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Foreign Direct Investment and Exchange Rate Pass-through: Access to Foreign Markets[1]

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[Abstracts]

We examine the effects of foreign direct investment on exchange rate pass-through. By distinguishing the purpose of foreign direct investment, different hypothesis for production subsidiary and distribution subsidiary can be tested. We are able to find a clear evidence of "power-shift" effect and "elimination" effect of distribution subsidiary, with foreign direct investment data properly constructed to capture the timing of establishment. We also obtained significant downward effect of local production, conforming to the previous research.

Keywords: distribution subsidiary, exchange rate pass-through, foreign direct investment.

Journal of Economic Literature Classification Numbers: F12; F14; L14; L63; L68

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1. Introduction

The lack of adjustment for the US current account after steady depreciation of the US dollar in the second half of the 1980s has re-motivated research examining the relationship between exchange rate and tradable prices. The less than proportionate response of tradable prices to changes in exchange rates, termed as incomplete pass-through in the literature, has been well documented in other circumstances as well.

The seminal work by Dornbusch (1987) has suggested that the some features of imperfect competition, namely the number of competitors, finite demand elasticity, and etc., lead to incomplete pass-through. Krugman (1987) on the other hand extended the decades old literature to a different direction, suggesting that same features affecting incomplete pass-through can explain the international price differentials arising from exchange rate fluctuations, termed as pricing-to-market. Enormous amounts of research both theoretical and empirical have followed these works[2].

Rather than providing an additional empirical evidence of incomplete pass-through as a contribution, empirical research has recently shifted more toward focusing on the causes of incomplete pass-through. Gron and Swenson (1996) has included the degree of local production in a pass-through equation to explain the partial reduction of pass-through with exporters with local plants. In stead of reduced-form pass-through equation, Kadiyali (2000) uses a structural econometric framework to capture interacting effects of market structures and pricing strategies in the US photographic industry. Bernhofen and Xu (2000) examines the effect of market share in exporting market in pass-through equation and finds that German and Japanese firms exercised significant market power in the US petrochemical market.

Recent development in macroeconomics in so-called new open economy macroeconomics takes these incomplete pass-through and pricing-to-market phenomena seriously into their dynamic general equilibrium model[3]. From the seminal work by Obstfeld and Rogoff (1995), many researchers have attempted to incorporate pricing behaviors of firms under imperfect competition in order to create deviation from perfectly flexible framework, see Chari and et al. (1998) and Corsetti and Pesenti (1997). Their research motive is to create a theoretical model that is capable of producing long persistence and high volatility of exchange rate movement after monetary shock[4]. It is, therefore, also important for new open economy macroeconomics to develop a more understanding of exchange rate pass-through behavior.

Whereas demand and cost fluctuations are, for each exporting firm, exogenous parameter

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2 See Goldberg and Knetter (1997) for a recent survey.

3 See an excellent survey for new open economy macroeconomics by Lane (2001)

4 There are many other empirical works that attempt to uncover the cause of long persistence and high volatility of exchange rate movement from different directions, see Engel (1999) and Cheung and Lai (2000).

that influence the pricing behavior, some changes in market structure, e.g., the entry decision to foreign markets or acquisition of foreign subsidiaries, are endogenously determined parameters that also affect the optimizing behavior. In search of a larger market for products, a manufacturer begins to access to foreign markets without sufficient information for the local market. Eventually exporting firm establishes distribution and production networks by setting up a new subsidiary firm or by acquisitions of local firms.

Figure 1 indicates that the number of Japanese foreign subsidiaries has almost doubled in recent ten years, 1988 - 1997. The most significant region is Asia in which the number of foreign subsidiary has increased approximately 150 percent within the period. Figure 2 summarized the response of Japanese parent firms to a questionnaire that asks for the most significant causes for establishing foreign subsidiaries. Although inexpensive wage for labor is significant in developing countries in Asia, the major reason for foreign direct investment is to secure access for local markets.

Intuitively, it is clear that these changes in market structure might affect the pricing behavior of exporting firms, consequently, exchange rate pass-through as well. In the next section we provide a concrete theoretical foundation for particular channels through which foreign direct investments affect exchange rate pass-through. Section 3 describes data and an econometric methodology. Section 4 discusses the empirical results. Section 5 concludes the paper.

2. Theoretical Background

2.1. A local distributor model

Yoshida (1999) examines pricing behavior of exporting firms with an explicit incorporation of local distributors in a pass-through model. With a successive monopolies model in an international setting, Yoshida shows that the degree of exchange rate pass-through is likely to be higher for an exporter with a subsidiary distributor than with a local independent distributor. This result then suggests that exchange rate pass-through increases with foreign direct investments, FDI henceforth, aiming for establishment of a local distribution network.

However, we need to be very cautious about interpreting underlying assumptions in the model when the results are used as empirical testing hypothesis. While the bargaining power between an exporter and an independent local distributor is assumed to fall entirely on the exporter side in a successive monopolies model of Yoshida (1999), it is more natural to assume that a local distributor retains some bargaining power. For example, this can be observed when a local distributor has private information about the local market. This is especially true at the initial development stage for exporting. Moreover, there are even cases in which the local distributor can be assumed to have all the bargaining power if there are sufficient competition among exporters.

If the bargaining power totally rests on the independent local distributor as in the latter case, then, the exchange rate pass-through becomes complete since an export price is fixed to be equal to a marginal cost of exporter in order to leave zero profit for an exporter. If pass-through is shown to be incomplete, i.e. less than proportionate, after vertical integration, FDI in this case results in decreasing pass-through. However, this should not be interpreted as a contradicting evidence against the results obtained in Yoshida (1999), rather they reveal different aspects of vertical integration effect. By vertically integrating forward with an independent local distributor, bargaining power is shifted to an exporter, forming successive monopolies, and negative externality arising from the structure of successive monopolies can be eliminated at the same time. We might call these effects as “power-shift” effect and “elimination” effect, respectively. In terms of exchange rate pass-through, power-shift effect is associated with decreasing pass-through and elimination effect with increasing pass-through. In this terminology, Yoshida (1999) analyzed only “elimination effect.”

In the following subsection we present a simple vertical structure model of export with an arbitrary bargaining weight between an exporter and a local distributor.[5] We follow very closely the analysis of Yoshida (1999) with an additional aspect of bargaining in terms of Nash bargaining solution. We can also reinterpret the Nash-bargaining model as that two firms are actually engaging in a sequential bargaining[6]. We obtain an explicit form of exchange rate pass-through for an arbitrary bargaining weight, α. Then, we establish the fact that exchange rate pass-through is the lowest when bargaining power entirely falls on an exporter. This result suggests that increase in bargaining power of exporter associated with acquiring a local distribution firm decreases the exchange rate pass-through.

2.1.1. Power shift effect

The profits for an exporter and a local distributor in explicit forms are, respectively,

$$\begin{aligned} \pi_U &= (w - c_1)q(p) \\ \pi_D &= (p - ew - c_2)q(p) \end{aligned} \tag{1}$$

where the exchange rate, e, is expressed as the price of domestic currency in terms of foreign currency. The cost for an exporter and a local distributor, c_1 and c_2 respectively, are denominated in domestic currency and foreign currency respectively. We also assume a

[5] The frameworks for this model and Yoshida (1999) are very similar in vein, except that the latter analyzes a model with a more general demand function but only for the limited case in which a bargaining weight of a local distributor is zero.

[6] It is well known that the solution of the Nash bargaining problem coincides with the solution to a particular non-cooperative sequential bargaining problem.

demand function for export is linear in retail price in foreign currency, $q(p) = d - p$. The wholesale price determined between two firms is w.

