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Exchange Rate Changes and Japanese Exports of Selected Industries

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I. Introduction

This paper presents the results of an empirical investigation of the impact of exchange rate variation on the exports of three major Japanese industries--motor vehicles, consumer electronics, and iron and steel. The study is conducted at a disaggregated product level, with the following five major Japanese exports chosen for analysis: subcompact passenger cars, color televisions, galvanized steel sheet, heavy steel plate, and tin plate.

Determining the extent to which the exchange rate influences trade flows is especially relevant in the Japanese context. One motivation for the adoption of various types of protectionist measures by some of Japan's major trading partners may be doubts as to the efficiency of the exchange rate as a tool for achieving adjustment in Japan's trade account. During the 1976-78 period, in particular, while Japan's real effective exchange rate appreciated by 24 percent, the surplus on merchandise trade grew from $2.4 billion in 1976 to $9.7 billion in 1977, to $18.2 billion in 1978. 2/ In 1979, Japan's trade balance finally deteriorated, registering a deficit of $7.6 billion, while its real effective exchange rate depreciated by 22 percent.

Assuming comparable rates of technological progress and of foreign and domestic inflation, the magnitude of the exchange rate impact on exports depends on the extent to which an exchange rate change is passed

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2/ IMF, International Financial Statistics Yearbook (1982); Japan, Ministry of Finance, Balance of Payments Statistics. The real effective exchange rate utilized here is that based on wholesale price indices.

through to foreign currency export prices and on the subsequent response of export volumes to such price changes. In recent years, increasing attention has been devoted to estimating the adjustment of export prices and volumes over the short run as well as over the long run. Traded goods' volumes have been found to adjust less rapidly than prices, leading to perverse short-run movements in merchandise trade balances following an exchange rate change, or so-called "J-curves." 1/ Thus, the analysis contained in this paper places emphasis on the explicit measurement of the time lags involved in the response of export prices and volumes to exchange rate variation.

Among others, researchers at Japan's Economic Planning Agency (EPA) have devoted considerable attention to Japan's trade adjustment problems during the late 1970s. 2/ Utilizing the Agency's quarterly macroeconomic model, with revision of the export and import equations to account for lags in adjustment, various simulation exercises were conducted within a general equilibrium framework to estimate the effects of exchange rate change on various aspects of the Japanese economy. Their results indicate perverse short-run impacts of changes in the yen exchange rate during the period. For example, in fiscal year 1977/78 (April 1977 to March 1978), during which Japan's nominal effective exchange rate appreciated by an estimated 22 percent and its real effective exchange rate appreciated by an estimated 13 percent, 3/ "J-curve" effects were estimated to have resulted in a $3.2 billion increase in Japan's trade balance. 4/ The estimated positive impact amounts to roughly one third of the $9.7 billion increase in Japan's trade surplus in 1977/78 over that of the previous year.

While the EPA analysis incorporated lags in adjustment of Japan's exports and imports to exchange rate changes, Wilson and Takacs (1980) took the analysis one step further by estimating the impact of exchange rate expectations, or leads in adjustment, on the behavior of Japanese trade flows. Namely, Wilson and Takacs estimated the extent to which expectations of appreciation of the yen exchange rate may have led to an export acceleration and import deceleration phenomenon that exacerbated the perverse movement of the Japanese trade balance during the late 1970s. Their results were rather striking: the estimated J-curve for Japan's trade balance continued to move in a perverse direction for several quarters subsequent to an exchange rate change, and in addition, for most of the adjustment period, implied a considerably larger perverse movement than that implied by a J-curve which they estimated incorporated only lags in adjustment. Such a result suggests that during the 1977-79 period, expectations of further yen appreciation gave rise to a series of perverse movements in the trade balance due to

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1/ See, e.g., Branson (1972) and Magee (1973).
2/ See Komine (1978) and Economic Planning Agency (1978).
3/ IMF, International Financial Statistics.
4/ Economic Planning Agency (1979), p. 393.

anticipatory behavior of traders, that overwhelmed the adjustment of trade flows to past exchange rate changes. Following the approach of Wilson and Takacs, the analysis contained in this paper thus also incorporates the impact of expectations of relative export prices on the demand for Japan's exports.

As mentioned previously, this paper examines the response of Japanese exports to changes in the yen exchange rate at a highly disaggregated level, looking at specific major export products. From a theoretical viewpoint, empirical analysis on a disaggregate basis avoids the aggregation problem of biased elasticity estimates made famous by Orcutt. 1/ For example, since the response of export prices to exchange rate changes varies across industries due to differential preferences on the part of suppliers with regard to maintaining prices that are in line with those of foreign competitors, estimation of aggregate demand equations implies biased estimates. Furthermore, tensions between Japan and her trading partners have tended to focus on specific industries, e.g., steel in the late 1970s, and automobiles, electronic equipment and machine tools in the 1980s. The products selected for analysis are subcompact passenger cars, color televisions, and three in the steel industry: heavy plate, tin plate and galvanized steel sheet. The exports of the Japanese motor vehicles, consumer electronics, and iron and steel industries accounted for 34 percent of the U.S. dollar value of Japan's total exports during the 1975-79 period, and in addition, have all been involved in recent disputes between Japan and her trading partners.

Simultaneous equations models of supply and demand for both exports and domestic sales of each product considered are estimated. The theoretical model specifies the following dynamic elements in the adjustment process: the extent to which an exchange rate change is passed through to foreign currency export prices over time; leads and lags in the response of export orders to relative export price changes; and delivery lags between orders and shipments. Although the analysis does take into account the indirect impact of exchange rate shifts on export prices through changes in prices of imported raw materials, the study is partial equilibrium in nature in the sense that foreign prices, wages, inventory accumulation, and the exchange rate are treated as exogenous. 2/

1/ See Orcutt (1950), Learner and Stern (1970), and Magee (1975).

