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Influence of Exchange Rate Fluctuation on Japan's Manufacturing Industry — Empirical Analysis : 1980-88

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This paper analyzes the influence of exchange rate fluctuation on the production of Japan's manufacturers. As a result, we find that the short-term cyclical relationship between production and the exchange rate, which was stable during the first half of the 1980s, seems to have greatly changed in the latest phase of the yen's appreciation. We argue that the structural change appears to be partly due to so-called "hysteresis." We also examine the background to the prosperity of manufacturers during the latest phase of the yen's appreciation. In addition, with respect to the short-term cyclical effect, sectorial and regional differences are being analyzed.

I. Introduction

Foreign exchange rate fluctuation has had a great effect on economic trends and industry, as evidenced by the so-called yen appreciation recession and boom. Such fluctuation has a direct effect on the import prices of raw materials and the export prices of most manufactured goods. On the other hand, with respect to non-manufacturers, exchange rate fluctuation has a direct effect on the prices of imported goods, and an indirect effect on production prices mainly through changes in the income of consumers etc.[1] Accordingly, the effect of foreign exchange rate fluctuation on prices differs considerably between manufacturers and non-manufacturers. This paper aims at analyzing the effect of exchange rate fluctuation in the 1980s on manufacturers prices and consequently production which is more directly affected than nonmanufacturing activity.

Typical examples of the great effect of exchange rate fluctuation on manufacturers' production can be seen in the weakening of the competitive edge of the United States and slump in the first half of the 1980s due to the sharp appreciation of the dollar and also

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[1] Corden constructed a model in which industries are classified into two categories — those producing tradable goods and those producing non-tradable goods — and exchange rate fluctuation has an effect on the latter category by bringing about changes in relative prices between the two categories (Corden 1986).

Japan's sluggish production for two years when the yen appreciated (the so-called yen appreciation recession) after the Plaza Agreement. However, it must be noted that the process of permeation and extent of the effect of exchange rate fluctuation on each nation's production is usually complex. For instance, exchange rate fluctuation not only has a short-term cyclical effect via changes in the competitiveness of each nation's manufacturing industry, but also a medium- and long-term or structural effect because, when strategic decisions (such as capital spending and the construction of sales networks) are made, exchange rate fluctuation greatly influences whether such action should be taken domestically or overseas. Hence, the effect of exchange rates on production activity not only depends on the exchange level at a specific point in time but also on the exchange rate fluctuation prior to that time as well as the economic situation.

This paper takes up this subject. Specifically, a) we will classify the effect of exchange rate fluctuation on the production of Japanese manufacturers into the short-term cyclical effect and the structural one (including so-called hysteresis), b) we will analyze the relationship between the sharp appreciation of the yen and structural adjustment in Japan's manufacturing industries, and c) the background to the rapid production recovery of Japanese manufacturers under the yen's appreciation since the fall of 1987 will also be analyzed. Although focus is basically on overall manufacturing, d) as for the short-term cyclical effect of exchange rates, we will examine sectoral and regional differences because, in the current phase of the yen's appreciation, such differences have often attracted attention from the standpoint of social policy. And, as empirical analysis of sectoral and regional differences using a similar analytical framework to this study has been already conducted in the United States (Branson and Love 1986, 1987, 1988), it would seem to be of interest to compare both analyses.

In Section II, after reviewing movements in the yen rate and the production of Japanese manufacturers over the past ten years, we will explain the theoretical model on which analysis in this paper is based and the equation derived from it. Section III deals with the short-term cyclical effect of exchange rate fluctuation on the production of Japanese manufacturers. In Section IV, we will consider structural effects in the 1980s. Based on the results obtained from the analysis in Section II, in Section V, we will consider the background against which Japanese manufacturers recovered and rapidly expanded production since the latter half of 1987, while continuing to suffer from the yen's appreciation. Lastly, in Section VI, we will refer to policy implications deriving from the results of the analysis and present analytical problems and issues to be tackled.

The major conclusions obtained from the analyses can be summarized as follows.

(1) As for the short-term cyclical relationship between the yen rate (in order to exclude the effect price fluctuation has on exchange rates, and in consideration of the fact that there are multiple partners and competitors in trade, the yen rate in this paper is taken to be the real effective rate) and production by Japan's manufacturers, the yen's appreciation theoretically ought to affect production negatively because it contributes to

a worsening of the price competitiveness of Japanese manufactured goods vis-à-vis foreign ones, and vice versa. Empirical analysis of the influence of foreign exchange rate fluctuation on production shows that, in fact, a stable relationship as mentioned above existed until the first half of the 1980s when the yen was relatively cheap (estimation period: from the second quarter of 1976 to the third quarter of 1985). According to estimation results, the trend of the cheap yen in real terms in the first half of the 1980s led to an average 1-2% increase in the production of Japanese manufacturers. As for sectoral differences, it was empirically proven that export-oriented industries (such as industrial machinery and electrical machinery) suffered more seriously than domestic demand-oriented ones (such as food and textiles).

(2) However, during the course of the rapid and high appreciation of the yen since the fall of 1985, the above relationship has changed. The estimation result shows that the effect of exchange rate fluctuation slightly weakened in the initial phase of the yen's appreciation (until mid-1986), but rapidly strengthened thereafter.

(3) The weakening effect of the yen's appreciation in the initial stage of the latest appreciation phase seems to stem from the fact that action taken by corporations in the process of the large and prolonged depreciation of the yen (from the end of the 1970s to the beginning of 1985) prior to the yen's appreciation occasioned substantial and protracted changes in the structure of markets. That is, since Japan's export industries newly set up overseas sales bases and expanded their overseas sales networks parallel with the yen's depreciation, they made efforts to suppress a rise in export prices (which narrowed profit margins) and maintain export volume when faced with the yen's sharp appreciation. This strategy (so-called hysteresis[2] which could be taken as a side effect of the yen's depreciation) is considered to have weakened the effect of the yen's appreciation in the initial stage. On the other hand, the greater effect after mid-1986 seems attributable to the fact that hysteresis disappeared with the further progress of the yen's appreciation and thereafter the structural effect of the yen's sharp appreciation expanded (a retreat from export markets and transfer of production bases overseas etc.) negatively affecting domestic production.

(4) In the process of the yen's sharp appreciation since 1985, in particular after mid-1986, its effect in suppressing domestic production was stronger than before. Nevertheless, since the latter half of 1987, production by Japanese manufacturers has showed a rapid recovery and expanded with the business picture consequently improving remarkably. This apparent paradoxical phenomenon can be attributed to the following develop-

[2] Hysteresis here means that once wide exchange rate fluctuation brings about structural changes in markets, then even if exchange rates return to their previous level, the effects would not be completely dissolved. For instance, a Japanese corporation which advanced into the U.S. market during a yen depreciation phase does not retreat even when faced with an appreciation of the yen. It is often pointed out that an incomplete pass-through (suppression of raising dollar-denominated export prices to cope with the yen's appreciation) caused a delay in an improvement in the trade imbalance. For details of causes of hysteresis, see Section IV.

ments: a) The strong effects of fiscal expansion and monetary relaxation, b) The declining profitability of exports along with the yen's appreciation (a fall in yen-denominated export prices) could be offset to a certain degree by the sharp fall in the prices of imported raw materials (drop in oil prices and yen-denominated import prices due to the yen's appreciation) and rationalization and cost-saving efforts to cope with the sharp appreciation of the yen (reduction of costs), and c) The profitability of manufactured goods for domestic markets is likely to worsen owing to the yen's appreciation through intensified price competition with imported goods. In Japan, however, as there seems to be rather strong segmentation between domestic and external markets, the deterioration in profit performance in domestic markets has been relatively slight. d) As Japanese manufacturers have pursued overseas production consistently both in the phase of the cheap yen (in order to cope with intensified trade friction due to a sharp increase in exports) and in the phase of the strong yen (advantages from the transfer of production bases abroad have begun to be felt), the effect of the yen's appreciation on domestic production has diminished.

(5) As shown by this analysis of the yen's appreciation phase since 1985, when and how the effect of exchange fluctuation on the production of Japanese manufacturers and Japan's trade balance materialize depends also on the yen rate in previous periods (hysteresis). Accordingly, influence of the yen's appreciation on Japan's trade surplus are likely to appear with a considerable time lag in a different sense from the so-called J-curve effect. Nevertheless, it seems appropriate to say that the yen rate plays a major role in Japan's efforts to restructure her economy, thereby improving its huge trade imbalance with other nations.

II. Relationship between Exchange Rate Fluctuation and Production

A. The yen rate and production

Prior to an empirical analysis, we will review the movement in the yen rate and the production of Japan's manufacturers over the past ten years. The yen rate against the dollar rapidly rose (Figure 1) both in nominal and real terms (after adjustment for the inflation differential between domestic wholesale prices and those in the United States) from 1977 through 1978 when Japan's current account surplus exceeded $10 billion annually. In 1979, though, it dropped significantly due to the effect of U.S. policy to defend the dollar (November 1978) and the second oil crisis (January 1979). In the first half of the 1980s, exchange rates moved in the direction of the yen's depreciation (dollar appreciation) on the whole. This trend of a cheap yen hit bottom at the beginning of 1985 and the yen began to surge in September when the Plaza Agreement was concluded to correct the strong dollar. The period from 1985-88 is the third phase of the yen's appreciation following that after the Nixon Shock (1971–73) and that from 1977–78 (see Sanuki 1988). By mid-1988, the yen rate against the dollar had risen by 50% in nominal terms

Figure 1. Yen/Dollar Exchange Rate

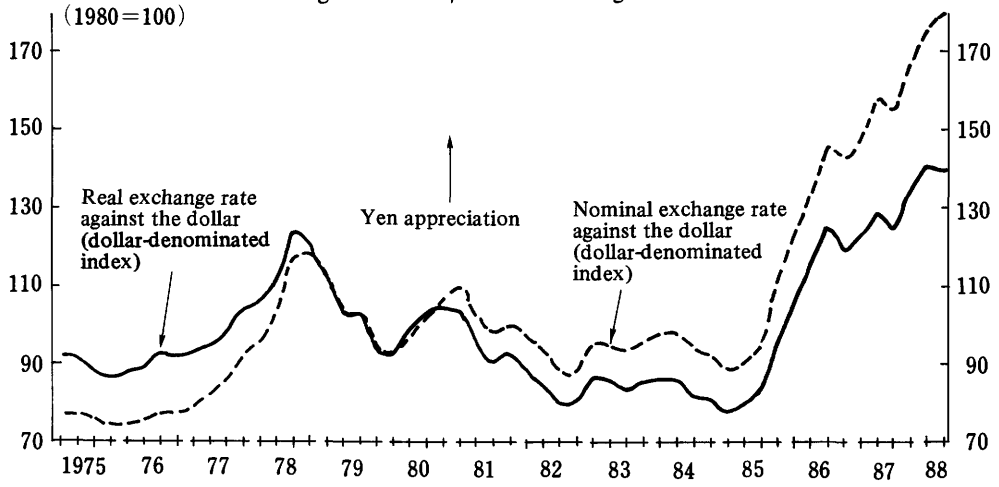


Figure 2. Change in Effective Exchange Rates

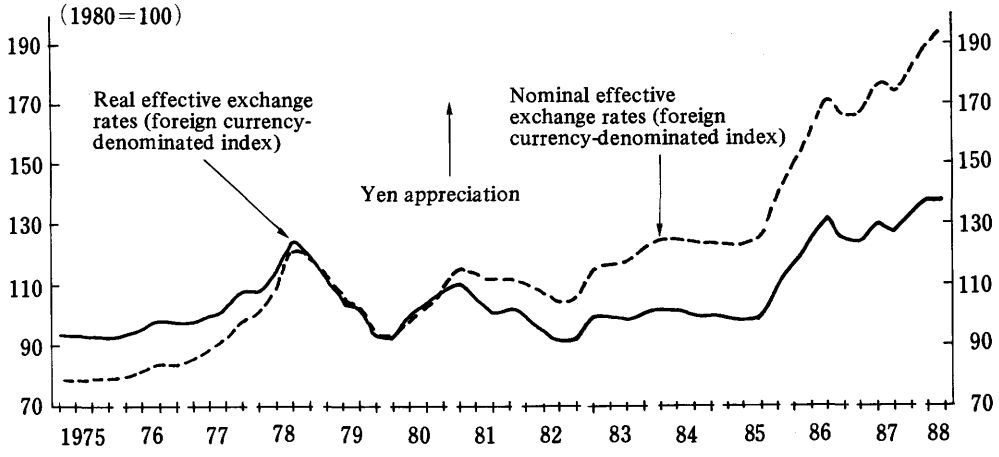


Figure 3. Index of Mining and Manufacturing Production

and more than 10% in real terms from the peak in 1978. The rate of appreciation was also much higher. Thus, yen-dollar adjustment in the third phase was substantial both in terms of scale and pace.[3]

Reviewing the effective rate, which takes the existence of multiple trade partners and competitors into consideration (Figure 2), we see that the nominal effective rate[4] of the yen rose narrowly in the first half of the 1980s, while the real effective rate[5] (adjusted for differences in inflation among nations) fell, reflecting the fact that Japan's prices were relatively stable. However, the rapid and significant appreciation after the Plaza Agreement is also true for the effective rate.[6] By the second quarter of 1988, the yen stood 60%

[3] Change in the yen/dollar exchange rate (dollar-denominated)

Period	Rise in nominal rate	Rise in real rate
1976/I —1978/IV	59%	38%
1985/III—1988/II	90%	68%

[4] The effective exchange rate index is a weighted average of bilateral exchange rates between a certain currency and other multiple currencies. The calculation formula differs depending on purpose. The nominal effective exchange rate index in this paper is calculated and announced by IMF (the MERM index) — the weight of each currency is based on IMF's multilateral exchange rate model (MERM). For further details of the nominal effective exchange rate, see Takagi (1989) and Rhomberg (1976).