In a symmetric information case with a given wholesale price, an outcome of profit optimizing behavior of distributor is common knowledge. Therefore, it is a derived demand of distributor for export products that matters to the exporter. We obtain the derived demand,

$$q(ew) = \frac{d - ew - c_2}{2}. \tag{2}$$

With equation (2) the profits for two firms can be reduced to,

$$\begin{aligned} \pi_U &= (w - c_1)(d - ew - c_2)/2 \\ \pi_D &= (d - ew - c_2)^2/4. \end{aligned} \tag{3}$$

The Nash bargaining solution can be obtained as a maximum of the weighted multiplicand of profits for both firms subject to participant constraints. The bargaining weight for an exporter is denoted as α.

$$\max_w [(d - ew - c_2)^2/4]^{1-\alpha}[(w - c_1)(d - ew - c_2)/2]^{\alpha}$$
$$s.t. \quad (d - ew - c_2)^2/4 \geq 0, \quad \text{and} \quad (w - c_1)(d - ew - c_2)/2 \geq 0$$

[α =1: successive monopolies]

When bargaining power totally rests on the exporter, it is successive monopolies as assumed in Yoshida (1999). From the first order condition for the Nash product, we obtain the export price in terms of foreign currency, $ew = (d + ec_1 - c_2)/2$. Defining exchange rate pass-through as the elasticity of export price in terms of foreign currency with respect to exchange rate,

$$\frac{(d \ln ew)}{(d \ln e)} = \frac{ec_1}{d + ec_1 - c_2} < 1. \tag{4}$$

We should note that in this case participant constraint for a local distributor is not binding.

[α =0: monopsony]

In this opposite extreme case, a distributor behaves as monopsony in wholesale market while remaining as monopoly in retail market. Since wholesale price is cost for a distributor, it will increase the profit by decreasing wholesale price as low as possible until an exporter leaves the contract. This will result in setting wholesale price equal to marginal cost, i.e., $w = c$. Therefore, the exchange rate pass-through becomes complete,

$$\frac{(d \ln ew)}{(d \ln e)} = \frac{ec_1}{ec_1} = 1 \tag{5}$$

[0<α<1: intermediate case]

As in the previous subsections, the first order condition for the Nash product is,

$$\begin{aligned} &-(1-\alpha)2e\frac{(d-ew-c_2)}{4}[(d-ew-c_2)^2/4]^{-\alpha}[(w-c_1)(d-ew-c_2)/2]^{\alpha} \\ &+\alpha\left\{-ew+\frac{(d+ec_1-c_2)}{2}\right\}[(d-ew-c_2)^2/4]^{1-\alpha}[(w-c_1)(d-ew-c_2)/2]^{\alpha-1} = 0 \end{aligned} \tag{6}$$

With some algebra, we obtain an explicit form of wholesale price in terms of foreign currency, $ew = (1-\alpha)ec_1 + \alpha(d + ec_1 - c_2)/2$. Then, the exchange rate pass-through is

$$\frac{(d \ln ew)}{(d \ln e)} = \frac{[(1-\alpha)2ec_1 + \alpha[ec_1]]}{[(1-\alpha)2ec_1 + \alpha[d + ec_1 - c_2]]} < 1 \tag{7}$$

It is easy to see that this equation is decreasing in α and converges to the previous two extreme cases if α is either one or zero.

By comparing equation (4), (5), and (7), we have formally established that exchange rate pass-through is, prior to vertical integration, larger if a distributor retains more bargaining power. Since vertical integration, i.e., acquiring entire stock of local distribution firm, by an exporter shifts all bargaining power to the exporter, namely α=1, foreign direct investment in this sense surely decreases exchange rate pass-through. This result gives a strong supporting theoretical evidence for power-shift effect in foreign direct investment for exchange rate pass-through.

2.1.2. Elimination effect

While the above analysis consideres the effect of shift in bargaining power of exporter associated with acquiring a local distributor, vertical integration also eliminates negative externality, emerging from coordination failure between an exporter and a local distributor, by allowing an exporter to maximize a joint profit of two firms. Once an exporter in domestic country and a distributor in foreign country are vertically integrated, transfer price, w, is irrelevant for a newly merged firm[7]. A new firm directly sets foreign price at final market. This can be easily seen from disappearance of transfer price from last equality in the following equation (8).

$$\pi_{VI} = \frac{1}{e}\{(p - ew - c_2)q(p)\} + (w - c_1)q(p) = \frac{1}{e}(p - ec_1 - c_2)q(p) \tag{8}$$

After rearranging first order condition for the price, we can obtain the exchange rate pass-through at final market,

$$\frac{d\ln p}{d\ln e} = \frac{ec_1}{d + ec_1 + c_2} \tag{9}$$

Since exchange rate pass-through in the last subsection are derived only for transfer price level, we derive exchange rate pass-through at final market level for successive monopolies case, $\alpha=1$,

$$\frac{d\ln p}{d\ln e} = \frac{ec_1}{3d + ec_1 + c_2} \tag{10}$$

It can be clearly seen that exchange rate pass-through at final market level is much larger for vertically integrated firm since d, intercept term for demand function, must exceed the value of total marginal cost, ec_1+c_2. Compared with the value of exchange rate pass-through at transfer price level in equation (4), it can be also seen that exchange rate pass-through becomes smaller at final market level. If we assume similar ratio of final market price level and transfer price level exchange rate pass-through for vertically integrated firm, we should also observe a larger pass-through at transfer price level for a vertically integrated firm[8]. We call this "elimination" effect.

Excluding a special case of two effects canceling out completely, our empirical null hypothesis is that foreign direct investment for establishing own distribution should appear as a significant explanatory variable in an exchange rate pass-through regression. As discussed fully in section 3, we also attempt to capture these two effects separately.

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[7] If, for example, there are differentials in corporate tax rates between two countries, there exists a strong incentive for a newly merged firm to adjust transfer price. However, we suppress this tax evasion incentive due to such conduct is strictly supervised and prohibited internationally.

[8] Technically, if foreign cost is negligibly small compared to domestic cost and ignoring a possibility of pass-through greater than unity must come to this result.

2.2. A local plant model

In addition to the effect of FDI for distributor, we also examine the effect of foreign direct investment for local production in this subsection. Gron and Svenson (1996) examine empirically the effect of local production plants on exchange rate pass-through in automobile industry. Although Gron and Svenson do not provide any theoretical model, their empirical evidence indicates that the ability to produce in multiple locations gives firms more flexibility to adjust to changes in exchange rates, resulting in a smaller pass-through[9].

Focusing on local production effect, there is a very important concept we need to distinguish when analyzing exchange rate pass-through. When a domestic manufacturing firm exports final products as automobile firms considered in Gron and Svenson (1996), owing production plants in both domestic country and a foreign country enable an exporter to adjust with flexibility to exchange rate fluctuations by modifying their production weight for two production sites. In this case these plants across national borders function as substitutes to each other. This effect can be called as “substitute” effect and examined with a simple model in section 2.2.1.

If a domestic manufacturing firm exports intermediate products or product parts to foreign final-product manufacturing firm, these two plants function as compliments to each other. It is compliment in a sense that increase in production at one plant leads to increase in production of the other[10]. If a newly acquired foreign plant acts as complimentary plant, our previous local distributor model can be reinterpreted as complimentary model. This is considered in section 2.2.2.

2.2.1. Substitution effect

In this subsection we analyze the effect of foreign direct investment for local production plant as a substitute to existing domestic plants. Upon constructing a model, the purpose of establishing a local plant overseas needs to be carefully reexamined. If a firm only needs to switch to foreign production due to relatively cheap labor cost, a domestic plant can be shut down at the start of foreign production to maintain the level of firm’s global production. This FDI process should be investigated by comparing two domestic plant case and one domestic plant and one foreign plant case. If a firm also intends to increase its global production level, appropriate analysis should involve the comparison of single domestic plant case and one domestic plant and one foreign plant case. In the followings, the exchange rate pass-through are examined respectively for ‘single domestic plant,’ ‘two domestic plants,’ and ‘one domestic

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[9] However, we note that the estimated coefficients of multiple location are sometimes insignificant in their estimation result.

[10] These uses of terminology are familiar in multinational corporation literature, see Blonigen (2001).

plant and one foreign plant' case.

