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Export Pricing Behavior of Manufacturing: A U.S.-Japan Comparison

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Abstract

Using domestic and export price data and a framework of markup over cost, pricing behavior of U.S. and Japanese manufacturers is compared. Major export industries in Japan have higher productivity growth and lower pass-through coefficients than American exporters, who tend to price to domestic cost. Japanese firms seem to price discriminate between domestic and export markets. Other related issues, including nonlinearity in pass-through and sectoral differences in productivity, are also examined.

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Contents

Introduction

The purpose of this study is to compare export pricing behavior of U.S. and Japanese manufacturing industries under the floating exchange rate regime.

The concept of pass-through plays the key role in this study. It is associated with how prices of internationally traded goods are affected by changes in exchange rates. Roughly speaking, pass-through is said to be complete when the exporter does not adjust prices in his home currency so that exchange rate fluctuations are reflected entirely in local import prices abroad. By contrast, if import prices in local currencies remain stable, it is prices received by exporters that must adjust to exchange rate shocks. In this case, we say pass-through is zero. Many of the manufacturing industries we consider here are characterized by imperfect competition. Thus, the pass-through coefficient is likely to be the result of conscious price-setting behavior of the export firm.

Pass-through is sometimes defined as the elasticity of import prices with respect to the nominal exchange rate. However, we cannot uniquely determine the pass-through coefficient this way. Suppose, on the one hand, a nominal depreciation is accompanied by a proportional inflation at home. In this purely nominal depreciation, nothing real is changed: the real exchange rate and competitiveness remain the same, exports will be priced the same abroad, and pass-through will be zero in the absence of money illusion. On the other hand, if there is no inflation differential and therefore a depreciation is both nominal and real, we might expect the export firm to adjust their prices to the new situation.

In the statistical tests that follow, we will define pass-through with respect to the real effective exchange rate. By so doing, we are in effect testing a joint hypothesis of no money illusion and a particular behavior of interest in each case.

Previous empirical studies suggest that dollar prices of U.S. manufacture exports seem insensitive to changes in the real exchange rate and, therefore, the movement of the dollar is almost completely passed through to foreign prices. In contrast, foreign manufacturers often "price to market" by revising export prices in their home currencies so that (for example) dollar prices of Japanese products remain relatively stable even when the dollar appreciates or depreciates. 1/

1/ See Baldwin (1987b), Dornbusch (1987), Helkie and Hooper (1988), Hooper and Mann (1987), Knetter (1988), Krugman (1987), Krugman and Baldwin (1987), Mann (1986), Woo (1984), Yamawaki (1988), and Economic Report of the President (1988).

To estimate the pass-through coefficient correctly, however, two statistical problems must be overcome.

First, one must control for changes in production cost. Observed changes in output prices may merely reflect exogenous changes in production cost rather than changes in markup. Furthermore, the exchange rate itself could systematically affect production cost by lowering and raising the price of tradable inputs. Therefore, even when the yen appreciates against the dollor, dollar prices of Japanese exports may not rise as much as the yen--a nominal yen appreciation systematically raises Japanese costs relative to American costs (i.e. the real yen exchange rate) only to the extend that inputs are nontradable.

There are several ways to capture production cost. In some studies, the domestic prices of similar goods are used as a proxy for cost. In others, direct measures of cost--such as unit labor cost--are employed. In some cases, one may also infer cost changes from the nonstructural, error-component model.

Our method of correcting for cost is a straightforward one: we will directly estimate a cost function with two inputs--labor and raw materials. This gross-input approach contrasts with the value-added approach taken by Marston (1987ab) where only labor (and capital) employed in each industry is considered. For estimation and comparison of competitiveness, the gross-input approach is superior to the value-added approach, because competitiveness depends on not only the productivity of an export industry but also the productivity of upstream industries from which it buys intermediate products.

Secondly, a researcher must choose between aggregate data and disaggregated data. Using aggregate data, Figures 1(a) and 1(b) show how domestic and export prices of all manufactures evolved since 1975. (Here, domestic prices could serve as a proxy for production cost.) The two price series diverge as the exchange rate changes substantially--as in the early 1980s in the United States, and in 1977-78 and 1985-86 in Japan. Alleged pricing asymmetry is not apparent.

But commodity baskets that measure these prices are not identical--can be very different--in each country. For example, Japan has a large domestic food industry which exports little. As a consequence, we do not know whether divergence of the two series is due to export pricing behavior or difference in product-mixes.

One could avoid the aggregation problem by looking at a number of highly disaggregated products. But then, conclusions obtained from such studies cannot be easily generalized because of a very limited coverage of industries.

In this study, we will use price data disaggregated to SIC (Standard Industrial Classification) 2-digit and 4-digit levels, with a large coverage of export industries. We will examine to what extent differences in U.S. and Japanese export pricing behavior result from different product-mixes, and to what extent they are apparent at the sectoral level.

In the next section, alternative theoretical models of pass-through are reviewed. In Section II, some basic statistics of American and Japanese manufacturing industries are presented. Section III introduces our model. Section IV reports the export pricing parameters. Section V explores nonlinearity in Japanese export pricing. Section VI re-estimates a simplified version of the model and calculates changes in competitiveness due to productivity differentials. The final section summarizes the results.

I. Existing Models of Pass-Through

Many recent theoretical models attempt to explain export pricing behavior across countries, across industries, or over time. We will briefly review three of them in this section. 1/ They all assume imperfect competition where the export firm sets rather than takes the price.

1. Static profit-maximization

The first type of model reduces different pass-through coefficients to different parameters determining demand and cost in the framework of static profit-maximization. In a most simple form, an oligopolistic foreign firm with a constant marginal cost faces a downward-sloping demand curve. To maximize (current) profit, marginal revenue must be equal to marginal cost, which dictates the firm's pricing strategy. According to this theory, the pass-through coefficient is critically dependent on the shape of the demand curve. In particular, pass-through

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1/ Other explanations of pass-through emphasize: (1) the dollar's role as a dominant invoice currency; (2) U.S. firms' global market power; (3) difference in the export dependency ratio; (4) aggregate demand conditions; (5) the size of firms--Japanese export firms are large and have deep pockets; and (6) difference in the profit-maximization horizon--Japanese are long-term maximizers, while Americans are short-term maximizers. This may be due to differences in corporate culture, capital cost, the role of the stock market, productivity growth or direct investment. There are also game-theoretic models of pass-through where, for example, no or little pass-through is Pareto-superior to the Cournot-Nash solution (Chadha, 1987). Also see Dornbusch (1987), Hooper and Mann (1987), and Krugman (1987a) for more models.

is different from one (complete pass-through) unless the demand curve has a constant price elasticity. This and similar models are presented in Knetter (1988), Krugman (1987a), and Mann (1986).

More generally, marginal cost can be increasing or decreasing. Feenstra (1987) develops a model where the shapes of demand and cost curves jointly determine the pass-through coefficient. He shows that pass-through of greater than unity is possible in some cases.

These models predict that pass-through will be different in each market, and as market conditions change, so will pass-through. Yamawaki (1988) tries to correlate different pass-through coefficients with different characteristics of individual industries. These models also predict that firms with similar technology which share the same market will have similar pass-through coefficients--say, Japanese and U.S. firms selling automobile tires in the third market.

2. Hysteresis

The second model of pass-through is based on hysteresis. Recent studies concerning the entry-exit decision of foreign exporters suggest that the pass-through relationship may be path-dependent or "hysteretic." This could occur if--on the supply side--there are unrecoverable or "sunk" costs associated with investment in (say) a service and distribution network (Baldwin, 1986; Baldwin and Krugman, 1986; Foster and Baldwin, 1986) or if--on the demande side--consumer demand is sticky because of brand loyalty (Froot and Klemperer, 1988).

In the Baldwin-Krugman model, the number of active foreign firms in the domestic market will remain unchanged while the exchange rate fluctuates within a certain range. However, once the exchange rate (even temporarily) moves out of such a range, entry or exit will occur, and the number of foreign firms--and therefore the industry supply curve--is permanently altered. Modeling this phenomenon as a stopping problem in stochastic dynamic programming--thus introducing uncertainty about the future exchange rate--Dixit (1987, 1988) shows that the hysteretic range of the exchange rate could be much wider than Baldwin and Krugman suggest. Similarly, Froot and Klemperer (1988) contend that pass-through depends on the expected future exchange rate--or how permanent the current depreciation or appreciation will be.

Hysteresis models predict that pass-through coefficients tend to change after an extreme movement in the exchange rate. Thus, if we detected such a structural break around 1985 (when the dollar peaked), it would be strong evidence in support of these models. This should preferably be accompanied by the data on the actual number of foreign exporters.

3. The nature of shocks

Finally, some authors regard pass-through as a function of the stochastic nature of the macroeconomy. The basic idea is that there is no reason to expect the same amount of pass-through when shocks driving the exchange rate are different. We have already argued that pass-through is likely to be zero when an appreciation is purely nominal but positive when it is not. We could generalize this principle to various other shocks.

Klein (1988) and Murphy (1988) add a signal extraction problem to this idea. Foreign firms infer the current domestic price level (a proxy for the prices of domestic rival firms) from the exchange rate. They argue that monetary shocks dominated exchange rate movements in the 1970s, and thus exchange rate was highly correlated with subsequent inflation. In contrast, most shocks to the exchange rate have been nonmonetary (mostly fiscal) in the 1980s. Deterioration in the signal-to-noise ratio should lower the extent to which foreign firms react to the exchange rate as a signal for future inflation. (See also Daniel, 1987.)

These models are interesting because of their general implication that pass-through could be anything depending on economic structure. And the relationship between the two endogenous variables--the exchange rate and export prices--presumably changes when there is a shift in economic structure. Although empirical verification of this hypothesis may be difficult, the idea appears worth pursuing.

In the remainder of this paper, we will also try to test these different theories by examining their implications against facts.

Our model is one of variable markup over cost, with the possibility of parameter shift over time. This is sufficiently general to nest different theoretical models in it. Our empirical model provides only a partial-equilibrium framework of analysis because it treats such variables as the exchange rate, wages, material prices and business cycles as exogenous. These macroeconomic variables should be endogenous in a general-equilibrium model, but regarding them as given is perhaps less objectionable when we deal with individual industries separately. Moreover, we will use the instrumental variables method in estimation to take account of what simultaneity might remain.

II. Some Basic Statistics

Let us review some basic statistics of manufacturing industries in the United States (for the year 1981) and Japan (for the year 1980). Using information in the input-output accounts, Tables 1 and 2 present (i) share in GNP, (ii) share in manufacture exports, (iii) the ratio of exports to output, and (iv) the ratio of value-added to output for

Table 1. Manufacturing Industries: The United States

Selected SIC 2-digit level industries	Share in GNP (1)	Share in Manufacture Exports (2)	Ratio of Exports to Output (3)	Ratio of Value-Added to Output (4)
	(--- In percent ---)			
Paper and allied products	0.9	2.7	.06	.34
Chemicals and allied products	1.7	11.5	.10	.30
Primary metal products	1.5	4.1	.05	.31
General machinery	2.9	22.3	.19	.45
Electrical machinery	1.9	10.4	.12	.40
Transportation equipment	2.5	18.3	.16	.37
Precision instruments	0.7	3.8	.15	.50
Total	12.1	73.1	--	--

Source: The U.S. Input-Output Accounts for 1981 (updated from the 1977 benchmark Input-Output Accounts), as reported in Department of Commerce, Survey of Current Business, January 1987.

Table 2. Manufacturing Industries: Japan

Selected SIC 2-digit level Industries	Share in GNP (1)	Share in Manufacture Exports (2)	Ratio of Exports to Output (3)	Ratio of Value-added to output (4)
	(---- In percent	---)		
Paper and allied products	0.8	0.7	.03	.25
Chemicals and allied products	2.1	6.4	.09	.27
Primary metal products	3.1	14.5	.11	.21
General machinery	3.0	14.4	.17	.33
Electrical machinery	3.2	17.7	.22	.31
Transportation equipment	3.1	26.7	.29	.31
Precision instruments	0.6	4.0	.32	.42
Total	15.9	84.4	--	--

Source: The Japanese Input-Output Accounts for 1980, Economic Planning Agency.

seven SIC two-digit level industries that comprise a large part of manufacturing exports (73.1 percent in the United States and 84.4 percent in Japan).

