russian Federation	518	2.0%
17	Taiwan	429	1.7%
18	India	400	1.5%
19	Switzerland	314	1.2%
20	Australia	313	1.2%
21	Saudi Arabia	307	1.2%

Continued on next page

Table A4 (cont'd)

Rank	Country	Trading Volume[1] ($US Billion)	Share
22	United Arab Emirates	305	1.2%
23	Malaysia	300	1.2%
24	Thailand	292	1.1%
25	Brazil	286	1.1%
26	Austria	283	1.1%
27	Sweden	273	1.1%
28	Poland	264	1.0%
29	Turkey	245	0.9%
30	Indonesia	220	0.8%
31	Czech	207	0.8%
32	Norway	187	0.7%
33	Ireland	178	0.7%
34	Denmark	173	0.7%
35	Hungary	157	0.6%
36	South Africa	143	0.6%
37	Finland	136	0.5%
38	Iran	122	0.5%
39	Viet Nam	115	0.4%
40	Portugal	114	0.4%
41	Israel	104	0.4%
42	Slovak	101	0.4%

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Table A4 (cont'd)

Rank	Country	Trading Volume[1] ($US Billion)	Share
43	Chile	99	0.4%
44	Venezuela	98	0.4%
45	Philippines	98	0.4%
46	Nigeria	97	0.4%
47	Ukraine	96	0.4%
48	Argentina	95	0.4%
49	Romania	91	0.4%
50	Greece	84	0.3%

[1] All volumes are the annual average during 2002-2012 and valued at current price.
Source: World Trade Organization

Table A5: Share of Imported Inputs by Manufacturing Industry Classification of Export Price Indexes

Industry	Import Shares[1]	Industry	Import Shares[1]
Naphta	0.875	Textile	0.382
Non-ferrous Metal	0.672	Paper	0.370
Organic Chemicals	0.659	Other Electrical Equipment	0.355
Fuel	0.635	Plastic	0.355
Leather	0.617	Other Basic Iron	0.351
Non-ferrous Metal Product	0.571	Electronic Component	0.350
Computer	0.566	Apparel	0.320
Man-Made Fiber	0.541	Domestic Electric Appliance	0.318
Synthetic Resin	0.523	Spectacle	0.317
Fiber	0.502	Cement	0.308
Synthetic Rubber	0.497	Electric Motor	0.306
Fertilizer	0.493	Other Manufacturing	0.306
Semiconductor	0.482	Special Purpose Machinery	0.296
Electronic Video and Audio	0.478	Industrial Conveying	0.290
Cold Rolled Iron	0.452	Engine	0.288
Telecommunication	0.443	Industrial Refrigerator	0.284
Other Chemicals	0.438	Hand Tool	0.283
Hot Rolled Iron	0.399	Motor Vehicle	0.281
Electronic Display	0.386	Machine Tool	0.262
Office Machinery	0.383	General Purpose Machinery	0.253
Tire and Tube	0.383	Food	0.215

[1] The time-averaged shares during 1995-2010.

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