[5] As for deflators to be used in calculating real exchange rates as an indicator of international price competitiveness, various price indices are used such as the wholesale price index, the consumer price index, the GNP deflator, etc. Marston (1986) pointed out that general price indices, including CPI and the GDP deflator, are not appropriate as indicators of international price competitiveness since indices include non-tradable goods. Here, however, we use the domestic wholesale price index for Japan, and wholesale or producer price indices for foreign nations, which are considered to correspond to Japan's wholesale price index.

[6] Change in the effective yen rate (foreign currency-denominated)

Period	Rise in nominal rate	Rise in real rate
1976/I —1978/IV	50%	29%
1985/III—1988/II	56%	39%

higher in nominal terms and 10% higher in real terms from the 1978 peak.

Meanwhile, production by Japan's manufacturers posted double-digit year-to-year increases throughout 1984 (Figure 3), then rapidly slowed down after 1985 when the yen's appreciation advanced and, from 1986, stood still for about a year and a half. These facts suggest the important effects of exchange rates. On the other hand, in 1982, production was stagnant in spite of the yen's depreciation. In addition, from the latter half of 1987, production rapidly recovered, despite the progress of the yen's appreciation at that time. These facts suggest that the production movements of Japanese manufacturers reflect factors other than the exchange rate.

B. Objects of analysis and theoretical model

The effect of exchange rate fluctuation on production is complicated. For instance, the yen's appreciation brings about a decline in yen-denominated import prices. While this phenomenon has favorable effects, such as a) a decrease in the cost of imported raw materials and b) an increase in the real income of domestic consumers, it also has negative effects, including c) a shift in demand from domestically-manufactured goods to imported ones and d) a decline in the prices of domestically-manufactured products. These effects can be roughly classified into two categories—the direct effect through relative prices which changes international price competitiveness and the indirect effect through the impact on the real income of consumers. Ordinarily, when we refer to the effect of exchange rate fluctuation on corporations, in particular the relatively short-term effect, it means the former influence, i.e. the relative price effect. Reference to "industries suffering a recession due to the strong yen" and "industries enjoying the merits of the strong yen" implies this former effect. On the other hand, the latter influence by way of effect on income is complicated because it permeates via the dynamic economy[7] thus making it difficult to quantify. Accordingly, in this paper, we will restrict analysis to the direct and relative price effect.

Analysis will focus on a regression equation with the yen rate as one explanatory variable. To corroborate our analysis, we will use a variety of price statistics, including the wholesale price index, the input and output price index, and results of surveys conducted by the Economic Planning Agency.

The regression equation is based on a reduced form equation for the determination of production, which is derived from a simple theoretical model. Under the framework of

[7] The route of the effect on consumer income can be classified into a domestic one and an external one. These two routes can be sub-divided into users of imported goods and producers of goods which compete with imported goods. During a yen appreciation phase, for example, the real income of users of imported goods is raised, while the real income of suppliers of goods which compete with imported goods is negatively affected. On the other hand, in the case of foreign nations, an adverse situation occurs. How the effect appears differs depending on the price elasticity of demand, restrictions on imports, distribution networks, the supply capability of foreign nations and price control power related to market shares etc. In order to analyze the whole trend of effects, a macroeconometric model is required.

this model we assume as follows. First, domestically-manufactured goods cannot be completely substituted by externally-manufactured goods. Second, the supply function is the function of relative prices of production factors (raw materials, labor and capital) to manufactured goods. Third, the demand function is a function of relative prices between domestically-manufactured goods and externally-manufactured ones and of the real income of domestic and external consumers. Lastly, the level of production of domestically-manufactured goods and their prices are determined when demand/supply is in equilibrium. With these assumptions, the reduced form of the production equation is as follows (for details, see Appendix I):

$$q = a_1A[(b_1+b_2)^{-1}\{b_1(p_N{}^F-e)+b_2w\}-(p^F-e)]$$

$$+a_2Ay+a_3Ay^F+(a_1+b_1+b_2)^{-1}a_1k, \quad (1)$$

where q = production volume of domestically-manufactured goods; $p_N{}^F$ = external price of raw materials (foreign currency denominated); w = nominal wages; p^F = price of externally-manufactured goods which are competitive with domestically-manufactured ones (foreign currency-denominated); e = nominal effective yen rate (foreign currency denominated); y and y^F = domestic and external real income, respectively, and k = capital stock of Japanese manufacturing industries. All these are logarithms.

The parameter, a_i (i=1,2,3), depicts elasticity of demand. a_1 is the elasticity of demand to the relative price between domestically-manufactured goods and externally-manufactured ones (price of domestically-manufactured goods/price of externally-manufactured goods). a_2 and a_3 depict elasticity of demand to domestic and external real income, respectively.

The sign conditions of these parameters are as follows. As for a_1, if the price of domestically-manufactured goods increases more than that of externally-manufactured goods, demand for domestically-manufactured goods would decrease. Accordingly, a_1 is clearly negative ($a_1 < 0$). a_2 and a_3, which represent the elasticity of demand to real income, are uncertain depending on the character of the goods. When a good is inferior, for example, there is a possibility that demand for it will decrease along with an increase in income. It may be appropriate, however, to consider that a_2 and a_3 are positive ($a_2 > 0$, $a_3 > 0$) for Japanese manufactured goods. b_1, b_2, respectively represent the relative price of raw materials to manufactured goods and the elasticity of supply of raw materials to real wages. The sign conditions are, therefore, negative ($b_1 < 0$ and $b_2 < 0$), and thus $A = (a_1 + b_1 + b_2)^{-1}(b_1 + b_2)$ will accordingly be positive ($A > 0$).

Let us next interpret the meaning of this reduced form equation. The identity inside the square brackets in the first term on the right side depicts the difference between a weighted mean of the yen-denominated price of raw materials ($p_N{}^F-e$) and nominal wages (w) and the yen-denominated price of externally-manufactured goods (p_N-e). This can be regarded as the real yen rate (foreign currency denominated)[8] calculated with

deflators for domestic production costs and prices of externally-manufactured goods. Since $a_1 < 0$ and $A = (a_1+b_1+b_2)^{-1}(b_1+b_2) > 0$, we have $a_1 A < 0$. Assuming $a_2 > 0$ and $a_3 > 0$, the parameter of domestic real income in the second term and the parameter of external real income in the third term are positive ($a_2 A > 0$, $a_3 A > 0$), since $A > 0$. As $(a_1 + b_1 + b_2)^{-1} < 0$ and $a_1 < 0$, the parameter of capital stock in the fifth term is positive ($(a_1 + b_1 + b_2)^{-1} a_1 > 0$).

In short, this reduced form equation shows that the production of domestically-manufactured goods is a decreasing function of the foreign currency-denominated real effective yen rate and an increasing function of domestic and external real income and existing capital stock.

C. Specification of estimating equation

We specified an estimating equation as follows based on the above-mentioned reduced form equation.

$$\text{Log}(Q) = \alpha+\beta\cdot TR+\gamma\cdot\text{Log}(REX)+\delta\cdot\text{Log}(Y)+\varepsilon\cdot\text{Log}(Y^F)+u \qquad (2)$$

where a dependent variable Log (Q) is a logarithm of production volume. Among independent variables, TR = time trend factors based on long-term trends in population, income, and industrial structure. Log (REX) is a logarithm of a foreign currency-denominated real effective yen rate index, the deflators of which are domestic production costs and prices of externally-manufactured goods. It shows relative price competitiveness between Japanese corporations and foreign competitors. It should be noted that as this real yen rate uses production costs as a deflator for domestic corporations it is therefore different from ordinary relative prices between two nations. Log (Y) and Log (Y^F) are logarithms of domestic and external real income, excluding time trend, respectively, depicting a cyclical demand factor. u is a disturbance term. α, γ, δ, ε, are parameters to be estimated. Observations were made based on quarterly data. Sources of data used in the observations and calculation methods are shown in Table 1.

As for exchange rate factors, in addition to values for the latest period, lagged values for the previous five quarters are included. With respect to domestic real income, lagged values for the previous three quarters are included in addition to values for the latest period. Real exchange rate factors have lags due to: a) the completion of contracts concluded in the past, b) the lag until corporations convince themselves that a change in exchange rates is going to continue and thus decide to change their in-house and prices, c) the lag until negotiations to change prices are completed, and d) the lag until consumers find a substitute for a good the price of which rose due to a change in the exchange rate. The length of lag was chosen after repeated trials within a range from zero to eight

[8] Although this variable is different from ordinary relative price since we use production cost as a deflator of the yen, it can be regarded as a kind of indicator of international price competitiveness.

Table 1. Data Sources and Calculation Method

Variables	Source	Base year/unit	Calculation method etc.
Production	Ministry of International Trade and Industry, *Indices of Industrial Production*	1985=100 Regional data, 1980=100	Manufacturing, seasonally-adjusted, basis for weighting is value added[a]
Exchange rate factor (REX)		1980=100	Nominal effective yen rate / (domestic cost of production / price of foreign products)
Nominal effective yen exchange rate	International Monetary Fund, *International Financial Statistics*	1980=100	MERM[b]
Domestic cost of production		1980=100	Weighted average of hourly wage index and input price index: proportion of compensation of employees to intermediate inputs was used to obtain fixed weight
Price of foreign products	International Monetary Fund, *International Financial Statistics*	1980=100	Weighted average of wholesale price indices of major 17 countries by MERM weighting
Hourly wage index		1980=100	Calculated using monthly salarly indices and monthly working hour indices
Monthly salarly index	Ministry of Labor, *Monthly Labor Survey*	1985=100	Cash earnings per regular employee (establishments with 30 employees and more)

Variables	Source	Base year/unit	Calculation method etc.
Index of monthly working hours	Ministry of Labor, *Monthly Labor Survey*	1985=100	Hours worked by regular employee (establishments with 30 employees and more)
Input price index	Bank of Japan, *Input-Output Price Indexes of Manufacturing Industry by Sector*	1980=100	Manufacturing, gross-weighted base
Domestic real income factor (Y)		¥ billion	Real domestic demand (post-1975 trend excluded)
Domestic demand (real)	Economic Planning Agency, *Report on National Accounts*	¥ billion	
Overseas real income factor (Y^F)		$ billion	World imports, except for Japan, constant prices (base year=1980), (post-1975 trend excluded)
World imports	International Monetary Fund, *International Financial Statistics*	$ billion	

[a]According to the model used in this paper, shipment value should be used as the basis for weighting. However, due to difficulty in obtaining data, value added was substituted.

[b]MERM (Multilateral Exchange Rate Model) indices are effective exchange rate indices calculated for 17 countries including Japan by IMF. For details, see Takagi (1989), Rhomberg (1976) etc.

quarters, based on a coefficient of determination and the Durbin-Watson ratio. Of course, we cannot affirm that our choice is absolutely the best one. However, considering the fact that a company's in-house exchange rate is usually reviewed every half-year or fiscal year and that negotiations to revise prices with regular users are made every quarter or half-year, a five-quarter lag may not be too unrealistic. As for including lagged values in a domestic real income factor, a justification can be made from the standpoint of the permanent income hypothesis, i.e. since wage negotiations are conducted once a year by most corporations in Japan, it is not unnatural if it takes about a year to review permanent income. On the other hand, external real income is not lagged—this is because overseas real imports are used as a proxy variable for real income and thus already realized as demand.

In addition, in their co-authored papers on production by U.S. manufacturers, Branson and Love (see Appendix III) included six-quarter lags in the real effective exchange rate factor and four-quarter lags in the real income factor in a similar examination to ours.

III. First Half of the 1980s—Stable Relationship Between the Yen Rate and Production

In this section, we will estimate the short-term cyclical relationship between real effective exchange rates and production by using the observation equation described in the previous section.