2/ Given the unique characteristics of the Japanese labor market and the tendency for wage increases to be linked to firm profitability, and the observed flexibility in real wages in Japan, the assumption of exogenous wages may not be overly restrictive. See Komiya and Suzuki (1977) and Shinkai (1981). In addition, wages account for a small proportion of total variable costs for all of the sample products, as indicated by input-output coefficients (see Appendix).

II. The Theoretical Model

This section presents the basic theoretical model of demand for and supply of exports and domestic sales underlying the empirical analysis presented in the paper. Additional product-specific variables included in the estimation procedure are discussed in the discussion of the estimation results. The demand side of the model consists of four equations. For both exports and domestic sales, the model specifies a demand equation that determines factory orders and an equation that specifies actual shipments as a function of current and past orders.

Export orders are specified in real terms as a log-linear function of foreign income, the relative price of exports, and a nonprice rationing variable. 1/ Nonprice rationing is incorporated on the assumption that since quoted prices may be relatively sticky in the short run, goods markets are also cleared by variables such as changes in delivery dates, length of queues, or credit terms. Since nonprice rationing is essentially a cyclical variable, it is represented by the ratio of inventories to total (export and domestic) orders. 2/ In addition, past values of foreign income and the relative export price are included since recognition and other lags may delay the response of export orders to changes in these factors, and expected relative export prices are included to account for the impact of price and exchange rate expectations on current export demand. The volume of export orders (XO) at time t is therefore specified as follows:

$$\ln(XO)_t = a_o + \sum_{i=0}^{m} a_{1i}\ln(YF)_{t-i} + \sum_{i=-k}^{n} a_{2i}\ln(PX/R\cdot PF)_{t-i} + a_3\ln_3(IO)_t \quad (1)$$

where: YF = foreign activity (in real terms)

PX = the contract export price in domestic currency

1/ Demand theory provides little guidance on the appropriate functional form. The choice is thus essentially an empirical one, and the log-linear formulation is adopted based on work by Khan and Ross (1977).

2/ See Gregory (1971), for an extensive treatment of the impact of nonprice elements on trade flows. Gregory considers only the impact of domestic nonprice rationing on import demand, but the same arguments may be used for including a domestic cyclical variable in the export demand equation; see also Ahluwalia and Hernandez-Cata (1975), and Hooper (1976).

R = the yen per foreign currency effective exchange rate weighted according to export market shares

PF = the weighted average foreign price, with weights as for the exchange rate (R).

IO = the ratio of inventories to total orders volume

Equation (1) takes account of adjustment lags in explaining export demand. Actual export shipments, however, represent a flow of goods generated by orders placed at some time in the past. Assuming a constant delivery lag structure, the volume of export shipments (QX) is specified according to the following linear relationship: 1/

$$QX_t = \sum_{i=o}^{n_1} b_i XO_{t-i} \qquad (2)$$

where: $\Sigma b_i = 1$, and

b_i = the share of export orders at time (t-i) shipped at time t

Domestic orders (DO) and shipments (QD) are derived analogously and specified (with time subscripts deleted) as follows:

$$\ln(DO) = c_o + \Sigma c_{1i} \ln(YD) + \Sigma c_{2i} \ln(RPD) + c_3 \ln(IO) \qquad (3)$$

$$\text{and } QD = \Sigma d_i \, DO \qquad (4)$$

where: $\Sigma d_i = 1$

1/ The shipments equation should not be specified in log-linear form since, as orders fluctuate over time, the relative shares of current and past orders in current shipments will also vary. In addition, the vector of delivery lag coefficients (the b_is) should vary over time, e.g., as a function of the ratio of unfilled orders to current production. Such variations are not considered here; see Hooper (1976), Ahluwalia and Hernandez-Cata (1975) and Artus (1974) for a similar treatment of delivery lags in the determination of shipments and unit values of trade flows.

YD = domestic activity (in real terms)

RPD = the relative domestic price, defined as the domestic price of the good relative to competing domestic prices 1/

The supply side of the model is developed within the context of a firm that discriminates between its export and domestic markets. The derivation proceeds as follows for both export and domestic sales. First, the optimal short-run price is derived from the theory of a firm that maximizes profits subject to a short-run production function; as the model considers adjustment in the short to medium term, the stock of capital is regarded as fixed. Second, the optimal adjustment path for contract prices is determined by incorporating certain longer-run considerations in addition to short-run profits. Third, the above steps are integrated to yield an equation for the actual contract price.

Maximizing total profits from both exports and domestic sales subject to a production function yields the familiar first order condition that sets the optimal short-run export price (PX*) equal to a markup over marginal cost as follows:

$$PX^* = (1 + 1/NX)^{-1} MC \tag{5}$$

where: NX = the price elasticity of export demand

MC = the marginal cost of production

The vintage capital production function of de Menil (1974) is utilized to determine short-run marginal cost. Under this vintage capital model, machines of different vintage are each assumed to have a fixed coefficient production function given by:

$$Q_v = \min \left(\frac{L_v^{a_1} \cdot RM_v^{a_2}}{be^{-r_1 v - r_2 t}} , \frac{K_v}{c} \right) \tag{6}$$

1/ Import prices are not included in the domestic orders equation, since imports into Japan are small for the products considered in this paper.

where: Q_v = the output from capital of vintage v

K_v = the amount of capital of vintage v in operation

L_v = the amount of labor employed by capital of vintage v

RM_v = the amount of raw materials employed by capital of vintage v

Labor and raw materials are combined by a Cobb-Douglas process into a composite variable input, with the assumption of constant returns to scale, i.e., $a_1 + a_2 = 1$. Embodied technical change raises the efficiency of new machines at the rate of r_1, and disembodied technical change raises the efficiency of all machines at the rate of r_2.

