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Shin-ichi Fukuda
The University of Tokyo
Masanori Ono
Fukushima University

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The Choice of Invoice Currency under Uncertainty: Theory and Evidence from Korea[*]

Shin-ichi Fukuda (University of Tokyo)[**]

Masanori Ono (Fukushima University)

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Abstract

The purpose of this paper is to investigate the choice of invoice currency under exchange rate uncertainty. The analysis is motivated by the fact that the U.S. dollar has been the dominant vehicle currency in developing countries. The theoretical analysis is based on an open economy model of monopolistic competition. The export prices are set before exchange rates are known. When the market is competitive enough, the exporting firms tend to set their prices not to deviate from those of the competitors. As a result, when the other exporters set their prices in the third currency, the exporting firm tends to choose the third currency as an equilibrium invoice currency. The tendency becomes conspicuous in the market where the shares of local firms are small. The latter part of the paper empirically investigates the relevancy of the theoretical results by using the export price data in Korea. We find that export prices in Korea are highly stable in terms of the US dollar even in the commodities for which Japan has had dominant shares. We also find that export prices in Korea are more stable against the US dollar in the commodities for which the shares of local firms are small in Japan. The empirical results are consistent with our theoretical model. The result may explain why the firm tends to set prices in the US dollar even if the United States is not a trade partner.

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[**] Correspondence to: Shin-ichi Fukuda, Faculty of Economics, University of Tokyo, 7-3-1 Hongo Bunkyo-ku Tokyo 113-0033 Japan, Phone: 81-3-5841-5504, Fax: 81-3-5841-5521, e-mail: sfukuda@e.u-tokyo.ac.jp

1. Introduction

The purpose of this paper is to investigate the choice of invoice currency in international trade. There are several theoretical studies that investigated the choice of invoice currency in international trade. Baron (1976) and Giovannini (1988) are their early attempts.[1] Most of the studies analyzed whether the exporting firm sets prices in its own currency or in the importer's currency. It is, however, well known that some of international trades are invoiced in a third currency, that is, vehicle currency. In particular, the U.S. dollar tends to be the dominant vehicle currency in developing countries. By using an open economy model of monopolistic competition, this paper tries to explain the choice of invoice currency in developing countries.

Except for primary commodities, the role of vehicle currency is relatively limited in international trade among developed countries (see Magee and Rao [1980]). The U.S. dollar is, however, the dominant vehicle currency in many developing countries.[2] For example, Table 1 reports the ratios of currencies used for payments in Thai international trade. It shows that payments in the US dollar have been dominant in Thai exports, although the ratios of the US dollar showed marginal declines in recent years (see Table 1a). The results hold true even if the export destinations are East Asian countries or European countries. In particular, the payment ratio of the Japanese yen is less than 10% even in Thai exports to Japan (see Table 1b). A similar result is observed for the currency ratios used for payments in Korean exports. In Korea, the dominant ratios of the US dollar declined during a past decade years (Table 2). However, even in recent years, the ratios of the US dollar still lied between 85% and 90% in Korean visible exports and around 75% in Korean invisible trades.

Table 3 summarizes the shares of each export destination from Korea and Thailand. We can see that Japan and Western Europe as well as other Asian countries have been the other important trade partners for Thai and Korean exports. The above evidence indicates that the U.S. dollar was chosen as the dominant vehicle currency even in the case where the United States is not a trade partner.

One may argue that these countries chose the U.S. dollar as the dominant invoice currency because their exchange rates were stable against the U.S. dollar. The argument may have been true before the Asian crisis when they effectively pegged their currencies to the U.S. dollar (see, for example, Frankel and Wei [1994]). However, after the crisis, these countries shifted the exchange rate regime from de fact dollar peg to float. As a result, there is no longer a natural reason for them to choose the U.S. dollar as the dominant invoice currency to stabilize their export prices in terms of domestic currencies.

The following theoretical analysis is based on an open economy model of monopolistic competition. Since the export prices are set before exchange rates are known, the exporting firms face uncertainty

[1] McKinnon (1979) is another seminal study that addressed this issue.
[2] The authors such as Ito (1993), Fukuda (1995), and Kawai (1996) discussed why the Japanese yen has not been used in international trade.

of exchange rates. If necessary, the exporting firm set prices in its own currency or in the currency of the importing country. However, when the market is competitive enough, the exporting firms tend to set prices not to deviate from those of the competitors. As a result, when the other exporters set their prices in the third currency, the exporting firms tends to invoice in the third currency. The tendency becomes conspicuous in the market where the shares of local firms are small.

Our model follows a partial equilibrium model in Bacchetta and van Wincoop (2002). It, however, has two distinctive features that the previous study did not have. First, we allow the exporting firms to choose the third currency as an invoice currency. In developing countries, the exporting firms are under competition because of less differentiated products. It is thus a natural choice for the exporting firm to set prices in the third currency when the competitors set their prices in the third currency. Secondly, we show that coordination failures can lead the third currency to be an equilibrium invoice currency. Since multiple equilibria are Pareto ranked, it implies that the equilibrium choice of the invoice currency may lead to a less efficient equilibrium.

The latter part of the paper empirically investigates the relevancy of the theoretical results by using the export price data in Korea. The approach follows Fukuda and Ji (1994) that studied the pricing behavior of Japanese firms. We find that the export prices in Korea were highly stable in terms of the US dollar even in the commodities for which Japan had dominant shares. We also find that the export prices in Korea were more stable against the US dollar in the commodities for which the shares of local firms are small. The results are consistent with our theoretical model. They are, however, inconsistent with pricing-to-the-market models that have provided the dominant approaches in previous literature. Since the exporting products are less differentiated in developing countries, the exporting firms are under competition when they choose the invoice currency. The result thus explains why the firm tends to set prices in the US dollar even if the United States is not a trade partner in developing countries.

In previous literature, some exceptional studies explored the role of vehicle currency in international trade. Krugman (1980) and Rey (2001) show that transaction costs might make vehicle currency a dominant medium of exchange in international trade. These studies are, however, successful only in explaining the role of vehicle currency as a medium of exchange, through which transactions between currencies are made. In contrast, our approach tries to explain the role of vehicle currency as a unit account in terms of which prices of commodities are set. A unit account is another important function of vehicle currency. Friberg (1998) is an exceptional study that investigated the role of vehicle currency as a unit account. Assuming that the exporter commits to sell the demanded quantity at the ex post realized price, he explored under what conditions the monopolistic exporter chooses the third currency as vehicle currency. It was, however, demonstrated that setting price in the importer's currency yields the highest expected profits for the exporters under reasonable demand and cost functions. Friberg thus cannot explain why the vehicle currency tends to be a dominant invoice currency in international trade with developing countries. It has been widely observed that export prices are stable in terms of the US dollar in developing countries. We will show that the exporters' pricing behavior is consistent with our model in developing countries.

2. The Model of Export Pricing Behavior under Uncertainty

The purpose of this section is to present the theoretical framework that discusses pricing behavior under uncertainty. The firms studied are exporters who produce only in their home country. For simplicity, we assume that all exporting firms are identical and sell all of their products in a single foreign market. There are three countries: the exporting country, the importing country, and the third country. The third country has no international trade with the other two countries. Each exporter, however, has the choice between setting the export price in its own, in the importers', or in the third currencies. The exchange rates s_0 and s are exogenous and assumed to be the only source of uncertainty. Selling s_0 units of the third currency leads to one unit of the exporter's currency on the spot market and selling s units of the importers' currency leads to one unit of the exporter's currency on the spot market. By definition, the exchange rate between the exporter's and the third currency is given by the relation s/s_0. We denote their variances as $\sigma_0^2 \equiv E\,(s_0 - E\,s_0)^2$ and $\sigma^2 \equiv E\,(s - E\,s)^2$. For analytical simplicity, we assume that s_0 and s are uncorrelated, so that $E\,(s_0 - E\,s_0)(s - E\,s) = 0$.

In the following analysis, each exporter is under monopolistic competition and firm j faces the demand function $D(p_j, P^*)$, where p_j is the price set by the firm j measured in the importers' currency. P^* is the aggregate price index in the importers' local market denominated in the importers' currency. It is generally a function of prices set by local firms and prices set by exporting firms. The importers' local firms always set their prices in the importers' currency, so that the price set by domestic firms is independent of the exchange rate. The exporting firms, however, set their prices either in its own, in the importers', or in the third currencies. The aggregate price index P^* thus depends on the exchange rate unless all exporting firms set their prices in the importers' currency. We assume that the total number of firms is large enough so that an individual firm does not affect the price index P^*.

The objective of each exporter is to maximize the expected profits in terms of his home currency. The central assumptions are that the exporter has to set price before the exchange rates are known and that demand is a function of the price that importers face after exchange rate uncertainty is resolved. Suppose that each exporter chooses p^E when setting a price in its own currency, p^I when setting a price in the importers' currency, and p^0 when setting a price in the third currency. By definition, the unit price of imports in terms of the importers' currency is p^E/s when set in the exporters' currency, p^I when invoiced in the importers' currency, and p^0/s_0 when invoiced in the third currency. Let Π^E, Π^I, and Π^0 respectively denote the exporter's profit when the price p_j is set in its own, in the importers', or in the third currencies. The profit is then respectively given by

(1) $\Pi^E = p^E D(p^E/s, P^*) - C[D(p^E/s, P^*)]$,
(2) $\Pi^I = s\, p^I D(p^I, P^*) - C[D(p^I, P^*)]$,
(3) $\Pi^0 = (s/s_0)\, p^0 D(p^0/s_0, P^*) - C[D(p^0/s_0, P^*)]$,

where $C[\cdot]$ is cost function that is increasing and convex. We assume that the costs are incurred in terms of the exporter's currency.