The estimation period is from the second quarter of 1976 to the third quarter of 1985. This period was chosen in order to avoid disturbances due to substantial fluctuation in data occasioned by the first oil crisis and the latest phase of the yen's sharp appreciation. But, at the same time, this choice is aimed at analyzing structural changes parallel with the yen's appreciation. The estimations are also preparatory to an analysis of structural influence in the next section.

A. Estimation result

The estimation result is as follows:

$$\underset{}{\mathrm{Log}(Q_t)} = \underset{(4.1)(3.2)}{-5.5-0.17\cdot\mathrm{Log}\left\{\sum_{j=0}^{5}(REX_{t-j})/6\right\}} \underset{(4.3)}{+0.55\cdot\mathrm{Log}\left\{\sum_{j=0}^{3}(Y_{t-j})/4\right\}}$$

$$\underset{(13.0)}{+0.63\cdot\mathrm{Log}(Y^F{}_t)} \underset{(43.4)}{+0.013\cdot TRt}$$

$$\bar{R}^2 = 0.993 \quad DW = 2.39 \quad SE = 0.01,$$

where Q = production index; REX = exchange rate factor (the real effective exchange rate measured by domestic production costs and external prices); Y = domestic real

income factor excluding trend; Y^F = external real income factor excluding trend; TR = time trend, and figures within parentheses below parameters are t-values. $\bar{R}^2$ denotes the coefficient of determinant adjusted by degrees of freedom. DW is the Durbin-Watson ratio and SE is standard error.

Figure 4 shows estimated and actual values during the estimation period. Looking at the parameters for each explanatory variable, that for the exchange rate factor parameter is negative, which is to be expected considering the theoretical model used in this paper (the appreciation of the yen in real terms negatively affects production), and is statistically significant at the 0.05 level. Parameters for domestic and external real income factors are also positive, as to be expected, and significant. The parameter for the time trend, i.e. the trend annual rate of growth, is significantly positive, and its value (about 5%) seems to be reasonable.

We then estimated the short-term cyclical effect of the exchange rate factor on production in the first half of the 1980s using the above estimation result, and tried to calculate to what extent the cheap yen (in real and effective terms) promoted production. The calculation method is as follows. Fixing the value of the exchange rate factor (real effective yen rate) at its peak level in the first half of the 1980s (the value in the first quarter of 1981) (Figure 5a), we extrapolated production and then subtracted it from ordinary extrapolated values. If the figure (difference) was positive, it meant that the yen's depreciation had pushed production up. As shown in Figure 5b, the cheap yen in the first half of the 1980s contributed to increasing Japanese production by about 1% only due to short-term cyclical effect stemming from relative prices. Whether this effect is serious or not depends upon the view of each economist but, judging from the fact that it has the same effect as a 2-3% increase in domestic and external real income, it can be said

Figure 4. Production Index Estimation Results before the Latest Phase of the Yen's Appreciation (1976/II – 1985/III)

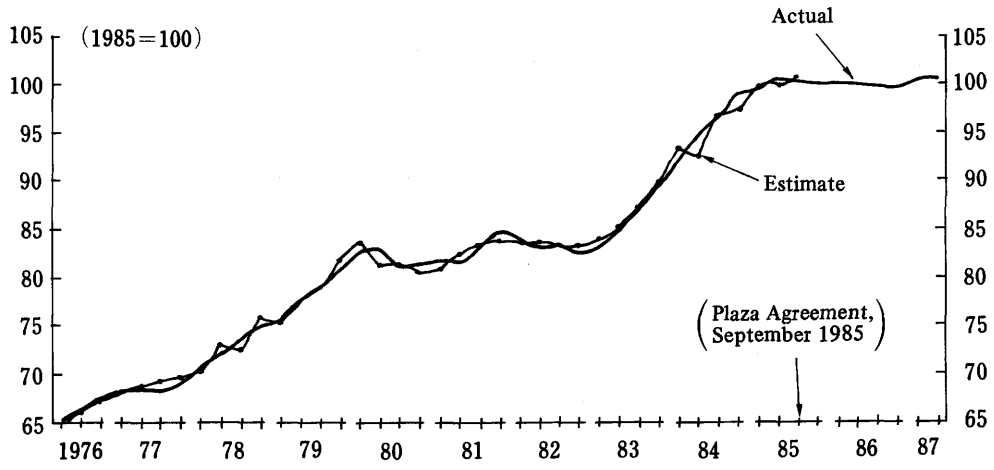


Figure 5a. Change in Exchange Rate Factors in the First Half of the 1980s

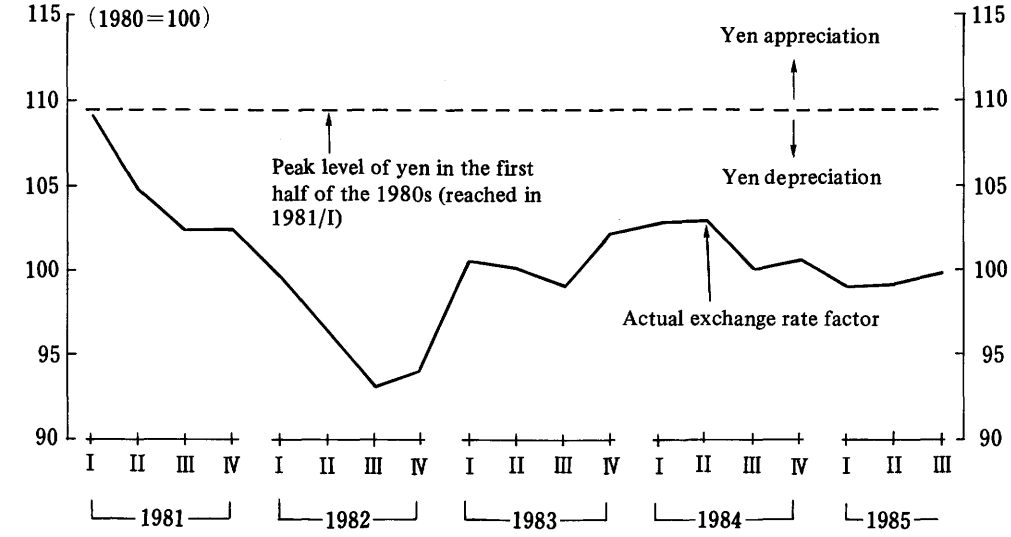


Figure 5b. Short-term Positive Effective of the Yen's Depreciation in the First Half of the 1980s on Production (comparison of exchange rate factors assuming the 1985 average was constant)

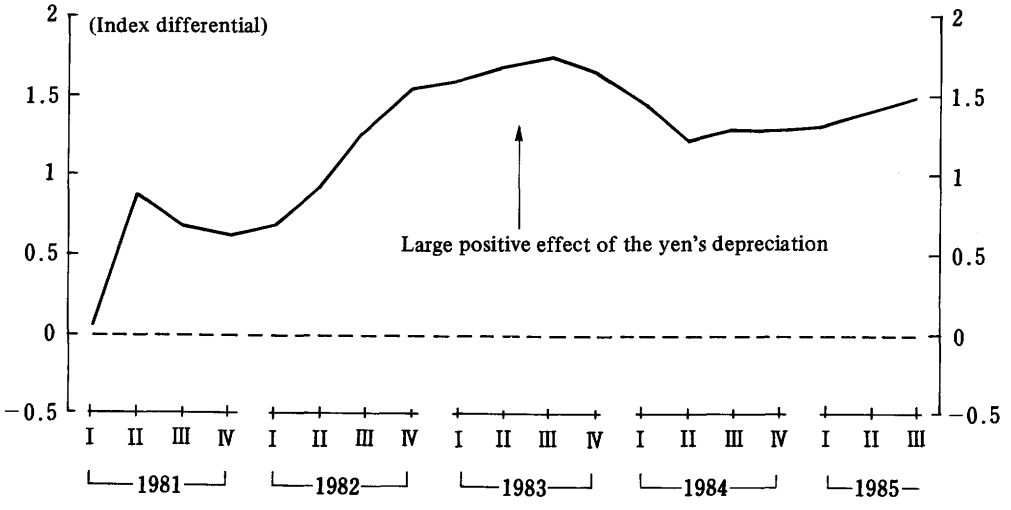


Table 2. Estimation Results of Recursive Regression
(Estimation periods: from 1976/II through 1980/III~1985/III)

Final term	Exchange rate factor	(t-value)	Domestic real income factor	(t-value)	Overseas real income factor	(t-value)	Time trend factor	(t-value)	$\bar{R}^2$	SE	DW
1980/III	−0.16*	2.9	0.91*	4.2	0.30*	2.5	0.013*	15.2	0.99	0.009	1.79
80/IV	−0.16*	3.0	0.91*	4.4	0.30*	2.8	0.013*	17.9	0.99	0.008	1.90
81/I	−0.16*	3.1	0.91*	4.7	0.30*	3.0	0.013*	19.9	0.99	0.008	1.89
81/II	−0.16*	3.1	1.00*	5.7	0.28*	2.8	0.012*	21.1	0.99	0.008	1.82
81/III	−0.16*	3.1	0.93*	5.9	0.30*	3.1	0.013*	23.3	0.99	0.008	2.01
81/IV	−0.15*	2.9	0.84*	5.5	0.32*	3.1	0.013*	23.7	0.99	0.008	1.86
82/I	−0.15*	3.0	0.85*	5.9	0.32*	3.2	0.013*	24.7	0.99	0.008	1.97
82/II	−0.15*	2.8	0.86*	5.5	0.36*	3.4	0.013*	22.7	0.99	0.009	1.93
82/III	−0.15*	2.7	0.82*	5.3	0.41*	4.2	0.013*	22.4	0.99	0.009	1.93
82/IV	−0.14*	2.4	0.74*	4.6	0.49*	5.2	0.013*	21.1	0.99	0.010	1.94
83/I	−0.14*	2.4	0.72*	4.5	0.52*	5.6	0.013*	21.1	0.99	0.010	1.95
83/II	−0.14*	2.4	0.72*	4.7	0.52*	5.7	0.013*	21.8	0.99	0.009	1.96
83/III	−0.15*	2.7	0.71*	4.8	0.53*	6.2	0.013*	24.1	0.99	0.009	2.00
83/IV	−0.15*	3.0	0.67*	5.1	0.55*	7.4	0.013*	28.3	0.99	0.009	2.06
84/I	−0.16*	3.1	0.67*	5.7	0.56*	9.4	0.013*	33.8	0.99	0.009	2.08
84/II	−0.17*	2.9	0.57*	4.3	0.61*	9.2	0.013*	30.7	0.99	0.010	2.02
84/III	−0.17*	3.0	0.57*	4.5	0.61*	10.6	0.013*	34.2	0.99	0.010	2.26
84/IV	−0.18*	3.2	0.55*	4.2	0.64*	11.5	0.013*	35.8	0.99	0.011	2.33
85/I	−0.17*	3.1	0.55*	4.3	0.63*	12.3	0.013*	38.4	0.99	0.010	2.38
85/II	−0.18*	3.3	0.55*	4.3	0.64*	12.9	0.013*	41.2	0.99	0.010	2.43
85/III	−0.17*	3.2	0.55*	4.3	0.63*	13.0	0.013*	43.4	0.99	0.010	2.39

Note: Figures listed under each factor are estimated coefficients. *indicates that t-value is significant at 5%.

that the trend of the yen's depreciation has had an effect which we cannot disregard.

B. Stability of the estimating equation

We will examine the stability of the estimating equation by comparing changes in estimation results with changes during estimation periods, i.e. fixing the first period, we shift the last period by a quarter (recursive regression). Considering the degree of freedom, the last quarter of the shortest estimation period is the third quarter of 1980 which was five years before the ending period of the first observation. The results are shown in Table 2.

Irrespective of estimation period, results are consistently good in terms of R, DW and SE (parameters of all explanatory variables mentioned above are all significant at the 0.05 level). Changes in the parameters of real income factors (smaller for domestic real income and larger for external real income) imply increasing dependence of Japanese manufacturers on external factors, though such changes are gradual. Exchange rate factor and time trend parameters are stable, particularly the relationship between the real effective yen rate and production. These results suggest that during the first half of the 1980s, Japanese manufacturers did not see dramatic structural changes in production. If the latest phase of the yen's appreciation is included in the estimation period, however, the stability of the estimation results is seriously undermined. This implies the occurrence of dramatic structural change due to the latest appreciation of the yen. In the next section, we will examine this point in detail.