Manufacturing industries are more important in Japan than in the United States, accounting for about 30 percent of GNP compared with a little over 20 percent in the United States. For the industries listed here, shares in GNP are roughly comparable between the United States and Japan--see column (1).

Column (2) in each table shows the commodity composition of manufacturing exports. Exports of the United States are relatively concentrated in paper, chemicals and general machinery, whereas Japanese exports are concentrated in primary metals, electrical machinery and transportation equipment. Precision instruments industries are relatively small in both countries and have similar export shares.

In column (3) the ratio of exports to output in each industry, or "export exposure" (Hooper and Mann, 1987), is reported. It is sometimes contended that Japanese industries are more dependent on exports than their American competitors. However, this does not hold for all industries--even though it may be true for a handful of top export firms. Not surprisingly, export dependency is highly correlated with commodity composition of exports. The United States is more export-dependent than Japan in paper, chemicals and general machinery, while the converse holds for the other industries.

The ratio of value-added to output is shown in column (4). Value-added is defined as the total value of output minus expenses for intermediate inputs. This includes wages and salaries, allowances for capital depreciation, indirect taxes less subsidies, and profit. In each country, materials industries (paper, chemicals, and primary metals) have lower value-added contents than processing and assembling industries (general machinery, electrical machinery, transportation equipment, and precision instruments). The United States has higher value-added ratios than Japan in all industries. However, these numbers should be interpreted with caution; they reflect only value-added directly employed or produced in each industry. In particular, they underestimate the true domestic value-added content of output because intermediate inputs also contain value-added. As such, these ratios are not independent of the degree of vertical integration of industry (e.g., prevalence of subcontracting).

III. The Model

In this paper, we define the pass-through coefficient to be the elasticity of f.o.b. prices in importers' currency (actually, a basket of importers' currencies) with respect to the real exchange rate, after adjusting for cost changes. Thus, our definition of pass-through reflects changes in markup but not changes in production cost. It also excludes changes in tariffs, surcharges, transportation and insurance costs, and distribution costs incurred in importing countries. In actual estimation, we will be estimating one minus the pass-through coefficient thus defined--which we shall call θ_x or θ_x^*.

Let us first consider the home country (the United States). Assume that each industry uses two inputs, labor (L) and materials (M). Labor represents nontradable inputs directly or indirectly employed by this industry, while materials are assumed to be internationally tradable. Production technology is characterized by constant returns to scale and Hicks-neutral technical change.

In each period, firms are assumed to minimize the unit cost of production by choosing the best combination of labor and materials. The cost function is given by a translog form:

$$\ell nc = \ell n\alpha_0 + \alpha_1 \ell nw + \alpha_2 \ell nq + \frac{1}{2}\gamma_{11}(\ell nw)^2 + \frac{1}{2}\gamma_{22}(\ell nq)^2 + \gamma_{12}\ell nw \cdot \ell nq - \phi t \qquad (1)$$

where c is unit cost, w is wages and q is materials prices. ϕ is the rate of technical change. The translog cost function is consistent with various degrees of input substitutability. In the special case where all γ_{ij} are zero, (1) reduces to a Cobb-Douglas cost function with unitary elasticity of substitution.

Linear homogeneity in input prices implies that: 1/

$$\alpha_1 + \alpha_2 = 1 \quad \text{and} \quad \gamma_{12} = -\gamma_{11} = -\gamma_{22} \qquad (2)$$

Thus, (1) can be simplified to:

$$\ell nc = \ell n\alpha_0 + \alpha\ell nw + (1-\alpha)\ell nq - \frac{1}{2}\gamma(\ell nw - \ell nq)^2 - \phi t \qquad (3)$$

By Shephard's lemma (log version), the share of each input in total cost is:

$$\left.\begin{aligned} S_L &= \partial\ell nc/\partial\ell nw = \alpha - \gamma\ell nw + \gamma\ell nq \\ S_M &= \partial\ell nc/\partial\ell nq = 1 - \alpha + \gamma\ell nw - \gamma\ell nq \end{aligned}\right\} \qquad (4)$$

1/ Totally differentiate (1) and set $\Delta\ell nc = \Delta\ell nw = \Delta\ell nq = \kappa$ and $\Delta t = 0$. The resulting equation must hold for any ℓnw or ℓnq, hence (2).

Using these notations, the elasticity of substitution is defined to be: 1/

$$\Sigma_{LM} = (\gamma + S_L S_M)/S_L S_M \quad (5)$$

From (3), the rate of change in unit cost is: 2/

$$\dot{c} = \alpha\dot{w} + (1-\alpha)\dot{q} - \gamma(\ell n w - \ell n q)(\dot{w} - \dot{q}) - \phi \quad (6)$$

where $\dot{X} \equiv d\ell nX/dt$. Suppose firms adopt the following markup strategy (in terms of rates of change):

$$\dot{\tilde{p}} = \lambda\dot{y} + \theta\dot{s} + \dot{c} \quad (7)$$

where $\tilde{p}$ is the desired price, y is an appropriate cyclical factor, and s is the real exchange rate based on relative costs (a real depreciation is shown as a rise in s). λ and θ are long-run elasticities of price with respect to the cyclical factor and the real exchange rate, respectively.

We propose three different measures of the real exchange rate. In the main part of our study, we will use industry-specific effective exchange rates deflated by normalized unit labor costs. Second, for sensitivity analysis, we replace these measures by an aggregate real effective exchange rate index in columns (b) of Table 4. Finally, for a bilateral comparison of competitiveness, industry-specific and endogenous measures of relative costs will be introduced in Section VI. (For details, see Appendix I.)

We assume that the actual price of output adjusts slowly due to the existence of long-term contracts and menu costs. The partial adjustment mechanism can be described as:

$$\dot{p} = (1-\mu)\dot{p}_{-1} + \mu\dot{\tilde{p}} + \varepsilon \quad (8)$$

where $\mu (0 < \mu < 1)$ is the adjustment speed and ε is an error term.

We allow the possibility of price discrimination between domestic sales and exports. In other words, parameters pertaining to pricing strategies (μ, λ, θ) can differ depending on whether the buyer is a domestic national or a foreigner, although parameters pertaining to technical constraints (α, γ, ϕ) are the same.

1/ See Berndt and Christensen (1973), Berndt and Wood (1975), Fuss (1977), and Denny and May (1977).

2/ From now on, all equations are in rates of change. The primary reason for this is to eliminate high serial correlation in the error terms. An alternative way is to model the structure of error explicitly, but this will increase computational difficulty.

Using subscript d for domestic-sales variables and parameters, and subscript x for those for exports, we can write the price equations, by combining (6) (7) (8), as follows:

The price equation for domestic sales (United States)

$$\dot{p}_d = (1-\mu_d)\dot{p}_{d,-1} + \mu_d[\lambda_d\dot{y}_d + \theta_d\dot{s} + \alpha\dot{w} + (1-\alpha)\dot{q} - \gamma(\ell nw - \ell nq)(\dot{w}-\dot{q}) - \phi] + \varepsilon_d \quad (9)$$

The price equation for exports (United States)

$$\dot{p}_x = (1-\mu_x)\dot{p}_{x,-1} + \mu_x[\lambda_x\dot{y}_x + \theta_x\dot{s} + \alpha\dot{w} + (1-\alpha)\dot{q} - \gamma(\ell nw - \ell nq)(\dot{w}-\dot{q}) - \phi] + \varepsilon_x \quad (10)$$

Both equations are expressed in the exporter's currency (i.e., dollar).

Note that the cyclical variables, $\dot{y}_d$ and $\dot{y}_x$, are different in (9) and (10). 1/ All other explanatory variables are common to both equations. The pass-through coefficient, or the proportion of exchange rate fluctuations reflected in local import prices (f.o.b.), is $1-\theta_x$. (Actually, pass-through in our model is θ_x-1. Here, we reverse the sign and follow the convention that pass-through is normally expressed as a positive fraction. Had we defined p_x in terms of importers' currency, the pass-through coefficient would be simply θ_x.)

The pass-through coefficient is a function alternatively of (i) shapes of demand and cost curves (the static profit-maximization theory); (ii) the number of foreign firms in the domestic market (the hysteresis theory); or (iii) the stochastic property of the macroeconomy (the nature-of-shocks theory).

Similar price equations can be derived for the other country. Using * for the foreign variable, we have, symmetrically:

The price equation for domestic sales (Japan)

$$\dot{p}_d^* = (1-\mu_d^*)\dot{p}_{d,-1}^* + \mu_d^*[\lambda_d^*\dot{y}_d^* + \theta_d^*\dot{s}^* + \alpha^*\dot{w}^* + (1-\alpha^*)\dot{q}^* - \gamma^*(\ell nw^* - \ell nq^*)(\dot{w}^*-\dot{q}^*) - \phi^*] + \varepsilon_d^* \quad (11)$$

The price equation for exports (Japan)

$$\dot{p}_x^* = (1-\mu_x^*)\dot{p}_{x,-1}^* + \mu_x^*[\lambda_x^*\dot{y}_x^* + \theta_x^*\dot{s}^* + \alpha^*\dot{w}^* + (1-\alpha^*)\dot{q}^*$$

1/ $\dot{y}_d$ is defined as the zero-mean adjusted rate of change in domestic real GNP, while $\dot{y}_x$ is a weighted average of zero-mean adjusted rates of change in real GNP of G-7 countries other than the home country.

$$- \gamma^*(\ell n w^* - \ell n q^*)(\dot{w}^* - \dot{q}^*) - \phi^*] + \varepsilon_x^* \qquad (12)$$

Both (11) and (12) are expressed in yen.

Equations (9)-(12) are to be estimated simultaneously to take advantage of possible cross-equation correlation of error terms. This also allows imposition and statistical tests of cross-equation parameter restrictions.

IV. Estimation and Some Tests

Equations (9)-(12) are estimated using the iterative three-stage least squares (I3SLS) method, with a constant and once-lagged dependent and independent variables of the entire system as instruments. 1/ Quarterly data are used. The beginning of the sample period differs from one industry to another depending on the availability of U.S. export prices and ranges from 1977:4 to 1983:3. The end of the sample period however is uniform (1987:3). Although the model is written in instantaneous rates of change, we use log-first differences as an approximation.

In the case of precision instruments, historical U.S. domestic prices are unavailable. Consequently, a system of three equations excluding the U.S. domestic price equation is estimated. Separately, for primary metal products and passenger cars, estimation produces incredibly low or high α coefficients for the United States. To obtain more reasonable estimates, conditions $\alpha = \alpha^*$ and $\gamma = \gamma^*$ are imposed for these industries.

In estimation, we do not restrict the adjustment speed to be less than one, and some estimates of μ indeed exceed unity (i.e., overcorrection). Note, however, that the system is stable as long as all μ's are between zero and two--note that we are using first differences in logarithm.

We do not have the problem of serial correlation in error terms--in fact, that is the main reason for estimating our system in rates of change. Of the 75 equations estimated, 7 (3) have statistically significant first-order serially correlated errors at the 10 percent (5 percent) level, which is roughly what we should expect from the Type I error. Higher-order correlations are also absent.

Detailed descriptions of the data and estimated results by industry are provided in the appendices. In addition to individual industries, the aggregate equations are also reported there. In what follows, we report our main results classified by topics.

1/ The MINDIS, or minimum-distance estimation, command of the RAL statistical package is used. The algorithm is due to Berndt, Hall, Hall, and Hausman (1974).

1. Technology

Table 3 presents estimated technical parameters for 7 SIC 2-digit level industries and 12 SIC 4-digit level industries.

The first two columns report the α coefficient for the U.S. and Japan, respectively. α is related to value-added both directly and indirectly--via upstream industries--generated by the industry, and should, therefore, be greater than the value-added ratio in Table 1 or 2. In two cases (chemicals and paperboard for Japan), α seems too low. In other two cases (precision instruments and power-driven hand tools for Japan), α is greater than one, which clearly cannot be. Nonetheless, these latter estimates are not significantly different from one, and thus consistent with true values close to but smaller than one. Otherwise, estimated values of α appear reasonable. Relatively high α in many industries implies that the direct effect of exchange rate fluctuations on material cost is small for these industries.