3. The Nash Equilibria

In equilibrium, each exporter sets a price in its own currency if $E\Pi^E \geq E\Pi^I$ and $E\Pi^E \geq E\Pi^o$, in the importers' currency if $E\Pi^I \geq E\Pi^E$ and $E\Pi^I \geq E\Pi^o$, and in the third currency if $E\Pi^0 \geq E\Pi^I$ and $E\Pi^o \geq E\Pi^E$. The optimal choice of the currency denomination thus generally depends on the forms of demand and cost functions. Let $\Pi^E(s_0, s)$, $\Pi^I(s_0, s)$, and $\Pi^o(s_0, s)$ be profit functions in its own, in the importers', or in the third currencies respectively. Then, a second order Taylor expansion near $s_0 = E\, s_0$ and $s = E\, s$ leads to

(4) $E\Pi^j(s_0, s) \approx \Pi^j(E\, s_0, E\, s) + (1/2)\, (\Pi_{11}^j\, \sigma_0^2 + \Pi_{22}^j\, \sigma^2)$, for $j = E, I$, and 0,

where $\Pi_{11}^j \equiv d^2\Pi^j(s_0, s)/d\,s_0^2$ and $\Pi_{22}^j \equiv d^2\Pi^j(s_0, s)/d\,s^2$ at $s_0 = E\, s_0$ and $s = E\, s$.

It is noteworthy that the choice of the currency denomination becomes irrelevant under certainty. It thus holds that

(5) $\Pi^E(E\, s_0, E\, s) = \Pi^I(E\, s_0, E\, s) = \Pi^o(E\, s_0, E\, s)$,
(6) $p^E/E\, s = p^I = p^0/E\, s_0$.

After some tedious calculations shown in Appendix 1, we therefore obtain that when $\partial P^*/\partial\, s = 0$,

(7) $E\Pi^0 - E\Pi^I = (1/2)[\partial^2\Pi^0/\partial\, s_0^2 + 2\, (\partial^2\Pi^0/\partial\, P^*\partial\, s_0)(\partial P^*/\partial\, s_0)]\, \sigma_0^2$,
(8) $E\Pi^0 - E\Pi^E = (1/2)\, \{[\partial^2\Pi^0/\partial\, s_0^2 + 2\, (\partial^2\Pi^0/\partial\, P^*\partial\, s_0)(\partial P^*/\partial\, s_0)]\, \sigma_0^2 - (\partial^2\Pi^E/\partial\, s^2)\, \sigma^2\}$,
(9) $E\Pi^I - E\Pi^E = -\, (1/2)\, (\partial^2\Pi^E/\partial\, s^2)\, \sigma^2$,

and that when $\partial P^*/\partial\, s_0 = 0$,

(10) $E\Pi^0 - E\Pi^I = (1/2)\,(\partial^2\Pi^0/\partial s_0^{\,2})\,\sigma_0^{\,2}$,

(11) $E\Pi^0 - E\Pi^E$

$= (1/2)\,((\partial^2\Pi^0/\partial s_0^{\,2})\,\sigma_0^{\,2} - \{\partial^2\Pi^E/\partial s^2 + 2[(\partial^2\Pi^E/\partial P^*\partial s) - (\partial^2\Pi^I/\partial P^*\partial s)](\partial P^*/\partial s)\}\,\sigma^2)$,

(12) $E\Pi^I - E\Pi^E = -\,(1/2)\,\{\partial^2\Pi^E/\partial s^2 + 2\,[(\partial^2\Pi^E/\partial P^*\partial s) - (\partial^2\Pi^I/\partial P^*\partial s)](\partial P^*/\partial s)\}\sigma^2$.

Based on (7)-(12), we investigate which currency the exporters denominate their product in a Nash equilibrium. We first explore whether the denomination in the importers' currency can be a Nash equilibrium. Assuming symmetry, we consider the case where $\partial P^*/\partial s = \partial P^*/\partial s_0 = 0$. This is the case where all of the other exporting firms set their prices in the importers' currency. Equations (7)-(9) show that $E\Pi^I \geq E\Pi^E$ and $E\Pi^I \geq E\Pi^o$ if and only if

(13) $\partial^2\Pi^0/\partial s_0^{\,2} \leq 0$ and $\partial^2\Pi^E/\partial s^2 \leq 0$.

Since each exporter sets a price in the importers' currency if $E\Pi^I \geq E\Pi^E$ and $E\Pi^I \geq E\Pi^o$, this implies that the denomination in the importers' currency is a Nash equilibrium only if (13) holds. Each of two inequalities in (13) does not always hold under general demand and cost functions. We can, however, see that each inequality always holds when each profit function is concave in each exchange rate around its expected value.

We can similarly investigate whether the denomination in the third currency can be a Nash equilibrium. Assuming symmetry, we consider the case where $\partial P^*/\partial s = 0$ but $\partial P^*/\partial s_0 \neq 0$. This is the case where all of the other exporting firms set their prices in the third currency. Equations (7)-(9) show that $E\Pi^0 \geq E\Pi^I$ and $E\Pi^0 \geq E\Pi^E$ if and only if

(14) $\partial^2\Pi^0/\partial s_0^{\,2} + 2\,(\partial^2\Pi^0/\partial P^*\partial s_0)(\partial P^*/\partial s_0) \geq 0$,

(15) $[\partial^2\Pi^0/\partial s_0^{\,2} + 2\,(\partial^2\Pi^0/\partial P^*\partial s_0)(\partial P^*/\partial s_0)]\,\sigma_0^{\,2} \geq (\partial^2\Pi^E/\partial s^2)\,\sigma^2$.

This implies that the denomination in the third currency is a Nash equilibrium only if both (14) and (15) hold.

We finally investigate whether the denomination in the exporters' currency can be a Nash equilibrium. Assuming symmetry, we consider the case where $\partial P^*/\partial s_0 = 0$ but $\partial P^*/\partial s \neq 0$. This is the case where some of the other exporting firms set their prices in the exporter's currency. Equations (10)-(12) show that $E\Pi^E \geq E\Pi^I$ and $E\Pi^E \geq E\Pi^o$ if and only if

(16) $\partial^2\Pi^E/\partial s^2 + 2\,[(\partial^2\Pi^E/\partial P^*\partial s) - (\partial^2\Pi^I/\partial P^*\partial s)](\partial P^*/\partial s) \geq 0$,

$$(17)\quad (\partial^2 \Pi^0/\partial s_0^2)\,\sigma_0^2 \leq \{\partial^2 \Pi^E/\partial s^2 + 2[(\partial^2 \Pi^E/\partial P^*\partial s) - (\partial^2 \Pi^I/\partial P^*\partial s)](\partial P^*/\partial s)\}\,\sigma^2.$$

This implies that the denomination in the exporters' currency is a Nash equilibrium only if both (16) and (17) hold.

It is interesting to note that both (14) and (15) can hold even if (13) holds and that both (16) and (17) can hold even if (13) holds. This indicates that the model can have multiple Nash equilibria for some demand and cost functions. Since multiple equilibria are Pareto ranked, coordination failures may thus make the equilibrium choice of invoice currency less efficient.

4. The Case of CES preferences

When we specify the demand and cost functions, our equilibrium conditions are solved explicitly. We consider the following set of constant elasticity demand and cost functions.

$$(18)\quad D(p_j, P^*) = A\,(p_j/P^*)^{-\mu},$$

$$(19)\quad C(D) = B\,D^{\eta},$$

where $\mu > 1$ and $\eta > 1$.

If the importers have CES preferences with elasticity $\mu > 1$ among the different products, we can specify the demand for goods from firm j as (18). In this case, the aggregate price index in the importers' local market P^* is given by

$$(20)\quad P^* = \left(\frac{1}{N}\sum_{i=1}^{N} p_i^{\,1-\mu}\right)^{1/(1-\mu)}$$

where N is the number of firms in the importers' local market and p_i is a price set by exporting firm i in the importers' currency. In the local market, a fraction f of firms is identical exporting firms and a fraction 1-f is identical local firms. Let p_j denote a price set by exporting firm j in the importers' currency and p^D a price set by local firms in the importers' currency. The overall price index faced by foreign country consumers is then

$$(21)\quad P^* = \left[\frac{f}{H}\sum_{j=1}^{H} p_j^{\,1-\mu} + (1-f)(p^D)^{1-\mu}\right]^{1/(1-\mu)}$$

We assume that the local firms always set their prices in the local currency, that is, in the importers' currency. Then, p^D is always independent of the exchange rate. The exporting firms, however, set their prices either in its own, in the importers', or in the third currencies. The price index thus depends on the exchange rate unless the exporting firms set their prices in the importers' currency.

Under (18) and (19), each profit function is respectively written as

(22) $\Pi^E = A\, p^E\, [(p^E/s) / P^*)]^{-\mu} - A^{\eta} B\, [(p^E/s) / P^*)]^{-\mu\eta}$,

(23) $\Pi^I = A\, s\, p^I\, (p^I / P^*)^{-\mu} - A^{\eta} B\, (p^I / P^*)^{-\mu\eta}$,

(24) $\Pi^0 = A\, (s/s_0)\, p^0\, [(p^0/s_0) / P^*)]^{-\mu} - A^{\eta} B\, [(p^0/s_0) / P^*)]^{-\mu\eta}$.

Assuming that all domestic and exporting firms are identical under certainty, it holds that $P^* = p^D = p^E/E\, s = p^I = p^0/E\, s_0$. The first-order conditions thus lead to

(25) $p^E = p^I\, E\, s = p^0(E\, s / E\, s_0) = A^{\eta-1} B\, \mu\eta/(\mu-1)$.

at $s_0 = E\, s_0$ and $s = E\, s$. In addition, after some tedious calculations shown in Appendix 2, we can derive that at $s_0 = E\, s_0$ and $s = E\, s$,

(26) $\partial^2 \Pi^0/\partial s_0^{\,2} = -\, (1/s_0)^{\,2}\, p^E\, (\mu-1)[\mu(\eta-1) + 1] < 0$,

(27) $\partial^2 \Pi^E/\partial s^2 = -\, (1/s)^{\,2}\, p^E\, (\mu-1)[\mu(\eta-1) - 1]$,

(28) $\partial^2 \Pi^0/\partial P^* \partial s_0 = -\, (p^E/p_0)\, (\mu-1)\, \mu(\eta-1) < 0$,

(29) $\partial^2 \Pi^E/\partial P^* \partial s = -\, \mu[\mu(\eta-1) - \eta]$,

(30) $\partial^2 \Pi^I/\partial P^* \partial s = \mu$,

(31) $\partial P^*/\partial p = f$.

Equations (26) and (27) imply that the condition (13) holds if and only if

(32) $\mu(\eta-1) \geq 1$.