[Single domestic plant]

First, we examine the exchange rate pass-through for single domestic plant case as a baseline for the later analysis of FDI effect on the exchange rate pass-through. Our specification for a local plant model follows very close to our local distributor model except for a slight modification on cost function. Since we focus on multi-plant model, maintaining constant marginal cost assumption from a local plant model causes a severe problem. For a multi-plant case the relative share of production for each plant becomes indeterminate if each plant has same constant marginal cost. If the level of marginal cost differs for each plants, production takes a place only on a plant with the lowest marginal cost. For international multi-plant case, this means that entire amount of production switches back and forth across national border if exchange rate fluctuates. So we assume increasing marginal cost for production in the following analysis.

Profit for a single plant firm with increasing marginal cost function is,

$$\pi_D = \frac{1}{e}\{p(q)q - ec(q)\} = \frac{1}{e}\{(d-q)q - \frac{1}{2}ec_1 q^2\}\,. \tag{11}$$

Rearranging first order condition for maximizing profit for single plant gives pricing equaiton as

$$p = \frac{d + dec_1}{(2+ec_1)}\,. \tag{12}$$

Solving for exchange rate pass-through as equation (13), we find that incomplete pass-through holds for our model specification.

$$\frac{d\ln p}{d\ln e} = \frac{ec_1}{2 + 3ec_1 + (ec_1)^2} < 1 \tag{13}$$

[Two domestic plants]

Before we directly compare the result for single domestic plant case with one domestic plant and one local plant case, we examine the effect of extending the number of production plants on exchange rate pass-through.

$$\pi_{DD} = \frac{1}{e}\{(d-q_1-q_2)q_1 - \frac{1}{2}ec_1q_1^2\} + \frac{1}{e}\{(d-q_1-q_2)q_2 - \frac{1}{2}ec_1q_2^2\} \tag{14}$$

$$p = \frac{2d + edc_1}{4 + ec_1} \tag{15}$$

$$\frac{d \ln p}{d \ln e} = \frac{ec_1}{4 + 3ec_1 + (1/2)(ec_1)^2} < 1 \tag{16}$$

Comparing equation (13) and (16) reveals that increase in the number of plants decreases the level of exchange rate pass-through if the curvature of cost function, denominated in foreign currency term, is not large, $ec_1<2$. Although we have analyzed only for plant expansion case from single plant to two plants, this condition on the curvature of cost function can be generalized for arbitrary number of plants (see the appendix.)

[One domestic plant and one foreign plant]

Now we investigate the effect of establishing local plant which is substitute to domestic plants.

$$\pi_{DF} = \frac{1}{e}\{(d - q_1 - q_2)q_1 - \frac{1}{2}ec_1 q_1^2\} + \frac{1}{e}\{(d - q_1 - q_2)q_2 - \frac{1}{2}c_f q_2^2\} \tag{17}$$

$$p = \frac{dec_1 + dc_f + dec_1 c_f}{2ec_1 + 2c_f + ec_1 c_f} \tag{18}$$

$$\frac{d \ln p}{d \ln e} = \frac{ec_1 c_{f2}^2}{(2ec_1 + 2c_f + ec_1 c_f)(ec_1 + c_f + (ec_1)^2)} < 1 \tag{19}$$

From equation (19) it is obvious that relative cost of domestic plant and foreign plant affects the degree of exchange rate pass-through. However, we set these two costs equal in order to isolate a pure effect of foreign direct investment for a subsidiary production.

$$\left.\frac{d \ln p}{d \ln e}\right|_{c_f = ec_1} = \frac{(ec_1)^2}{8 + 6ec_1 + (ec_1)^2} < 1 \tag{20}$$

From comparison of equation (16) with (20), it is surprising to find that replacing a domestic plant with a foreign plant decreases the level of exchange rate pass-through if the same condition for the curvature of cost function holds, i.e., $ec_1<2$. Although coincidence of these conditions is surely due to our specifications for assumptions, we believe that we can claim in general that foreign direct investment for local plants decreases exchange rate pass-through if the conditions hold for decreasing exchange rate pass-through with expansion of the number of domestic plants.

2.2.2. Complementary effect

If an exporter manufactures intermediate products for foreign final product manufacturers, acquiring one of these firms is a vertically integration similar to a model considered in section 2.1. In this case, domestic cost and foreign cost are additive in an entire production process. We rewrite equation (1) from section 2.1.

$$\begin{aligned} \pi_U &= (w - c_1)q(p) \\ \pi_D &= (p - ew - c_2)q(p) \end{aligned} \tag{21}$$

From the analysis of previous section, we understand that there exist two offsetting effects for this model. However, excluding a special case of two effects canceling out completely, our empirical null hypothesis is that foreign direct investment for establishing own final production plant should appear as a significant explanatory variable in an exchange rate pass-through regression.

3. The Data and The Model for Estimation

3.1. Empirical model

We will follow the panel estimation approach in line with Knetter (1989) and Takagi and Yoshida (2001). In addition we add FDI variables in order to test the hypothesis that FDI affects the degree of exchange rate pass-through. Our general estimation model for pass-through equation is expressed in equation (22).

$$p_{it} = \beta e_{it} + \gamma e_{it} FDI_{it} + \alpha_i + \lambda_t + \varepsilon_{it} \tag{22}$$

The log of price denominated in the currency of destination market, p_{it}, is regressed on the foreign currency price of the Japanese yen, e_{it}, FDI variable, FDI_{it}, time dummy, λ_t, a fixed effect error component, α_i, and a disturbance term, ε_{it}. The FDI variable is multiplied by exchange rate in order to capture the effect of subsidiaries on exchange rate pass-through, rather than on the price level. Inclusion of FDI variable in the pass-through equation is utilized in Gron and Swenson (1996) although destination market is only restricted to a single country, namely the US. Therefore, testing the effect of local production on pass-through with a panel of destination countries is also our contribution to the literature.

The fixed effect error component is necessary for eliminating absolute price level dispersion among destination countries, due to the differences in quality level of products. Without an explicit cost data, estimated exchange rate pass-through might be biased since an observed price movement is also affected by the change in industry cost. Time dummy variable is introduced to capture these underlying cost fluctuations.

3.2. Data source

The Japan Exports and Imports, Japan Tariff Association, contains values and quantities for nine-digit CCFTS-classified commodities by country[11]. The Commodity Classification for Foreign Trade Statistics, CCFTS, is based upon the Harmonized Commodity Description and Coding System, HS. The values of commodity export are the FOB values. We calculated a unit price for each commodity from dividing corresponding value by quantity. The Overseas Japanese Companies Data, Toyo Keizai, contains relevant information for approximately 19000 Japanese foreign subsidiaries. From 68 industry classifications, electronics manufacturer (1900) and electronics wholesaler (3700) were actually used, totaling 3204 subsidiary firm data. The average annual exchange rates for destination countries are obtained from the International Financial Statistics, International Monetary Fund.

3.3. Selection process for products and countries

For a preliminary empirical examination, we selected three commodities satisfying the two criteria, among the largest share in exports and sufficient FDI observation for corresponding commodity. In addition, we narrow down the commodity classification to only electronics products due to its overwhelming share in the Japanese exports. Some of the candidates are dispelled due to the shot length of time for the availability. With these selection procedures, chosen are video recording or reproducing apparatus of magnetic tape-type (852110000), parts of electronic integrated circuits or microassemblies (854290000), and electrostatic photocopier (900912000)[12]. The volumes and unit prices of these products for total exports are shown in Figure 3-5.

For each product, sample countries are selected only if its share in 1998-export value for that product exceeds one percent share[13]. This selection process avoids unfavorably excessive volatility of export price due to a change in the composition within the product category and missing data due to the lack of transaction for more than a year.

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[11] See Takagi and Yoshida (2001) for a more description of this data source.

[12] The values of exports in 1998 for video, IC, and copier are 197 billion, 273 billion, and 390 billion yen, respectively. We note that the 1998-export value of the largest export of Japan, motor cars with engine exceeding 2000cc but not exceeding 3000cc, is 2017 billion yen.