The next two columns test whether γ is zero--technology is Cobb-Douglas--for the U.S. and Japan, respectively, using t-statistics. Results are mixed, with some industries rejecting the hypothesis and others not rejecting it.

The fifth column tests, by the log-likelihood ratio test (LLRT) method, whether the two technical parameters, α and γ, are identical across countries. Again outcome depends on individual industries. At the least, we may say that there is no overwhelming evidence that these two technical parameters are different between the United States and Japan.

What is most striking about the bilateral comparison of technology is prominent gaps in the rates of technical change, $\phi - \phi^*$, as shown in the last three columns of Table 3. In all industries examined here, Japan has higher rates of Hicks-neutral technical change than the United States--and in ten instances the difference is statistically significant by LLRT (see the last column). This is in accordance with Marston (1987a,b) and HatsoPoulos, Krugman and Summers (1988) who report similar differentials in labor productivity growth between the United States and Japan. It supports the view that many U.S. manufacturing industries are lagging behind Japanese competitors in productivity--despite the recent rise in U.S. manufacturing productivity after the stagnant 1970s (see Economic Report of the President, 1988).

We will come back to this important issue in Section VI.

Table 3. Technical Parameters

Industry	α United States	α Japan	γ=0 United States	γ=0 Japan	α=α* γ=γ* LLRT	Technical Change (ϕ) Percent per Quarter United States	Technical Change (ϕ) Percent per Quarter Japan	LLRT
				SIC 2-digit level				
Paper	0.85	0.76				-0.4	0.8	
Chemicals	0.62	0.26		**		-0.2	0.3	
Primary metal products	0.50	0.50	**	**	n.a.	0.1	1.4	**
General machinery	0.93	0.87		**		0.3	1.3	
Electrical machinery	0.92	0.65		**	**	0.2	1.4	**
Transportation equipment	0.90	1.00				-0.2	0.9	**
Precision instruments	0.83	1.06				0.1	1.7	
				SIC 4-digit level				
Paperboard	0.51	0.30				-0.1	0.8	
Tires and tubes	0.84	0.75		**		0.8	0.8	
Valves and pipe fittings	0.92	0.87				-0.1	1.5	**
Int. combustion engines	0.89	0.45	*			-0.1	0.1	
Farm machinery	0.94	0.90				0.1	0.9	**
Construction machinery	0.84	0.93				0.1	1.2	
Power-driven hand tools	0.92	1.09			**	0.2	1.0	**
Printing machinery	0.96	0.97		*		0.0	0.2	**
Pumps	0.85	0.97	**		**	0.1	0.7	**
Radios and TV sets	0.92	0.71	**	**	*	0.8	1.2	
Semi-conductor devices	0.94	0.54				0.9	3.2	**
Passenger cars	0.98	0.98			n.a.	0.0	1.1	**

Note: * or underscore indicates significance at the 10 percent level and ** at the 5 percent level.

2. Export price elasticities and pass-through

In the columns denoted (a) in Table 4, estimates of export price elasticities with respect to the real exchange rate for the United States (θ_x) and Japan (θ_x^*) are reported. Recall that our definition of the pass-through coefficient (controlled for cost changes, business cycles and adjustment speed) is $1 - \theta_x$ and $1 - \theta_x^*$, respectively. We therefore expect θ_x and θ_x^* to be normally between 0 and 1, which, however, is not the case for all industries. 1/

Anomaly seems to arise in industries that rely heavily on one input (e.g., pulp in paper and paperboard industries) as well as some of the SIC 4-digit level industries (e.g., internal combustion engines and printing machinery). It is probable that, at disaggregated levels, θ_x and θ_x^* are picking up the effects of industry-specific shocks (product innovations, taxes, trade barriers, price fluctuations of major inputs, etc.) which are spuriously correlated with the exchange rate.

There is no reason to expect the same pass-through across all industries since they face different demand and cost curves (see Section I). From the (a) columns in Table 4, one may see no evidence of Japanese export price elasticities systematically higher (i.e., pass-through systematically lower) than those of the United States, since Japanese coefficients are not always higher. But this impression is deceptive. Let us aggregate estimated SIC 2-digit level U.S. and Japanese export elasticities, using alternatively U.S. and Japanese export weights from Tables 1 and 2 (adjusted to sum to one):

Using	U.S. estimates	Japanese estimates
U.S. weights	0.05	0.21
Japanese weights	0.03	0.22

Results are unambiguous: U.S. estimates yield low export price elasticities (i.e., almost complete pass-through) whether U.S. or Japanese weights are used, while Japanese estimates yield lower pass-through in the aggregate regardless of weights. This arises from the fact that general machinery, electrical machinery and transportation equipment, which weigh heavily in the exports of both countries, have

1/ However, $\theta_x < 0$ cannot be ruled out under certain assumptions about cost and demand--see Feenstra (1987).

Table 4. Export Price Elasticities and Price Discrimination

Industry	United States (θ_x) (a)	United States (θ_x) (b)	Japan (θ_x^*) (a)	Japan (θ_x^*) (b)	LLRT $\theta_x=\theta_x^*$	LLRT $\theta_x=\theta_d$	LLRT $\theta_x^*=\theta_d^*$
			SIC 2-digit level				
Paper	1.51	1.25	0.19	0.19	**		*
Chemicals	0.15	0.12	0.15	0.01			
Primary metal products	0.42	0.19	0.26	0.05			
General machinery	-0.02	-0.02	0.23	0.17			
Electrical machinery	0.00	0.02	0.23	0.25	**		
Transportation equipment	-0.19	-0.10	0.22	0.14			
Precision instruments	0.04	-0.02	0.11	0.16		n.a.	
			SIC 4-digit level				
Paperboard	1.58	1.15	-0.19	-0.51	**		
Tires and tubes	-0.11	0.06	0.62	0.52			**
Valves and pipe fittings	0.02	0.02	0.94	1.23			**
Int. combustion engines	-0.20	-0.09	-0.49	-0.78			
Farm machinery	-0.20	-0.08	0.11	0.03			**
Construction machinery	-0.11	-0.09	0.58	0.59			
Power-driven hand tools	0.11	0.08	0.26	0.32			
Printing machinery	0.01	-0.01	-0.22	-0.24			
Pumps	-0.10	-0.05	-0.05	-0.04			
Radios and TV sets	0.28	0.08	0.24	0.42			
Semi-conductor devices	0.03	0.11	0.72	0.69			*
Passenger cars	0.24	0.08	0.37	0.40			

Note: * or underscore indicates significance at the 10 percent level and ** at the 5 percent level.

very different estimates--positive and significant in Japan, non-positive and insignificant in the United States. 1/ Thus, the aggregation problem does not appear to be the main reason for the observed asymmetry in export pricing behavior between the United States and Japan--at least at the SIC 2-digit level. And, on average, the United States has a pass-through coefficient of 0.95 (=1-0.05) and Japan has a pass-through coefficient of 0.78 (=1-0.22).

This can also be demonstrated graphically, in Figures 2, 3, and 4. In each figure, panel (a) depicts yearly changes in domestic-sale prices (in domestic currency) and export prices (in domestic currency and in the foreign currency basket representing export destinations of each industry) for the United States, and similarly for Japan in panel (b). Domestic and export prices tend to move together in the United States, whereas Japanese export prices adjust systematically to the exchange rate.

3. The aggregation problem in the exchange rate?

Can the use of an aggregate measure of the real exchange rate, rather than industry-specific ones, change these results substantially? Columns denoted (b) in Table 4 report export price elasticities using the common real exchange rate measure. Comparing (a) and (b), we discover that different measures of the real exchange rate do not alter the result much in most cases. However, there are notable exceptions. The coefficients for primary metal products, American passenger cars and Japanese transportation equipment become smaller and lose significance when the aggregate measure is used.

4. Price discrimination

Figures 2, 3, and 4 raise another important issue. If major export industries of Japan adjust export prices but not domestic prices as the yen rises or falls, the discrepancy between the two develops systematically with the exchange rate. For instance, at the time of a strong yen, the same brands and even models of Japanese automobiles, cameras, stereo equipment, etc. will become cheaper abroad than at home. This generates periodical deviations from purchasing power parity (PPP) at the most disaggregated level and prompts the allegation of "dumping." However, such violation of the law of one price should be regarded not so much as an unfair trade practice as a natural consequence of a yen appreciation given Japanese export pricing behavior. In times of a weak yen, the reverse phenomenon of selling the same goods cheaper at home than abroad is observed.

The last two columns of Table 4 show LLRT results of price discrimination between domestic and export markets. None of the U.S. industries

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1/ However, LLRT results in Table 4 are less conclusive. Only paper-related industries and electrical machinery are seen to have statistically different export price elasticities between the two countries.

price discriminate while some Japanese industries do. However, the hypothesis of no price discrimination is not rejected for the three Japanese industries plotted in Figures 2(b)-4(b). This apparent inconsistency between the visual impression and LLRT is puzzling--although we should be aware that the power of LLRT may not be very high.

V. Nonlinearity in Pass-Through

Hysteresis models predict certain nonlinearity in the relationship between the dollar and import prices in the United States. For example, export prices may respond differently to large changes in the exchange rate than to small changes. Furthermore, pass-through coefficients may be permanently altered after an extreme but temporary appreciation or depreciation. Using aggregate U.S. import price data, Baldwin (1987b) and Kim (1988) detect such a structural break sometime in the first half of the 1980s. However, such a break can also occur when the demand and cost curves shift, or when the nature of shocks changes.

In this section, we explore the possibility of nonlinear relations between the exchange rate and Japanese export prices for the sample period of 1975:4-87:3. (American data are too short for such tests.) The general method used for this purpose can be described as follows. Equation (11)--the Japanese domestic price equation--is combined with the modified equation (12):

$$\dot{p}_x^* = (1-\mu_x^*)\dot{p}_{x,-1}^* + \mu_x^*[\lambda_x^*\dot{y}_x^* + \theta_{x,1}^*\dot{s}_1^* + \theta_{x,2}^*\dot{s}_2^*$$

$$+ \alpha^*\dot{w}^* + (1-\alpha^*)\dot{q}^* - \gamma^*(\ell n w^* - \ell n q^*)(\dot{w}^* - \dot{q}^*) - \phi^*] + \varepsilon^*_x \qquad (12)'$$

where $\dot{s}_1^*$ is equal to $\dot{s}^*$ (real exchange rate) when the latter satisfies a certain condition (e.g., positive) and zero otherwise, and $\dot{s}^*_2 \equiv \dot{s}^* - \dot{s}^*_1$. Equations (11) and (12)' are estimated by I3SLS with these exchange rate variables entered separately. In this way, we examine whether export price elasticities are different depending on (i) whether the yen is rising or falling; (ii) whether changes in the yen are large (greater than the sample standard deviation) or small; (iii) before or after 1981:1; and (iv) before or after 1985:2.

These various estimates of θ_x^* are presented in Table 5, together with LLRT for the hypothesis that two export price coefficients are identical. (However, most LLRT statistics are insignificant despite marked differences in numerical estimates, questioning again the power of LLRT.) Let us discuss our findings for the four major export industries of Japan: primary metal products, general machinery, electrical machinery and transportation equipment.

Regarding the sign of exchange rate changes, primary metal products show similar export price responses to either appreciation or depreciation. But for the other three machinery and equipment industries, there is a tendency to raise yen prices more readily when the yen depreciates (positive changes) than to lower them when the yen appreciates (negative changes). The results remain the same even in a simpler model (not shown here) where cost, business cycles and adjustment speed are not considered. This is quite contrary to the popular belief that Japanese exporters tend to keep dollar prices lower than what short-term profit maximization would dictate whether the yen is strong or weak.

As to the magnitude of changes in the yen, large changes prompt large adjustment in export prices in some industries but small adjustment in other industries--and generalization seems difficult. Ideally, one would like to look at large cumulative changes versus small cumulative changes in the exchange rate for such tests--whereas our criterion for large changes is for each period. This is not as bad as it seems, however, because variance in the real exchange rate is highly serially correlated. Thus, our large changes are indeed often cumulative.