Short-run marginal cost is derived by noting that marginal cost for the firm is equal to the marginal cost of production on the oldest machine in operation, and is given by the following expression: 1/

$$MC = be^{-(r_1 v' + r_2 t)} \left(\frac{W}{a_1}\right)^{a_1} \left(\frac{PRM}{a_2}\right)^{a_2} \tag{7}$$

where: W = the wage rate

PRM = the price of raw materials

v' = the vintage of the oldest machine in operation

Replacing v' by (t - U), where U is the age of the oldest machine in operation, and substituting equation (7) into equation (5), the optimal short-run export price is written according to the following log-linear expression:

$$\ln(PX^*) = B - (r_1 + r_2)t + r_1 U + a_1 \ln(W) + a_2 \ln(PRM) \tag{8}$$

where: $B = \ln[(1 + (1 + \frac{1}{NX})^{-1} (\frac{1}{a_1})^{a_1} (\frac{1}{a_2})^{a_2} b]$

1/ See de Menil (1974), p. 132, for a full derivation of the marginal cost function.

The second stage of the derivation of the export price involves the determination of its optimal adjustment path in domestic currency. The contract export price may deviate from the short-run optimum due to a number of factors. Prices in domestic currency may be sticky due to administrative costs of frequent price changes or general uncertainty as to the reactions of either buyers or competitors to price changes. Firms exporting goods in competitive markets or those with a strong preference for maintaining or expanding market shares will be inclined, if necessary, to sacrifice short-term profits in order to stay in line with prices of competitors. In addition, firms may be willing to cut prices in order to smooth out fluctuations in levels of inventories or in rates of capacity utilization, especially those with a relatively high proportion of fixed costs.

The contract export price is assumed to be set so as to achieve the best possible compromise between the short-run profit maximization target and the additional considerations noted above. The contract export price (PX) at time t is determined by minimizing the total cost that results from not meeting all targets simultaneously, i.e., by minimizing the following quadratic loss function: 1/

$$L = \ell_1[\ln(PX/PX^*)]^2 + \ell_2[\ln(PX/PX_{-1})]^2 + \ell_3[\ln(QX/R\ PF)]^2$$

$$+ \sum_{i=1}^{k} \ell_{4i}[\ln(\frac{PX/PX_{-i}}{R\cdot PF/R_{-i}PF_{-i}})]^2 + \ell_5[\ln(IO)]^2 \qquad (9)$$

where L is the total loss subjectively perceived by suppliers. ℓ_1 is the loss coefficient associated with deviating from the short-run optimum, and ℓ_2 is that associated with not maintaining price stability. The loss related to the price competitiveness target is split into two elements-- ℓ_3 determines the loss that results from deviating from the competing foreign price in terms of its <u>level</u>, and the ℓ_{4i} are the loss coefficients on price <u>changes</u> over various time horizons that differ from those of competitors. The first coefficient measures the desire of firms to stay in with competing prices in the long run; the second set of coefficients determines losses associated with short-run relative

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1/ Although this approach is rather ad hoc, a rigorous formulation of adjustment path of the contract price may be extremely complex due to the conflicting nature of the various goals and the fact that the latter considerations are motivated by entrepreneurial preferences not easily measured in terms of traditional economic variables. The approach is motivated by similar formulations found in Artus (1974) and Ahluwalia and Hernandez-Cata (1975).

price changes, and thus, K is finite and assumed to be small. Finally, ℓ_5 determines the loss resulting from fluctuation in real activity, which is assumed related to the ratio of inventories to total orders.

Minimizing the loss function (10) with respect to PX, the contract export price, while assuming a constant short-run export price elasticity of the inventory-orders ratio ($N_{IO,PX}$), we obtain:

$$\ln(PX) = m_1 \ln(PX^*) + m_2 \ln(PX)_{-1} + m_3 \ln(R \cdot PF) + \sum_{i=1}^{k} m_{4i} \ln\left(\frac{R \cdot PF \cdot PX_{-i}}{R_{-i} PF_{-i}}\right) + m_5 \ln(IO) \qquad (10)$$

where:

$$m_1 = \ell_1 / S,$$
$$m_2 = \ell_2 / S,$$
$$m_3 = \ell_3 / S,$$
$$m_{4i} = \ell_{4i} / S,$$
$$m_5 = - \ell_5 N_{IO,PX} / S, \text{ and}$$
$$S = \ell_1 + \ell_2 + \ell_3 + \Sigma \ell_{4i}$$

The equation determining the contract export price is now obtained by substituting equation (9) into equation (11) and combining terms:

$$\ln(PX) = g_o + g_1 t + g_2 U + g_3 \ln(W) + g_4 \ln(PRM) + g_5 \ln(PX_{-1}) + g_6 \ln(R\ PF) + \Sigma g_{7i} \ln(PX/R\ PF)_{-i} + g_8 \ln(IO) \qquad (11)$$

The domestic contract price equation is derived according to an identical procedure. In determining the adjustment path of the domestic price, it is assumed that firms on the domestic market achieve the best possible compromise between short-run profits, price stability and "cyclical smoothness." Given the limited extent of import penetration into the Japanese markets of the products sampled in this paper, the maintenance of competitiveness relative to imports is not considered. The domestic contract price (PD) is thus specified as follows:

$$\ln(PD) = h_o + h_1 t + h_2 U + h_3 \ln(W) + h_4 \ln(PRM) + h_5 \ln(PD)_{-1} + h_6 \ln(IO) \qquad (12)$$

The theoretical model utilized as a basis for the empirical analysis contained in this note is now complete. It consists of equations for the volumes of export orders and shipments, (1) and (2); the volumes of domestic orders and shipments, (3) and (4); the contract export price (12); and the contract domestic price (13).