[13] Sample countries for video are Australia, Canada, China, Germany, Hong Kong, Netherlands, Saudi Arabia, Singapore, UAE, UK, US; for copier, Australia, Belgium, Canada, France, Germany, Hong Kong, Italy, Netherlands, Singapore, UK, US; for IC, Canada, Germany, Korea, Malaysia, Philippine, Singapore, Thailand, US.

3.4. Construction of FDI variables

As a first proxy for the relevant FDI data, we used the total number of foreign subsidiaries in electronics industry by country. This FDI data, denoted as *FDIIND*, is a common variable for all products. Since foreign subsidiaries for specific products are not distinguished, counting all subsidiaries in electronics industry as relevant FDI may also pick up interactive effects among subsidiaries, considered as distribution or/and production network effects. For a given product, however, it is likely to blur the significant effect of establishing a relevant subsidiary from an irrelevant subsidiary.

Next, we created product level FDI dummy variables for each product, taking a value of one if there exists a related foreign subsidiary for specific product in a destination country during the sample period and a distinction between distribution and production subsidiaries is also made. *FDIDEAL*1 and *FDIPLANT1* denote for subsidiary for distribution and production, respectively. These dummy variables might overstate the presence of subsidiary for a country if the first subsidiary is established at the end of sample period. Therefore, we modified these dummy variables to take a value of zero for years in which the first subsidiary is not present yet. These modified variables are denoted as *FDIDEAL2* and *FDIPLANT2*. Since these dummy variables do not assess the number of multiple subsidiaries, estimated coefficient may understate the effect of foreign subsidiary for a country with multiple subsidiaries. Finally, *FDIDEAL3* and *FDIPLANT3* are created for the number of subsidiary in a destination country. The summary statistics for FDI data are given in Table 1.

The simultaneous appearance of *FDIDEAL2* and *FDIDEAL3* in the regression is a scope of interest to test our theoretical hypothesis. The presence of subsidiary can make a great difference if the bargaining power is tilted a priori toward independent local distributors because it will shift the bargaining power to an exporting firm. Therefore, the “power-shift” effect from establishing the first subsidiary distributor can be captured by *FDIDEAL2* while the “elimination” effect, which can be attributed to *FDIDEAL3,* can be gradually achieved as the number of subsidiary distributors increases, replacing independent local firms. We recall that the “power-shift” effect decreases pass-through and “elimination” effect increases pass-through. Expected signs for *FDIDEAL2* and *FDIDEAL3* are negative and positive, respectively, when they appear simultaneously in the regression.

4. Estimation results

Table 2 to 4 present estimation results for video, copier, and IC, respectively. The first column (i) of each table show that the industry wide FDI is not significant and the estimated coefficient is actually zero at least up to two decimal digits for all three products. As shown in column (ii) the breakdown of subsidiary into distribution and production purpose for each product does not provide any evidence that FDI affects exchange rate pass-through at five percent significant level.

However, as FDI data are modified to correctly capture the timing of entry to foreign market with establishment of subsidiary, the effect of FDI on pass-through appears to be significant in many specifications for all products. These estimation results are shown in columns (iii) to (vi). Only *FDIDEAL2* and *FDIPLANT2* are included in column (iii) whereas only *FDIDEAL3* and *FDIPLANT3* appear as regressors in column (iv). For specifications (v) to (vi), we proceeded in the following steps. In column (v) we incorporate all *FDIDEAL2*, *FDIDEAL3*, *FDIPLANT2*, and *FDIPLANT3* in the regression. Then insignificant FDI variables are omitted in column (vi).

Column (vi) for video in Table 2 provides that a Japanese exporter will pass 85 percent of exchange rate shock to a price if products are sold through independent local distributors. However the pass-through is reduced to 65 percent if there is at least one subsidiary for distribution in local market. Moreover, for each additional local plant the pass-through is reduced 5 percent. For the purpose of giving a clear interpretation of the result, for example, the exchange rate pass-through is 85 percent for Australia due to no Japanese subsidiary for video and the pass-through is 40 percent for China after 1996.

For copier column (vi) in Table 3 shows the most striking result of this paper. Both FDI variables for subsidiary distribution firm remain significant and the signs are consistent with the null hypothesis discussed in the previous section. As the first subsidiary is established in a foreign market as captured in *FDIDEAL2*, the bargaining power is shifted to an exporting firm and it results in decreasing the pass-through. But at the same time acquisition of this first subsidiary instantly eliminates the negative externality previously existing between the exporter and local distributor. The exporter consequently increases pass-through from elimination. Surprisingly, for the copier product case the magnitude of these effects turn out to be exactly the same, therefore a simple regression only containing one distribution FDI variable as in specification (iii) or (iv) can not capture the significant effect of FDI on exchange rate pass-through. In addition, the estimated coefficient for production FDI is also significant at one percent level while the exchange rate pass-through coefficient is imprecise for copier.

For the IC pass-through regression in Table 4, column (vi) shows two FDI variables are significant at 5 percent level. Whereas the exporters for parts of integrated circuits and microassemblies pass 67 percent of exchange rate shock to their prices to a foreign market without their foreign subsidiary plants, the exporters pass extra 14 percent to IC prices if local production subsidiaries are present in a local market. For a distribution subsidiary, the "power-shift" effect is extremely large whereas the "elimination" effect is insignificant.

This increase in pass-through associated with local production seems to contradict with the hypothesis of Gron and Swenson (1996) or substitution in section 2.2.1 of this paper, however it can be explained in the framework of Yoshida (1999) or complimentary effect in section 2.2.2. A local distributor in a model can be reinterpreted as a local downstream manufacturer, with a constant marginal cost, which uses products of an exporter as an intermediate input. In this case vertical integration results in a higher exchange rate pass-through. The important key is that a local production is compliment in the entire production process in Yoshida (1999) whereas it is a substitute in Gron and Swenson (1996). Since IC parts are obviously intermediate inputs, the establishment of local downstream subsidiary can theoretically result in a higher exchange rate pass-through and in fact it is higher as in column (vi). Alternative explanation might be that *FDIPLANT2* is only distinguishing two non-Asian countries, namely Canada and Germany, from others since the Japanese IC manufacturing firms have foreign plants in only Asian area and US, although the first Philippine plant is established only after 1995.

As first emphasized in Knetter (1989), the degree of pass-through can differ substantially among industries and products. Our results also confirm the previous empirical results in this manner if we compare as a baseline the degree of pass-through for the country without Japanese subsidiaries. Whereas pass-through for video and IC parts are relatively high, 85 percent and 67 percent respectively, pass-through for copier is only 35 percent and it is not significantly larger than zero at 10 percent level.

5. Concluding Remarks

Observing estimation results from our limited number of products in electronics industry we tentatively conclude that establishing own distribution network in local market shifts the bargaining power to an exporter and consequently exchange rate pass-through is decreased. More strikingly, the degree of exchange rate pass-through is increased simultaneously for copier product due to elimination of negative externality between two successive monopolistic firms. This gives the strong supporting evidence for the theoretical results obtained in Yoshida (1999).

Conforming to the results of Gron and Swenson (1996), we also consistently found the significant downward effect of local production on exchange rate pass-through. Moreover, significant positive effect of foreign plant for IC suggests that distinction between complimentary production and substitute production in foreign plants with respect to products of parent firms must be clearly defined in an empirical analysis.

In any case, inclusion of FDI variable properly constructed to capture the timing of establishment is essential to the estimation of exchange rate pass-through. In addition, we are able to capture the dynamic behavior of exchange rate pass-through due to a change in establishment of own network for both production and distribution. Example of changes in the degree of pass-through is depicted for video products in Figure 6. Whereas existing local subsidiary prior to the beginning of sample period contribute to the difference in the degree of pass-through among sample countries, FDI during sample period shifts the responsiveness of export prices with respect to exchange rate changes.