The denomination in the importers' currency is thus a Nash equilibrium if and only if (32) holds. On the other hand, from equations (28)-(31), we can show that the condition (14) holds if and if

(33) $\mu(\eta-1)(2f-1) \geq 1$,

and that the condition (16) holds if and if

(34) $\mu(\eta\text{-}1)(2fh\text{-}1) + 1 \geq 0$,

where parameter h is a fraction of exporting firms that set their prices in the exporter's currency. Since $\partial^2 \Pi^E/\partial s^2 < 0$ when (33) holds, the condition (15) holds if (33) holds. This implies that the denomination in the third currency is a Nash equilibrium if and only if (33) holds. Similarly, since $\partial^2 \Pi^0/\partial s_0{}^2 < 0$, the condition (17) holds if (16) holds. The denomination in the exporters' currency is therefore a Nash equilibrium if and only if (34) holds.

Among the above three inequalities, the condition (34) is the only inequality that holds when $\mu(\eta\text{-}1) < 1$. Since the parameter μ becomes small when the importers' local market is less competitive, the denomination in the exporters' currency is thus a Nash equilibrium when the local market is less competitive. This implies that the exports of differentiated products, which prevail in developing countries, tend to be denominated the exporters' currency.

In contrast, when $\mu(\eta\text{-}1) \geq 1$, the denomination in the importers' currency is always a Nash equilibrium. Since the parameter μ becomes large enough when the local market is competitive, this indicates that the denomination in the importers' currency is a Nash equilibrium in the competitive local market. However, when $\mu(\eta\text{-}1) \geq 1$, Nash equilibrium may not be unique in general. The denomination in the third currency is another Nash equilibrium when $2f\text{-}1 \geq 1/[\mu(\eta\text{-}1)]$. The denomination in the exporters' currency is another Nash equilibrium when $2fh\text{-}1 \geq -1/[\mu(\eta\text{-}1)]$. When the market is competitive, the model therefore has multiple Nash equilibria for some parameter set, particular when a fraction of exporting firms in the importers' local market f is large.

When the local market is competitive enough, the exporting firms tend to keep their prices not to deviate from those of the competitors. As a result, when the other exporters are expected to set their prices in some currency, the exporting firm tends to set its price in the same currency. The denomination in the arbitrary currency can therefore be a Nash equilibrium depending on the expectations on the choice of invoice currency of the other exporters.

Because of the less differentiated exporting products, the exporters in developing countries tend to face serious competition in the importers' local markets. The above result thus indicates that when a fraction of exporting firms is large in the local market, the choice of invoice currency can be arbitrary in the exports from developing countries. In particular, since the US dollar has historically been the dominant invoice currency in most developing countries, the exporters in the developing countries may not have an incentive to change their invoice currency from the US dollar to the other currency even if the United States is not a trade partner. It is noteworthy that multiple equilibria are Pareto ranked. This implies that the equilibrium choice of invoice currency may be a less efficient equilibirum.

5. Empirical Evidence

(i) Framework

It is well known that the U.S. dollar has been the dominant vehicle currency in many developing countries. In particular, as we showed in introduction, payments by the US dollar have been dominant in most East Asian countries even though other East Asian countries, particularly Japan, are important trade partners. There is, however, no direct evidence that shows how dominant the use of US dollar was as "contract currency" of export prices in the East Asian countries. The contract currency is usually the same as the payment currency in international trade. The role of medium of exchange is, however, theoretically different from that of a unit account in international trade. We thus need some formal tests to examine to what extent export prices are stable in terms of the US dollar in most of East Asian international trade.

This section empirically investigates the stability of export prices against the US dollar in Korea. We used the export prices in Korea because the data are available for varieties of commodities. We examine how the export prices of various commodities are correlated with the US dollar, the Japanese yen, and the Euro. In particular, we explore whether export prices in Korea can be highly stable in terms of the US dollar even in the commodities which were exported to Japan.

All data are monthly. Define the relative export price of commodity *i* at time t by $REP_{i,t} \equiv EPI_{i,t} / PPI_{i,t}$, where $EPI_{i,t}$ = the export price index of commodity *i* at time t and $PPI_{i,t}$ = the producer price index of commodity *i* at time t. We regressed its growth rate on the growth rates of USD (= the exchange rate of the US dollar), JPY (= the exchange rates of the Japanese Yen), and EUR (= the exchange rate of the Euro [the German Mark before December 2002]).[3] For each relative export price of commodity *i*, we estimated the following equation

$$(35)\quad d\,REP_{i,t} = \text{constant} + \sum_{k=0}^{K} a_k \; d\ln USD_{t-k} + \sum_{k=0}^{K} b_k \; d\ln JPY_{t-k} + \sum_{k=0}^{K} c_k \; d\ln EUR_{t-k},$$

where $d\,REP_{i,t} \equiv \ln REP_{i,t} - \ln REP_{i,t-1}$ and $d\ln S_{t-k} \equiv \ln S_{t-k} - \ln S_{t-k-1}$ for S = USD, JPY, and EUR. All exchange rates are monthly average rates in terms of the Korean won. To allow the lag structure, we used the Almon lag, where *K* is the number of lags. Some preliminary estimations could not reject the hypothesis that the end point constraint that $a_3 = b_3 = c_3 = 0$ when $K = 2$. We thus estimated equation (35) assuming that $K = 2$ and imposing the end point constraint that $a_3 = b_3 = c_3 = 0$.[4]

[3] When converting the German Mark to the Euro, we applied the euro conversion rate: 1 Euro = 1.95583 Mark.

[4] We first estimated (35) with seasonal dummies. None of them was, however, significant. The following analysis reports the estimation results without seasonal dummies.

The sum of the coefficients respectively reflects the impact of the exchange rate change on the export price in Korea. That is, $\sum_{k=0}^{K} a_k$ reflects the impact of the change of the US dollar, $\sum_{k=0}^{K} b_k$ that of the change of the Japanese Yen, and $\sum_{k=0}^{K} c_k$ that of the change of the Euro. If the export price in Korea is denominated by the currency of the export destination, all of $\sum_{k=0}^{K} a_k$, $\sum_{k=0}^{K} b_k$, and $\sum_{k=0}^{K} c_k$ would lie between zero and one. In contrast, if the US dollar is the dominant invoice currency, $\sum_{k=0}^{K} a_k$ would be close to one and $\sum_{k=0}^{K} b_k$ but $\sum_{k=0}^{K} c_k$ would be small.

(ii) The data

The sample period of estimations is from March 1998 to December 2002. In order to exclude the turbulent period after the currency crisis, we start the sample period from March 1998. We ended the sample period in December 2002 because the commodity classification of the export price index was revised after January 2003.

The data of the export price index ($EPI_{i,t}$) and the producer price index ($PPI_{i,t}$) are downloaded from the website of the Bank of Korea. The base year of each index is 1995. The commodity classifications are based on “won basis Basic Groups” of each index. Unfortunately, the classifications do not have one-to-one correspondences between the two indexes. We therefore reclassified each classification and sorted out 21 commodities. Among these 21 commodities, we excluded agricultural products and marine products from our samples because the export prices were highly volatile over time. We consequently obtained 19 commodities: (1) mining products, (2) processed marine products, (3) plastic products, (4) non-metallic mineral products, (5) iron & steel, (6) basic nonferrous metals & related primary, (7) furniture, (8) footwear, (9) hand tools & general hardware, (10) electric machinery & apparatus, (11) precision instrument, (12) sports & leisure goods, (13): musical instruments, (14) rubber products, (15) general purpose machinery, (16) special purpose machinery, (17) radio, TV, & communication equipment, (18) transportation equipment, and (19) apparel.

The column (A) in table 4 displays the list of 19 commodities we use in the following analysis. The columns (B) and (C) in table 4 summarize how each classified commodity corresponds to that in the export price index (EPI) and that in the producer price index (PPI) in the following analysis.

(iii) The Estimation Results

Table 5 summarizes the results of regressions for the 19 commodities. The sum of the coefficient $\sum_{k=0}^{K} a_k$ was significantly positive in eighteen among the 19 commodities. The exception was nonmetallic mineral products in which none of $\sum_{k=0}^{K} a_k$, $\sum_{k=0}^{K} b_k$, and $\sum_{k=0}^{K} c_k$ was significantly positive (No.6-1 in the table). However, even in non-metallic mineral products, $\sum_{k=0}^{K} a_k$ turned out significantly positive when we estimate (35) with the restriction that $\sum_{k=0}^{K} b_k = \sum_{k=0}^{K} c_k = 0$ (No.6-2 in the table). Excluding No.6-1, the average value of $\sum_{k=0}^{K} a_k$ was 0.837, which implies that export prices are highly stable in terms of the US dollar in Korean exports. In particular, $\sum_{k=0}^{K} a_k$ was greater than 0.9 in eight commodities: mining products, plastic products, nonmetallic mineral products, footwear, sports & leisure goods, musical instruments, rubber products, and general purpose machinery.

In contrast, the sum of the coefficient $\sum_{k=0}^{K} b_k$ was significantly positive in eight commodities but not in eleven commodities. Even in the eight commodities in which $\sum_{k=0}^{K} b_k$ was significantly positive, $\sum_{k=0}^{K} b_k$ was less than 0.4 except for processed marine products. The sum of the coefficient $\sum_{k=0}^{K} c_k$ was significantly positive only in one commodity and not in the other eighteen commodities. The results indicate that export prices in Korea had only modest correlation with the Japanese yen and little correlation with the Euro.

(iv) Trade Destinations and Export Prices

In the last subsection, we showed that the US dollar was the dominant invoice currency in Korean exports. However, interpreting the results in Table 5, we need to note that the United States is the largest export destination from Korea and that China and Hong Kong peg their exchange rates to the US dollar. To the extent that the US dollar is dominant in invoicing the Korean exports to the United States, China, and Hong Kong, the results do not necessarily mean that the US dollar is the dominant invoice currency in Korean exports to the other countries. The following analysis investigates whether export prices in Korea are highly stable in terms of the US dollar even in the commodities for which the United States is not a dominant export partner.

Table 6 summarizes the shares of the United States (US/W) and the shares of Japan (JP/W) in the Korean exports for each of the 19 commodities over 1998 - 2001. It also reports the summed shares of China and Hong Kong [(C+HK)/W] and those of the United States, China, and Hong Kong [(US+C+HK)/W]. The table shows that the United States has large shares in several commodities. In particular, the summed shares of the United States, China, and Hong Kong exceed 50% in eight commodities. Japan, however, has large shares in several commodities. In particular, the shares of Japan exceed 20% in seven commodities.