III. Estimation Results

This section presents the results obtained by applying the theoretical model presented above to the estimation of prices and quantities (domestic and export) of Japanese subcompact passenger cars, color televisions, galvanized steel sheet, heavy steel plate, and tin plate. 1/ Separate orders and shipments equations are estimated only for heavy steel and tin plate, due to a lack of adequate data for the other three products. In addition to the variables specified in the basic model, explanatory variables relevant to specific products are also included in the analysis. The price of gasoline relative to other consumer items (in the United States) is included in the demand equation for subcompact automobile exports to take account of the dramatic shift in consumer preferences toward Japanese cars, particularly in the United States, as a result of the oil price increases during the 1970s. Dummy variables are employed to account for export restraint agreements during the sample period with respect to color televisions and steel products. The expected relative export price proxies are created by utilizing ARIMA time-series techniques to generate separate forecasts for export prices, foreign prices, and exchange rates.

The structural model of simultaneous supply and demand, also including lagged endogenous variables, is estimated according to an

1/ A detailed description of the data employed may be found below in the Appendix.

iterative estimation procedure appropriate for such systems. 1/ Statistical estimation is based on monthly data over the 1970-79 period, and thus, while the theoretical relationships of the model would be appropriate in any current applications, the estimates of its behavioral parameters are strictly applicable only to the 1970-79 sample period.

Regression results for the export equations are presented in Table 1. 2/ The model performs quite well, as indicated by the R^2 calculated with respect to the original data, i.e., that prior to transformation to account for serial correlation. In addition, the estimated coefficients of the explanatory variables included in the simultaneous equations estimation procedure all have the expected signs.

Looking first at the export demand equations, the distributed lag structure on foreign income is statistically significant at the 5 percent level for only two of the five products considered, i.e., heavy plate and galvanized steel sheet. 3/ Further analysis suggests that the insignificance of the distributed lags for the other three products reflects an even quicker response of export demand with respect to changes in foreign income than specified. Regressions that include only current foreign income and foreign income lagged one month result in a significant estimated coefficient on foreign income for subcompacts and tin plate, and on lagged foreign income for color televisions.

Relative export prices are significant at the 5 percent level only in the subcompact and color television export demand equations; they are significant, however, at the 15 percent level for heavy plate and tin plate export demand. The nonprice rationing variable (the inventory-sales ratio) is significant for all but one product, subcompact passenger cars; it is particularly significant with a large estimated coefficient for the three steel products, suggesting the initiation of so-called "export drives" during times of weak domestic demand.

1/ The presence of lagged endogenous variables coupled with the expectation of serial correlation, reflecting estimation over monthly time series, implies that the usual two-stage or three-stage least squares estimation techniques are inconsistent. Estimation is therefore conducted by applying an iterative modification of a two-step procedure developed for such models by Hatanaka (1976). Incorporated into the procedure is the estimation of distributed lag structures according to the method derived by Shiller (1973).

2/ Due to the relatively complex estimation methodology, preliminary regressions were run utilizing single equation techniques to determine lag lengths and whether or not to include certain variables in the final estimation.

3/ t-statistics do not have their usual interpretation for the distributed lag coefficients estimated according to the Shiller lag method, a Bayesian procedure that imposes prior constraints on the shape of lag structures. Thus, the statistical significance of the various lag structures are tested by calculating appropriate F-statistics for their group influence.

Table 1. Japan: Regression Estimates: Export Volume and Price Equations 1/

1. Export shipment volume (QX)	XO--lag length (in months)	R^2 2/
Heavy plate	1--5	0.729
Tin plate	1--5	0.560

2. Export demand	ln(PGAS)	ln(IO)	ln(YF)--lagged terms	$\ln(RPX)^e$ 3/	ln(RPX)--lagged terms	R^2 2/
Subcompact cars (lnXS)	1.32 (5.81)	0.04 (0.77)	0.97--2	0.10	-2.80***--18 4/	0.936
Color television (lnXS)		0.16 (1.78)	0.79--2	-0.78	-2.18**--13 4/	0.915
Galvanized steel (lnXS)		0.22 (3.57)	1.73***--2	0.001	-1.06--10	0.861
Heavy plate (lnXO)		0.61 (3.08)	0.94***--2	-0.13	-0.65--4	0.823
Tin plate (lnXO)		0.94 (3.34)	0.36--2	1.15	-2.65--15	0.466

3. Export price (lnPX)	ln(VCOST)	ln(IO)	ln(PF·R)	$\ln(PX/PF\cdot R)_{-1}$	$\ln(PX/PR\cdot R)_{-2}$	$\ln(PX)_{-1}$	R^2
Subcompact cars	0.15 (3.95)	-0.016 (-3.79)	0.43*** 5/	0.23*** 5/	0.071*** 5/	0.42 (6.32)	0.990
Color television	0.14 (3.61)		0.66*** 5/	0.38*** 5/	0.22*** 5/	0.20 (3.77)	0.980
Galvanized steel sheet	0.070 (1.80)	-0.027 (-2.50)	0.47*** 5/	0.28*** 5/	0.17*** 5/	0.46 (4.49)	0.990
Heavy plate	0.46 (4.88)		0.54*** 5/	0.29*** 5/	0.13*** 5/		0.987
Tin plate	0.023 (1.23)		0.47*** 5/	0.26*** 5/	0.077*** 5/	0.50 (5.78)	0.990

Note: QX = export shiptments (real); XO = export orders (real); PGAS = relative price of gasoline (in U.S.);
IO = Inventory-orders or inventory-sales ratio; YF = foreign income; RPX^e = expected relative export price;
RPX = PX/PF R relative export price;
PX = contract export price (in yen); VCOST = variable input cost;
PF = foreign price.

1/ Coefficient estimates for the constant and various dummy variable terms are omitted. For variables with lagged terms, the sums of estimated coefficients are presented. Estimation procedure corrected for first-order serial correlation. t-statistics are in parentheses. ** denotes F-statistics for distributed lag structure significant at the 5 percent level; *** denotes F-statistics significant at the 1 percent level.

2/ The R^2 are calculated on the original data, i.e., that prior to transformation to correct for serial correlation.