Regarding the overall effect of foreign direct investment on pass-through, it seems that negative effects reflecting either power-shift effect in distribution subsidiary or local plant effect are more dominant. However, a further investigation is necessary to correctly assess the direction of effects from the ongoing world trend for globalization and regionalization on balance of payment adjustments.

Appendix:

[General analysis of exchange rate pass-through for n-plants]

Profit for n-domestic-plants firm is,

$$\pi = PQ - eC(q_1 \cdots q_n) \quad \text{where} \quad \mathrm{Q} \equiv \sum_{\mathrm{i=1}}^{\mathrm{n}} q_i \,. \tag{A1}$$

Summing up all first order conditions and rearrangement gives a pricing equation,

$$Pn\left(\frac{\varepsilon - 1}{\varepsilon}\right) = e\sum_{i=1}^{n} C_{qi} \,. \tag{A2}$$

Here, ε is price elasticity of demand defined as $\varepsilon \equiv -\dfrac{d\ln Q}{d\ln p}$.

We obtain a general pass-through equation by totally differentiating equation (A2).

$$\frac{d\ln P}{d\ln e} = 1 - \frac{d\ln\left(\dfrac{\varepsilon - 1}{\varepsilon}\right)}{d\ln e} + \frac{d\ln\left(\sum C_{qi}\right)}{d\ln e} \tag{A3}$$

In equation (A3) exchange rate pass-through is broken down to two components, demand elasticity term and marginal cost term. In the following we first establish that these two components are contributing to incomplete pass-through separately, with our specification for a model.

[The value of exchange rate pass-through with our model specification]

With specifications assumed in section 2 for demand function, $P = d - Q$ and cost function, $C = \sum \frac{1}{2} q_i^2$, we can obtain total production level at equilibrium by algebraically solving the n sets of first order conditions.

$$Q = \frac{nd}{2n + ec} \quad \text{where} \quad \mathrm{q_i} = \frac{\mathrm{Q}}{\mathrm{n}} \quad \text{for any i.} \tag{A4}$$

$$P = \frac{nd + dec}{2n + ec} \tag{A5}$$

$$\varepsilon = \frac{n + ec}{n} \tag{A6}$$

Equation (A5) and (A6) are obtained by substituting equilibrium production value (A4) for demand function and demand elasticity.

With price elasticity of demand evaluated at equilibrium in (A6), demand elasticity term in (A3) can be derived.

$$-\frac{d\ln\left(\frac{\varepsilon-1}{\varepsilon}\right)}{d\ln e}=-\frac{n}{n+ec} \tag{A7}$$

Marginal cost function term in (A3) can be also derived as

$$\frac{d\ln\left(\sum C_{qi}\right)}{d\ln e}=-\frac{ec}{2n+ec}\,. \tag{A8}$$

We confirm that each component separately reduce the exchange rate pass-through from unity. The exchange rate pass-through can be obtained by substituting (A7) and (A8) into (A3).

$$\frac{d\ln P}{d\ln e}=\frac{ec}{2n+3ec+\frac{1}{n}(ec)^2} \tag{A9}$$

It is well known that constant elasticity demand, which can be derived from CES utility form, leads (A7) to be zero and constant marginal cost leads (A8) to be zero. Both specifications combined would result in complete pass-through as in Obstfeld and Rogoff (1995) and Betts and Devereux (2000)[14].

[The effect of increase in the number of domestic plants on the exchange rate pass-through]

We can analyze the effect of increase in the number of domestic plants on the exchange rate pass-through by partially differentiating (A3).

$$\frac{\partial\left[\frac{d\ln p}{d\ln e}\right]}{\partial n}=-\frac{\partial\left[\frac{d\ln\left(\frac{\varepsilon-1}{\varepsilon}\right)}{d\ln e}\right]}{\partial n}+\frac{\partial\left[\frac{d\ln\left(\sum C_{qi}\right)}{d\ln e}\right]}{\partial n} \tag{A10}$$

[14] Although they are aware of the fact pricing-to-market, at least in short term, does not occur because price elasticity of demand in each country are identical, their assumptions also put a strict restriction that exchange rate pass-through must be complete.

The effect of exchange rate pass-through from demand elasticity term in (A11) is negative.

$$-\frac{\partial\left[\dfrac{d\ln\left(\dfrac{\varepsilon-1}{\varepsilon}\right)}{d\ln e}\right]}{\partial n}=-\frac{ec}{(n+ec)^{2}} \tag{A11}$$

The effect on exchange rate pass-through from marginal cost term in (A12) is positive.

$$\frac{\partial\left[\dfrac{d\ln\left(\sum C_{qi}\right)}{d\ln e}\right]}{\partial n}=\frac{2ec}{(2n+ec)^{2}} \tag{A12}$$

The overall effect on exchange rate pass-through must be determined by relative size of (A11) and (A12).

$$\frac{\partial\left[\dfrac{d\ln p}{d\ln e}\right]}{\partial n}=-\frac{ec(2-\dfrac{(ec)^{2}}{n^{2}})}{-(2n+3ec+{}^{1}\!/_{n}(ec)^{2})^{2}} \tag{A13}$$

From equation (A13), the effect of increase in the number of domestic plants on exchange rate pass-through is decreasing if $ec < n\sqrt{2}$. This condition can be interpreted as the bounded-above condition for a curvature of cost function. The difference between the condition in the appendix and section 2 comes from an infinitesimal change effect in the appendix and discrete jump effect in section2. It is noteworthy that bounded-above condition becomes less stringent as the number of domestic plants becomes large. Therefore, once this condition holds for expansion from single plant to two plants, it continues to hold for any extent of new plants establishments. Here, we establish that claim in section 2.2.1 do not depend on a specific number of plants we used in analysis, namely one and two.

References:

Bergin, Paul R. and Robert C. Feenstra, 2000, Staggered price setting, translog preferences, and endogenous persistence, *Journal of Monetary Economics* 45, 657-680.

Bergin, Paul R. and Robert C. Feenstra, 2001, Pricing-to-market, staggered contracts, and real exchange rate persistence, *Journal of International Economics* 54, 333-359.

Berhofen, Daniel and Peng Xu, 2000, Exchange rates and market power: evidence from the petrochemical industry, *Journal of International Economics*, 52, 283-297.

Blonigen, Bruce A., 2001, In search of substitution between foreign production and exports, *Journal of International Economics*, 53, 81-104.

Chari, V.V., Patrick J. Kehoe, and Ellen R. McGrattan, 1998, Can sticky price models generate volatile and persistant real exchange rates? *Federal Reserve Bank of Minneapolis Reserch Department Staff Report*, 223.

Cheung, Yin-Wong and Kon S. Lai, 2000, On the purchasing power parity puzzle, *Journal of International Economics* 52, 321-330

Corsetti, Giancarlo and Paolo Pesenti, 1997, Welfare and macroeconomic interdependence, *NBER Working Paper,* 6307.

Dornbusch, Rudiger, 1987, Exchange rates and prices, American Economic Review, 77, 93-106.

Engel, Charles, 1999, Accounting for U.S. real exchange rate changes, *Journal of Political Economy* 107, 507-538.

Goldberg, Pinelopi K. and Michael M. Knetter, 1997, Goods prices and exchange rates: What have we learned?, Journal of Economic Literature, 35, 1243-1272.

Gron, Anne and Deborah L. Swenson, 1996, Incomplete exchange-rate pass-through and imperfect competition; The fffects of local production, *American Economic Review*, 86 No.2, 71-76.

Kadiyali, Vrinda, 1997, Exchange rate pass-through for strategic pricing and advertising: An empirical analysis of the U.S. photographic film industry, *Journal of International Economics,* 43, 437-461.

Knetter, M. M., 1989, Price discrimination by U.S. and German exporters, *American Economic Review*, 79, 198-210.

Krugman, Paul, 1987, Pricing to market when the exchange rate changes, in S. W. Arndt and J. D. Richardson, eds. *Real-Financial Linkage among Open Economies*, Cambridge, MIT Press.

Lane, Philip R., 2001, The new open economy macroeconomics: A survey, *Journal of International Economy* 54, 235-266.