If the US dollar is the dominant invoice currency only in the Korean exports to the United States, export prices in Korea would be stable in terms of the US dollar only in the commodities for which the United States has large shares. Because China and Hong Kong peg their exchange rates to the US dollar, it is also likely that the US dollar is dominant in invoicing the Korean exports to China and Hong Kong. In contrast, if the US dollar is the dominant invoice currency in all of the Korean exports, export prices in Korea would be stable in terms of the US dollar even in the commodities for which Japan has large shares.

By using the estimated coefficients in equation (35), we test these alternative hypotheses. Denoting commodity *i* by subscript *i*, we estimate the following equations:

$$\text{(36a)} \quad \left(\sum_{k=0}^{K} a_k\right)_i = \text{constant} + d_1\, US_i/W_i + d_2\, (C+HK)_i/W_i + d_3\, JP_i/W_i,$$

$$\text{(36b)} \quad \left(\sum_{k=0}^{K} b_k\right)_i = \text{constant} + e_1\, US_i/W_i + e_2\, (C+HK)_i/W_i + e_3\, JP_i/W_i,$$

$$\text{(36c)} \quad \left(\sum_{k=0}^{K} a_k\right)_i - \left(\sum_{k=0}^{K} b_k\right)_i = \text{constant} + g_1\, US_i/W_i + g_2\, (C+HK)_i/W_i + g_3\, JP_i/W_i,$$

where US_i/W_i denotes the shares of the United States, $(C+HK)_i/W_i$ the shares of China and Hong Kong, and JP_i/W_i, the shares of Japan. If the invoice currency is determined by the currency of the export destination, we can expect that the parameters d_1, d_2, e_3, g_1, and g_2 would be significantly positive and that the parameter g_3 would be significantly negative.

Table 7 reports the regression results. In the table, all of the parameters had expected signs. This implies that invoicing in the US dollar was more dominant in the Korean exports to the United States, China, and Hong Kong but less in the Korean exports to Japan. However, except for g_1 and g_2, the estimated parameters were not significantly positive. Even the parameters g_1 and g_2 took small positive values. The results suggest that export prices in Korea were highly stable in terms of the US dollar even in the commodities for which Japan has had dominant shares.

6. Consistency of our Empirical Results with our Theoretical Results

One of the most prominent features in our theoretical model is that the third currency can be an equilibrium invoice currency when the exporters are under competition and when local firms have small shares in the market. Because of less differentiated products, the first condition tends to hold in the exports from developing countries. Our theoretical implication will thus be supported if the third currency is used as an invoice currency in the exports from developing countries when the second condition holds, that is, when a fraction of local firms is small in the market. In this section, we examine this hypothesis by using the regression results in the last section. Specifically, we explore whether the US dollar is the dominant invoice currency in the products of which local firms have small shares in the competitive market.

In the analysis, we investigate how the difference in the import shares in Japan affects the choice of invoice currency of each commodity. We chose the Japanese market as a representative local market because Japan had been the second biggest export destination for Korea for a long period.[5] If the theoretical hypothesis is true, we expect that invoicing in the U.S. dollar tends to be large in commodities for which the import share is large in the Japanese market.

Define the import share in Japan f_i as

(37) $f_i \equiv$ [the amount of imports in commodity i] / [the amount of sales in commodity i],

where domestic sales ≡ total domestic production – exports + imports. We calculate f_i by using the 2000 Input-Output Tables reported by the Ministry of Economy, Trade, and Industry. To avoid the aggregation biases, we first calculated f_i 's for basic 71 commodities and then used those for which imports from Korea are more relevant in Japan (see Appendix 3).

The estimated values of $\sum_{k=0}^{K} a_k$ reflect not only the impacts of the dollar-won exchange rate on Korean export prices to non-US dollar areas such as Japan but also those to the US dollar areas (i.e., the U.S., China, and Hong Kong). To identify the invoice ratios in the exports to Japan, we thus need to subtract those to the US dollar areas from $\sum_{k=0}^{K} a_k$. Define $A(USD)_i$ as the invoice ratio in the exports to the US dollar areas and $A(Non\text{-}USD)_i$ as that to non-US dollar areas. For commodity i, the value of $\sum_{k=0}^{K} a_k$ is then represented as the weighted average of $A(USD)_i$ and $A(Non\text{-}USD)_i$ as follows

(38) $[\sum_{k=0}^{K} a_k]_i = w_i \cdot A(USD)_i + (1-w_i) \cdot A(Non\text{-}USD)_i$,

where w_i is the ratio of Korean exports to the US dollar areas divided by Korean exports to the World.

We use the value of (US+C+HK)/W in Table 6 for w_i, and the estimates in Table 5 for $[\sum_{k=0}^{K} a_k]_i$. Assuming that all of the exports to the US dollar areas are invoiced in the US dollar, that is, $A(USD)_i \equiv 1$ for all i, equation (38) then leads to the estimates of $A(Non\text{-}USD)_i$. For Korea, a primary part of $1-w_i$ is the weight of the exports to Japan. The estimates of $A(Non\text{-}USD)_i$ would therefore reflect the extent to which the US dollar is chosen as an invoice currency in Korean exports to Japan.

[5] In recent years, China became the second biggest export destination for Korea.

Table 8 reports the value of f_i as well as the estimates of A(Non-USD)$_i$ for 19 commodities. Because the aggregation biases still remain, the calculated values of f_i were less than 50% except for mining products. We can, however, observe a tendency that A(Non-USD)$_i$ is large in commodities for which f_i is large. For example, f_i exceeds 40% in three commodities: mining products, footwear, and apparel. In these commodities, the average of A(Non-USD)$_i$ is 1.103. In contrast, in the other sixteen commodities, the average of A(Non-USD)$_i$ is 0.761. Welch's test reveals that the former average is statistically greater than the latter one at the 1% significance level. The results support our theoretical hypothesis that the US dollar tends to be the dominant invoice currency in the products for which local firms have small shares.

When the market is competitive enough, the exporting firms tend to keep their prices not to deviate from those of the competitors. As a result, when the competitors are expected to set their prices in the US dollar, the exporting firm tends to set its price in the same currency. The local firms usually set their prices in the local currency. To the extent that the shares of local firms are large, it is thus unlikely that the competitors are expected to set their prices in the US dollar outside the United States. However, when the shares of local firms are small, it is possible that the competitors are expected to set their prices in the US dollar outside the US market. Our empirical result supports this view.

7. Concluding Remarks

This paper investigated the choice of invoice currency under exchange rate uncertainty. The analysis was motivated by the fact that the U.S. dollar has been the dominant vehicle currency in developing countries. Our theoretical analysis was based on an open economy model of monopolistic competition. When the market is competitive enough, the exporting firms tend to set their prices not to deviate from those of the competitors. As a result, when the other exporters set their prices in the third currency, the exporting firm tends to choose the third currency as the invoice currency. The tendency becomes conspicuous in the market where the shares of local firms are small. The latter part of the paper empirically investigated the relevancy of the theoretical results by using the export price data in Korea. We found that export prices in Korea were highly stable in terms of the US dollar even in the commodities for which Japan had dominant shares. We also found that export prices in Korea were more stable against the US dollar in the commodities for which the shares of local firms were small.

The empirical results are consistent with our theoretical model. They are, however, inconsistent with pricing-to-the-market models that have analyzed whether the exporting firm sets prices in its own currency or in the importer's currency. It is well known that some of international trades are invoiced in the U.S. dollar in developing countries. Since the exporting products are less differentiated in developing countries, our results may provide one plausible explanation on why the exporting firms in developing countries tend to set prices in the US dollar even if the United States is not a trade partner.

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Table 1a. Structure of Export Receipts (Percent share)

Currencies	1993	1994	1995	1996	1997	1998	1999	2000
US dollar	91.8	90.5	91.0	91.7	92.0	90.6	87.6	87.0
baht	0.9	1.6	2.4	1.3	2.1	2.6	3.7	3.9
Japanese yen	3.9	4.7	4.1	4.5	3.3	3.7	5.2	5.7
Deutsche mark	1.0	0.8	0.5	0.5	0.4	0.7	1.5	1.2
Pound sterling	0.8	0.6	0.3	0.4	0.3	0.4	0.3	0.2
Euro	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.6
Singapore dollar	0.8	0.7	0.5	0.4	0.4	0.3	0.3	0.2
Others	0.8	1.1	1.2	1.2	1.5	1.7	1.2	1.2
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source) Bank of Thailand.

Table 1b. Structure of export receipts from major trading partners classified by currency in Thailand (Percent share)

Partner Country	2001			2002		
	USD	JPY	THB	USD	JPY	THB
Japan	71.8	20.5	7.3	71.0	20.9	7.4
	USD	JPY	THB	USD	JPY	THB
NAFTA						
- USA	97.1	0.3	2.6	96.4	0.4	3.2
- Canada	97.3	0.0	0.2	97.3	0.2	0.3
- Mexico	99.7	0.0	0.2	98.1	0.0	0.2
Total	**97.1**	**0.3**	**2.5**	**96.4**	**0.4**	**3.0**

Partner Country	2002						
	USD	GBP	DEM	THB	EURO	Others	Total
European Union							
- Belgium	74.5	2.0	0.0	1.8	21.4	0.3	100.0
- Denmark	92.8	0.0	0.0	2.6	2.6	2.0	100.0
- France	87.2	0.0	0.0	0.8	11.4	0.6	100.0
- Germany	50.1	0.0	0.2	1.1	47.8	0.8	100.0
- Greece	81.7	0.0	0.0	0.6	17.6	0.1	100.0
- Ireland	96.6	0.0	0.1	0.0	2.2	1.1	100.0
- Italy	83.4	0.0	0.0	0.5	15.4	0.7	100.0
- Luxembourg	16.7	0.0	0.0	0.0	83.1	0.2	100.0
- Netherlands	61.4	0.0	0.0	0.3	37.4	0.9	100.0
- Portugal	74.1	0.0	0.7	0.2	24.9	0.1	100.0
- Spain	81.4	0.2	0.1	0.4	17.7	0.2	100.0
- United Kingdom	88.5	6.8	0.0	2.1	2.4	0.2	100.0
- Austria	41.2	0.0	0.2	7.5	50.9	0.2	100.0
- Sweden	88.7	0.1	0.0	4.3	1.2	5.7	100.0
- Finland	91.2	0.0	0.0	0.8	6.5	1.5	100.0
Total	**73.0**	**2.1**	**0.1**	**1.3**	**22.9**	**0.6**	**100.0**

Partner Country	2002						
	USD	JPY	THB	SGD	MYR	Others	Total
ASEAN							
- Singapore	91.6	2.2	3.3	1.3	0.0	1.6	100.0
- Indonesia	79.2	2.8	10.3	0.2	0.0	7.5	100.0
- Philippines	84.2	1.9	5.9	6.8	0.0	1.2	100.0
- Malaysia	93.3	1.1	3.8	0.4	0.8	0.6	100.0
- Brunei Darussalam	64.5	0.4	9.3	25.2	0.0	0.6	100.0
- Cambodia	47.0	0.2	52.0	0.4	0.0	0.4	100.0
- Laos	49.3	0.2	49.9	0.0	0.0	0.6	100.0
- Myanmar	65.6	0.2	33.7	0.0	0.1	0.4	100.0
- Vietnam	95.9	0.5	3.5	0.0	0.0	0.1	100.0
Total	**89.0**	**1.9**	**6.1**	**1.3**	**0.1**	**1.6**	**100.0**

Source) Bank of Thailand.