There is strong evidence, as far as the four major export industries are concerned, that export price elasticities increased (and thus the degree of pass-through decreased) after the first quarter of 1981. This confirms other empirical studies that detect a structural break in U.S. import prices sometime in the early 1980s. 1/ However, when the break point is shifted to the second quarter of 1985 when the dollar finally started to fall, we no longer have firm evidence of structural change. When one takes explicit account of cost changes, business cycles and adjustment speed (as we do here), it may be that discontinuity of pass-through relationship in 1985 which some studies find may disappear.

Our results leave us unsure as to why these nonlinearities are occurring. In particuler, a break in pass-through in the early 1980s when the dollar was neither extremely high nor low cannot be regarded as strong evidence of hysteresis.

At the same time, Table 5 makes clear that the outcomes of nonlinearity tests depend very much on individual industries chosen for study, particularly at highly disaggregated levels. This is perhaps because other important variables specific to each industry are not properly taken account of. In this sense, aggregated data which cancel out idiosyncracies of individual industries may be more suitable for the study of pass-through, provided that the aggregation problem is not serious.

1/ Curiously, this is not apparent from Figures 2(b) through 4(b). Nor does a simpler model with no correction for cost, business cycles and adjustment speed detect such a break.

Table 5. Japan: Export Price Elasticities and Nonlinearity

(Estimates of θ_x^* under certain conditions)

Industry	Entire Sample (75:4–87:3)	Sign: Positive	Sign: Negative	Sign: LLRT	Magnitude: Large	Magnitude: Small	Magnitude: LLRT	1981:1 Before	1981:1 After	1981:1 LLRT	1985:2 Before	1985:2 After	1985:2 LLRT
SIC 2-digit level													
Paper	-1.25	-1.51	-1.08		-0.21	-0.44	**	-0.88	-0.73	**	-0.41	-0.08	**
Chemicals	0.84	0.25	0.29		0.53	1.02	**	0.13	0.52		0.65	0.31	**
Primary metal products	0.82	0.86	0.85		1.32	-0.86		-0.56	0.70		0.56	0.98	
General machinery	0.20	0.77	-0.02		0.20	0.17		-0.20	0.30		0.23	0.09	
Electrical machinery	0.47	1.01	0.17		0.22	0.81		-0.23	0.64		0.53	-0.18	
Transportation equipment	0.41	0.59	0.38		0.36	-0.15		0.00	0.42		0.47	0.15	
Precision instruments	0.01	-0.01	0.18		0.04	0.02		-0.03	0.18		0.16	-0.03	
SIC 4-digit level													
Paperboard	-1.01	-2.58	-2.34		-0.41	-1.71		-1.28	-1.18		-0.41	0.74	**
Tires and tubes	0.58	0.44	0.69		0.90	-0.66		0.51	0.63		0.40	0.82	
Valves and pipe fittings	-0.36	-0.62	-1.15		0.99	-0.63		-0.55	-0.08	**	-0.19	0.80	
Int. combustion engines	0.51	0.47	0.54		0.91	-0.05		0.29	0.99		0.54	0.29	**
Farm machinery	0.05	-0.16	0.26		0.52	-1.24		-0.31	0.33		-0.27	0.51	
Construction machinery	0.42	0.35	0.43		0.35	0.49		0.16	0.53		0.34	0.41	
Power-driven hand tools	0.49	0.12	0.55	**	0.05	0.70		0.50	0.08	**	0.42	-0.25	
Printing machinery	-0.06	-0.06	0.01		-0.09	0.44		0.08	0.08		0.11	0.16	
Pumps	1.41	1.12	1.24		0.73	0.83		1.09	1.87	**	1.02	1.01	
Radios and TV sets	0.51	0.67	0.35	**	0.72	0.60		0.14	0.56		0.42	0.20	**
Semi-conductor devices	-0.37	-0.46	0.02		-0.57	3.04	**	0.50	-0.54	**	0.02	-0.21	**
Passenger cars	0.13	0.49	-0.07		0.53	-0.53		-0.60	0.29		0.06	0.16	**

Note: * or underscore indicates significance at the 10 percent level and ** at the 5 percent level.

VI. Bilateral Competitiveness

In this section, we simplify our basic model so as to calculate required changes in the nominal yen/dollar rate that would keep relative competitiveness of American and Japanese industries unchanged, under the assumption of given nominal wage movements. Obviously, such changes would differ from one industry to another and, therefore, there is no single rate of dollar depreciation which would maintain a "level playing field" for every industry. 1/ In the short run, productivity changes are a minor factor in determining competitiveness relative to exchange rate swings (Helkie and Hooper, 1988). But, as a trend term, its importance increases as one's time horizon is extended (Marston, 1987a,b).

Let us impose the following restrictions on the model consisting of two export price equations (10) and (12):

$$\alpha = \alpha^* \text{ and } \gamma = \gamma^* = 0 \tag{13}$$

$$\mu_x = \mu_x^* = 1 \tag{14}$$

$$\lambda_x = \lambda_x^* = 0 \tag{15}$$

$$\dot{q}^* = \dot{q} + \dot{e} \tag{16}$$

while we ignore the domestic price equations. (Industries which reject some of these restrictions are nonetheless included in this exercise for the sake of completeness.) Equation (13) assumes Cobb-Douglas technology with two internationally identical technical parameters. (14) and (15) assume that adjustment speed is unity (i.e., we consider the long run) and business conditions are normal. Equation (16) posits that PPP always holds for industrial raw materials (e is the nominal yen/dollar rate). Note, however, that rates of technical change need not be equal between the two countries, nor is PPP assumed to hold for nominal wages (i.e., $\phi \neq \phi^*$ and $\dot{w}^* \neq \dot{w} + \dot{e}$).

Under these assumptions, rates of change in production cost are written as follows:

$$\dot{c} = \alpha\dot{w} + (1-\alpha)\dot{q} - \phi \tag{17}$$

1/ Our exercise is not intended to have policy implications regarding the desirability of this rate of dollar depreciation against that or, for that matter, managed float against a fixed rate system. Such discussion would require explicit assumptions about how nominal wages are (should be) determined in each country (see McKinnon and Ohno, 1988). A more complete model of productivity differentials and real exchange rates is developed by Marston (1987b). Marston's model is formulated with unit labor costs and labor productivity data in mind. In contrast, we estimate productivity ϕ from a cost function.

$$\dot{c}^* = \alpha\dot{w}^* + (1-\alpha)(\dot{q}+\dot{e}) - \phi^* \qquad (18)$$

Define the change in bilateral competitiveness in terms of relative production costs (not just labor costs):

$$\dot{\sigma} \equiv \dot{c}^* - \dot{c} - \dot{e}$$

$$= \alpha(\dot{w}^* - \dot{w} - \dot{e}) + \phi - \phi^* \qquad (19)$$

A positive $\dot{\sigma}$ signifies improvement in U.S. competitiveness relative to Japan.

Export pricing equations are:

$$\dot{p}_x = \theta_x\dot{\sigma} + \dot{c} + \eta \qquad (20)$$

$$\dot{p}_x^* = -\theta_x^*\dot{\sigma} + \dot{c}^* + \eta^* \qquad (21)$$

where η and η^* are error terms. Combining (17)-(21) we have:

$$\dot{p}_x = (1-\theta_x)\alpha\dot{w} + \theta_x\alpha(\dot{w}^* - \dot{e}) + (1-\alpha)\dot{q} - (1-\theta_x)\phi - \theta_x\phi^* + \eta \qquad (22)$$

$$\dot{p}_x^* = (1-\theta_x^*)\alpha\dot{w}^* + \theta_x^*\alpha(\dot{w}+\dot{e}) + (1-\alpha)(\dot{q}+\dot{e})$$

$$- (1-\theta_x^*)\phi^* - \theta_x^*\phi + \eta^* \qquad (23)$$

The export price elasticity, θ_x or θ_x^*, has a clear interpretation in (22) and (23): it is the degree to which exporters adjust their prices to the evolution of foreign cost, as against that of domestic cost. For example, if $\theta_x = 0$ (complete pass-through), (22) becomes:

$$\dot{p}_x = \alpha\dot{w} + (1-\alpha)\dot{q} - \phi + \eta \qquad (24)$$

and export prices are unaffected by foreign technology or foreign input prices. At the other extreme, if $\theta_x = 1$ (no pass-through), we have:

$$\dot{p}_x = \alpha(\dot{w}^* - \dot{e}) + (1-\alpha)(\dot{q}^* - \dot{e}) - \phi^* + \eta \qquad (25)$$

and domestic exporters must price to foreign cost.

To keep bilateral competitiveness constant, let $\dot{\sigma} = 0$ in (19) to get:

$$\dot{e} = \dot{w}^* - \dot{w} + (\phi - \phi^*)/\alpha \qquad (26)$$

which defines the hypothetical rate of change in the yen/dollar rate required to keep U.S. and Japanese manufacturers equally competitive.

This rate depends on the differential in nominal wages ($\dot{w}^*-\dot{w}$) which we assume to be common to all industries, and the technical factor $(\phi-\phi^*)/\alpha$ which is industry specific. Note that, under our assumptions, prices of tradable inputs do not affect bilateral competitiveness--say, a rise in the oil price does not make Japanese industries more or less competitive vis-à-vis American industries, so long as their energy input coefficients are similar.

Table 6 reports a subset of the coefficients obtained from I3SLS estimation of (22) and (23), and the term $(\phi-\phi^*)/\alpha$, for each SIC 2-digit level industry. 1/ This term varies from -1.2 percent to -3.3 percent per quarter.

Krugman and Baldwin (1987) suggest the possibility that a bilateral comparison of manufacturing productivity as a whole might underestimate the needed change in the yen/dollar rate if Japanese export industries on average had higher productivity growth rates than non-export manufacturing industries. To examine this problem, quarterly changes in competitiveness due to productivity differentials in Table 6 are aggregated using four different sets of weights: value-added (GNP share) weights and export weights of the United States and Japan in Tables 1 and 2, respectively. Results are as follows:

Using	Average change in competitiveness due to $(\phi-\phi^*)/\alpha$
	(In percent per quarter)
U.S. value-added weights	-2.1
U.S. export weights	-2.3
Japanese value-added weights	-1.9
Japanese export weights	-2.1

This tabulation assures us that the aggregation problem in productivity differentials is not serious at the SIC 2-digit level. Whichever weights one may use, the Japanese manufacturing sector is seen to have a productivity edge of about 2 percent per quarter over the U.S. manufac-

1/ When the estimated value of α exceeds 1, it is constrained to 1 in calculation of the term $(\phi-\phi^*)/\alpha$. Numbers in Table 6 are not dissimilar to those in Table 3, although rates of technical change are rather high for Japanese chemicals and electrical machinery.

Table 6. Changes in the Competitive Yen/Dollar Rate

Industry	Estimated coefficients α	φ	φ*	Change in Competitiveness due to Productivity Differential (Percent per quarter)
			SIC 2-digit level	
Paper	0.88	-0.001	0.013	-1.6
Chemicals	0.72	-0.001	0.019	-2.9
Primary metal products	0.51	-0.004	0.012	-3.3
General machinery	0.92	0.002	0.014	-1.3
Electrical machinery	1.25	0.003	0.034	-3.1 1/
Transportation equipment	1.05	-0.003	0.009	-1.2 1/
Precision instruments	1.04	0.002	0.021	-1.9 1/

Note: Underscore indicates significance at the 10 percent level.

1/ α =1 is imposed.

turing sector. To keep overall bilateral competitiveness constant, Japanese nominal wages must rise faster than American nominal wages by some 8 percent per year if the yen/dollar rate were to be stable, or the yen must continue to appreciate against the dollar by the same amount if nominal wages in both countries were to be constant.

However, to test the Krugman-Baldwin hypothesis of productivity bias more properly, our comparison should include less export-oriented industries such as food, textiles and ceramics. Thus, our conclusion here remains a modest one of no significant productivity bias among export industries.