IV. Latter Half of the 1980s—Structural Changes in the Relationship between the Yen Rate and Production

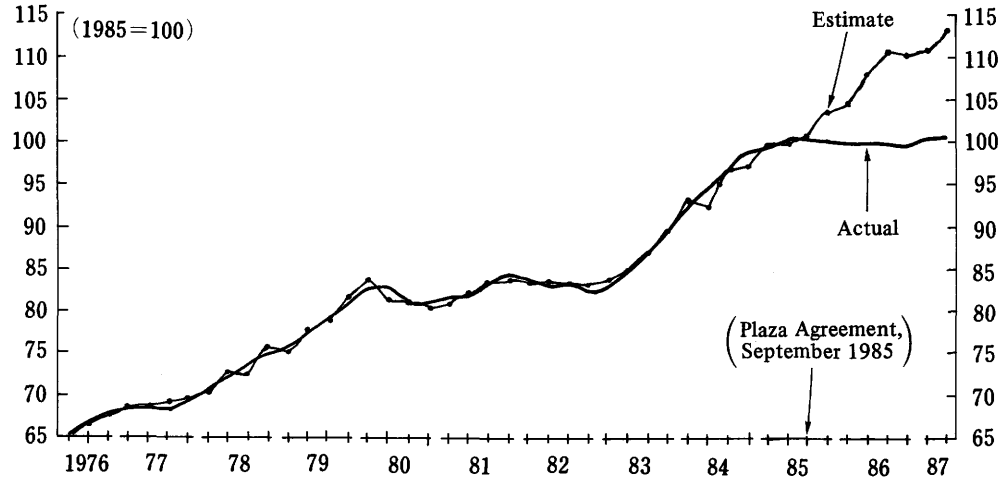
As shown in the previous section, when exchange rate changes are large, there are not only short-term cyclical effects but also continuous and structural ones, which have an effect on market structure. This section will examine the structural effects occasioned by sharp changes in exchange rates.

A. Structural change due to the yen's appreciation after 1985

As shown in Section II, the rise in the yen rate in the latest phase of exchange rate adjustment occasioned major structural changes among and within Japanese manufacturers which it is hoped will lead to an improvement in international balance of payments imbalances. We will begin by examining whether structural changes occurred or not.

(1) Using the parameters in the estimation result which are estimated using data for the period before the latest appreciation of the yen (see Section III), we extrapolated production in the latest phase (from the fourth quarter of 1985 through the second quarter of 1987) and compared with actual values. Figure 6 shows the comparison. There are considerable estimation errors and, since mid-1986 in particular, considerable over-

Figure 6. Estimation Results of Production Index after the Latest Phase of the Yen's Appreciation



Note: The production level in the latest phase of the yen's appreciation (1985/IV – 1987/II) was extrapolated using prior observation equation parameters.

estimation can be discerned. This suggests that, assuming the structure in the first half of the 1980s, stagnant production of Japan's manufacturers during this period (from the latter half of 1986 to the first half of 1987) cannot be completely explained even considering the sharp appreciation of the yen.

(2) Next, in the same way as when we examined the stability of the estimation equation in Section III, we change the estimation period by shifting the end of the period by a quarter from the fourth quarter of 1985 when the yen appreciation phase started. We repeated the estimation and compared the results. As shown in Table 3, when the latest yen's appreciation phase was included in the estimation period, the values of $\bar{R}^2$ and DW sharply declined and the parameter of each independent variable sharply changed. This result also suggests the occurrence of structural changes due to the yen's appreciation.

(3) Thirdly, we added a constant dummy for the latest phase of the yen's appreciation to explanatory variables (estimation period: third quarter of 1976 to the second quarter of 1987). We did try both constant and trend dummy variables and, when introduced, shifted every estimation and compared the estimation results of each. As a result, estimation results improved the most (in terms of $\bar{R}^2$, DW, and SE) when a constant dummy was introduced from the first quarter of 1986. Table 4 compares this result with that of the estimation conducted, excluding the latest phase of the yen's appreciation. Due to the introduction of the constant dummy, $\bar{R}^2$ and DW improved (Table 3) to almost the levels in the estimation results based on the data before the yen's appreciation. As for the parameters of each independent variable, values were much the same as results obtained using data prior to the yen's appreciation. The parameter of the dummy

Table 3. Estimation Results of Recursive Regression (the latest phase of the yen's appreciation) (Estimation periods: from 1976/II through 1985/IV~1987/II)

Final term	Exchange rate factor	(t-value)	Domestic real income factor	(t-value)	Overseas real income factor	(t-value)	Time trend factor	(t-value)	$\bar{R}^2$	SE	DW
1985/IV	−0.14*	2.4	0.51*	3.6	0.60*	11.3	0.013*	40.2	0.99	0.011	1.86
86/I	−0.12	1.8	0.50*	3.1	0.57*	9.6	0.013*	35.9	0.99	0.013	1.34
86/II	−0.12	1.4	0.52*	2.6	0.49*	6.9	0.012*	28.4	0.98	0.016	0.80
86/III	−0.16	1.6	0.59*	2.4	0.41*	5.0	0.012*	23.3	0.98	0.020	0.49
86/IV	−0.22*	2.1	0.65*	2.5	0.39*	4.3	0.012*	21.2	0.97	0.022	0.38
87/I	−0.27*	2.5	0.68*	2.4	0.38*	4.0	0.012*	20.4	0.97	0.023	0.34
87/II	−0.33*	3.0	0.70*	2.4	0.38*	3.8	0.012*	19.6	0.97	0.024	0.32

Note: *indicates that t-value is significant at 5%.

Table 4. Estimation Results of Regression Equation Including Constant Dummy Variable

Explanatory variables	Estimation equation 1[a]		Estimation equation 2[b]	
	Parameter	(t-value)	Parameter	(t-value)
Exchange rate factor	−0.17	3.2	−0.22	3.5
Domestic real income factor	0.55	4.3	0.59	3.5
Overseas real income factor	0.63	13.0	0.59	9.5
Time trend factor	0.013	43.4	0.013	35.3
Dummy variable for the latest yen's appreciation			−0.08	9.1
$\bar{R}^2$	0.99		0.99	
DW	2.39		2.05	
SE	0.01		0.014	

[a] Estimation period: 1976/II~1985/III (before the latest phase of the yen's appreciation)
[b] Estimation period: 1976/II~1987/II (including a dummy variable for the latest phase of the yen's appreciation: 1986/I~1987/II=1)

variable for the latest phase of the yen's appreciation was significantly negative. This estimation result also implies that the latest phase of the yen's appreciation (probably after mid-1986) contributed to the occurrence of structural changes that suppressed production to a level lower than what would be expected based on structure existing in the first half of the 1980s.

(4) Lastly, we examined structural changes by a kind of Chow test, which made it possible to examine structural changes in each parameter for each explanatory variable (see Moriguchi 1977). The result showed that there is a great likelihood that in the latest phase of the yen's appreciation, structural changes occurred in such a way that the effects of the exchange rate factor and the domestic real income factor on production strengthened (in other words, the absolute value of parameters expanded) (See Appendix II).

In conclusion, it can be summarized that in the latest phase of the yen's appreciation, in particular after mid-1986, structural changes occurred in a way that allowed the influence (i.e. the suppression of production) of the exchange rate factor on Japan's manufacturers to strengthen and, accordingly, production remained lower than expected from the average relationship in the first half of the 1980s.

A rough calculation of the negative effects of the latest phase of the yen's appreciation on production using the estimation result, including a constant dummy for that appreciation phase, is shown in Figure 7. The bold line at the bottom represents actual production. The difference between the bottom and center lines shows the scale of the short-term cyclical effect of the yen's appreciation in 1985 compared with the average of 1985 (to suppress production). The value depicted by the thin line is the sum of the actual value of production plus the product of the parameter of the exchange rate factor times the difference between the exchange rate factor and its average in 1985. The broken line at the top depicts the values shown by the line plus the negative portion of the constant dummy. Accordingly, the difference between this and the thin line indicates structural change caused by the yen's appreciation, while the difference between the broken line and the bold line depicts the total effect. It should be noted that these calculated values do not take into account estimation errors. However, the effects of the yen's appreciation in suppressing production is over 4% in terms of short-term cyclical effects and more than 10% in terms of total influence. This attests to how serious the influence of the latest appreciation of the yen on Japan's manufacturers was. It should also be noted that the influence in the form of structural change is about twice as serious as that in the form of usual short-term cyclical change.

B. Content of structural change

The above analysis shows that there is a great likelihood that the sharp appreciation of the yen from the fall of 1985 occasioned considerable structural change in Japan's manufacturing industry. We will thus now examine contents of this structural change (shifts in parameters).

Figure 7. Simulation of Effect on Production of the Latest Phase of the Yen's Appreciation (1985/IV – 1987/II) (comparison of exchange rate factors assuming the 1985 average was constant)

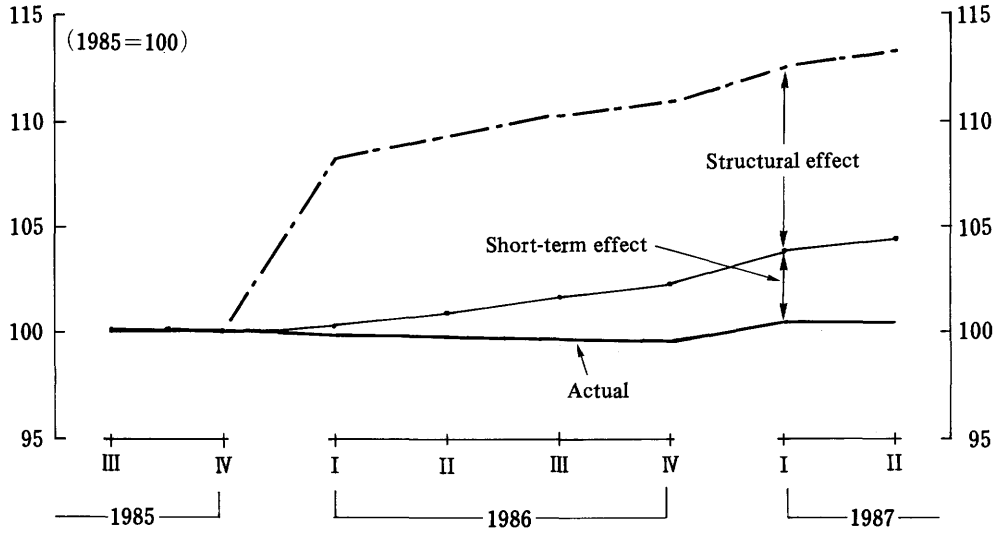
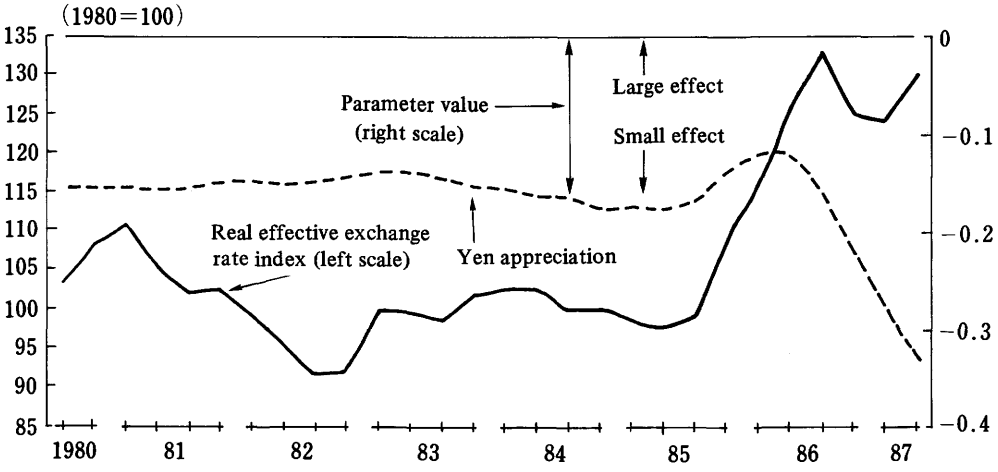


Figure 8. Real Effective Exchange Rates and Foreign Exchange Factor Parameters



1. Structural change discerned in the exchange rate factor parameter

The Chow test using additional variables showed that the influence of the exchange rate factor likely increased in the latest phase of the yen's appreciation. Figure 8 gives a time-series for the exchange rate factor parameter from the result of the estimation obtained by recursive regression (Tables 2 and 3) together with the real effective exchange rate in one graph in order to compare them. The parameter (broken line) of the exchange rate factor moved stably in the first half of the 1980s, but rose in the first half of 1986 and then reversed to sharply decline. As the parameter is negative, the above phenomenon means that the influence of the exchange rate factor increased after mid-1986 when about one year had passed from the start of the yen's appreciation (i.e. the effect of the yen's appreciation in suppressing production in terms of comparative prices became stronger).

An increase in the negative influence of the exchange rate factor on production after mid-1986 seems to be attributed to the fact that export-oriented corporations applied measures which had a substantial effect on domestic production, including withdrawing from exports and the transfer of production bases abroad. In a survey on "business behavior" by the Economic Planning Agency, respondents said export operations had turned to post losses which were sharply increasing[9]—as of January 1986, 22% of export-oriented corporations replied that they would decrease exports and shift production bases abroad. This suggests that the transfer of production bases overseas accelerated around that time.