Table 2. The Shares of Payment Currencies in Korean Exports

(1) Visible Trade

(Unit: %)

	US Dollar	Yen	Mark	Pound
1976	99.08	0	0.25	0.37
1980	95	2.15	1.58	0.45
1985	94.24	3.84	0.76	0.38
1990	88.21	7.44	2.2	0.87
1992	88.78	6.25	2.82	0.85
1994	88.86	6.41	2.58	0.50
1996	89.1	5.13	2.21	0.98
1997	89.21	5.02	1.76	0.85
1998	88.54	4.95	2.66	0.97
1999	85.61	5.96	2.39	0.95
2000	84.76	5.39	1.8	0.67
2001	87.42	5.39	1.47	0.71

(2) Invisible Trade

(Unit: %)

	US Dollar	Yen	Mark	Pound
1976	83.86	5.73	2.09	0.29
1980	83.45	4.60	0.98	0.39
1985	87.78	8.86	0.97	0.41
1990	65.58	25.67	2.99	2.81
1992	67.79	22.51	3.65	2.06
1994	70.08	22.09	3.11	0.91
1996	75.48	17.18	2.40	0.80
1997	77.22	15.77	2.35	0.99
1998	77.79	16.32	1.79	0.67
1999	74.52	18.96	1.12	1.03
2000	75.87	16.27	0.65	1.23
2001	74.38	14.06	0.47	1.37

Sources) The Bank of Korea, Monthly Statistical Bulletin, various issues.

Table 3. Korea and Thailand's exports by destination (ratio= exports to an area ／exports to the world)

	Destination	1997	1998	1999	2000	2001
Korea's exports	Industrial countries	41.6%	48.1%	50.5%	51.3%	48.6%
	United States	15.2%	17.4%	20.6%	22.0%	20.9%
	Japan	10.3%	9.2%	11.0%	11.9%	11.0%
	Western Europe	13.5%	18.0%	15.8%	14.3%	13.7%
	Canada, Australia, New Zealand	2.8%	3.4%	3.0%	3.1%	3.0%
	Eastern Europe	4.4%	4.2%	2.7%	2.3%	2.7%
	East Asia	35.1%	31.8%	32.9%	33.6%	33.6%
	China:Mainland	9.4%	9.0%	9.5%	10.7%	12.1%
	China:Hong Kong	8.1%	7.0%	6.3%	6.2%	6.3%
	Indonesia	2.5%	1.3%	1.8%	2.0%	2.2%
	Malaysia	3.0%	2.7%	2.5%	2.0%	1.8%
	Philippines	1.8%	2.1%	2.2%	2.0%	1.7%
	Thailand	1.6%	1.1%	1.2%	1.2%	1.2%
	Vietnam	1.1%	1.0%	1.0%	1.0%	1.2%
	Singapore	4.0%	3.1%	3.4%	3.3%	2.7%
	Others	3.6%	4.3%	4.9%	5.1%	4.4%
	South Asia	1.8%	2.2%	1.8%	1.6%	1.8%
	Middle East, Afganistan	3.4%	4.7%	4.2%	4.2%	4.6%
	Western Hemishere	5.8%	6.5%	5.9%	5.3%	6.4%
	Africa, N. Korea, & Area not specified	7.9%	2.5%	2.0%	1.6%	2.3%
	DOTS World Total	100.0%	100.0%	100.0%	100.0%	100.0%
Thailand's exports	Industrial countries	54.4%	58.2%	57.4%	56.5%	56.5%
	United States	19.4%	22.3%	21.7%	21.3%	20.3%
	Japan	15.2%	13.7%	14.1%	14.7%	15.3%
	Western Europe	16.9%	19.0%	17.9%	16.7%	17.3%
	Canada, Australia, New Zealand	2.9%	3.2%	3.7%	3.7%	3.6%
	Eastern Europe	1.0%	0.8%	0.9%	1.0%	0.9%
	East Asia	36.4%	32.0%	32.0%	33.9%	33.7%
	China:Mainland	3.0%	3.2%	3.2%	4.1%	4.4%
	China:Hong Kong	5.9%	5.1%	5.1%	5.0%	5.1%
	Indonesia	2.4%	1.8%	1.7%	1.9%	2.1%
	Korea	1.8%	1.1%	1.6%	1.8%	1.9%
	Malaysia	4.3%	3.3%	3.6%	4.1%	4.2%
	Philippines	1.2%	1.4%	1.6%	1.6%	1.8%
	Vietnam	0.9%	1.1%	1.0%	1.2%	1.2%
	Singapore	11.1%	8.6%	8.7%	8.7%	8.1%
	Others	5.7%	6.3%	5.7%	5.5%	5.0%
	South Asia	1.3%	1.3%	1.5%	1.7%	1.7%
	Middle East + Afganistan	3.4%	3.4%	3.5%	3.0%	3.3%
	Western Hemishere	1.1%	1.5%	1.3%	1.5%	1.7%
	Africa, N. Korea, & Area not specified	2.4%	2.7%	3.3%	2.3%	2.3%
	DOTS World Total	100.0%	100.0%	100.0%	100.0%	100.0%

Source: IMF DOTS(Direction of trade statistics)
Note: The countries of South Asia are Pakistan, Nepal, Indea, Sri Lanka, Bhutan, Bangladesh, and the Maldives.

Table 4. Classification of Commodities

No.	(A)	(B)	(C)	(D)
	Commodities	Korea EPI (HGEC No., name) 1995=100	Korea PPI (HGDA No, name) 1995=100	OECD Classification (to use in Table 7)
1	Mining products	2 Mining products	2 Mining products	27 Crude fertilizers other than division 56, and crude minerals +28 Metalliferous ores and metal scrap +3 Mineral fuels, lubricants and related materials
2	Processed marine products	3011 Processed marine products	30112 Processed marine products	037 Fish, aqua. invertebrates, prepared, preserved, n.e.s.
3	Plastic Products	30532 Plastic Products	3082 Plastic Products	57 Plastics in primary forms + 58 Plastics in non-primary forms
4	Nonmetallic mineral products	306 Nonmetallic mineral products	309 Non-metallic mineral products	66 Non metallic mineral manufactures, n.e.s.
5	Iron & steel	30711 Iron & steel	3101 Iron & steel	67 Iron and steel
6	Nonferrous metals & related primary	3072 Nonferrous metals & related primary	3102 Basic non-ferrous metal products	68 Non-ferrous metals
7	Furniture	3141 Furniture	3171 Furniture	82 Furniture and parts thereof
8	Footwear	30233 Footwear	3032 Footwear	85 Footwear
9	Hand tools & general hardware	3081 Hand tools & general hardware	3113 Hand tools & general hardware	695 Tools for use in the hand or in machine
10	Electrical machinery & apparatus	310 Electrical machinery & apparatus	313 Electrical machinery & apparatus	77 Electrical machinery, apparatus and appliances, n.e.s.
11	Precision instruments	312 Precision instruments	315 Precision instruments	87 Professional and scientific instruments, n.e.s. + 88 Photo apparatus, optical goods, watches and clocks
12	Sports & leisure goods	3143 Sports & leisure goods	3173 Sports & leisure goods	894 Baby carriages, toys, games & sporting goods
13	Musical instruments	3142 Musical instruments	3172 Musical instruments	898 Musical instruments, parts; records, tapes & similar
14	Rubber products	30531 Rubber products	3081 Rubber products	62 Rubber manufactures, n.e.s.
15	General purpose machinery	3091 General purpose machinery	3121 General purpose machinery	74 General (Other) industrial machinery and parts
16	Special purpose machinery	3092 Special purpose machinery	3122 Special purpose machinery	72 Specialised machinery
17	Radio, TV & communication equipment	311 Radio, TV & communication equipment	314 Radio, television & communication equipment	76 Telecommunication and sound recording apparatus
18	Transport equipment	313 Transport equipment	316 Transportation equipment	78 Road vehicles +79 Other transport equipment
19	Apparel	3022 Apparel	3025 Apparel	84 Articles of apparel & clothing accessories

Table 5. Regressions of Export Prices on Exchange Rates

No.	Commodities	Σa_k		Σb_k		Σc_k		R squared	D W	P-value
1	Mining products	1.006	**	0.055		0.097		0.48	2.04	0.05
2	Processed marine products	0.820	**	0.690	**	-0.189		0.63	2.17	0.28
3	Plastic products	1.110	**	0.161		-0.091		0.67	1.74	0.47
4	Nonmetallic mineral products	0.965	**	0.368	**	-0.266	**	0.77	1.82	0.64
5	Iron & steel	0.638	**	-0.385	**	-0.120		0.54	1.28	0.12
6-1	Nonferrous metals & related primary	0.061		0.234		0.333		0.37	2.45	0.31
6-2	Nonferrous metals & related primary	0.528	**	0.000		0.000		0.31	2.38	0.77
7	Furniture	0.828	**	-0.098		-0.092		0.51	1.86	0.32
8	Footwear	1.024	**	0.076		-0.109		0.63	1.74	0.08
9	Hand tools & general hardware	0.556	*	0.321		0.114		0.47	2.23	0.82
10	Electrical machinery & apparatus	0.779	**	0.159	**	-0.010		0.83	2.27	0.17
11	Precision instruments	0.852	**	0.375	**	-0.105		0.74	2.16	0.59
12	Sports & leisure goods	1.142	**	0.399	*	-0.314		0.48	1.56	0.86
13	Musical instruments	0.999	**	0.128		-0.063		0.65	2.36	0.95
14	Rubber products	1.231	**	0.382	**	-0.385	**	0.69	2.15	0.53
15	General purpose machinery	0.966	**	0.129		-0.034		0.84	2.85	0.87
16	Special purpose machinery	0.803	**	0.088		-0.009		0.80	2.51	0.09
17	Radio, TV & communication equipment	0.586	**	0.219	**	-0.049		0.67	2.19	0.92
18	Transport equipment	0.730	**	0.073		0.245	**	0.84	2.68	0.16
19	Apparel	1.124	**	0.158	*	-0.088		0.82	2.30	0.21
	Avg.(excl. 6-1)	0.837		0.177		-0.057				
	S.d. (excl. 6-1)	0.274		0.221		0.170				

**Statistically significant at the 5% level,
*Statistically significant at the 10% level

Note: The P-value is the marginal significance level of the F-statistic testing for the restrictions on the parameters due to the specification of the degree of the polynomial, and due to the end-point constraint on the polynomial.