Some authors (e.g., Helkie and Hooper, 1988; Krugman, 1988; Economic Report of the President, 1988) conjecture that the productivity gap between the United States and Japan has either narrowed or become less important in recent years compared with the 1970s. However, our results, which cover mostly the 1980s, still show substantial differentials in ϕ and ϕ^* (sample periods are the same as in Appendix II). Moreover, productivity gaps remain essentially the same even if the sample period is shortened to 1982:3-1987:3 (in unreported estimation). Thus, it appears premature to discount productivity as an important determinant of bilateral competitiveness--even though the gap may have narrowed since the previous decade.

VII. Summary and Conclusions

The main findings of our study can be summarized as follows.

1. Japan has higher rates of technical change vis-à-vis the United States in all industries considered here. However, there is no strong evidence that other technical parameters are dissimilar between the two countries.

2. In general machinery, electrical machinery and transportation equipment, which are major export industries in both countries, U.S. pass-through coefficients are close to and insignificantly different from one. Japanese pass-through coefficients are less than 0.8 and significantly different from one. Evidence is less clear at a more disaggregated level or for materials industries.

3. At the SIC 2-digit level, data do not support the hypothesis that aggregate U.S. and Japanese export prices behave differently because of different product-mixes. In other words, the asymmetry is present even at the sectoral level.

4. Japanese major exporting industries appear to price discriminate between domestic and overseas markets as the exchange rate changes. No such tendency is detected for American manufacturers.

5. There seems to have been a structural break in pass-through of Japanese machinery and equipment exports in the early 1980s.

6. The change in bilateral competitiveness due to productivity differential ranges from -4.8 percent to -13.2 percent per year at the SIC 2-digit level. There is no evidence of aggregation bias in bilateral productivity comparisons among export industries.

While we have learned a lot about pass-through, our information is still insufficient to evaluate different theoretical models of pass-through. In particular, detection of a structural break does not necessarily support the hysteresis hypothesis, since such a break could occur for various other reasons as well.

Data

U.S. domestic prices, published by the Bureau of Labor Statistics (BLS) of the U.S. Department of Labor, are retrieved from DRI Database. For all SIC 2-digit level industries and SIC 3546 (pumps and pumping equipment), new producer price indices are too short for our analyses, and therefore wholesale price indices are used. For all other SIC 4-digit level industries, producer price indices are used. SIC-based U.S. export prices are obtained from BLS. The limited availability of these data is the main constraint on the coverage and sample periods of our analyses.

Japanese domestic and export wholesale price indices are obtained from the Bank of Japan (BOJ). Since BOJ data are not organized according to SIC, they are matched up with U.S. data, by aggregating multiple series if necessary. One outlier in the export price of precision instruments (1982:3) is ignored. Some products are excluded from our study because we cannot establish reasonable concordance (e.g., certain fabrics and X-ray equipment). All U.S. and Japanese price data are quarterly (last month of the quarter).

Exchange rate series are generated in three different ways. First, industry-specific real effective exchange rate series are constructed for individual industries in each country. Weights are derived from bilateral export shares of 16 industrial countries (Canada, the United States, Japan, Belgium, Denmark, France, Germany, Ireland, Italy, the Netherlands, the United Kingdom, Austria, Finland, Norway, Sweden, Switzerland, Spain minus the home country), published in the United Nation's Commodity Trade Statistics for 1984. IMF's normalized (i.e., cyclically adjusted) unit labor costs for manufacturing are used as deflators. Second, in columns (b) of Table 4, real effective exchange rate series for the United States and Japan, not disaggregated by industry, are obtained from IMF's database. Weights are based on multilateral (i.e., including third market effects) manufacturing export shares of the same sixteen countries, and the same deflators are used--see McGuirk (1987). Finally, in Section VI, the nominal yen/dollar rate from IMF International Financial Statistics (IFS) is used to generate the real bilateral exchange rate endogenously.

Cyclical variables are constructed as follows. For domestic price equations, the change in seasonally adjusted domestic real GNP is used. For export price equations, the weighted average of changes in seasonally adjusted real GNPs of G-7 nations excluding the home country is used, with weights proportional to 1981 GNP. These cyclical variables are zero-mean adjusted for each sample period.

Wages are obtained from IFS. They are seasonally adjusted. Material prices for the United States are BLS's wholesale prices for nonfood materials (including fuel). Material prices for Japan are the import price index in IFS (Japanese imports are predominantly fuel and raw materials). Logarithms of wages and material prices used in estimation are zero-mean adjusted for each sample period.

Estimation Results by Industry

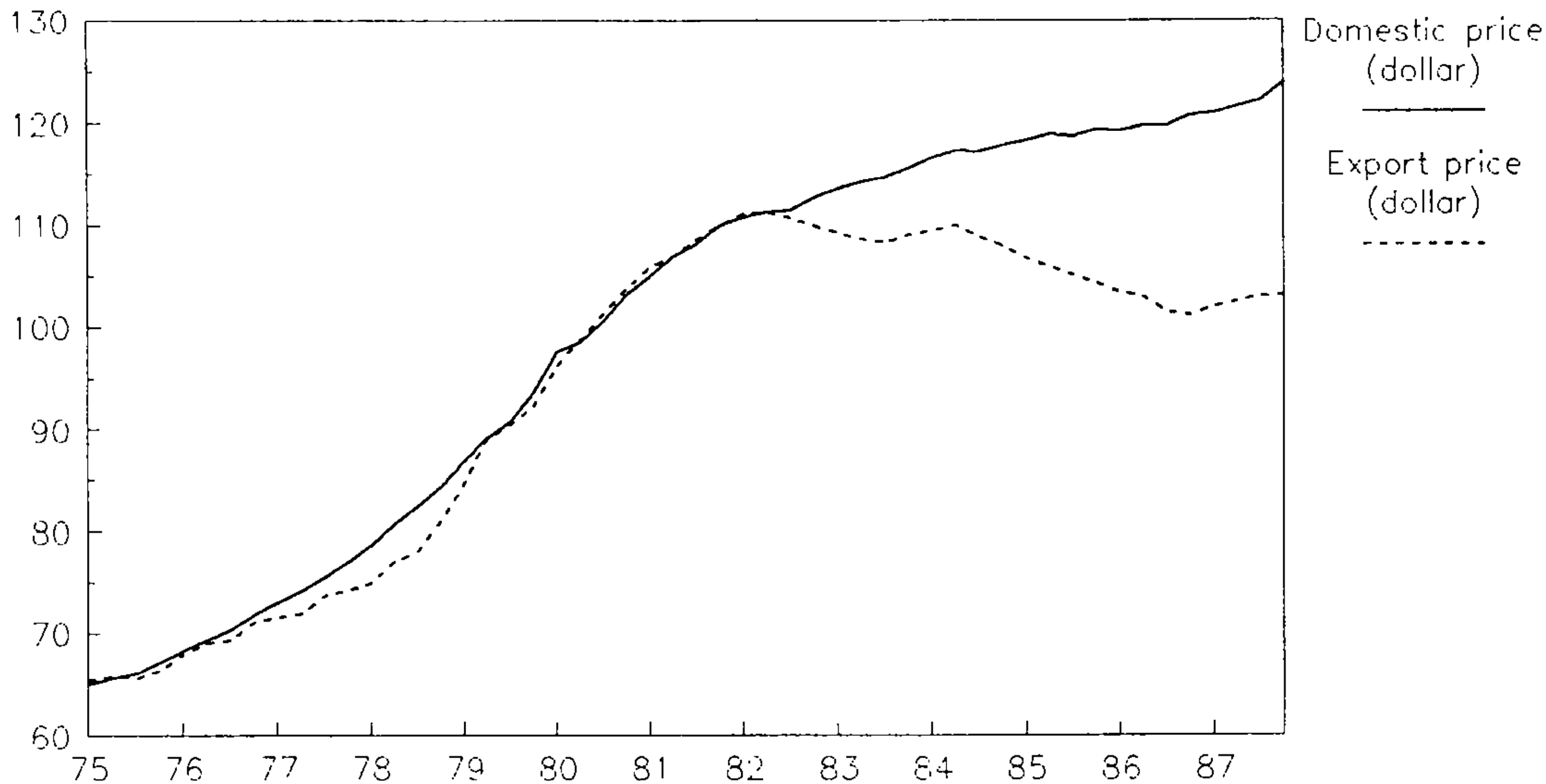
	Technical			Domestic			Export			Adjusted R-squared	
	η	τ	ϕ	μ_d	λ_d	θ_d	μ_x	λ_x	θ_x	Domestic	Export
SIC 26: Paper and allied products (1981:Q3-1987:Q3)											
United	0.85	-0.88	-0.004	0.92	-0.19	0.05	0.30	0.47	1.51	0.03	0.71
States	(6.6)	(-1.4)	(-1.5)	(5.1)	(-0.8)	(0.7)	(3.0)	(0.3)	(2.4)		
Japan	0.76	-0.20	0.008	0.88	-0.02	-0.29	1.01	-0.26	0.19	0.00	0.51
	(6.6)	(-1.1)	(2.0)	(2.8)	(-0.03)	(-1.8)	(7.3)	(-0.4)	(1.2)		
SIC 28: Chemicals and allied products (1983:Q3-1987:Q3)											
United	0.62	-0.21	-0.002	0.55	0.95	0.15	0.78	-0.86	0.15	0.32	0.59
States	(4.3)	(-0.2)	(-0.5)	(2.6)	(1.3)	(1.2)	(5.3)	(-1.7)	(1.4)		
Japan	0.26	-0.79	0.003	0.15	5.30	-0.65	1.20	0.51	0.15	0.54	0.86
	(2.1)	(-2.9)	(0.7)	(2.1)	(1.6)	(-1.8)	(10.1)	(0.6)	(0.8)		
SIC 33: Primary metal products (1982:Q3-1987:Q3)											
United			0.001	0.74	0.28	0.09	0.59	-2.80	0.42	0.34	0.36
States	0.50	-0.91	(0.4)	(3.5)	(0.6)	(0.7)	(4.2)	(-2.1)	(1.7)		
	(4.1)	(-3.0)									
Japan			0.014	0.30	0.06	0.00	1.20	3.50	0.26	0.49	0.55
			(2.5)	(2.8)	(0.04)	(0.00)	(5.2)	(2.7)	(1.7)		
SIC 35: General (nonelectrical) machinery (1979:Q1-1987:Q3)											
United	0.93	-0.27	0.003	0.24	0.30	-0.05	0.76	-0.27	-0.02	0.86	0.70
States	(23.5)	(-1.0)	(2.1)	(2.0)	(0.6)	(-0.5)	(4.3)	(-1.1)	(-0.4)		
Japan	0.87	-0.27	0.013	0.20	-0.55	-0.06	1.31	0.29	0.23	0.64	0.70
	(20.5)	(-2.5)	(7.3)	(2.2)	(-0.7)	(-0.5)	(9.3)	(0.9)	(3.2)		
SIC 36: Electrical machinery (1981:Q2-1987:Q3)											
United	0.92	-0.72	0.002	0.93	-0.09	-0.00	0.70	-0.11	0.00	0.13	0.06
States	(7.6)	(-1.3)	(0.9)	(5.0)	(-0.6)	(-0.04)	(4.4)	(-0.4)	(0.02)		
Japan	0.65	-0.61	0.014	0.12	1.60	-0.33	1.36	0.40	0.23	0.17	0.81
	(6.5)	(-3.5)	(4.7)	(1.7)	(0.9)	(-1.6)	(13.7)	(1.0)	(2.6)		
SIC 37: Transportation equipment (1979:Q2-1987:Q3)											
United	0.90	-0.44	-0.002	1.50	0.46	0.00	0.79	-0.68	-0.19	0.31	0.35
States	(14.4)	(-1.3)	(-1.1)	(9.6)	(1.0)	(0.01)	(4.0)	(-2.2)	(-1.3)		
Japan	1.00	-0.02	0.009	0.51	-0.34	-0.08	1.08	-0.61	0.22	0.03	0.35
	(19.4)	(-0.2)	(4.2)	(3.7)	(-0.7)	(-1.0)	(6.8)	(-1.2)	(2.3)		
SIC 38: Precision instruments (1977:Q4-1987:Q3)											
United	0.83	-0.15	0.001	n.a.	n.a.	n.a.	1.05	-1.14	0.04	n.a.	0.09
States	(9.1)	(-0.2)	(0.4)				(5.4)	(-1.5)	(0.4)		
Japan	1.06	-0.31	0.017	0.42	-0.86	0.18	0.66	0.09	0.11	0.03	0.02
	(16.0)	(-0.2)	(7.8)	(3.4)	(-1.2)	(1.5)	(5.0)	(0.1)	(1.0)		
SIC 2631: Paperboard mill products (1977:Q4-1987:Q3)											
United	0.51	-1.69	-0.001	0.41	-0.55	0.18	0.25	0.17	1.58	0.39	0.69
States	(1.7)	(-0.9)	(-0.1)	(3.3)	(-0.5)	(0.5)	(3.1)	(0.1)	(1.8)		
Japan	0.30	-0.77	0.008	0.87	0.34	-0.24	0.80	1.12	-0.19	0.23	0.39
	(1.4)	(-1.3)	(1.0)	(6.1)	(0.1)	(-0.6)	(6.1)	(0.7)	(-0.6)		
SIC 3011: Tires and inner tubes (1979:Q4-1987:Q3)											
United	0.84	-0.27	0.008	0.80	0.25	-0.32	0.79	-0.51	-0.11	0.43	0.23
States	(9.7)	(-0.6)	(3.1)	(4.7)	(0.5)	(-1.8)	(4.6)	(-0.7)	(-0.4)		
Japan	0.75	-0.61	0.008	0.84	-0.73	-0.00	1.18	0.69	0.62	0.10	0.72
	(8.2)	(-3.0)	(2.1)	(4.1)	(-0.5)	(-0.01)	(11.0)	(0.7)	(4.4)		
SIC 3494: Metal valves and pipe fittings (1979:Q1-1987:Q3)											
United	0.92	-0.30	-0.001	0.78	-0.20	-0.09	1.06	-0.29	0.02	0.37	0.25
States	(15.3)	(-0.8)	(-0.4)	(3.8)	(-0.6)	(-0.8)	(5.4)	(-0.7)	(0.2)		
Japan	0.97	-0.37	0.015	0.93	-3.49	0.11	1.16	-0.39	0.94	0.03	0.15
	(6.5)	(-1.1)	(2.5)	(4.9)	(-2.1)	(0.5)	(8.1)	(-0.2)	(3.5)		