In fact, direct foreign investment by Japanese manufacturers remarkably increased around 1986 (based on notification and on a dollar basis, the year-to-year increase was 62% in fiscal 1986 and 105% in fiscal 1987). The aim of such direct overseas investment also shifted from setting up sales bases to reinforce exports to establishing production bases to substitute for exports (Table 5). As a result, the percentage of production overseas (sales by foreign subsidiaries/sales by domestic manufacturing industries) steadily rose by 3% in fiscal 1985, 3.2% in fiscal 1986, and 3.9% in fiscal 1987, despite a shrinkage in external sales on a yen basis due to the yen's appreciation (according to a survey conducted by the Ministry of International Trade and Industry). Such structural adjustment parallel with the yen's appreciation seems to have contributed to a low increase in domestic production, which cannot be explained based on the structure existing in the first half of the 1980s.

[9] The remunerative exchange rate for export-oriented corporations in February 1986 was an average ¥207 among export-oriented corporations responding to a survey. The actual yen rate against the dollar during respective five quarters during 1985/III–1986/III was ¥239, ¥207, ¥188, ¥170, and ¥156 . In 1986, the difference between the two rates rapidly expanded.

Table 5. Objective of Overseas Direct Investments of Manufacturing Industries

(multiple answers; %)

Objective	Past 3 years	Future 3 years
Production of finished goods	56.9	66.9
Production of parts and semi-finished goods	27.4	46.6
Repair of products	9.7	9.0
Sales	64.2	51.1
Resources development	5.0	2.6
Survey/information collection	22.7	20.7
Research and development	12.0	11.7
Fund procurement/management	15.1	10.2

Source: Economic Planning Agency, Research Bureau (1987).

2. Structural change discerned in the domestic real income factor parameter

Another structural change due to the latest phase of the yen's appreciation, suggested as a result of the Chow test, is that the effect of domestic real income on production (parameter), which had been on a shrinking trend in the first half of the 1980s, turned to expand (see Table 2 and Appendix II). This can be classified into two factors: first, an increase in the ratio of domestic sales to total sales expands the influence of domestic income on aggregate demand and consequently also on production; second, a rise in the elasticity of domestic demand for domestically-manufactured goods to income also increases the influence of domestic income on production. Of these two factors, the first seems to reflect a fall in dependence on exports, while the second seems to reflect strengthening of a preference for domestically-manufactured goods and/or propensity to consume. The background to this structural change can be considered as a change in corporate strategy from emphasizing exports to putting more significance on domestic markets and reinforcing efforts to promote domestic sales.

For instance, according to a survey on business behavior (conducted in January 1986), 55% of the respondents who replied they would decrease exports to cope with the yen's appreciation, said they would increase domestic sales instead. This fact suggests that those corporations which were forced to reduce exports made efforts to expand domestic sales to offset the export decrease. Looking at shifts in parameters in the recursive regression results (Figure 9), the domestic real income parameter (bold line) consistently dropped in the first half of the 1980s, but has turned upward in the latter half of the 1980s. This turnabout occurred almost at the same time as a sharp decline in the exchange rate factor parameter. This implies that corporate export behavior dramatically

Figure 9. Domestic and Overseas Real Income Factor Parameter

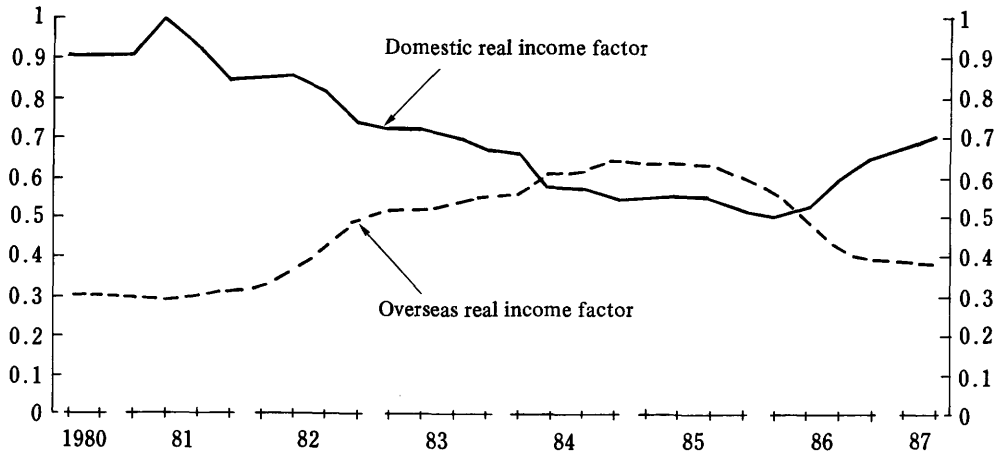
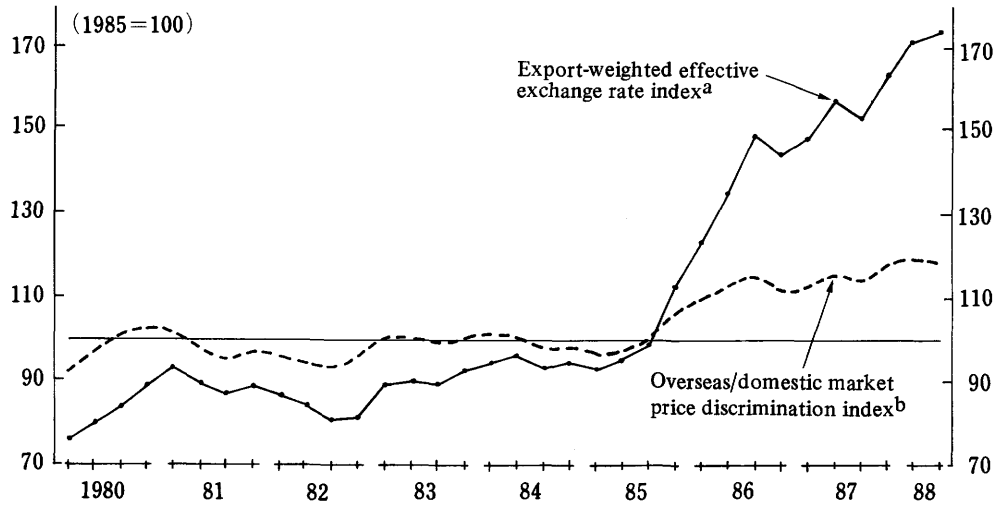


Figure 10. Price Discrimination between Domestic and Overseas Markets



[a]Export-weighted effective exchange rate indexes of 22 countries (17 countries included in MERM and 5 Asian countries): The basis of weighting is share in world export in 1985.

[b]Overseas/domestic market price discrimination index = $\frac{\text{wholesale price for domestic demand}}{\text{yen-denominated export prices}} \times 100$

changed (a shift of production bases overseas and/or a withdrawal from exports) with management strategy coming to attach more significance to domestic demand.

In addition, by comparing the wholesale prices for domestic demand and for exports (yen-denominated), we can grasp when corporations change their strategy from maintaining export volume or external market share. Looking at a ratio of wholesale prices for domestic demand against yen denominated export prices (wholesale price index for domestic demand/yen-denominated export price index × 100) (Figure 10), the rate showed comparatively stable movement in the first half of the 1980s and there was no significant difference between movements in domestic prices and yen-denominated export prices. In the latest phase of the yen's appreciation (after mid-1985), however, the rate sharply rose initially, i.e. domestic prices rose relatively higher at that time and, after the latter half of 1986, remained high but stable. Looking at the effective exchange rate on an export-weighted basis[10] which is directly related to export profit, the exchange rate sharply rose from the end of 1985 through 1988, albeit at a slightly decelerated tempo from 1986. The difference between the movements in the above two factors after the latter half of 1986 implies that a major change in the relative profitability of domestic sales and exports resulted in a change in conventional corporate behavior in deciding prices in mid-1986 (conventionally, priority was put on the maintenance of external market share).

In conclusion, expansion of the influence of the domestic real income factor (increase in parameter value) can be considered to reflect the likelihood of structural change, such as Japanese manufacturers' modifying policy to put more significance on domestic markets, resulting in the increasing redirection of domestic production toward domestic demand. In order to judge to what degree these changes will take root in Japan's manufacturing industries, however, it will be necessary to watch developments.

C. Structural effect: hysteresis

We have examined the structural influence of the latest sharp appreciation of the yen on Japan's manufacturing industries. It is pointed out that once such structural changes occur due to dramatic exchange rate fluctuation, they tend to persist, i.e. what is important is that once market structure and production structure undergo such change, they cannot be restored even if exchange rates return to their former level. As a result, trends in production and the trade balance depend not only on the level of current exchange rates but previous levels—the hysteresis[11] hypothesis. On this premise, it can be said that,

[10] The export-weighted effective exchange rate is a weighted average of the exchange rate of 23 areas, including MERM's 17 nations and 6 Asian areas (China, South Korea, Hong Kong, Taiwan, Singapore and Thailand), using each area's share of world exports in 1985 as a base weight. The above 23 areas accounted for 77% of world exports in 1985.

[11] Baldwin(1986) is considered to be the first to apply the engineering term "hysteresis" to economic analysis. The Japanese who introduced this way of thinking for the first time in Japan may be Ito (1986).

once changed by the sharp depreciation of the yen (sharp appreciation of the dollar) at the end of the 1970s and the following period of a weak yen, market and production structures could not have returned to their former state simply by the appreciation of the yen to its former level. Accordingly, in order to solve trade imbalances, the yen rate needs to appreciate to a higher level than when the trade account was balanced. Actually, as the previous analysis shows, when structural changes occurred due to the latest appreciation of the yen, the yen exchange rate was higher than its past peak level. This suggests the likelihood of the existence of hysteresis. We will examine the structural influence of exchange rate fluctuation from the viewpoint of hysteresis, which will not only be useful in realizing the effects of the yen's depreciation prior to the latest phase of appreciation, but also in seeing how structural changes caused by the latest appreciation will work during depreciation phases. Thus, we will first explain the content of the hysteresis hypothesis, and study the background.

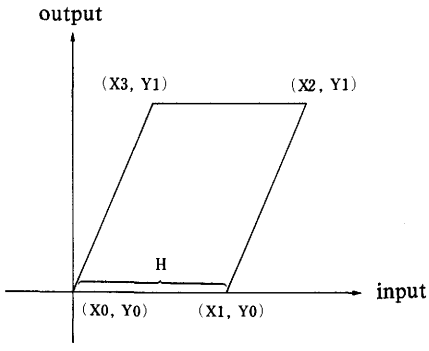
1. *Definition of hysteresis and reasons for occurrence*

Hysteresis is originally an engineering term.[12] What it means in relation to exchange rates is that large and long-term changes in real exchange rates cause changes in the market and production structures of the nations concerned. As a result, even if exchange rates return to their former level (unless larger changes in the opposite direction occur), structural effects on production and imports persist.

More specifically, when the real exchange rate of a certain nation's currency sharply

[12] In engineering, hysteresis means that an output level is not determined only by an input level at a given time, since it also depends on the input level in the previous period. A retardation in the effect is caused, since the output volume starts changing when a change in the input volume exceeds a certain level.

The following figure depicts the above-mentioned phenomenon. The horizontal axis is the input level, the vertical axis output, and the parallelogram shows the corresponding relation between them; i.e. suppose the initial situation is point (X0, Y0), and input is raised, then it is not until the change in input exceeds H (input level exceeds X1) that output starts rising . On the other hand, when the input level is lowered from X2 and Y1, it is not until the drop exceeds H (input level decline below X3) that output begins to decline. Accordingly, output depends not only on current input but also on that in the previous period (hysteresis). Thus, output does not return to its previous level even if the input level does.



rises and maintains that level for a long period, the advance of foreign corporations into domestic market of that nation (exports) is promoted while the price competitiveness of the domestic production in that nation weakens. As a result, structural changes which have a negative effect on domestic production and the trade balance appear (a decrease in production and shrinkage in the trade surplus or expansion of the trade deficit), e.g. the transfer of production bases overseas. Under the new market and production structure, neither production nor the trade balance can recover former levels, even if exchange rates return to former levels, and the medium- and long-term structural influence remain. Thus, the level of production and trade balance are subject to the previous exchange rate fluctuation. This is the hysteresis of exchange rates. Accordingly, in order to dissolve hysteresis and restore production and/or the trade balance to previous levels, a dramatic fluctuation in exchange rates, enough to occasion structural change in the opposite direction is required, assuming other conditions are unchanged.

The following factors are often pointed out as causes of hysteresis:

a) Existence of "sunk cost"

As a factor on the supply side, we can point out the existence of "sunk cost." "Sunk cost" is the cost of the firm-specific and market-specific assets that are required to sell in the market, such as the cost of setting up a distribution and service network, of establishing a brand name through advertising, or of making a foreign product meet domestic health and safety regulations (see Baldwin 1988).