Table 6. Korea's Exports by Commodity and Destination (%, avg. over 1998-2001)

No.	Commodities	US/W	(C+HK)/W	(US+C+HK)/W	JP/W
1	Mining products	6.8	33.0	39.8	35.2
2	Processed marine products	13.2	0.8	14.0	56.3
3	Plastic products	5.7	40.6	46.4	6.3
4	Nonmetallic mineral products	12.1	20.2	32.3	20.1
5	Iron & steel	16.2	26.3	42.5	16.7
6	Nonferrous metals & related primary	7.3	36.7	44.0	11.9
7	Furniture	26.2	5.6	31.9	28.5
8	Footwear	17.9	27.0	44.9	21.6
9	Hand tools & general hardware	20.9	6.4	27.3	12.9
10	Electrical machinery & apparatus	22.9	14.9	37.8	10.2
11	Precision instruments	19.9	11.3	31.2	15.3
12	Sports & leisure goods	30.5	15.4	45.9	22.4
13	Musical instruments	36.3	11.8	48.1	14.9
14	Rubber products	21.2	2.8	24.0	2.6
15	General purpose machinery	18.9	12.1	31.0	8.6
16	Special purpose machinery	15.4	23.8	39.1	6.1
17	Radio, TV & communication equipment	27.5	13.9	41.4	6.8
18	Transport equipment	21.2	1.7	22.9	1.2
19	Apparel	47.6	3.8	51.4	20.9

Source: OECD International Trade in Goods Statistics (www.oecd.org).

Table 7. Regressions of Price-Exchange Rate Correlations on Exporting Destination Ratios

	depedent variable	constant	US_i/W_i	$(C+HK)_i/W_i$	JP_i/W_i	R squared
(1)	$\left(\sum_{k=0}^{K} a_k\right)$	0.6365 ** (0.2323)	0.0073 (0.0065)	0.0035 (0.0056)	0.0022 (0.0041)	0.0847
(2)	$\left(\sum_{k=0}^{K} b_k\right)$	0.42687 * (0.2194)	-0.0067 (0.0061)	-0.0110 * (0.0052)	0.0037 (0.0039)	0.3028
(3)	$\left(\sum_{k=0}^{K} a_k\right) - \left(\sum_{k=0}^{K} b_k\right)$	0.2096 (0.2504)	0.0140 * (0.0070)	0.0145 ** (0.0060)	-0.0015 (0.0044)	0.3201

Note: Standard errors are in parentheses.
** Statistically significant at the 5% level,
* Statistically significant at the 10% level.

Table 8. Price-Exchange Rate Correlations and the Value of *f*

No.	Commodities	A(Non-USD)	*fi*
1	Mining products	1.010	60.2%
2	Processed marine products	0.790	24.4%
3	Plastic products	1.205	3.7%
4	Nonmetallic mineral products	0.948	5.0%
5	Iron & steel	0.370	2.4%
6−2	Nonferrous metals & related primary	0.157	27.2%
7	Furniture	0.748	14.4%
8	Footwear	1.044	44.5%
9	Hand tools & general hardware	0.388	16.4%
10	Electrical machinery & apparatus	0.644	14.0%
11	Precision instruments	0.785	28.7%
12	Sports & leisure goods	1.263	22.3%
13	Musical instruments	0.997	20.7%
14	Rubber products	1.304	5.5%
15	General purpose machinery	0.950	5.8%
16	Special purpose machinery	0.677	8.9%
17	Radio, TV & communication equipment	0.293	19.4%
18	Transport equipment	0.650	5.7%
19	Apparel	1.255	41.8%
Group A	*fi*>0.40：Average (Variance)	1.103 (0.018)	
Group B	*fi*<0.40：Average (Variance)	0.761 (0.119)	
Welch's test	t-value	2.970	
	One-tailed critical t-value for the 1% significance level	2.896	

Note: See Appendix 3 for the classification of Japanese imports used to calculate the value of *fi*

Appendix 1: Derivations of (7)-(10) and (11)-(14).

Equations (1)-(3) and (6) imply that $\partial \Pi^E/\partial P^* = \partial \Pi^I/\partial P^* = \partial \Pi^0/\partial P^*$, $\partial \Pi^I/\partial P^*\partial s = \partial \Pi^0/\partial P^*\partial s$, and $\partial^2 \Pi^E/\partial^2 P^* = \partial^2 \Pi^I/\partial^2 P^* = \partial^2 \Pi^0/\partial^2 P^*$ at $s_0 = E\, s_0$ and $s = E\, s$. It thus holds that when $\partial P^*/\partial s = 0$,

(A1) $\Pi_{11}{}^E = \Pi_{11}{}^I = (\partial^2 \Pi^E/\partial^2 P^*)(\partial P^*/\partial s_0)^2 + (\partial \Pi^E/\partial P^*)(\partial^2 P^*/\partial^2 s_0)$,

(A2) $\Pi_{11}{}^0 = \Pi_{11}{}^E + \partial^2 \Pi^0/\partial s_0{}^2 + 2\, (\partial^2 \Pi^0/\partial P^*\partial s_0)(\partial P^*/\partial s_0)$,

(A3) $\Pi_{22}{}^I = \Pi_{22}{}^0 = 0$,

(A4) $\Pi_{22}{}^E = \partial^2 \Pi^E/\partial s^2$,

at $s_0 = E\, s_0$ and $s = E\, s$. Similarly, when $\partial P^*/\partial s_0 = 0$,

(A5) $\Pi_{11}{}^E = \Pi_{11}{}^I = 0$,

(A6) $\Pi_{11}{}^0 = \partial^2 \Pi^0/\partial s_0{}^2$,

(A7) $\Pi_{22}{}^I = \Pi_{22}{}^0 = (\partial^2 \Pi^I/\partial^2 P^*)(\partial P^*/\partial s)^2 + (\partial \Pi^I/\partial P^*)(\partial^2 P^*/\partial^2 s) + 2\, (\partial^2 \Pi^I/\partial P^*\partial s)(\partial P^*/\partial s)$,

(A8) $\Pi_{22}{}^E = \Pi_{22}{}^I + \partial^2 \Pi^E/\partial s^2 + 2\, [(\partial^2 \Pi^E/\partial P^*\partial s) - (\partial^2 \Pi^I/\partial P^*\partial s)](\partial P^*/\partial s)$,

at $s_0 = E\, s_0$ and $s = E\, s$.

Equations (4) and (5) lead to

(A9) $E\Pi^0 - E\Pi^I = (1/2)\, [(\Pi_{11}{}^0 - \Pi_{11}{}^I)\, \sigma_0{}^2 + (\Pi_{22}{}^0 - \Pi_{22}{}^I)\, \sigma^2]$,

(A10) $E\Pi^0 - E\Pi^E = (1/2)\, [(\Pi_{11}{}^0 - \Pi_{11}{}^E)\, \sigma_0{}^2 + (\Pi_{22}{}^0 - \Pi_{22}{}^E)\, \sigma^2]$,

(A11) $E\Pi^I - E\Pi^E = (1/2)\, [(\Pi_{11}{}^I - \Pi_{11}{}^E)\, \sigma_0{}^2 + (\Pi_{22}{}^I - \Pi_{22}{}^E)\, \sigma^2]$.

We can therefore derive that when $\partial P^*/\partial s = 0$,

(A12) $E\Pi^0 - E\Pi^I = (1/2)[\partial^2 \Pi^0/\partial s_0{}^2 + 2\, (\partial^2 \Pi^0/\partial P^*\partial s_0)(\partial P^*/\partial s_0)]\, \sigma_0{}^2$,

(A13) $E\Pi^0 - E\Pi^E = (1/2)\, \{[\partial^2 \Pi^0/\partial s_0{}^2 + 2\, (\partial^2 \Pi^0/\partial P^*\partial s_0)(\partial P^*/\partial s_0)]\, \sigma_0{}^2 - (\partial^2 \Pi^E/\partial s^2)\, \sigma^2\}$,

(A14) $E\Pi^I - E\Pi^E = -\, (1/2)\, (\partial^2 \Pi^E/\partial s^2)\, \sigma^2$.

and that when $\partial P^*/\partial s_0 = 0$,

(A15) $E\Pi^0 - E\Pi^I = (1/2)\, (\partial^2 \Pi^0/\partial s_0{}^2)\, \sigma_0{}^2$,

(A16) $E\Pi^0 - E\Pi^E = (1/2)\, ((\partial^2 \Pi^0/\partial s_0{}^2)\, \sigma_0{}^2$

$– \{\partial^2 \Pi^E/\partial s^2 + 2\, [(\partial^2 \Pi^E/\partial\, P^*\partial\, s) - (\partial^2 \Pi^I/\partial\, P^*\partial\, s)](\partial P^*/\partial\, s)\}\, \sigma^2)$,

(A17) $E\Pi^I - E\Pi^E = - (1/2)\, \{\partial^2 \Pi^E/\partial s^2 + 2\, [(\partial^2 \Pi^E/\partial\, P^*\partial\, s) - (\partial^2 \Pi^I/\partial\, P^*\partial\, s)](\partial P^*/\partial\, s)\}\, \sigma^2$.