Estimation Results by Industry (Concluded)

	Technical			Domestic			Export			Adjusted R-squared	
	σ	τ	ϕ	μ_d	λ_d	θ_d	μ_x	λ_x	θ_x	Domestic	Export
SIC 3519: Internal combustion engines (1978:Q4-1987:Q3)											
United States	0.89 (15.5)	-0.52 (-1.7)	-0.001 (-0.7)	1.64 (5.1)	-0.70 (-3.8)	-0.21 (-2.0)	1.34 (10.0)	-0.13 (-0.5)	-0.20 (-1.6)	0.30	0.32
Japan	0.45 (2.2)	-0.21 (-0.5)	0.001 (0.1)	0.12 (1.1)	-4.87 (-0.8)	-0.39 (-0.8)	1.06 (6.8)	-0.03 (-0.02)	-0.49 (-1.8)	0.03	0.27
SIC 3523: Farm machinery and equipment (1978:Q4-1987:Q3)											
United States	0.94 (18.6)	-0.45 (-1.3)	0.001 (0.3)	0.91 (3.6)	-0.31 (-1.6)	-0.12 (-1.1)	1.16 (6.8)	0.76 (1.7)	-0.20 (-1.2)	0.53	0.19
Japan	0.90 (20.1)	0.01 (0.1)	0.009 (4.9)	1.33 (8.8)	-0.22 (-0.4)	-0.21 (-2.8)	1.36 (6.3)	0.55 (0.9)	0.11 (1.1)	0.20	0.34
SIC 3531: Construction equipment (1979:Q1-1987:Q3)											
United States	0.84 (19.0)	-0.36 (-1.1)	0.001 (0.9)	0.67 (3.7)	-0.18 (-0.8)	-0.04 (-0.5)	0.70 (4.0)	-0.05 (-0.1)	-0.11 (-1.6)	0.63	0.71
Japan	0.93 (21.7)	-0.19 (-1.5)	0.012 (6.6)	1.15 (4.3)	0.03 (0.1)	-0.13 (-2.2)	0.97 (7.1)	0.61 (0.8)	0.58 (5.5)	0.09	0.68
SIC 3546: Power-driven hand tools (1978:Q4-1987:Q3)											
United States	0.92 (16.9)	-0.51 (-1.5)	0.002 (1.5)	1.03 (6.1)	0.00 (0.01)	-0.03 (-0.5)	0.90 (5.3)	-0.48 (-1.1)	0.11 (1.1)	0.48	0.16
Japan	1.09 (11.0)	0.62 (0.4)	0.010 (2.9)	0.45 (2.8)	-2.85 (-1.8)	0.25 (1.3)	0.63 (5.9)	-0.32 (-0.5)	0.26 (1.6)	0.06	0.26
SIC 3555: Printing trades machinery and parts (1979:Q1-1987:Q3)											
United States	0.96 (19.9)	-0.16 (-0.4)	-0.000 (-0.03)	1.01 (6.4)	0.32 (1.1)	0.16 (2.1)	1.16 (6.3)	-0.43 (-1.1)	0.01 (0.1)	0.15	0.09
Japan	0.97 (17.2)	0.35 (2.0)	0.002 (0.7)	1.26 (7.6)	0.20 (0.3)	-0.21 (-2.4)	1.24 (6.3)	-0.10 (-0.2)	-0.22 (-2.3)	0.02	0.31
SIC 3561: Pumps and pumping equipment (1979:Q2-1987:Q3)											
United States	0.85 (16.5)	-1.21 (-3.6)	0.001 (0.9)	0.37 (1.4)	-0.14 (-0.2)	0.03 (0.1)	0.94 (7.6)	0.05 (0.1)	-0.10 (-1.1)	0.71	0.59
Japan	0.97 (17.6)	-0.10 (-0.7)	0.007 (2.8)	0.97 (7.5)	-0.07 (-0.4)	-0.03 (-0.3)	0.99 (7.4)	-0.03 (-0.3)	-0.05 (-0.5)	0.00	0.00
SIC 3651: Radio and TV equipment (1981:Q1-1987:Q3)											
United States	0.92 (10.1)	-0.92 (-2.0)	0.008 (4.4)	0.99 (5.5)	0.01 (0.1)	0.26 (2.1)	0.96 (4.3)	-0.31 (-0.7)	0.28 (1.5)	0.16	0.05
Japan	0.71 (5.3)	-0.68 (-2.5)	0.012 (2.7)	0.32 (1.5)	-5.08 (-1.2)	0.38 (0.8)	1.23 (7.9)	0.34 (0.5)	0.24 (1.8)	0.05	0.57
SIC 3674: Semi-conductor devices (1979:Q4-1987:Q3)											
United States	0.94 (8.4)	0.48 (0.7)	0.009 (2.6)	0.77 (4.4)	0.08 (0.1)	0.18 (1.6)	1.18 (8.7)	-0.03 (-0.01)	0.03 (0.2)	0.00	0.01
Japan	0.54 (2.0)	-0.69 (-1.4)	0.032 (2.8)	0.98 (6.0)	-0.13 (-0.05)	-0.30 (-0.8)	1.00 (6.9)	0.45 (0.2)	0.72 (1.6)	0.06	[illegible]
SIC 3711: Motor vehicles and passenger car bodies (1981:Q4-1987:Q3)											
United States			-0.000 (-0.2)	1.52 (11.3)	-0.24 (-0.5)	0.19 (0.6)	1.17 (7.3)	-0.19 (-0.7)	0.24 (1.7)	[illegible]	0.32
	0.98 (14.1)	-0.25 (-1.1)									
Japan			0.011 (2.6)	0.13 (1.2)	-0.55 (-0.4)	-0.18 (-0.6)	1.27 (6.4)	-1.20 (-1.9)	0.37 (3.2)	0.02	0.38
(Using aggregate data in Figure 1) All manufacturing (1975:Q4-1987:Q3)											
United States	0.86 (16.9)	-0.19 (-0.5)	0.002 (1.5)	0.67 (6.0)	0.11 (0.6)	0.05 (1.1)	0.56 (4.5)	0.16 (0.7)	0.07 (0.7)	0.57	0.58
Japan	0.75 (11.4)	-0.28 (-2.0)	0.012 (6.8)	0.44 (4.2)	0.34 (0.3)	0.07 (0.5)	1.14 (9.7)	0.19 (0.2)	0.19 (1.9)	0.72	[illegible]

Note: These are the results of 3SLS estimation of (9)-(12).
t-statistics are in parentheses.

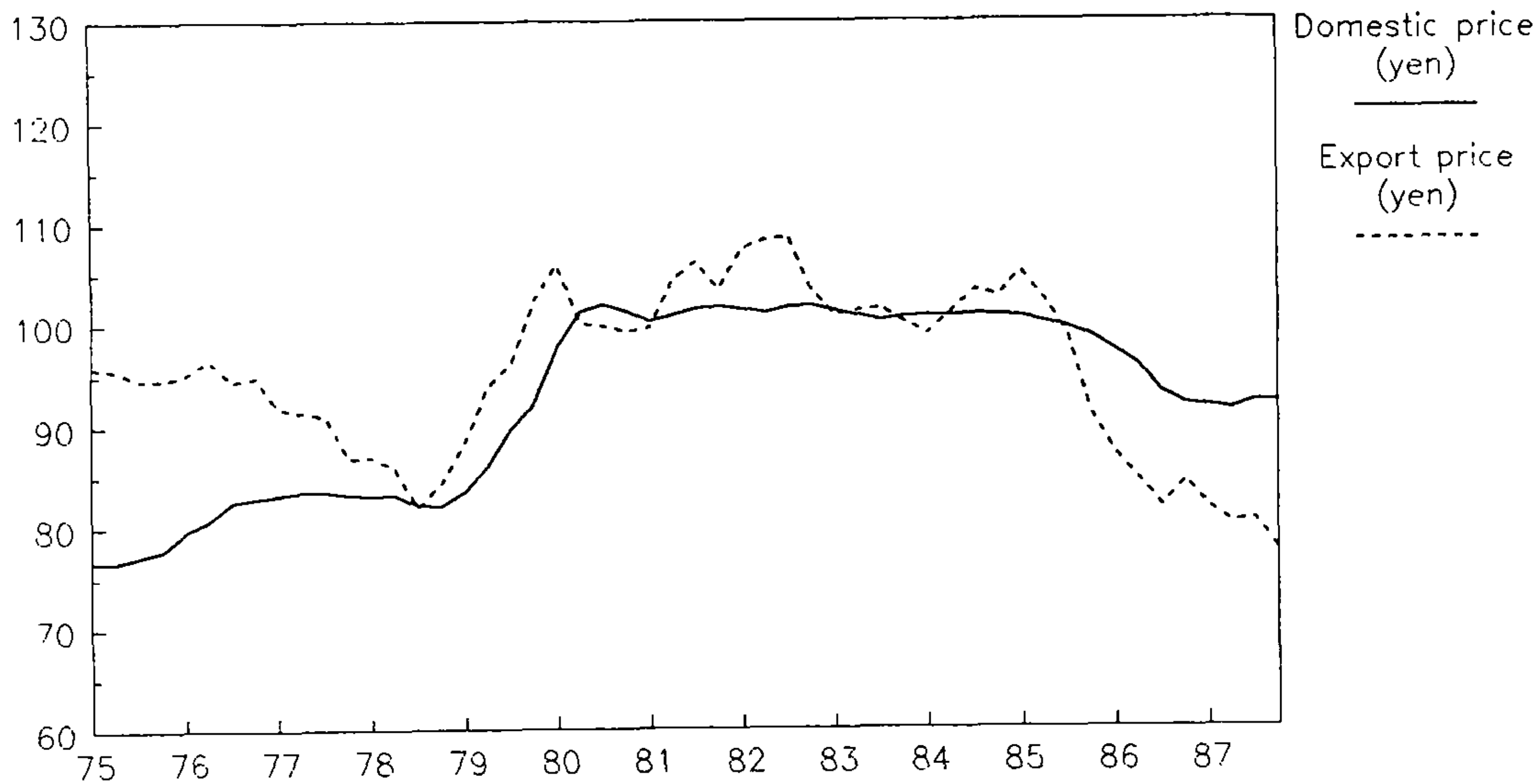
Figure 1 (a)
Manufacture Prices: U.S.
(1980 = 100)



Sources: Department of Labor, the producer price index for durable manufactures;
Department of Commerce, the implicit price deflator for nonagricultural exports.