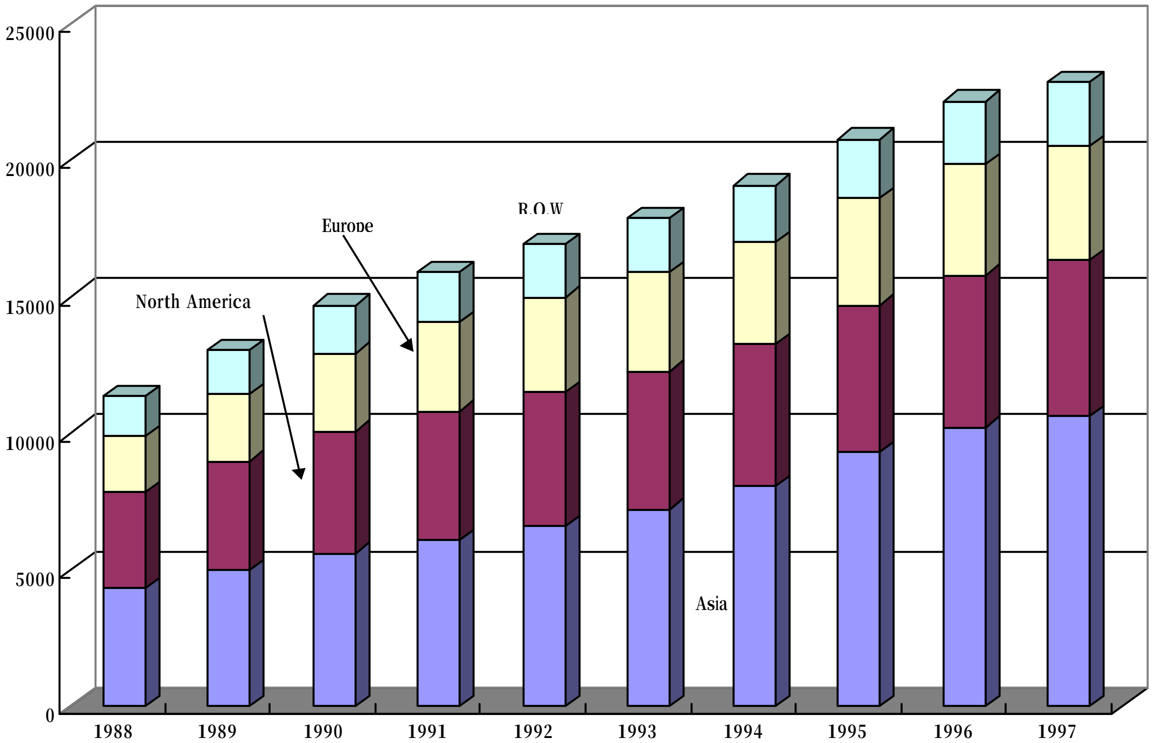
Obstfeld, Maurice and Kenneth Rogoff, 1995, Exchange rate dynamics redux, *Journal of Political Economy* 103, 624-660.

Obstfeld, Maurice and Kenneth Rogoff, 2000, New directions for stochastic open economy models, Journal of International Economics 50, 117-153.

Takagi, Shinji and Yushi Yoshida, 2001, Exchange rate movements and tradable goods prices in East Asia: An analysis based on Japanese customs data, 1988-98, *forthcoming in IMF Staff Papers*.

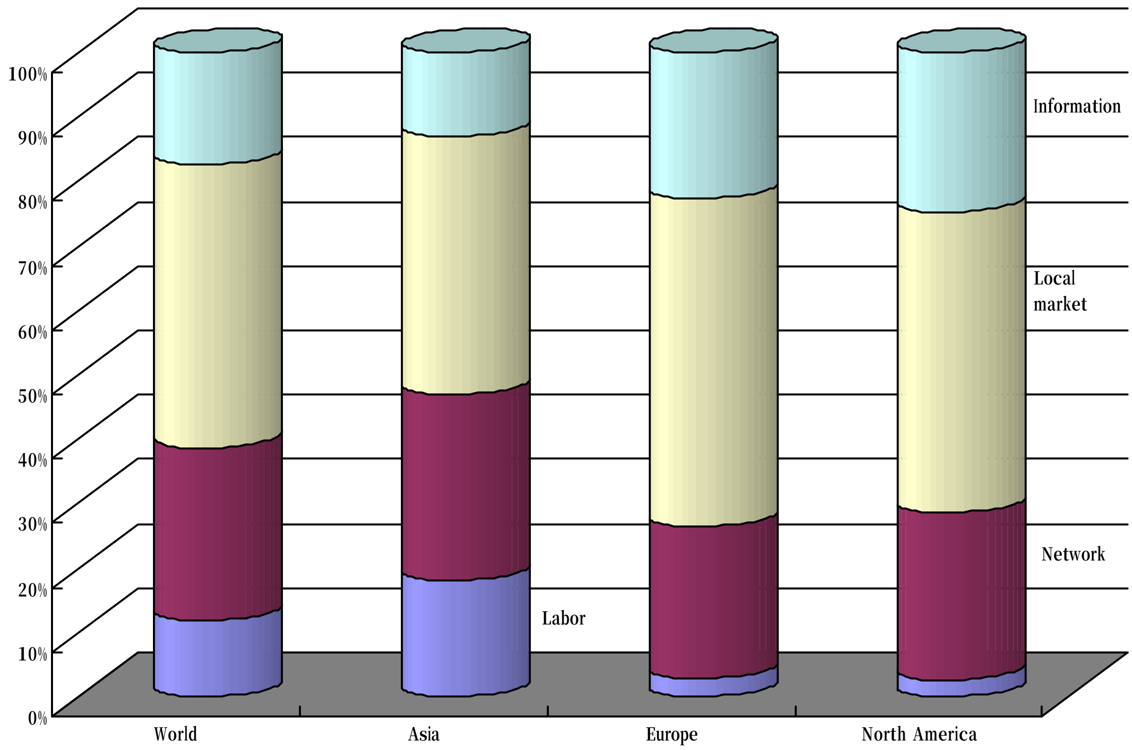
Yoshida, Yushi, 1999, The Effect of vertical structure on exchange rate pass-through, *Kyushu Sangyo University Discussion Paper Series* No.5.

Figure1: Number of Local Subsidiaries



Source: Overseas Japanse Companies Data

Figure2: Investment Purpose by Geography



Source: Overseas Japanse Companies Data

Figure 3: Volumes and Unit Prices of Total Exports for Video (852110000)