Appendix 2: Derivations of (29)-(34)

Equations (22), (23), and (24) lead to

(A18) $\partial \Pi^E/\partial\, s = A\, \mu\, p^{E\ 1-\mu}\ s^{\mu-1}\, P^{*\ \mu} – \mu\eta\, A^\eta B\, s^{\mu\eta-1}\, (P^*/p^E)^{\mu\eta}$,

(A19) $\partial \Pi^I/\partial\, s = A\, p^{I\ 1-\mu-}\, P^{*\ \mu}$,

(A20) $\partial \Pi^0/\partial\, s_0 = A\, (\mu-1)\, s\, p^{0\ 1-\mu}\ s_0^{\mu-2}\, P^{*\ \mu} – \mu\eta\, A^\eta B\, s_0^{\mu\eta-1}\, (P^*/p^0)^{\mu\eta}$,

Since $P^*\, E\, s = p^E = p^I\, E\, s = p^0(E\, s\, /E\, s_0) = A^{\eta-1}B\, \mu\eta/(\mu-1)$ at $s_0 = E\, s_0$ and $s = E\, s$, it holds that

(A21) $\partial^2 \Pi^0/\partial\, s_0^{\ 2} = (\mu-1)\, (\mu-2)\, A\ \ s\, p^0\ \ s_0^{\ -3}\, (P^*\, s_0/p^0)^\mu – \mu\eta(\mu\eta-1)\, A^\eta B\, s_0^{\ -2}\, (P^*\, s_0/p^0)^{\mu\eta}$,

$= (1/s_0)^{\,2}\, [(\mu-1)\, (\mu-2)\, A\ \ p^0\, (s/s_0) – \mu\eta\, A^\eta B\, (\mu\eta-1)]$,

$= - (1/s_0)^{\,2}\, p^E\, (\mu-1)[\ \mu(\eta-1) + 1] < 0$

(A22) $\partial^2 \Pi^E/\partial\, s^2 = \mu\, (\mu-1)\, A\, p^E\ \ s^{-2}\, (P^*\, s/p^E)^\mu – \mu\eta\, A^\eta B\, (\mu\eta-1) s^{-2}\, (P^*\, s/p^E)^{\mu\eta}$,

$= (1/s)^{\,2}\, [\mu\, (\mu-1)\, A\, p^E\ \ s^{-2} – \mu\eta\, A^\eta B\, (\mu\eta-1)]$,

$= - (1/s)^{\,2}\, p^E\, (\mu-1)[\ \mu(\eta-1) - 1]$,

(A23) $\partial^2 \Pi^0/\partial\, P^*\partial\, s_0 = A\, \mu\, (\mu-1)\ \ (s/s_0)\, (P^*\, s_0/p^0)^{\mu-1} – (\mu\eta)^{\,2}\, A^\eta B\, (1/p^0)\, (P^*\, s_0/p^0)^{\mu\eta-1}$,

$= (1/p^0)\, [A\, \mu\, (\mu-1)\, (p^0\, s/s_0) – (\mu\eta)^{\,2}\, A^\eta B]$,

$= - (p^E/p_0)\, (\mu-1)\, \mu(\eta-1) < 0$,

(A24) $\partial^2 \Pi^E/\partial\, P^*\partial\, s = A\, \mu^2\, (P^*\, s/p^E)^{\mu-1} – (\mu\eta)^{\,2}\, A^\eta B\, (1/\, p^E)\, (P^*/\, s\, p^E)^{\mu\eta-1}$,

$= A\, \mu^2 – (\mu\eta)^{\,2}\, A^\eta B\, (1/\, p^E)$,

$= - \mu[\mu(\eta-1) - \eta]$,

(A25) $\partial^2 \Pi^I/\partial\, P^*\partial\, s = A\mu\, (P^*/p^I)^{\,\mu-1} = \mu$.

Appendix 3. Japan's *f* by Commodity

Code	Commodities	(1) Total domestic	(2) Exports	(3) Imports	(1) - (2) + (3)	*f* = (3)／{(1)-(2)+(3)}
Mining products						
0611-011	Iron ores	60	29	365,191	365,222	100.0%
0611-012	Non-ferrous metallic ores	11,595	2,615	416,873	425,853	97.9%
0621-011	Limestone	135,936	1,807	891	135,020	0.7%
0621-019	Other materials for ceramics	49,060	2,101	58,653	105,612	55.5%
0622-011	Gravel and quarrying	323,654	546	18,730	341,838	5.5%
0622-021	Crushed stones	474,951	820	8,697	482,828	1.8%
0629-099	Other non-metallic ores	9,613	6,567	70,119	73,165	95.8%
0711-011	Coking coal	0	0	340,990	340,990	100.0%
0711-012	Steam coal, lignite and anthracite	39,267	44	275,660	314,883	87.5%
	Total			1,555,804	2,585,410	60.2%
Processed marine products						
1113-011	Frozen fish and shellfish	2,067,207	24,758	1,160,575	3,203,024	36.2%
1113-021	Salted, dried or smoked seafood	792,687	10,353	67,270	849,604	7.9%
1113-031	Bottled or canned seafood	151,547	1,675	12,853	162,725	7.9%
1113-041	Fish paste	549,830	3,732	0	546,098	0.0%
1113-051	Fish oil and meal	30,640	2,062	24,409	52,987	46.1%
1113-099	Other processed seafood	1,229,773	19,169	274,683	1,485,287	18.5%
	Total			1,539,790	6,299,725	24.4%
Plastic products						
2211-011	Plastic films and sheets	2,044,255	230,749	131,486	1,944,992	6.8%
2211-012	Plastic plates, pipes and bars	838,233	70,681	31,953	799,505	4.0%
2211-013	Foamed plastic products	534,943	12,632	7,314	529,625	1.4%
2211-014	Industrial plastic products	3,283,105	123,262	11,215	3,171,058	0.4%
2211-015	Reinforced plastic products	496,252	14,512	9,153	490,893	1.9%
2211-016	Plastic containers	1,084,740	34,371	41,640	1,092,009	3.8%
2211-017	Plastic table ware, kitchen ware and other household articles	518,913	5,494	28,212	541,631	5.2%
2211-019	Other plastic products	1,424,587	4,311	110,371	1,530,647	7.2%
	Total			371,344	10,100,360	3.7%
Non-metallic mineral products						
2511-011	Sheet glass	114,989	15,260	35,183	134,912	26.1%
2511-012	Safety glass and multilayered glass	469,840	7,462	15,530	477,908	3.2%
2512-011	Glass fiber and glass fiber products, n.e.c.	252,023	30,784	21,375	242,614	8.8%
2519-091	Glass processing materials	330,482	158,384	27,876	199,974	13.9%
2519-099	Other glass products, n.e.c.	488,564	50,534	58,938	496,968	11.9%
2521-011	Cement	512,157	13,439	7,147	505,865	1.4%
2522-011	Ready mixed concrete	1,828,394	698	0	1,827,696	0.0%
2523-011	Cement products	1,485,139	1,016	8,984	1,493,107	0.6%
2531-011	Pottery, china and earthenware for construction	267,986	5,922	12,255	274,319	4.5%
2531-012	Pottery, china and earthenware for industry	425,193	96,624	9,105	337,674	2.7%
2531-013	Pottery, china and earthenware for home use	259,068	27,096	47,223	279,195	16.9%
2599-011	Clay refractories	242,040	25,412	17,518	234,146	7.5%
2599-021	Other structural clay products	263,282	4,649	2,655	261,288	1.0%
2599-031	Carbon and graphite products	200,745	74,152	12,845	139,438	9.2%
2599-041	Abrasive	164,704	39,460	5,939	131,183	4.5%
2599-099	Miscellaneous ceramic, stone and clay products	959,352	56,019	119,506	1,022,839	11.7%
	Total			402,079	8,059,126	5.0%

Iron and steel						
2611-011	Pig iron	1,329,794	3,042	13,536	1,340,288	1.0%
2611-021	Ferro alloys	172,837	25,234	117,544	265,147	44.3%
2611-031	Crude steel (converters)	2,718,015	0	0	2,718,015	0.0%
2611-041	Crude steel (electric furnaces)	1,268,491	2,861	493	1,266,123	0.0%
2612-011	Scrap Iron	0	26,517	24,972	0	
2621-011	Section steel (ordinary steel)	386,869	36,413	1,785	352,241	0.5%
2621-012	Steel plate (ordinary steel)	468,344	47,454	32,145	453,035	7.1%
2621-013	Steel strip (ordinary steel)	2,090,407	231,331	65,583	1,924,659	3.4%
2621-014	Steel bar (ordinary steel)	380,050	4,839	887	376,098	0.2%
2621-015	Other hot rolled steel (ordinary steel)	368,723	118,696	8,085	258,112	3.1%
2621-016	Hot rolled steel (special steel)	1,647,858	226,919	28,728	1,449,667	2.0%
2622-011	Steel pipes and tubes (ordinary steel)	560,621	104,043	9,412	465,990	2.0%
2622-012	Steel pipes and tubes (special steel)	294,562	91,961	5,317	207,918	2.6%
2623-011	Cold-finished steel	2,687,259	309,725	59,237	2,436,771	2.4%
2623-021	Coated steel	1,487,280	295,085	31,115	1,223,310	2.5%
2631-011	Forged steel	158,976	1,481	1,031	158,526	0.7%
2631-012	Cast steel	125,548	0	0	125,548	0.0%
2631-021	Cast iron pipes and tubes	140,425	2,228	66	138,263	0.0%
2631-031	Cast materials (iron)	846,897	1,475	10,778	856,200	1.3%
2631-032	Forged materials (iron)	461,929	4,116	899	458,712	0.2%
2649-011	Iron and steel shearing and slitting	1,332,384	0	0	1,332,384	0.0%
2649-099	Other iron or steel products	169,315	7,854	12,988	174,449	7.4%
	Total			424,601	17,981,455	2.4%
Basic nonferrous metals and related primary						
2711-011	Copper	308,090	66,243	47,095	288,942	16.3%
2711-021	Lead and Zinc (inc. regenerated lead)	178,343	6,870	13,925	185,398	7.5%
2711-031	Aluminum (inc. regenerated aluminum)	576,074	19,365	526,962	1,083,671	48.6%
2711-099	Other non-ferrous metals	623,614	100,414	829,346	1,352,546	61.3%
2712-011	Non-ferrous metal scrap	0	8,938	113,384	104,446	108.6%
2721-011	Electric wires and cables	1,006,850	176,455	227,733	1,058,128	21.5%
2721-021	Optical fiber cables	281,398	157,445	26,145	150,098	17.4%
2722-011	Rolled and drawn copper and copper alloys	491,410	147,241	27,500	371,669	7.4%
2722-021	Rolled and drawn aluminum	1,151,583	129,998	36,631	1,058,216	3.5%
2722-031	Non-ferrous metal castings and forgings	961,326	2,710	714	959,330	0.1%
2722-041	Nuclear fuels	210,954	0	4,706	215,660	2.2%
2722-099	Other non-ferrous metal products	432,460	125,779	117,256	423,937	27.7%
	Total			1,971,397	7,252,040	27.2%
Furniture						
1711-011	Wooden furniture and fixtures	1,249,247	35,980	262,043	1,475,310	17.8%
1711-031	Metallic furniture and fixtures	924,921	6,846	97,868	1,015,943	9.6%
	Total			359,911	2,491,252	14.4%
Footwear						
2319-011	Rubber footwear	52,622	720	135,847	187,749	72.4%
2319-021	Plastic footwear	123,841	1,833	113,940	235,948	48.3%
2411-011	Leather footwear	298,248	2,836	126,779	422,191	30.0%
	Total			376,566	845,888	44.5%
Hand tools and general hardware						
2899-033	Cutlery and tools	313,210	55,748	50,506	307,968	16.4%