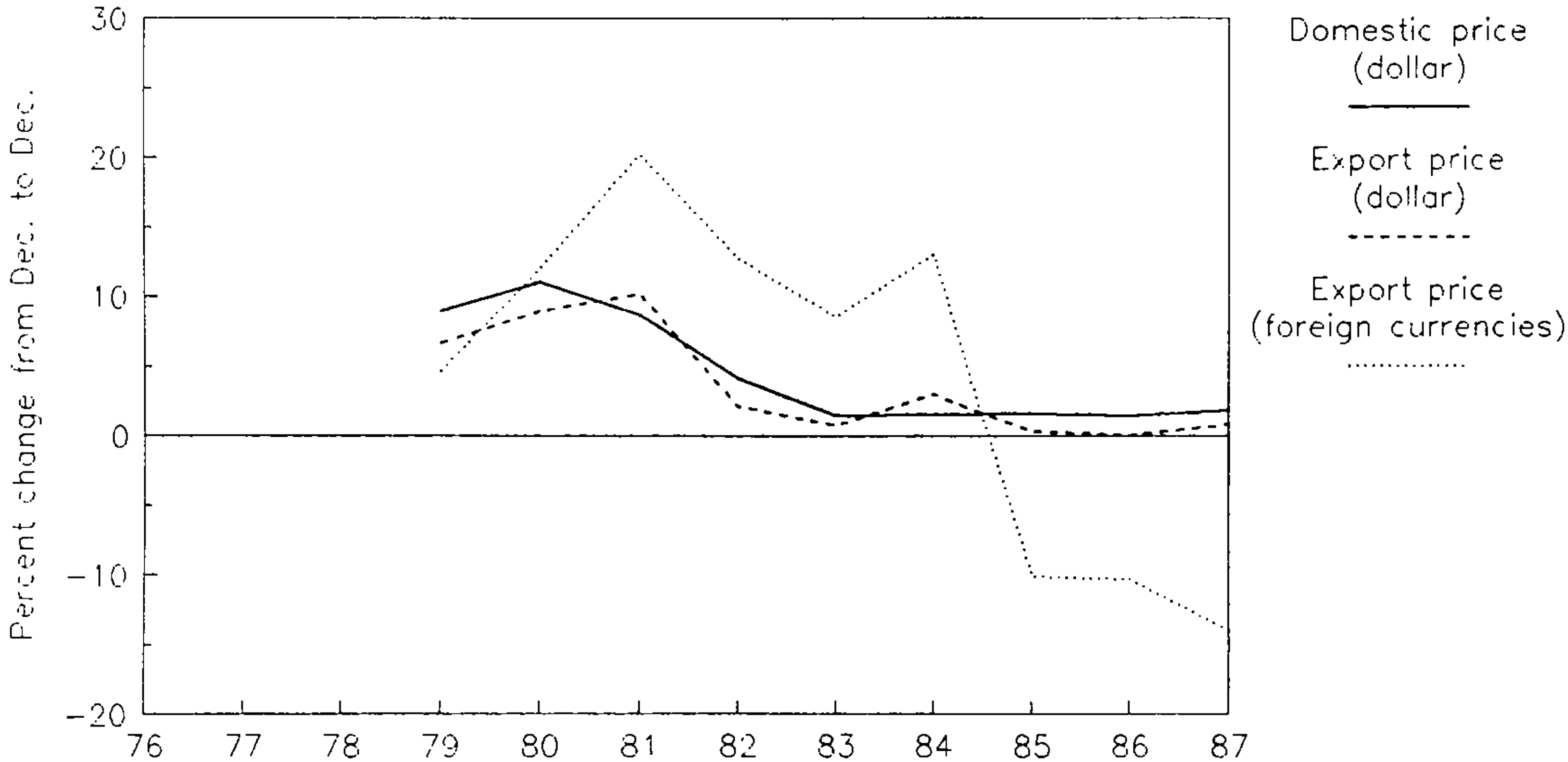
Figure 1 (b)

Manufacture Prices: Japan
(1980 = 100)



Sources: Bank of Japan, the domestic wholesale price index for manufactures and the overall wholesale price index.

Figure 2 (a)
U.S. General Machinery
Changes in Domestic and Export Prices



Note: export prices before 1979 are unavailable.

Figure 2 (b)

Japanese General Machinery
Changes in Domestic and Export Prices

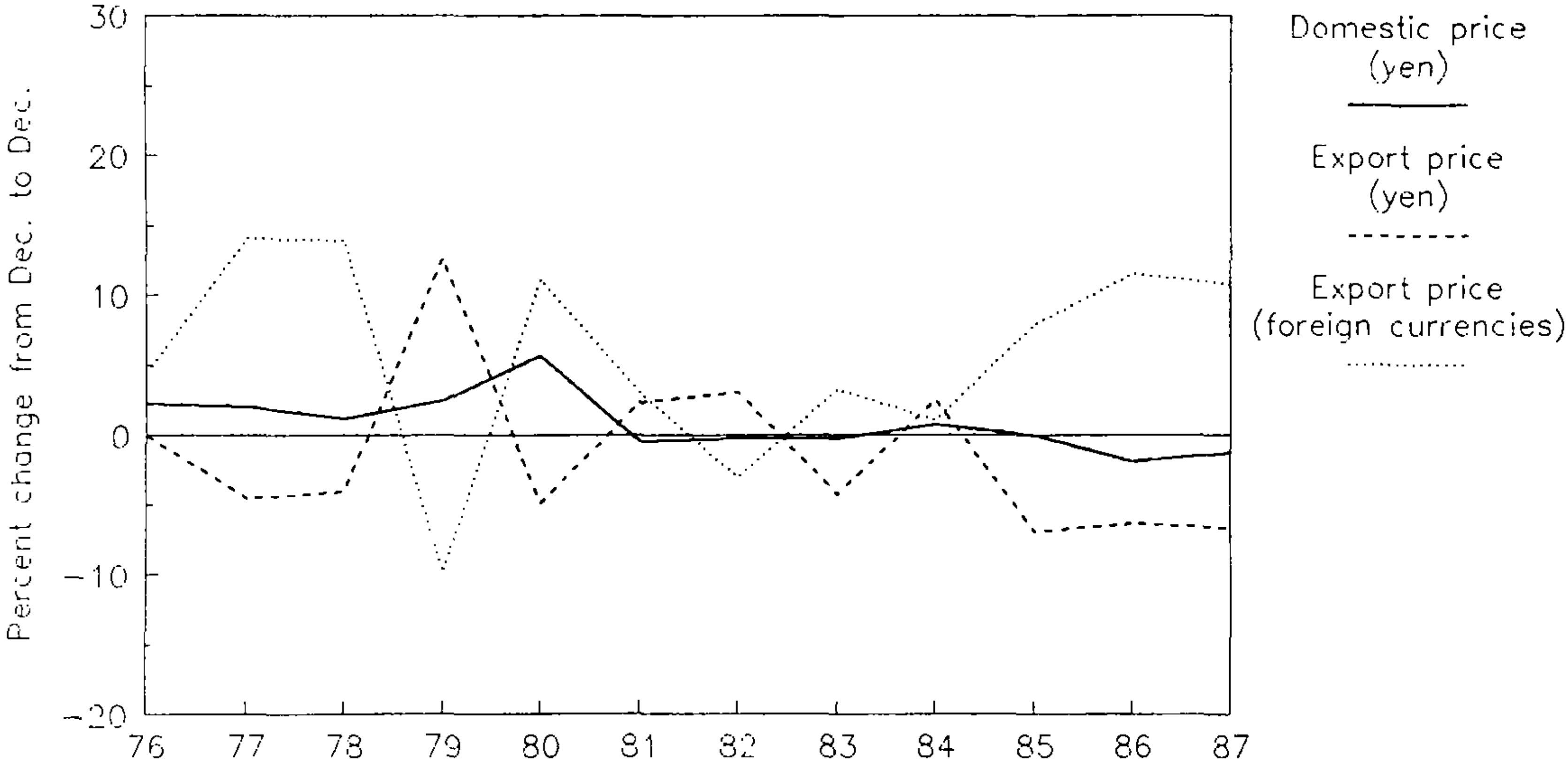
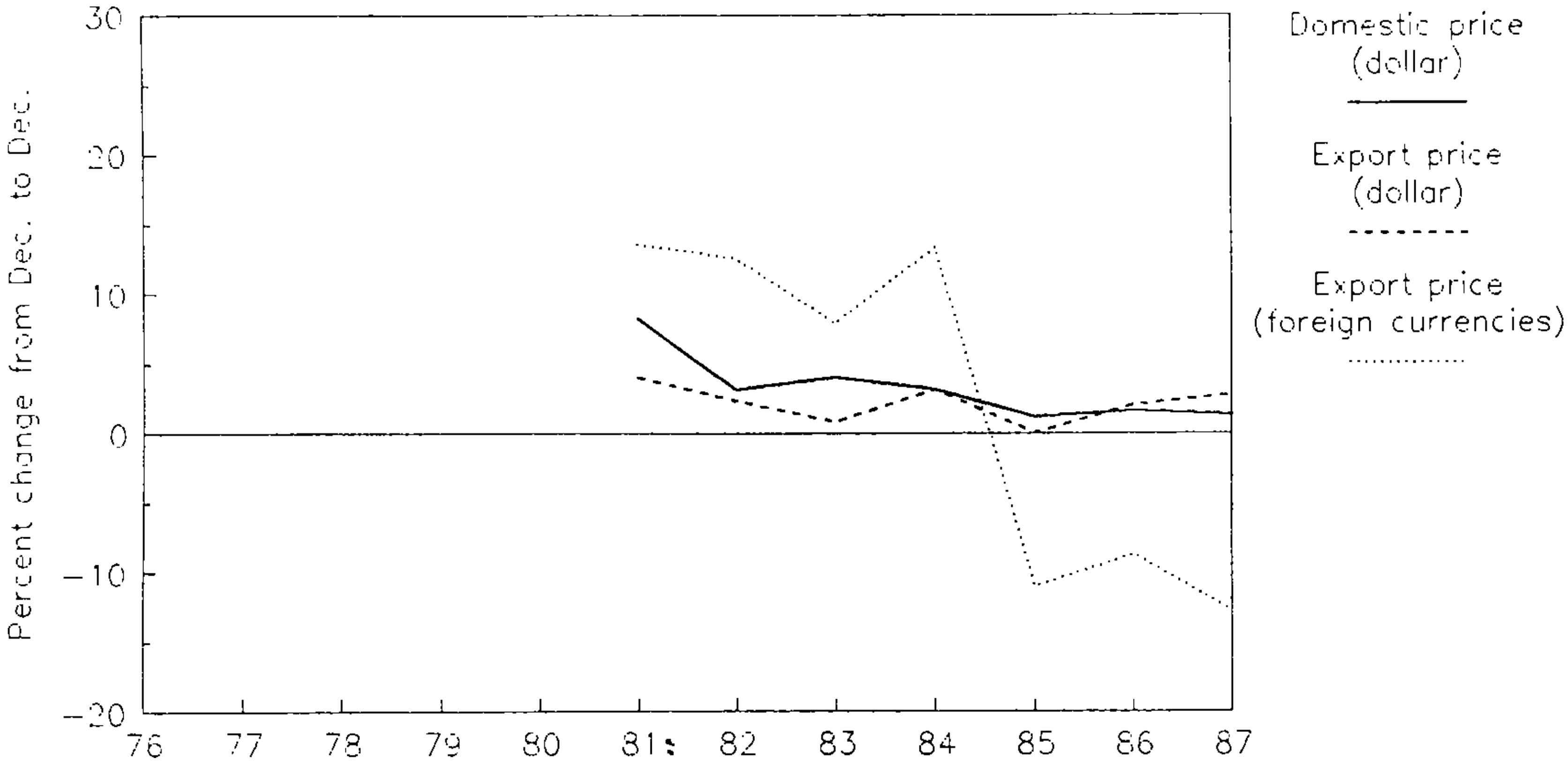


Figure 3 (a)
U.S. Electrical Machinery
Changes in Domestic and Export Prices



Note: export prices before 1981 are unavailable.