When there is a huge amount of such costs in the initial investment made at the time of setting up sales and/or production bases (beach-heads) abroad, the exchange rate determining entry into foreign markets is different from that determining withdrawal. This is because the exchange rate for deciding entry is that which can bring about enough profits to recover "sunk costs" (so-called "appropriate rate"), while the exchange rate for deciding withdrawal is at a level which makes it impossible to retrieve "sunk cost" and accumulated losses (the marginal rate to corporations). Accordingly, once the exchange rate rises to a level where foreign corporations decide to enter Japan or domestic corporations decide to transfer production bases overseas, a decline in the exchange rate thereafter to the previous level is not sufficient to force foreign corporations to withdraw from Japan or for domestic corporations to restore domestic production bases. Therefore, the market structure does not easily return to the previous situation. Long run, however, with the renewal of investment after the end of the retrieval period of the initial investment, market and production structure recovers its previous position.

b) Effect of "experience goods"

When we look at hysteresis from the demand side, we can point out the effects of "experience goods[13]" as one factor (Baldwin 1988). Suppose foreign corporations enter the Japanese market and the Japanese public becomes familiar with externally-

[13] As for "experience goods" effects, see Schmalensee (1982) et al.

manufactured goods which they have never tried. Then, such goods become "experience goods," i.e. people recognize the quality of foreign goods. When domestic consumers "experience" such externally-manufactured goods and their preference for such goods heightens, then the demand curve for these goods shifts upward (i.e. the market structure changes to favor imports). Accordingly, even if the exchange rate returns to its previous level, foreign corporations do not retreat nor does the market structure return to its previous situation.

2. *Effect of hysteresis of exchange rates on the production of Japanese manufacturers*

Empirical analyses on effect of exchange rate hysteresis by Baldwin (1988) and Hooper and Mann (1987) inferred that the pass-through ratio[14] of U.S. import prices changed due to exchange rate fluctuation. The papers point out that in the phase of the dollar's depreciation from the fall of 1985, hysteresis due to the dollar's appreciation from the end of the 1970s to the first half of the 1980s likely occurred. Here, we will examine whether exchange rate hysteresis is discerned also in the production trend of Japanese manufacturers. Specifically, the questions to be examined are: did Japan's market structure change parallel with the yen's depreciation from the end of the 1970s to the first half of the 1980s similarly as pointed out for the United States? As a result, can hysteresis be observed in the latest phase of the yen's appreciation? And, did the further appreciation of the yen thereafter cause structural change in an opposite direction?

a) Effect of "sunk cost"

The existence of sunk cost effect means that Japanese manufacturers have relatively large surpluses when they decide to enter foreign markets through exports, i.e. when currency appreciation is sharp, by compressing profit ratios within sunk cost depreciation, exporters can cope by suppressing a price rise to adjust to the appreciation within a level which does not have a great effect on sales. In this case, as part of the effect of exchange rate fluctuation is not passed through to foreign currency-denominated export prices, the difference in relative prices between externally-manufactured goods and domestically-manufactured ones (weakening competitiveness) remains small and, therefore, the effect of exchange rate on production becomes smaller than in the ordinary case. In other words, the pass-through rate differs depending on whether or not the degree of exchange rate fluctuation is within a range enabling a price rise to adjust to the situation. Accordingly, with respect to estimation results, the absolute value of the exchange rate factor parameter is expected to shrink.

[14] The pass-through accompanying exchange rate fluctuation means the adjustment of export and import prices in new contract negotiations (which are made after fulfilling contracts concluded before the exchange rate fluctuation) up to when adjustments in volume terms begin to appear due to changing prices. If the pass-through occurs, export prices rise in a nation whose currency has appreciated (import prices decline), on the other hand, in a nation whose currency has depreciated, export prices decline (import prices rise). The degree of rise (decline) depends on the price elasticity of demand and supply (see Magee, 1973).

Looking once again at the movement of the exchange rate factor parameter in Figure 8, we see that it sharply rose (the absolute value shrank) in the initial stage of the latest phase of the yen's appreciation from the latter half of 1985 through the first half of 1986. This implies that due to sunk cost effect caused by the protracted depreciation of the yen from the end of the 1970s to the first half of the 1980s, Japanese export-oriented corporations reacted in the initial period of the yen's appreciation phase putting priority on maintaining and securing export markets (i.e. hysteresis occurred). In order to cope with the sharp appreciation of the yen, export-oriented corporations squeezed profit margins to maintain market shares overseas, provided the appreciation was not so sharp as to force them to withdraw from markets where sales networks had been extended during the phase of the yen's depreciation.[15] This seems to explain the weakening of the correlation between production and real exchange rates as measured by input costs, and the shrinking of the absolute value of the exchange rate factor parameter in the initial stage of the yen's appreciation. Actually, it is pointed out that changes in pricing behavior on the part of Japanese exporters (U.S. bound) in the latest phase of the dollar's depreciation is one reason for the delayed improvement in the U.S. current account deficit (Hooper and Mann 1987, etc.). According to a survey by the Economic Planning Agency on Japanese manufacturers, only one-third (34.5%) of corporations were able to raise prices to cope with the yen's appreciation in February 1986, and only 1.6% could cover the ensuing loss by so doing.

On the other hand, the turnabout in the parameter to a downward trend after mid-1986 (expanded effect of the yen rate on production) suggests that exchange rate adjustment reached a level causing structural change in an opposite direction.

b) Effect of "experience goods"

Next, we will review the existence of hysteresis from the viewpoint of "experience goods" effect. The "experience goods" effect occurs when preferences for externally-manufactured goods become strong. As the explanatory variables of the estimation equation used in this paper do not take account of this preference, the influence of this factor (change in the share of domestically-manufactured goods in the expenditures of external and domestic consumers as a result of shifts in preferences) is expected to appear in the form of a parameter shift in the real income factor, which means a change in the elasticity of demand to real income.

In a yen's depreciation phase, Japan's share of external markets increases parallel with the increasing exports of Japanese corporations. As a result, foreigners who "experience" and love Japanese goods gradually increase, and the preference for Japanese goods in foreign markets appears to become stronger. Elasticity of aggregate demand for

[15] As for the profit performance of exports in 1985, a survey showed that in the case of exports to the United States, the remunerative rate for the manufacturing industry was ¥226 against an actual rate of ¥240 (Sanuki 1988). This suggests that, for manufacturers, there had been a rather wide margin between the actual rate and their breakeven rate, which forced them to retreat from the United States.

Japanese products to external real income should then rise and, consequently, the external real income factor parameter in the production estimating equation will expand gradually. On the other hand, when the yen appreciates, the experience goods effect with respect to externally-manufactured goods in Japanese markets expands, domestic demand for externally-manufactured goods will gradually increase, and domestic demand for domestically-manufactured goods which are competitive with externally-manufactured ones will dwindle. In this case, the experience goods effect seems to contribute to a decline in the domestic real income factor parameter.

Looking at changes in the real income factor parameters in Figure 9, we see that the external real income factor parameter (broken line) consistently rose during the yen's depreciation in the first half of the 1980s. Even if this trend was not always due to the experience goods effect, the figure suggests at least the existence of the experience goods effect. On the other hand, if the experience goods effect were already working in the latest phase of the yen's appreciation, then the domestic real income factor parameter should have shrunk. However, in fact, the domestic real income factor parameter expanded. Thus we cannot confirm the existence of the experience goods effect directly from the trend of the domestic real income factor parameter.

This, of course, does not necessarily deny the existence of the experience goods effect. We might put it this way: since the experience goods effect gradually increases as time passes, other items boosting the domestic real income factor parameter (for instance, corporate efforts to expand domestic demand, etc.) will probably become more influential, and hence the experience goods effect has not been discerned yet. In addition, Japan's ratio of manufactured imports to total imports stood at 42% in 1986, much lower compared with other industrialized nations (the United States 81%, the United Kingdom 75%, France 71% and West Germany 64%). The ratio of manufactured imports to domestic output, including intermediate materials, is also very small at around 3%. Accordingly, in Japan the experience goods effect on production due to the latest yen's appreciation does not seem to be large for the present. Judging from the fact that the ratio of imported consumer goods (which seem to be closely related to the experience goods effect among manufactured goods) to total imports rapidly increased during the latest phase of the yen's appreciation, however, it is thus very likely that the experience goods effect will appear in the future.

V. Background to Recovery of Production under the Yen's Appreciation

In the previous section, we showed that the yen's appreciation likely not only had a short-term cyclical negative effect on Japan's production but also a negative effect in terms of supply structure change. These observation results are, to be sure, in accord with a "yen appreciation recession," as was often mentioned to in the initial stage of the latest phase of the yen's appreciation. Looking at movements in Japan's manufacturers, howev-

er, production rapidly recovered from the latter half of 1987 (see Figure 3) and business results have recovered and expanded.[16] In the latter half of 1988, the term "yen appreciation boom" replaced "yen appreciation recession." In this section, we will examine factors which offset the negative effects of the latest sharp appreciation of the yen and occasioned the recovery of Japan's manufacturers.

A. Lower costs

In explaining the prosperity of Japan's manufacturers during the latest phase of the yen's appreciation, it is often pointed out that a) advantages of the yen appreciation manifested themselves (a decline in the prices of imported raw materials) and b) reduced costs reflecting corporate rationalization and cost saving were seen.

Firstly, domestic production factor prices (we use the domestic production factor price index applied in the production estimation equation, i.e. the weighted average of input price and hourly wages) (Figure 11), dropped more than 10% from 1985 through 1987. On the other hand, output prices also dropped after the yen's appreciation, though the decline was smaller. Accordingly, judging from the movement in the ratio between output prices and the production factor price, profitability improved in the latest phase of the yen's appreciation. In addition, if we take the decline in the input coefficient due to cost-saving into account, there is a strong likelihood that corporate profit performance improved more than indicated by this figure. In fact, according to the *Annual Report on National Accounts*, the manufacturers' ratio of operating profit to net sales[17] in 1986 and 1987 were higher than those in years in the first half of the 1980s. This implies that the negative effects, quantitatively, were offset by the improvement in profit performance, enabling the recent recovery and expansion of business.

However, improved profit (output price/production factor price) is not always a consequence of an appreciation of the yen. When foreign products are highly substitutable for domestic products, thus making it necessary to keep relative prices in order to maintain competitiveness, prices of domestic products must drop by the difference be-

[16] We can see how rapidly the business picture of the manufacturers recovered and improved, by looking at results in the *Short-term Economic Survey of Principal Enterprises in Japan* (conducted by the Bank of Japan) — looking at the diffusion index of business conditions (percentage of answers, favorable−unfavorable), the bottom (-27%) was in February and May 1987, but then turned on a favorable trend in February 1988 (11%) and reached 52% in February 1989, equivalent to the previous high percentages (November 1967 and November 1973).

[17] Ratio of operating profit to sales for the manufacturing in the 1980s (%)

1980	1981	1982	1983	1984	1985	1986	1987
7.56	7.10	7.25	7.02	7.42	7.48	7.72	7.85

Ratio of operating profit to sales=operating surplus/output value × 100.
Operating surplus=output value − (intermediate input + consumption of fixed capital + net indirect tax + compensation of employees).