3/ The time horizon for relative export price expectations was assumed to be three months for all products.

4/ Significance level of F-statistics for distributed lag structure including the expected relative price terms.

5/ Significance level of F-statistics for the distributed lag structure related to foreign competing prices.

Table 2 presents the structural equation effects of various factors on export volumes and prices in the long run. 1/ Export demand is estimated to be quite responsive to relative price changes for subcompacts and color televisions, but relatively price inelastic for the three steel products. The results shown in parts A and B of Table 2 indicate that export shipments are estimated to adjust to a relative price change with a lag ranging from 9 months for heavy plate to 20 months for tin plate.

Relative price expectations are estimated to have a strong impact on the export demand for tin plate and for color televisions. The elasticity of tin plate export orders with respect to expected relative export prices, i.e., the sum of the estimated coefficients on the relative price expectations variables, is estimated to amount to 1.15. This implies a considerable initial increase (decrease) in export demand for tin plate subsequent to a rise (fall) in relative export prices, due to anticipations of further price increases (decreases) in the near future. For color televisions, on the other hand, the estimated price expectations elasticity of export demand is equal to -0.78, indicating an initial fall (rise) in foreign demand following an effective appreciation (depreciation), reflecting expectations of a reversal in relative prices in the future. During the 1970-79 sample period, when there was a trend appreciation of the yen exchange rate, one would hope that expectations would have had a temporary positive impact on export demand; in fact, such an impact was found to be an important effect of exchange rate changes on total Japanese exports during 1972-78 by Wilson and Takacs (1980). The opposite result obtained in the case of exports of color televisions could reflect the competitive nature of the North American market during the 1970s, where customers expected that exchange rate changes soon would be offset by cost-cutting or quality-improving technological advances by Japanese suppliers.

With regard to the export price equations, the lag structures related to competing foreign prices, the lagged export price (representing the price stability target), and the price of variable inputs are all significant at the 5 percent level with the exception of the lagged export price for heavy plate (insignificant and not included) and

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1/ These effects are based on single equation results and do not take account of the simultaneity of the model. Due to the nonlinear nature of the specified model, in-sample simulation of the estimated model is required in order to calculate the simultaneous effects of changes in exogenous variables. The presence of the inventory sales ratio as an explanatory variable makes the model nonlinear in logarithms and prevents a reduced-form solution. Thus, reduced-form elasticities may not be calculated.

Table 2. Japan: Long-Run Effects of Selected Factors on Japanese Export Volumes and Prices--Structural Equation Estimates

A. Export shipment sequations

	Export orders	
	Long-run elasticity 1/	Adjustment period 2/
Heavy plate	1	5
Tin plate	1	5

B. Export demand equations

	Relative export price (including expected)	
	Long-run elasticity 3/	Adjustment period 2/
Passenger cars	-2.70**	18
Color televisions	-2.96**	13
Galvanized sheet	-1.06	10
Heavy plate	-0.78	4
Tin plate	-1.51	15

C. Contract export price equations

	Foreign competing prices (PF·R)	
	Long-run elasticity	Adjustment period 2/
Passenger cars	0.47**	4
Color televisions	0.30**	26
Galvanized sheet	0.21	36 4/
Heavy plate	0.20*	6
Tin plate	0.85**	23

Note: Asterisk (*) indicates an elasticity significantly different from zero at the 10 percent confidence level. Double asterisk (**) indicates significance at the 5 percent level.

1/ The cumulative elasticity of shipments with respect to orders was constrained to be equal to 1.

2/ In months.

3/ Sum of the structural coefficients of relative export prices.

4/ Cumulative elasticity estimate within 1 percent of long-run solution.

the price of variable inputs for tin plate (significant at the 11 percent level). 1/ The export price seems to respond to cyclical conditions in the case of subcompact autos and galvanized steel sheet; vintage of the capital stock is not estimated to significantly affect the export price of any product.

Reflecting the significance of the competing price and lagged export price variables, the estimation results indicate that contract export prices can deviate significantly from levels based purely on profit-maximizing considerations. In the short-run, export prices in domestic currency are estimated to respond to changes in foreign prices for all products, implying that exchange rate changes are not fully passed through to foreign currency prices. The results suggest that exchange rate changes may not be fully passed through in the long run as well. The estimated long-run foreign price (or exchange rate) elasticity of the contract export price in yen terms ranges from 0.85 (for tin plate) to 0.20 (for heavy plate), i.e., the pass-through estimates range, correspondingly, between 15 percent and 80 percent. The long-run elasticity estimates are all significantly different from zero except in the case of galvanized steel sheet. 2/ The adjustment period is estimated as relatively short for subcompacts and heavy plate, and quite long for color televisions, galvanized sheet and tin plate, although a substantial portion of the adjustment for the latter group is estimated to occur within 12 months.

IV. Simulation Results

In order to account for model simultaneity, the impact of a hypothetical 10 percent appreciation of the yen is simulated for each product over the period 1977-79. 3/ The simulation exercise also incorporates estimates of the indirect impact of appreciation on contract

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1/ Wages and raw material prices are combined into a single variable cost term according to input-output weights in order to overcome multicollinearity problems encountered in the estimation process. See Appendix.

2/ The estimated variances of the long-run elasticity estimates are calculated according to equation (11.40), Kmenta (1971), p. 444.

3/ Simulations are run on the estimated models according to two constant exchange rates over 1977-79, one at the December 1976 level and the other at a level 10 percent higher, with the results then compared to determine the impact of appreciation.

export prices due to changes in raw materials costs. 1/ The simulated exchange rate effects over time are presented in Table 3. The adjustment of prices and volumes may be viewed as virtually complete within a three-year period subsequent to the hypothetical 10 percent appreciation in January 1977.