Electrical machinery and apparatus						
3411-011	Generators	187,725	107,558	25,206	105,373	23.9%
3411-012	Electric motors	1,095,722	214,033	141,005	1,022,694	13.8%
3411-021	Relay switches and switchboards	3,033,969	699,551	145,322	2,479,740	5.9%
3411-031	Transformers and reactors	302,397	90,978	69,484	280,903	24.7%
3411-099	Other industrial heavy electrical equipment	873,042	387,549	238,411	723,904	32.9%
3421-011	Electric lighting fixtures and apparatus	841,979	62,786	57,630	836,823	6.9%
3421-021	Batteries	729,931	447,731	44,104	326,304	13.5%
3421-031	Electric bulbs	409,485	77,957	31,583	363,111	8.7%
3421-041	Wiring devices and supplies	640,508	263,446	109,798	486,860	22.6%
3421-051	Electrical equipment for internal combustion engines	1,974,300	175,458	17,196	1,816,038	0.9%
3421-099	Other electrical devices and parts	1,604,226	1,129,520	432,681	907,387	47.7%
	Total			1,312,420	9,349,136	14.0%
precision instrument						
3711-011	Camera	635,005	221,258	84,810	498,557	17.0%
3711-099	Other photographic and optical instruments	646,974	402,304	166,321	410,991	40.5%
3712-011	Watches and clocks	379,444	134,661	220,841	465,624	47.4%
3719-011	Professional and scientific instruments	103,676	3,007	202	100,871	0.2%
3719-021	Analytical instruments, testing machine, measuring instruments	1,402,414	350,488	243,877	1,295,803	18.8%
3719-031	Medical instruments	829,800	159,641	380,297	1,050,456	36.2%
				1,096,348	3,822,303	28.7%
sports and leisure goods						
3911-011	Toys	1,095,649	199,732	189,730	1,085,647	17.5%
3911-021	Sporting and athletic goods	494,919	46,180	195,762	644,501	30.4%
	Total			385,492	1,730,148	22.3%
Musical instrument						
3919-011	Musical instruments	253,051	83,071	44,372	214,352	20.7%
Rubber products						
2311-011	Tires and inner tubes	940,176	335,505	52,935	657,606	8.0%
2319-099	Other rubber products	1,718,573	192,330	70,309	1,596,552	4.4%
	Total			123,244	2,254,158	5.5%
General purpose machinery						
3011-011	Boilers	627,747	33,029	4,521	599,239	0.8%
3011-021	Turbines	650,651	220,962	117,209	546,898	21.4%
3011-031	Engines	1,210,394	227,005	24,121	1,007,510	2.4%
3012-011	Conveyors	1,158,608	168,442	29,953	1,020,119	2.9%
3013-011	Refrigerators and air conditioning apparatus	998,215	124,654	34,389	907,950	3.8%
3019-011	Pumps and compressors	1,936,469	484,810	123,178	1,574,837	7.8%
3019-021	Machinists' precision tools	844,472	270,063	51,135	625,544	8.2%
3019-099	Other general industrial machinery and equipment	2,096,944	323,929	79,915	1,852,930	4.3%
3031-011	Metal molds	1,604,471	171,583	33,696	1,466,584	2.3%
3031-021	Bearings	955,925	296,183	54,003	713,745	7.6%
3031-099	Other general machines and parts	1,059,472	244,777	97,826	912,521	10.7%
	Total			649,946	11,227,877	5.8%

Special purpose machinery						
3021-011	Mining, civil engineering and construction machinery	2,084,726	521,273	59,750	1,623,203	3.7%
3022-011	Chemical machinery	845,374	138,088	64,279	771,565	8.3%
3023-011	Industrial robots	767,809	346,474	3,199	424,534	0.8%
3024-011	Metal machine tools	1,775,504	459,601	59,065	1,374,968	4.3%
3024-021	Metal processing machinery	724,439	158,594	24,738	590,583	4.2%
3029-011	Agricultural machinery	582,392	26,335	21,846	577,903	3.8%
3029-021	Textile machinery	628,936	301,625	45,866	373,177	12.3%
3029-031	Food processing machinery	443,624	149,046	53,872	348,450	15.5%
3029-041	Semiconductor making equipment	1,528,604	883,806	221,628	866,426	25.6%
3029-091	Sawmill, wood working, veneer and plywood machinery	98,605	50,336	8,717	56,986	15.3%
3029-092	Pulp equipment and paper machinery	58,688	11,359	5,108	52,437	9.7%
3029-093	Printing, bookbinding and paperprocessing machinery	666,207	192,459	54,696	528,444	10.4%
3029-094	Casting equipment	108,550	24,301	4,448	88,697	5.0%
3029-095	Plastic processing machinery	531,486	179,152	19,596	371,930	5.3%
3029-099	Other special industrial machinery, n.e.c.	793,902	711,399	81,599	164,102	49.7%
	Total			728,407	8,213,406	8.9%
Radio, TV and communication equipment						
3211-011	Electric audio equipment	1,550,115	414,746	268,657	1,404,026	19.1%
3211-021	Radio and television sets	521,313	167,842	342,117	695,588	49.2%
3211-031	Video recording and playback equipment	1,358,655	969,999	123,909	512,565	24.2%
3212-011	Household electric appliances	3,173,171	171,250	193,755	3,195,676	6.1%
3311-011	Electric computing equipment (main parts)	5,147,097	454,177	860,055	5,552,975	15.5%
3311-021	Electric computing equipment (accessory equipment)	4,636,875	2,359,071	2,141,412	4,419,216	48.5%
3321-011	Wired communication equipment	1,641,502	185,222	280,407	1,736,687	16.1%
3321-021	Radio communication equipment	4,856,325	139,438	63,694	4,780,581	1.3%
3321-099	Other communication equipment	343,596	41,571	25,171	327,196	7.7%
3331-011	Applied electronic equipment	2,099,435	574,255	194,676	1,719,856	11.3%
3332-011	Electric measuring instruments	1,517,370	696,171	299,468	1,120,667	26.7%
3341-011	Semiconductor devices	1,207,751	849,583	180,883	539,051	33.6%
3341-012	Integrated circuits	5,329,455	2,889,775	2,014,388	4,454,068	45.2%
3359-011	Electron tubes	521,693	235,306	35,692	322,079	11.1%
3359-021	Liquid crystal devices	1,453,661	231,615	107,668	1,329,714	8.1%
3359-031	Magnetic tapes and discs	344,908	250,737	67,431	161,602	41.7%
3359-099	Other electronic components	9,205,994	1,853,006	582,918	7,935,906	7.3%
	Total			7,782,301	40,207,451	19.4%
transportation equipment						
3511-011	Passenger motor cars	12,157,018	5,671,791	789,914	7,275,141	10.9%
3521-011	Trucks, buses and other cars	2,453,242	729,918	16,775	1,740,099	1.0%
3531-011	Two-wheel motor vehicles	629,180	528,914	27,439	127,705	21.5%
3541-011	Motor vehicle bodies	1,857,133	12,305	11,783	1,856,611	0.6%
3541-021	Internal combustion engines for motor vehicles and parts	4,839,142	926,340	94,391	4,007,193	2.4%
3541-031	Motor vehicle parts and accessories	16,162,719	1,939,470	277,080	14,500,329	1.9%
3611-011	Steel ships	1,312,886	1,075,614	6,480	243,752	2.7%
3611-021	Ships except steel ships	32,203	14,207	13,237	31,233	42.4%
3611-031	Internal combustion engines for vessels	526,330	142,135	4,858	389,053	1.2%
3611-101	Repair of ships	233,707	45,247	20,340	208,800	9.7%
3621-011	Rolling stock	380,978	39,575	8,624	350,027	2.5%
3621-101	Repair of rolling stock	430,108	0	0	430,108	0.0%
3622-011	Aircrafts	673,788	235,684	549,577	987,681	55.6%
3622-101	Repair of aircrafts	184,704	8,201	12	176,515	0.0%
3629-011	Bicycles	218,098	55,973	65,093	227,218	28.6%
3629-091	Transport equipment for industrial use	520,075	114,993	5,644	410,726	1.4%
3629-099	Other transport equipment, n.e.c.	147,183	236	1,150	148,097	0.8%
	Total			1,892,397	33,110,288	5.7%
Apparel						
1521-011	Woven fabric apparel	2,054,973	14,724	1,152,505	3,192,754	36.1%
1521-021	Knitted apparel	985,354	14,495	1,017,295	1,988,154	51.2%
1522-099	Other wearing apparel and clothing accessories	185,998	9,186	250,276	427,088	58.6%
1529-011	Bedding	187,323	2,169	120,311	305,465	39.4%
1529-099	Other ready-made textile products	369,680	8,012	141,750	503,418	28.2%
	Total			2,682,137	6,416,880	41.8%

Source: The 2000 input-output tables based on the 1995 ones reported by the Ministry of Economy, Trade and Industry (in million yen)