Figure 11. Profit Performance of Manufacturing Industries

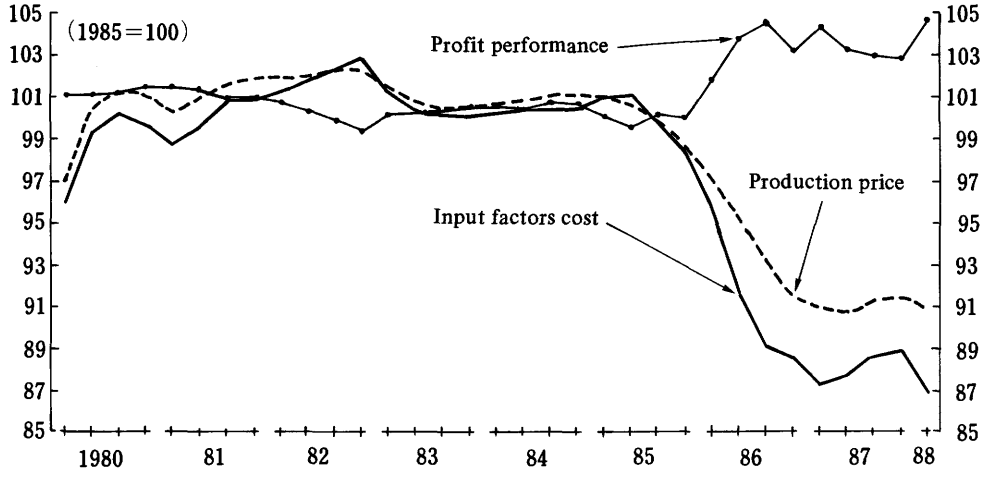
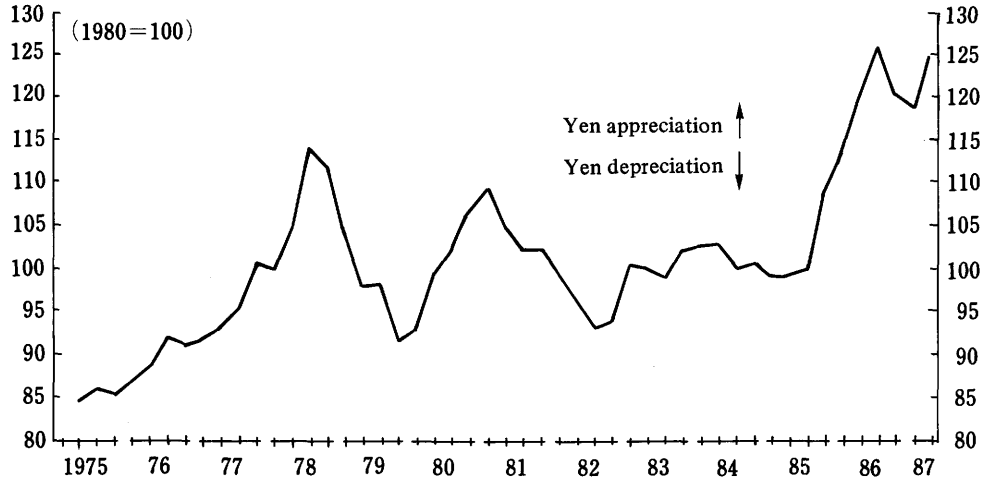


Figure 12. Evolution of Actual Effective Foreign Exchange Rates (Foreign Exchange Market Factors) used in Simulation Equation



Note: Calculation method is different from that for the real effective exchange rate in Figure 2 (see footnote 5).

tween the rate of appreciation and that of price increase in foreign products: In this case, in order to maintain both relative prices and profit performance, it is necessary to reduce the production factor price by the same difference. In the latest phase of the yen's appreciation, the real effective yen-dollar exchange rate adjusted by external prices and the domestic production factor price (a variable of the exchange rate factor in the estimation equation) dropped (Figure 12). This means that in the latest phase of the yen's appreciation, the decrease in the price of domestically-manufactured goods required to maintain relative prices with externally-manufactured goods has been higher than the rate of decrease in the production factor price. Accordingly, if the substitutability of foreign goods to domestic goods is high and their price competitiveness is severe, then the profit performance of Japan's manufacturers should have deteriorated. Therefore, an improvement in the profit performance during the latest phase of the yen's appreciation suggests that price competition between domestic products and foreign ones was not so severe.[18]

However, even if the less sharp price competition with foreign goods in domestic markets than that in foreign markets and the low substitutability of foreign products for domestic ones are factors preventing profit performance from worsening due to the yen's appreciation, an improvement in profitability suggests an expansion of demand (upward shift in the demand curve due to an increase in real income or an increase in the elasticity of income).

Profit performance is a ratio of output price to the production factor price. There is a strong possibility that actual profitability further improved due to a decline in the input coefficient as mentioned before. Although there is a likelihood that profitability was improved by the delay in the pass-through of profits due to lower crude oil prices and the yen's appreciation, the improvement ought to have been temporary. The fact that the level attained by the improvement has been maintained shows that the improvement was not only due to the delay of pass-through.

B. Separation of domestic and external markets

Next, we will examine the difference in degree of competitiveness between domestic and external markets. Figure 13 shows the wholesale price index of manufactured goods for domestic demand and also for exports (yen-denominated). Obviously, a) there is a large difference in movements between the price index of domestic products for domestic demand and that for export and b) the fact that the decline in the price of manufactured goods is smaller than that in production factor prices can be attributed to the stability of

[18] The reasons for the incomplete substitutability of externally-manufactured goods for domestically-manufactured goods are: a) difference in quality, b) insufficient supply capability of foreign corporations (including production capacity and delivery), c) Japanese quantitative trade restrictions (quota), and d) inefficient distribution system (complexity; the network monopoly of Japanese makers; etc.).

Figure 13. Whosesale Price Index (Industrial Goods)

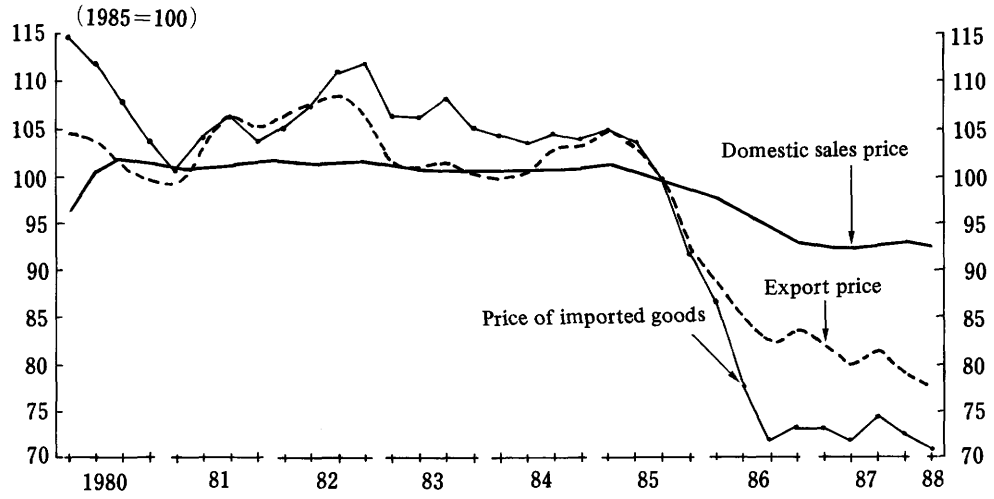
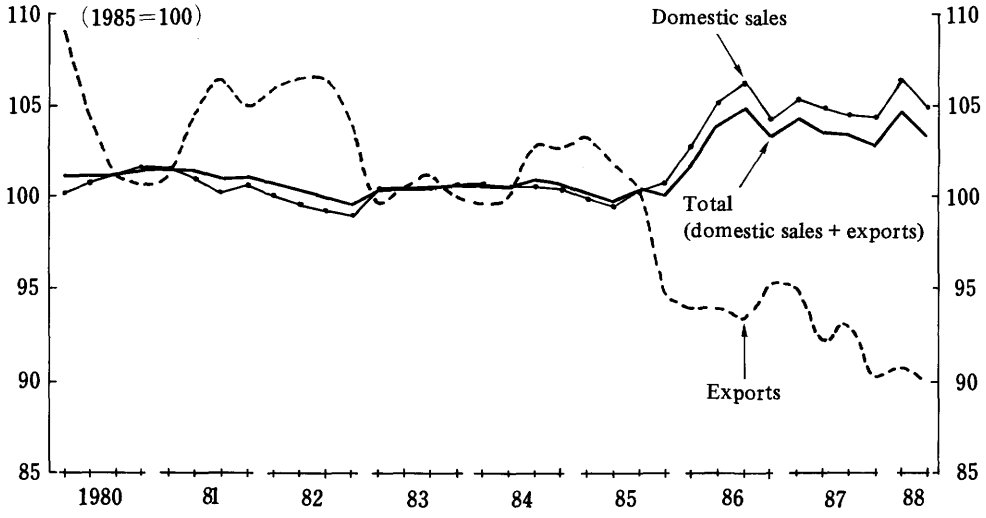


Figure 14. Profit Performance of Manufacturers



Note: Profit performance was calculated by dividing the weighted average of both domestic sales and exports in the general whosesale price index by the domestic production factor price index.

Table 6. Change in Competitive Power with NIEs due to the Latest Appreciation of the Yen

(%)

Domestic market			Overseas market		
Largely deteriorated	Somewhat deteriorated	Almost unchanged	Largely deteriorated	Somewhat deteriorated	Almost unchanged
26.9	31.2	41.9	49.2	29.0	21.8

Source: Economic Planning Agency, Research Bureau (1987).

prices for domestic demand. In other words, the improvement in profit performance previously mentioned is discerned in domestic markets only and the profit performance of exports has deteriorated (Figure 14). The difference in the movement of prices and subsequent profit performance between domestic and external markets suggests that domestic and external markets are segmented. This separation seems to be an important factor behind economic recovery in the latest yen appreciation phase. If domestic markets are not segmented from external ones, and the degree of substitutability of foreign products for domestic ones in domestic markets is the same as in external markets, the yen's appreciation has the same effect in both markets, and it is impossible for Japanese corporations to escape from the difficulty by switching their main market from overseas to Japan. The fact that competition with externally-manufactured goods is more severe in foreign markets than in domestic ones is evidenced by a survey on business behavior conducted in January 1987, in which many corporations replied that the deterioration in competitive conditions due to the yen's appreciation was greater in foreign markets than in domestic ones (Table 6). This is also shown by the estimation results of sectoral production as described below.

Since the exchange rate factor parameter represents the effect of relative price change, the parameter is expected to reflect the degree of competitiveness between domestically-manufactured goods and externally-manufactured ones. Tables 7, 8, and 9e show results of the sectorial estimation. The same estimation equation and the same explanatory variables were applied to all sectors, i.e. only independent variables were different in each estimation. The observation period was from the third quarter of 1976 through the second quarter of 1987, which includes the latest phase of the yen's appreciation. The explanatory variables of the estimation equation include a dummy variable for the latest phase of the yen's appreciation. Table 9a shows the parameter of the exchange rate factor reordered according to the size of the negative effect. It clearly shows that the so-called export-centered industries such as the electrical machinery industry, the transportation equipment industry and other industries suffer relatively serious negative external effect (Table 10). This suggests that the degree of competitiveness with externally-

Table 7. Estimation Results by Industry (Estimation period: 1976/II~1987/II)

	Exchange rate factor	(t-value)	Domestic real income factor	(t-value)	Overseas real income factor	(t-value)	Time trend factor	(t-value)	Dummy variable for the latest yen's appreciation	(t-value)	Constant	(t-value)	$\bar{R}^2$	SE	DW
Manufacturing industries (total)	−0.22*	3.52	59*	3.52	0.59*	0.54	0.013*	35.26	−0.08*	9.05	−5.50*	3.11	0.99	0.01	2.05
Food & tabacco	0.18	1.95	0.77*	3.10	−0.18	1.96	0.003*	5.02	−0.04*	2.86	−4.64	1.78	0.78	0.02	1.63
Textiles	−0.06	1.18	0.25	1.96	0.19*	4.17	0.000	0.93	−0.06*	9.05	0.74	0.56	0.82	0.01	1.33
Pulp, paper & paper prod.	−0.28*	2.49	1.33*	4.53	0.48*	4.36	0.010*	15.45	−0.02	1.23	−13.49*	4.32	0.95	0.02	0.53
Petroleum & coal prod.	0.09	0.75	0.70*	2.31	0.46*	4.10	−0.005*	7.46	−0.08*	4.96	−6.75*	2.10	0.94	0.02	1.15
Ceramics stone & clay	−0.03	0.33	1.66*	6.50	0.25*	2.65	0.005*	8.15	−0.11*	8.30	−17.06*	6.29	0.80	0.02	1.16
Chemicals	0.17	1.38	0.74*	2.34	0.44*	3.73	0.012*	17.47	−0.07*	4.22	−8.24*	2.45	0.97	0.03	1.07
Iron & steel	−0.40*	3.37	1.59*	5.05	0.82*	6.98	0.007*	10.19	−0.13*	7.62	−17.95*	5.37	0.79	0.03	1.49
Non-ferrous metal prod.	0.10	0.96	0.91*	3.32	0.53*	5.18	0.005*	7.67	−0.08*	5.20	−10.23*	3.50	0.83	0.02	1.20
Fabricated metals	0.37*	3.17	0.76*	2.48	0.27*	2.35	0.002*	3.09	−0.08*	4.86	−8.05*	2.46	0.71	0.03	1.20
Industrial machinery	−0.25	1.52	1.97*	4.44	0.46*	2.82	0.017*	17.49	−0.18*	7.73	−21.51*	4.58	0.95	0.04	0.83
Electrical machinery	−0.58*	3.74	−1.28*	3.12	1.08*	7.11	0.038*	40.80	−0.10*	4.43	14.91*	3.43	0.99	0.03	1.23
Transportation equipment	−0.48	1.69	1.38	1.84	0.13	0.46	0.012*	6.99	−0.09*	2.33	−11.17	1.40	0.73	0.06	0.30
Precision instrument	−0.26	0.75	2.87*	3.13	0.35	1.02	0.032*	15.62	−0.18*	3.75	−32.47*	3.33	0.96	0.08	0.38

Note: *indicates that t-value is significant at 5%.