The results of full model simulation indicate once again that exchange rate changes are partially offset by movements in export prices in domestic currency terms and, therefore, are not fully reflected in prices in foreign markets. The extent to which the domestic currency price is estimated to decline during the three-year period following a 10 percent appreciation ranges from a high of 8.0 percent for tin plate to 3.4 percent for heavy plate. The simulated decreases in export prices (in yen terms) are greater than those based on the structural coefficient estimates which are implied by Part C of Table 2; the difference almost totally reflects the fall in raw materials prices following an appreciation. 2/ The offsetting impact of lower raw materials costs on export prices is most significant for heavy plate and for galvanized steel sheet, reflecting the importance of imported inputs in Japan's steel industry coupled with a large estimated coefficient on the variable input cost term in the export price equation.

A relatively rapid adjustment of the export price toward its long-run position is simulated for all products; the adjustment occurs almost immediately for subcompacts and heavy plate. However, the products are split into two groups with respect to whether or not the domestic currency price response increases or decreases over time. For color televisions, heavy plate and galvanized steel sheet, the fall in contract export price in yen terms decreases over time, reflecting increasing pressure to move back toward a profit-maximizing price. For subcompacts and, in particular, tin plate, however, the price declines continuously with time. In the case of subcompacts, the slight further increase in the price response largely reflects the lagged response of lower raw materials prices to appreciation. The adjustment path for tin plate reflects slow adjustment from the pre-appreciation price due to a large estimated coefficient on the lagged export price; this price

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1/ Employing coefficients from Japan's 1975 Input-Output Table, the Economic Planning Agency estimated the exchange rate elasticity of raw materials prices at a sectoral level; the relevant estimates are transport equipment--(0.09), electrical equipment--(0.12), and iron and steel products--(0.23) (see Economic Planning Agency, 1978). The variable input cost terms are adjusted according to these estimates, with the adjustment period assumed to be three months.

2/ For subcompact cars and galvanized steel sheet, the significant cyclical variable in the export price equation has an additional, albeit marginal, negative impact.

Table 3. Japan: Simulated Cumulative Impact of 10 Percent Yen Appreciation in January 1977 on Prices and Volumes of Japanese Exports, 1977-79

(In percent)

Monthly Period	Contract Export Prices (in yen)	Export Orders	Export Shipments
		Subcompact passenger cars	
January 1977	-4.1	...	0.6
April	-4.7	...	-0.2
July	-4.8	...	-2.1
October	-4.8	...	-5.3
January 1978	-4.9	...	-8.8
April	-5.0	...	-11.1
July	-5.0	...	-11.6
October	-5.0	...	-11.4
January 1979	-5.1	...	-11.1
April	-5.1	...	-11.0
July	-5.1	...	-10.9
October	-5.2	...	-10.8
December 1979	-5.2		-10.8
		Color televisions	
January 1977	-6.1	...	-5.0
April	-5.3	...	-4.8
July	-4.6	...	-8.1
October	-4.1	...	-10.8
January 1978	-3.9	...	-12.7
April	-3.7	...	-13.5
July	-3.6	...	-13.8
October	-3.6	...	-14.2
January 1979	-3.6	...	-14.4
April	-3.5	...	-14.6
July	-3.5	...	-14.4
October	-3.5	...	-14.5
December 1979	-3.5	...	-14.7
		Galvanized steel sheet	
January 1977	-4.4	...	-0.6
April	-4.8	...	-2.3
July	-4.6	...	-3.7
October	-4.5	...	-4.4
January 1978	-4.4	...	-4.8
April	-4.3	...	-4.8
July	-4.2	...	-4.9
October	-4.2	...	-5.0
January 1979	-4.1	...	-5.2
April	-4.1	...	-5.1
July	-4.1	...	-5.2
October	-4.1	...	-5.2
December 1979	-4.1	...	-5.1

Table 3. Japan: Simulated Cumulative Impact of 10 Percent Yen Appreciation in January 1977 on Prices and Volumes of Japanese Exports, 1977-79 (concluded)

(In percent)

Monthly Period	Contract Export Prices (in yen)	Export Orders	Export Shipments
	Heavy plate		
January 1977	-5.3	-1.6	-0.1
April	-3.8	-3.8	-1.9
July	-3.4	-4.4	-3.9
October	-3.4	-4.9	-4.6
January 1978	-3.4	-5.1	-5.0
April	-3.4	-5.2	-5.2
July	-3.4	-5.4	-5.3
October	-3.4	-5.5	-5.4
January 1979	-3.4	-5.7	-5.6
April	-3.4	-5.8	-5.7
July	-3.4	-6.1	-5.9
October	-3.4	-6.2	-6.1
December 1979	-3.4	-6.4	-6.2
	Tin plate		
January 1977	-4.4	5.5	0.7
April	-6.1	0.6	1.5
July	-6.8	-1.7	-0.1
October	-7.3	-3.6	-2.1
January 1978	-7.6	-4.2	-3.6
April	-7.7	-3.4	-3.8
July	-7.9	-2.7	-3.2
October	-7.9	-2.3	-2.7
January 1979	-8.0	-2.1	-2.3
April	-8.0	-1.9	-2.1
July	-8.0	-1.9	-1.9
October	-8.0	-1.7	-1.8
December 1979	-8.0	-1.7	-1.8

stickiness in turn may be due to strong supplier preference for minimizing price fluctuation so as to reduce administrative costs or prevent the loss of goodwill among customers.

A 10 percent appreciation results in considerable declines in export volumes of subcompacts (10.8 percent) and of color televisions (14.7 percent). Exports of the three steel products on the other hand, are quite inelastic with respect to the exchange rate; the estimated volume decline amounts to 6 percent or less. For all items, the exchange rate responsiveness of export volumes is substantially lower than that indicated by the estimated structural relative price elasticities, due primarily to appreciation not being fully passed through to foreign currency export prices.