Figure 3 (b)

Japanese Electrical Machinery
Changes in Domestic and Export Prices

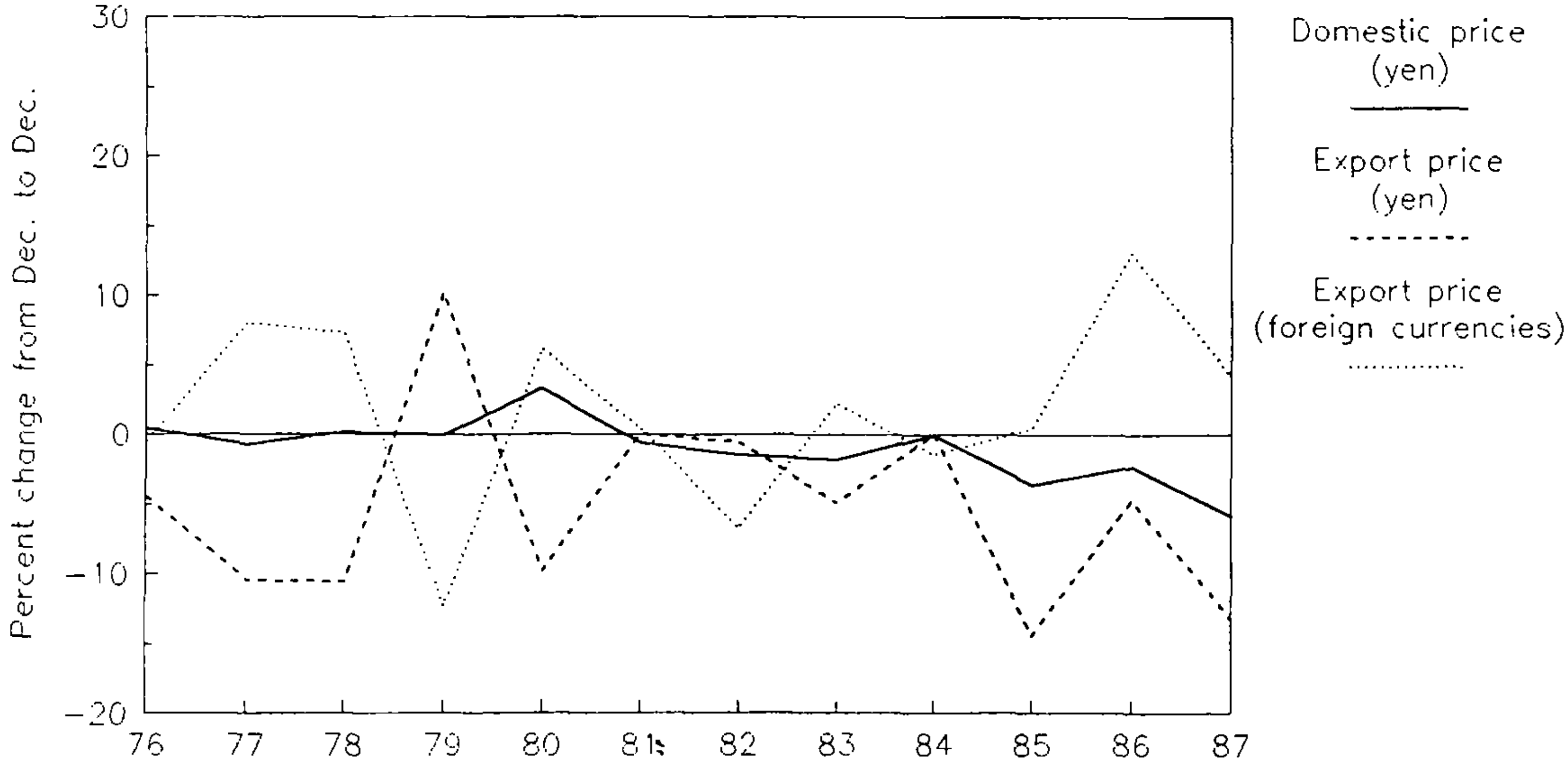
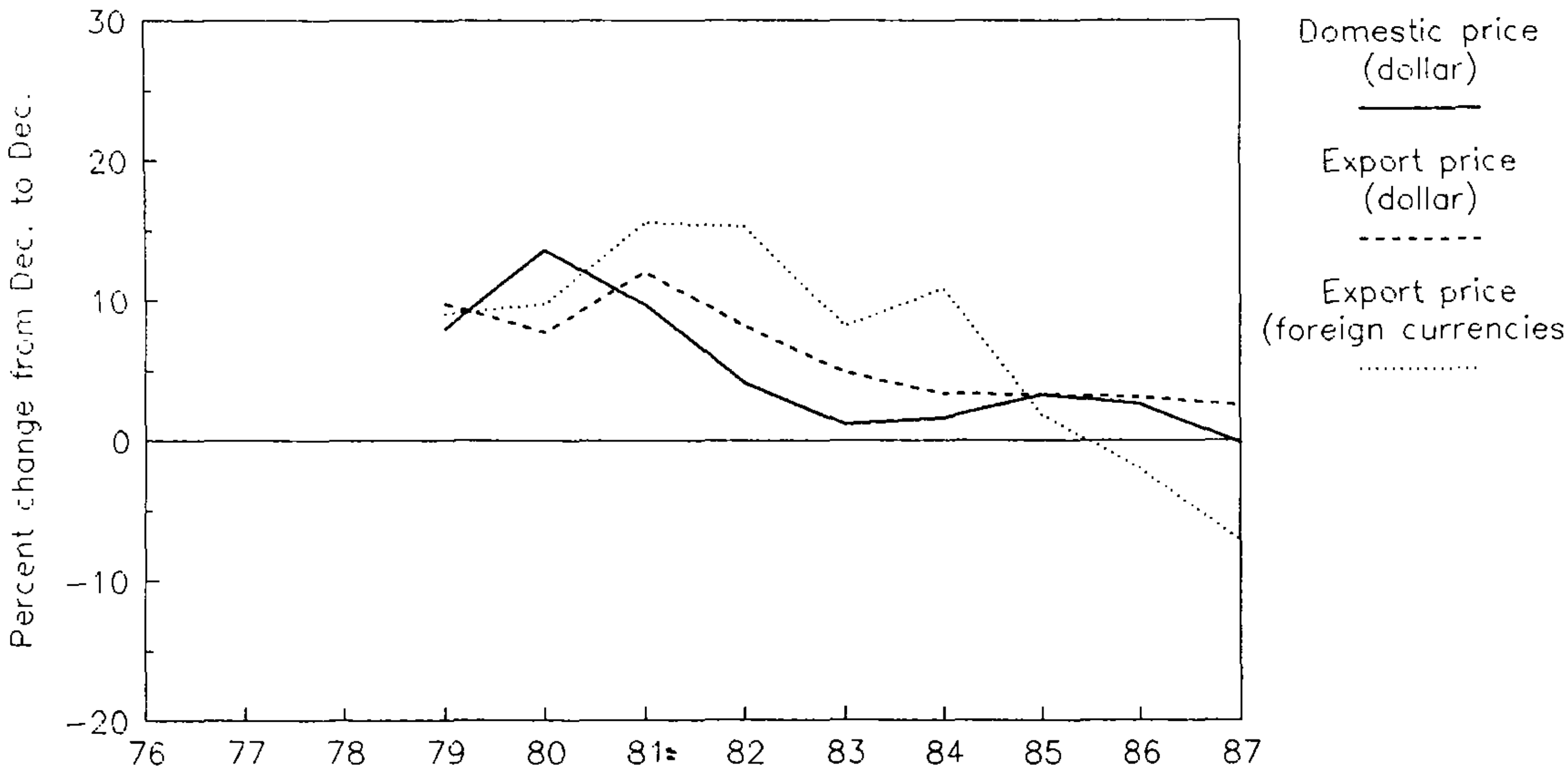


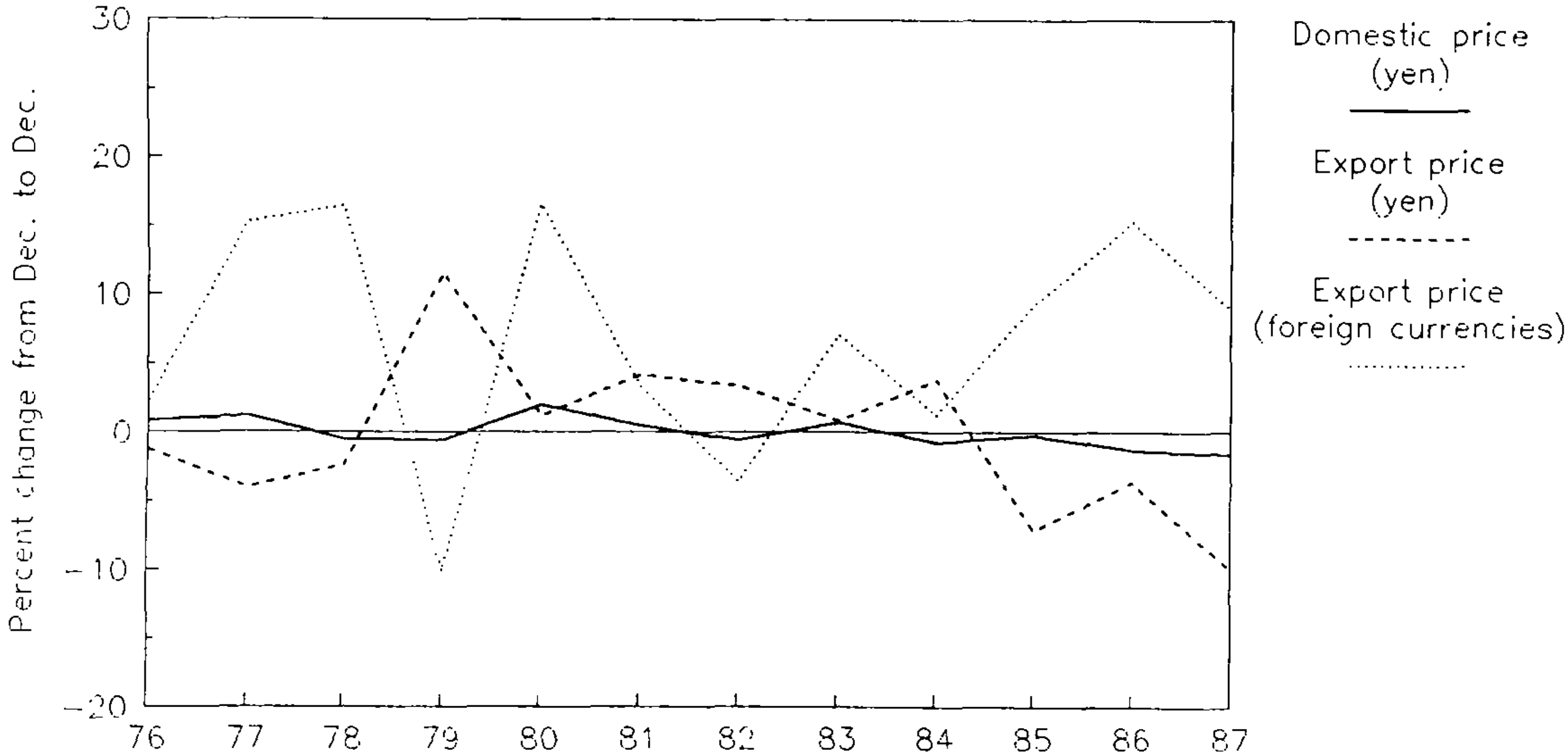
Figure 4 (a)

U.S. Transportation Equipment
Changes in Domestic and Export Prices



Note: export prices before 1979 are unavailable.

Figure 4 (b)
Japanese Transportation Equipment
Changes in Domestic and Export Prices



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