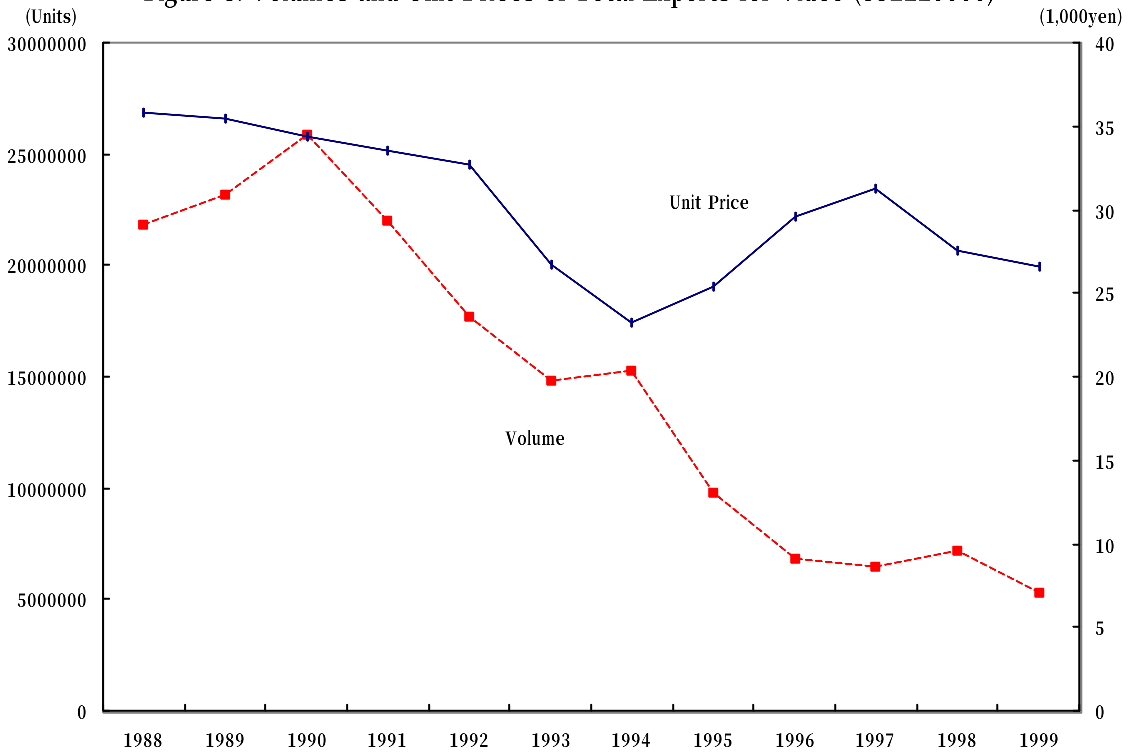


Figure 4: Volumes and Unit Prices of Total Exports for Copier (900912000)

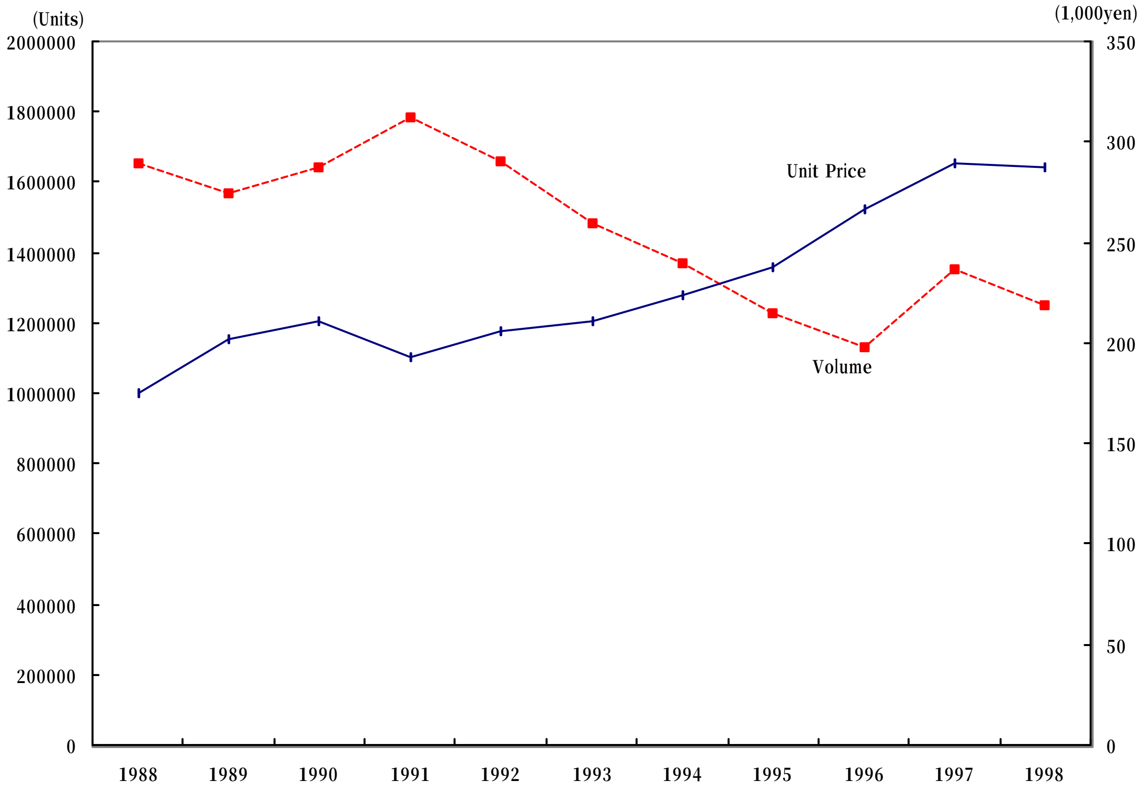


Figure 5: Volumes and Unit Prices of Total Exports for Parts of IC (854290000)

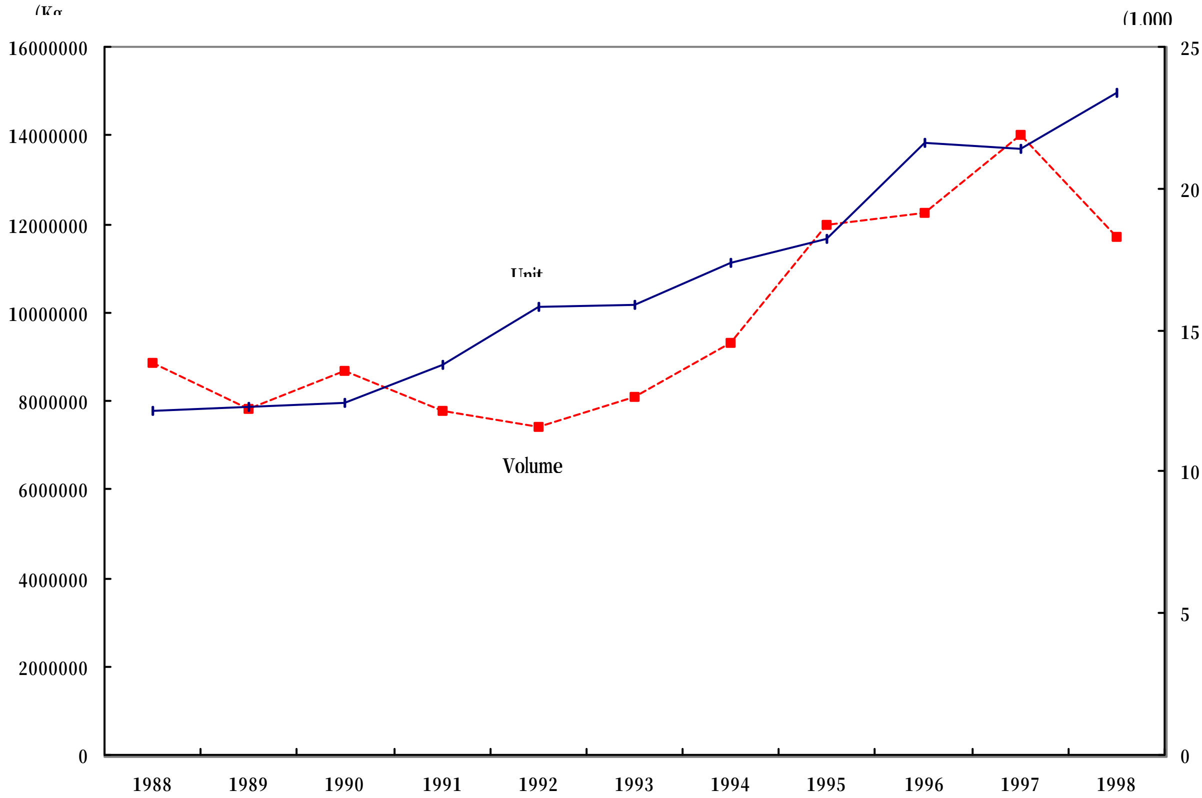


Figure 6: Estimated Pass-through for Video (852110000)