The simulations indicate that export volumes adjust to appreciation with a considerable lag. Nevertheless, over three quarters of the response of shipments occurs during the first year for all five products. With the exception of tin plate exports, volumes are largely observed to gradually decline toward long-run levels. For tin plate, however, the results indicate a considerable positive response of volumes in the short run; this unusual movement reflects the estimated strong positive impact of exchange rate expectations on export orders. 1/

A stronger yen is estimated to have a dampening long-run impact on the value of exports in foreign currency for two of the five products in the sample, subcompacts and color televisions (Table 4). For these two items, export value is estimated to adjust downward as the decline in volume in the long run is large enough to exceed the increase in the foreign currency price. With respect to the three steel products, however, yen appreciation is estimated to result in small positive movements of export value in the long run; this counterintuitive result reflects inelastic price responsiveness of demand.

The dynamic response of export values over the adjustment period may not be precisely calculated for all products, since the lack of orders data for some items prevents estimation of the dynamic response of unit values. 2/ Nevertheless, the results indicate the presence of significant "J-curve" effects. In addition to an increase in the value of exports of the three steel products throughout the adjustment period,

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1/ Demand rises initially due to expectations of further appreciation in the near future.

2/ Export unit value at time of delivery is a function of the order-delivery lag structure, the currency denomination of trade contracts, and exchange rate changes between order and delivery. See, e.g., Artus (1974).

the slow response of export volumes while contract export prices increase in foreign currency terms suggest a considerable rise in the value of subcompact exports during most of the first year subsequent to yen appreciation.

Table 4. Japan: Simulated Long-Run Impact of 10 Percent Yen Appreciation on Export Shipment Values in Foreign Currency 1/

(In percent)

	Response of Export Value
Subcompacts	-6.0
Color televisions	-8.2
Galvanized steel sheet	0.8
Heavy plate	0.4
Tin plate	0.2

Source: Fund staff estimates.

1/ The long-run adjustment of export prices and volumes is defined to be equal to that which is obtained at the end of the three-year simulation period, with the unit value of exports equal to the contract export price.

V. Conclusions

Notwithstanding the fact that the simulation results are strictly applicable to only the 1977-79 period, 1/ several implications seem well established. For all five Japanese export items studied, the impact of

1/ The exchange rate impact on export volumes would be lower during periods when exports accounted for a higher share of total sales, since the offsetting influence of the nonprice rationing variable would be greater.

exchange rate changes on exports is subject to lags on both the supply and demand side, with the adjustment of demand being particularly slow. Furthermore, competitors' prices appear to play an important role in the pricing decisions of suppliers; thus, exchange rate changes are not fully passed through to export prices (in foreign currency), in the long run as well as in the short run. 1/

The analysis clearly indicates that exchange rate effects over time differ by product. The exchange rate does seem to work as a tool for adjusting Japan's subcompact passenger car and color television exports, 2/ even though adjustment is particularly slow in the case of automobiles. However, the exchange rate does not seem to have as great an impact on the various exports of Japan's iron and steel industry; in fact, export values in foreign currency are estimated to increase subsequent to appreciation. Even though such products are generally considered to be homogenous in nature, Japanese suppliers seem to face relatively price inelastic foreign demand for the three steel products in the sample, suggesting that quality may be a significant factor in world demand for Japanese iron and steel products. In addition, the relative importance of the nonprice rationing and cyclical variables in the demand equations suggests that suppliers in the steel industry place a premium on the maintenance of stable production levels and prices.

In addition to the partial equilibrium nature of some aspects of the model, the divergence of estimated effects of an exchange rate change by product cautions one from generalizing the results obtained to an aggregate level. Although the results suggest that the full response of aggregate exports will entail a lag of at least one year and that exchange rate changes may not be fully passed through to foreign currency prices in the aggregate, additional estimation is required that incorporates other major Japanese export industries. Further analysis would preferably be conducted on a disaggregated basis, since changes in commodity composition will alter the adjustment of Japan's aggregate exports to shifts in exchange rates.

1/ The estimated lack of full pass-through in the long run may reflect suppliers' expectations of relative productivity gains, lower wages, or offsetting future exchange rate movements.

2/ This result, of course, is based on the 1970-79 sample period, and should be interpreted with caution in the presence of voluntary export restraints.

Data Sources and Methodology

The data employed in the empirical analysis were obtained from a number of sources and constructed as described below.

Export shipments and orders

Volumes of Japanese export shipments were obtained from the Japan Tariff Association, "Japan Exports and Imports." The export commodities covered by the study are: (i) subcompact passenger cars, or passenger cars with engines of a piston displacement of not more than 2,000 cc.; (ii) color television broadcast receivers, including chassis and kits; (iii) heavy plate, or sheets and plates of iron and steel not less than 6 mm in thickness; (iv) tin plate, or trimmed sheets, plates, hoops and strips of iron and steel; and (v) galvanized steel sheets, plates, hoops and strips of iron and steel.

Export order volumes of heavy plate and tin plate were obtained from the Japan Iron and Steel Federation (JISF).

Domestic shipments and orders

Volumes of domestic shipments and orders were obtained from Japan's Ministry of International Trade and Industry (MITI) and JISF sources, respectively, with commodity coverage equivalent to that defined under export volumes above.

Foreign and domestic activity

Except in the case of heavy plate, foreign activity (YF) in the export demand equations was proxied by total world imports in real terms less (real) imports by Japan, obtained from IFS. In the case of heavy plate, foreign activity was defined in terms of the volume of foreign shipping under construction, since the major end-user of Japan's heavy plate exports during the sample period was the foreign ship construction industry. Quarterly data on the gross tonnage of foreign shipping under construction was obtained from the United Nations, "Monthly Bulletin of Statistics;" monthly estimates utilized in estimation were generated based on the quarterly data through use of the TROLL software package's spline function routine.

Domestic activity was represented by three different indices, depending on the product under consideration. In the case of subcompacts and color televisions, both consumer items, domestic activity was represented by an index of real disposable income (YD) constructed as follows:

$$YD = (YDEF \cdot JPOP)/(ASIZE \cdot JCPI)$$

where YDEF = average disposable income of Japanese employee households,

JPOP = Japanese population,

ASIZE = average family size of Japanese employee households,

JCPI = Japan's overall consumer price index.

The data utilized in constructing YD were obtained from the Economic Planning Agency. For the three steel products, it was assumed that domestic activity would be more appropriately represented by an index based on activity in the manufacturing and construction sectors. Regressions were run based on two alternative indicators; (i) an index of manufacturing output; and (ii) a composite index of manufacturing and construction activity. The composite index was calculated as:

$$DD = W_1 \cdot QI + W_2 \cdot QC$$

where QI = the index of manufacturing output,

QC = the value construction works executed deflated by the construction cost index,

W_1 = the value of total manufacturing output, adjusted annually,

W_2 = the value of construction work completed, adjusted annually.

The index of manufacturing output was obtained from MITI sources and the construction data from the Ministry of Construction, "Construction Statistics Monthly."

Prices

Japanese prices were obtained on a monthly basis from the Bank of Japan (BOJ), "Price Indices Annual." Contract export price indices (based on f.o.b. value) were available corresponding to the five products covered by the study; domestic prices were represented by the wholesale price indices for the various commodities. For each product considered, the relative domestic price was defined as the ratio of its domestic price to the wholesale price index for all other commodities.

Raw materials price indices were not available at the relevant product levels, and were therefore proxied by indices constructed at appropriate industry levels of aggregation, i.e. automobiles (subcompacts), consumer electrical appliances (color televisions), hot-rolled steel products (heavy plate) and cold-rolled steel products (tin plate and galvanized steel sheet). The proxy indices were calculated as weighted-average wholesale price indices of the major raw material inputs of each of the above industries, with weights according to input coefficients given by the 1970 Input-Output Table for Japan.

For subcompacts and color televisions, foreign prices in yen terms (R.PF) were calculated as weighted averages of foreign wholesale prices converted into yen, with the weights based on average foreign market shares of Japanese exports for each category during 1971-75. Amongst the major markets, monthly price series for passenger cars and color televisions were available for the United States, the United Kingdom and Canada, 1/ which together accounted for about three fourths of Japan's total exports for both products during the above period.

In the case of the three steel products, disaggregated prices in the relevant exports markets were readily available only for the United States. The competing foreign price was thus defined as follows. For galvanized steel sheet, the foreign price was represented solely by the United States wholesale price of galvanized steel sheet; the North American market accounted for about one-half of total Japanese exports of galvanized steel sheet during 1971-75. For heavy steel plate and tin plate, foreign prices were calculated as weighted averages of the United States wholesale price of the relevant product and overall wholesale price indices in other major export markets, of which the latter were obtained from the IFS. This treatment thus captured broad price trends in the non-United States export markets and also yen exchange rate changes vis-a-vis those markets. The countries covered accounted for 51 percent and 54 percent, respectively, of Japanese exports of heavy steel and tin plate.

The expected relative export price proxies were generated by forecasting 1-3 months forward based on ARIMA models estimated separately for the various foreign prices, exchange rates and contract export prices employed in the analysis. The estimated ARIMA models utilized are available from the author upon request.

The relative price of gasoline in the United States and in Japan, included respectively in the export and domestic demand equations for subcompact passenger cars, was defined in both cases as the consumer price of gasoline relative to that for all other items included in the consumer price index.

1/ Sources: U.S. Department of Labor, Bureau of Labor Statistics, "Producer Prices and Price Indexes;" U.K., "Central Statistical Office, "Price Index Numbers for Current Cost Accounting;" Canada, The Ministry of Industry Trade and Commerce, "Industry Selling Prices."

Wages

The monthly wage rate (W) was defined as equal to total regular wages (excluding bonuses) divided by total regular hours worked (excluding overtime). As the data was not available at the relevant product level of disaggregation, wage costs were assumed equal to that in the automobiles, consumer electrical appliances, and rolled steel products industry, respectively, for subcompacts, color televisions, and the three steel products. Data was obtained from the Ministry of Labor (Japan), "Monthly Labor Statistics."

Variable Costs

Due to multicollinearity problems encountered in preliminary regressions, a variable cost variable defined as a geometric weighted-average of raw materials and wage costs was employed in the final regressions. The weights were determined by average input-output weights for 1970-72 obtained from MITI, "Census of Manufactures;" the weights and the respective levels of disaggregation available in the Census for each product considered are listed below.

		Weights	
Sample product	Industry	Wages	Raw materials prices
Subcompacts	Automobiles	0.081	0.919
Color television	Televisions and radios	0.095	0.905
Heavy plate	Hot rolled steel products	0.098	0.902
Tin plate	Galvanized steel	0.229	0.771
Galvanized steel sheet	Galvanized steel sheet	0.086	0.914

Nonprice rationing variable

The nonprice rationing variable was represented by either the inventory-sales or the inventory-orders ratio. Inventory data was obtained form MITI sources; total sales were defined as the sum of export and domestic shipments, and total orders as that of export and domestic orders.

Vintage of the capital stock

As data on the age of oldest machine in operation were not available, it was approximated as a linear function of the average age of the capital stock in place and the rate of capacity utilization. 1/ For subcompacts and color televisions, the average age of machinery in place was estimated from firm level balance sheet data on plant and equipment stocks and plant and equipment investment and depreciation obtained from the Japan Industrial Development Bank. Vintage data for the steel industry was provided by Sumitomo Metal Industries. As the balance sheet data was available only on an annual basis, monthly estimates were generated by the TROLL software package's spline function routine. Capacity utilization rates were available for automobiles and color televisions from MITI, and were estimated for each of the three steel products from output data according to the methodology employed in the construction of the Wharton index of capacity utilization. 2/

1/ This approach was motivated by de Menil (1974).
2/ See Klein (1966).

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