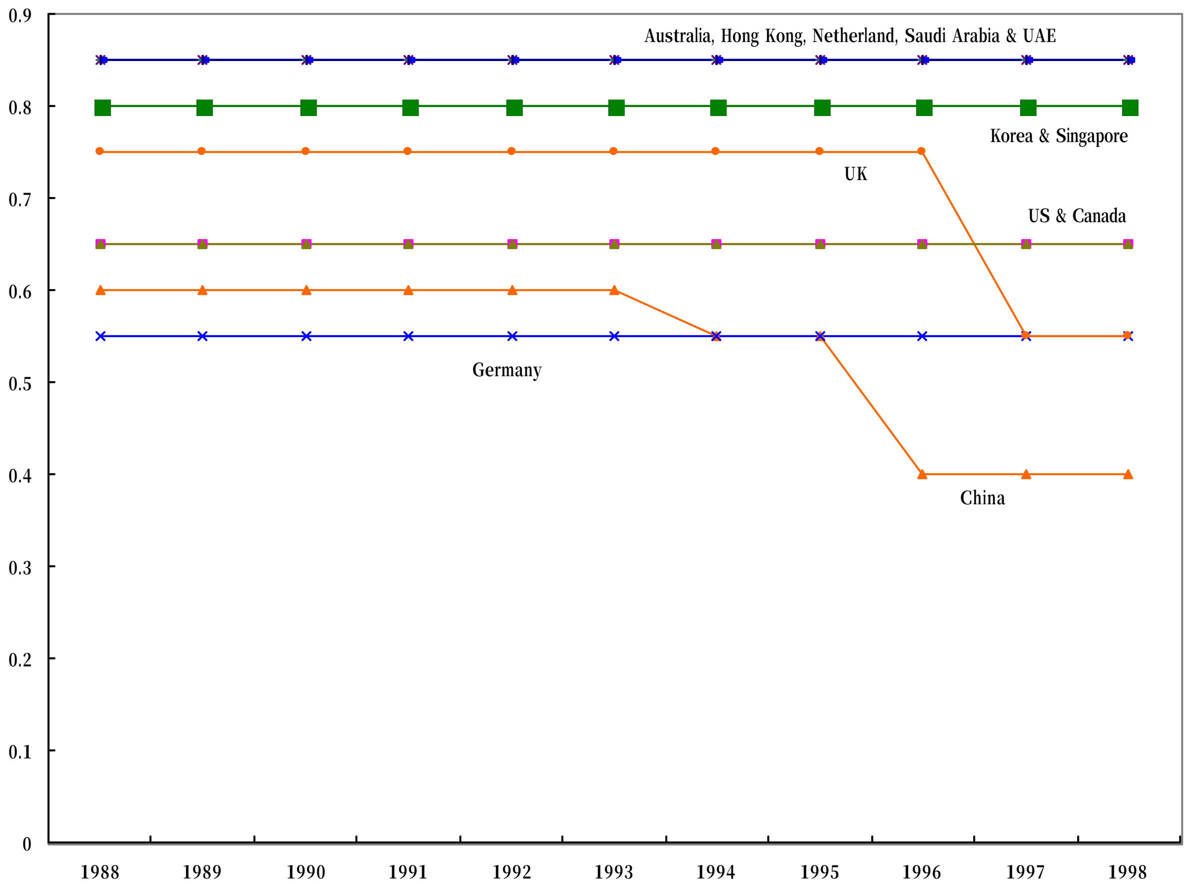


Table 1: Summary Statistics

		mean	std. dev.	min	max
FDIINDS		85.83	87.63	1	372
Video					
	FDIDEAL1	0.42	0.49	0	1
	FDIDEAL2	0.35	0.47	0	1
	FDIDEAL3	0.86	1.48	0	6
	FDIPLANT1	0.41	0.49	0	1
	FDIPLANT2	0.41	0.49	0	1
	FDIPLANT3	0.69	1.02	0	5
Copier					
	FDIDEAL1	0.36	0.48	0	1
	FDIDEAL2	0.31	0.46	0	1
	FDIDEAL3	0.42	0.69	0	2
	FDIPLANT1	0.36	0.48	0	1
	FDIPLANT2	0.36	0.48	0	1
	FDIPLANT3	0.53	0.88	0	3
IC					
	FDIDEAL1	0.56	0.50	0	1
	FDIDEAL2	0.48	0.50	0	1
	FDIDEAL3	0.92	1.28	0	5
	FDIPLANT1	0.78	0.42	0	1
	FDIPLANT2	0.63	0.49	0	1
	FDIPLANT3	1.12	1.30	0	4

Note: Sample countries for video are Australia, Canada, China, Germany, Hong Kong, Netherlands, Saudi Arabia, Singapore, UAE, UK, US; for copier, Australia, Belgium, Canada, France, Germany, Hong Kong, Italy, Netherlands, Singapore, UK, US; for IC, Canada, Germany, Korea, Malaysia, Philippine, Singapore, Thailand, US.

Table2: Estimated Pass-Through of Video Price

Independent variable:	Specification (i)	(ii)	(iii)	(iv)	(v)	(vi)
ER	0.72***	0.80*	1.01***	0.67***	0.79*	0.85***
	(2.96)	(1.71)	(2.50)	(2.54)	(1.93)	(3.46)
FDIINDS*ER	0.00*					
	(-1.92)					
FDIDEAL1*ER		-0.02				
		(-0.06)				
FDIDEAL2*ER			-0.20***		-0.21***	-0.20***
			(-4.51)		(-4.32)	(-4.74)
FDIDEAL3*ER				-0.04*	0.01	
				(-1.76)	(0.31)	
FDIPLANT1*ER		0.05				
		(0.12)				
FDIPLANT2*ER			0.07		0.06	
			(0.22)		(0.18)	
FDIPLANT3*ER				-0.04	-0.05**	-0.05**
				(-1.50)	(-2.24)	(-2.25)
Adj-R2	0.98	0.97	0.98	0.98	0.98	0.98

Note: Figures in parenthesis are t-values; ***, **, and * indicate that the coefficient is significant at the 1, 5, and 10 percent, respectively

Table3: Estimated Pass-Through of Copier Price

Independent variable:	Specification (i)	(ii)	(iii)	(iv)	(v)	(vi)
ER	0.18	0.31	0.34	0.39	0.37	0.35
	(0.60)	(1.06)	(1.20)	(1.43)	(1.39)	(1.32)
FDIINDS*ER	0.00					
	(1.43)					
FDIDEAL1*ER		0.16				
		(0.44)				
FDIDEAL2*ER			0.00		-0.13***	-0.10*
			(-0.18)		(-2.32)	(-1.92)
FDIDEAL3*ER				0.02	0.13***	0.10**
				(0.90)	(2.49)	(2.11)
FDIPLANT1*ER		-0.18				
		(-0.44)				
FDIPLANT2*ER			-0.07		0.54	
			(-0.21)		(1.50)	
FDIPLANT3*ER				-0.22***	-0.34***	-0.29***
				(-3.10)	(-3.98)	(-3.67)
Adj-R2	0.99	0.99	0.99	0.99	0.99	0.99

Note: Figures in parenthesis are t-values; ***, **, and * indicate that the coefficient is significant at the 1, 5, and 10 percent, respectively.

Table4: Estimated Pass-Through of IC Parts Price

Independent variable:	Specification (i)	(ii)	(iii)	(iv)	(v)	(vi)
ER	0.69**	0.64	0.67**	1.21***	0.80***	0.67**
	(2.10)	(1.54)	(2.62)	(4.14)	(2.82)	(2.62)
FDIINDS*ER	0.00					
	(1.33)					
FDIDEAL1*ER		0.62*				
		(1.84)				
FDIDEAL2*ER			-0.55***		-0.56***	-0.55***
			(-4.28)		(-4.36)	(-4.28)
FDIDEAL3*ER				-0.03	-0.02	
				(-1.46)	(-1.00)	
FDIPLANT1*ER		0.10				
		(0.25)				
FDIPLANT2*ER			0.14**		0.18**	0.14**
			(2.06)		(2.50)	(2.06)
FDIPLANT3*ER				-0.02	-0.04	
				(-0.92)	(-1.54)	
Adj-R2	0.98	0.98	0.99	0.98	0.99	0.99

Note: Figures in parenthesis are t-values; ***, **, and * indicate that the coefficient is significant at the 1, 5, and 10 percent, respectively.