Table 8. Number of Industries by Parameter Signs

	Positive	Negative
Exchange rate factor	5 (1)	8 (3)
Domestic real income factor	12 (11)	1 (1)
Overseas real income factor	12 (10)	1 (1)
Time trend factor	12 (11)	1 (1)
Dummy variable for the latest yen's appreciation	0 (0)	13 (12)

Note: Number of significant industries in parentheses (significant at 5%).

Table 9a.

Rank	Exchange rate factor	Parameter	(t-value)
Average	Manufacturing industries (total)	−0.22*	3.5
1	Electrical machinery	−0.58*	3.7
2	Transportation equipment	−0.48	1.7
3	Iron & steel	−0.40*	3.4
4	Pulp, paper & paper prod.	−0.28*	2.5
5	Precision instrument	−0.26	0.7
6	Industrial machinery	−0.25	1.5
7	Textiles	−0.06	1.2
8	Ceramics, stone & clay	−0.03	0.3
9	Petroleum & coal prod.	0.09	0.8
10	Non-ferrous metal prod.	0.10	1.0
11	Chemicals	0.17	1.4
12	Food & tabacco	0.18	1.9
13	Fabricated metals	0.37*	3.2

Table 9b.

Rank	Domestic real income factor	Parameter	(t-value)
Average	Manufacturing industries (total)	0.59*	3.5
1	Precision instrument	2.87*	3.1
2	Industrial machinery	1.97*	4.4
3	Ceramics, stone & clay	1.66*	6.5
4	Iron & steel	1.59*	5.1
5	Transportation equipment	1.38	1.8
6	Pulp, paper & paper prod.	1.33*	4.5
7	Non-ferrous metal prod.	0.91*	3.3
8	Food & tabacco	0.77*	3.1
9	Fabricated metals	0.76*	2.5
10	Chemicals	0.74*	2.3
11	Petroleum & coal prod.	0.70*	2.3
12	Textiles	0.25*	2.0
13	Electrical machinery	−1.28*	3.1

Table 9c.

Rank	Overseas real income factor	Parameter	(t-value)
Average	Manufacturing industries (total)	0.59*	9.5
1	Electrical machinery	1.08*	7.1
2	Iron & steel	0.82*	7.0
3	Non-ferrous metal prod.	0.53*	5.2
4	Pulp, paper & paper prod.	0.48*	4.4
5	Industrial machinery	0.46*	2.8
6	Petroleum & coal prod.	0.46*	4.1
7	Chemicals	0.44*	3.7
8	Precision instrument	0.35	1.0
9	Fabricated metals	0.27*	2.4
10	Ceramics, stone & clay	0.25*	2.6
11	Textiles	0.19*	4.2
12	Transportation equipment	0.13	0.5
13	Food & tabacco	−0.18*	2.0

Table 9d.

Rank	Time trend factor	Annual rate, 1985=100	
			(t-value)
Average	Manufacturing industries (total)	5.5*	35.3
1	Electrical machinery	16.3*	40.8
2	Precision instrument	13.8*	15.6
3	Industrial machinery	7.2*	17.5
4	Chemicals	5.1*	17.5
5	Transportation equipment	4.9*	7.0
6	Pulp, paper & paper prod.	4.2*	15.4
7	Iron & steel	2.9*	10.2
8	Non-ferrous metal prod.	1.9*	7.7
9	Ceramics, stone & clay	1.9*	8.1
10	Food & tabacco	1.1*	5.0
11	Fabricated metals	0.9*	3.1
12	Textiles	0.1	0.9
13	Petroleum & coal prod.	−0.2*	7.5

Table 9e.

Rank	Dummy variable for the latest yen's appreciation	1985=100	
			(t-value)
Average	Manufacturing industries (total)	−0.7*	9.1
1	Precision instrument	−16.6*	3.7
2	Industrial machinery	−16.5*	7.7
3	Iron & steel	−11.9*	7.6
4	Ceramics, stone & clay	−10.6*	8.3
5	Electrical machinery	−9.1*	4.4
6	Transportation equipment	−8.8*	2.3
7	Petroleum & coal prod.	−7.6*	5.0
8	Fabricated metals	−7.6*	4.9
9	Non-ferrous metal prod.	−7.3*	5.2
10	Chemicals	−6.8*	4.2
11	Textiles	−5.8*	9.1
12	Food & tabacco	−3.6*	2.9
13	Pulp, paper & paper prod.	−0.9	1.2

Table 10. Export Ratio in Aggregate Demand by Industry (1985)

(%)

Manufacturing industries (total)	11.4
Food & tabacco	0.7
Textiles	8.3
Pulp, paper & paper prod.	2.6
Petroleum & coal prod.	1.4
Ceramics, stone & clay	5.9
Chemicals	8.4
Primary metal industries	9.1
Fabricated metals	6.4
General machinery	17.6
Electrical machinery	22.4
Transportation equipment	30.1
Precision instrument	25.9

Source: *Annual Report on National Accounts*, Economic Planning Agency.

manufactured goods is more serious in foreign markets than in domestic markets.[19]

C. Expansion of domestic demand and corporate management efforts

The expansion of domestic demand, which was regarded as an important factor

[19] There are cases where the significance level of parameters are not always high and where real exchange rate parameters are positive. Such cases do not conform with the theoretical model. These problems, which are discernible in several sectors, can be attributed to the fact that the estimation was conducted by applying the same exchange rate factor to all sectors. Since the exchange rate factor is composed of external prices, nominal effective exchange rates, and domestic production cost, its actual movement might differ depending on the sector.

For instance, if the trade partner or the competitor is different, the nominal effective exchange rate and external prices are different. Depending on how imported raw materials are used, the rate of decrease in cost differs. As a result, when the exchange rate factor of the sector is different to a large extent from that of the entire manufacturing industry, then the parameter of the estimation equation does not correctly reflect the degree of international price competitiveness of the sector. If the exchange rate factor of the sector has an adverse correlation with the exchange rate factor of the entire manufacturing industry, then the parameter of the common exchange rate factor would be positive. Accordingly, sectoral differences observed in this paper might not only reflect the difference in influence of the exchange rate but also a problem in terms of estimation method.

contributing to improved profit performance in the latest phase of the yen's appreciation, is composed of two factors in terms of the estimation equation — an increase in domestic real income (the explanatory variable) and a rise in the elasticity of domestic demand to real income (the domestic real income factor parameter). Background to an increase in domestic real income are a) improved terms of trade and price stability due to the yen's appreciation and declining oil prices, b) fiscal policies such as the comprehensive economic policy implemented in September 1986 and the emergency economic package carried out in May 1987, and c) monetary relaxation. These points have been thoroughly analyzed in the Economic Planning Agency's *Economic White Paper (Keizai Hakusho) for 1988*, and Annual Review, as well as the Bank of Japan monthly reports (September 1987 and May 1988). Since domestic and external income are dealt with as exogenous variables in this paper, we will not analyze them here. Judging from the analytical results of this paper, however, it can be pointed out that the rise in the elasticity of domestic demand to real income which seems to reflect structural change in the latest phase of the yen's appreciation amplified the effect of increasing domestic real income on production. Accordingly, if this increment is attributed to efforts of the Japanese manufacturers to switch their main market as mentioned in Section IV, it is possible to think that efforts such as the development of new products and reinforcement of sales power in domestic markets (in other words, structural adjustments parallel with the yen's appreciation) contributed to the recovery and expansion of the business climate during the yen appreciation phase, as the *Economic White Paper for 1988* pointed out.

D. Measures to cope with trade friction and the yen's appreciation

Lastly, from the viewpoint of measures taken by corporations, another point we have to take note of in the estimation results is when the external real income factor parameter began to shrink (Figure 9). Differing from the case of the domestic real income factor, this parameter turned to shrink at the end of 1984 when the yen was not appreciating. The pace of shrinkage accelerated in the latter half of 1985 when the yen rapidly appreciated. This shrinkage, which occurred parallel with the increased influence of the domestic real income factor can be seen to reflect structural change, i.e. the increasing importance of domestic demand related to changes in relative profit performance between domestic and foreign markets. However, the shrinkage in the external real income factor parameter prior to the yen's appreciation cannot be attributed to a movement in relative profit performance. Judging from the timing, shrinkage might have been caused by trade friction. From 1983 through 1984, the U.S. current account deficit expanded dramatically ($8.1 billion in 1982, $40.8 billion in 1983, $101.5 billion in 1984) amid a worldwide recovery led by U.S. economic expansion. Trade friction between the United States and Japan worsened, and Japan was forced to draft an "external economic policy" (decided in April 1985). In addition, measures to directly deal with export volume were taken, e.g. a U.S.-Japan agreement on steel and iron stipulating that Japan should

hold exports within 5.8% of U.S. consumption was concluded in May 1985. The voluntary restriction by Japanese automakers on passenger car exports to the United States, which was initiated in 1981, has been maintained even though profits of the U.S. automobile industry have recovered considerably since 1983.

A shrinkage in the external real income factor parameter means that the importance of external demand on Japanese production has diminished. Accordingly, such shrinkage could also be caused by a decline in the reliance of Japanese industry on exports.[20] It is therefore possible to interpret the turnaround in the parameter prior to the rapid appreciation of the yen as a reflection of moves to reduce reliance on exports by setting up production bases abroad to cope with intensified trade friction. Actually, according to a survey conducted by the Economic Planning Agency in February 1986, 52% of the respondents replied that an effective measure to reduce trade friction was to expand production bases abroad. As a matter of fact, the number of Japanese automakers setting up overseas production rapidly increased amid continuing voluntary restrictions. Following Honda and Nissan in 1982 and 1983, respectively, Toyota started production in the United States in 1984.

Production abroad as a measure to reduce trade friction followed efforts to raise the value added domestic products and also happened to become a measure to cope with the yen's appreciation simultaneously. This likely was one of the factors reducing the effect of the yen's appreciation on production and profit. It is said that overseas production takes less than four years, on average, to reach breakeven point (according to a survey on business behavior conducted in January 1988). Accordingly, the transfer of production bases by Japanese enterprises in 1984 prior to the latest phase of the yen's appreciation seems to have contributed to supporting profits in 1988.

VI. Conclusion

In this section, after considering policy implications of the results stemming from the analysis in this paper, we will discuss analytical problems and issues to be examined in the future.

A. Policy implications of analytical results

As for the relationship between the yen rate and Japanese manufacturing industries, analysis in this paper shows that in the initial stage of the latest phase of the yen's appreciation (from mid-1985 to the first half of 1986), the negative effects on production were reduced by hysteresis due to the sharp depreciation of the yen at the end of the

[20] Shrinkage in the parameter of the external income factor is also caused by declining competitiveness, but there seems to be little likelihood that competitiveness weakened before the rapid appreciation of the yen.

1970s. Owing to the yen's appreciation thereafter, however, structural changes occurred and the influence of the exchange rate factor on production is likely to have become rather stronger than in the first half of the 1980s (accordingly, the recession due to the yen's appreciation might have been further deepened).

Hysteresis discerned in the initial stage of the yen's appreciation (corporate strategy was placed on keeping export volume or shares in external markets for a while even after the yen appreciated) appeared in the form of the suppression of rising export prices in order to adjust to the yen's appreciation. This phenomenon seems to have hindered exchange rate adjustment from improving trade imbalances. This suggests that for the effects of exchange rate adjustment on trade imbalances to have any substantial effect, it would be necessary to bring about such a dramatic appreciation of the yen so as to cause structural change opposite in direction to that occasioned by the yen's depreciation and also to erase hysteresis.

In our analysis of the fact that production recovered and expanded during the yen appreciation phase although hysteresis gradually disappeared after mid-1986 and that the effect of the exchange rate factor on production should have increased, we pointed out the following: a) the expansion of domestic demand against the background of a reflation policy and monetary relaxation and corporate efforts to cope with the yen's appreciation offset the negative effects on exports; b) in domestic markets, the degree of competitiveness (substitutability) between domestically-manufactured goods and imported goods is low—accordingly, in spite of the inflow of imported goods, prices of which were comparatively cheap due to the yen's appreciation, prices of domestically-manufactured goods in domestic markets were comparatively stable, contributing to the improved profit performance of domestic products and an increase in production; and c) due to differences in reliance on exports among industries, the effect of exchange rate fluctuation on production differed considerably.

These results have the following policy implications: (i) As the yen's appreciation has helped firms switch their structure from being export-centered to domestic demand-centered, it has certainly been effective from the standpoint of restructuring the Japanese economy to a domestic demand-led one and rectifying the huge trade imbalance. (ii) If the low substitutability between domestically-manufactured goods and imported goods in domestic markets, which is likely to have contributed to reducing the deflationary effect of the yen's appreciation on Japan's manufacturers, was brought about as a result of Japan's manufacturers' efforts to make their goods superior to imported ones by raising value added, then presumably it would lead to an international division of labor (while Japan's manufacturers specialize in high value-added goods, some parts are imported from NIEs) and thus does not necessarily conflict with the objective of improving the trade imbalance. However if such low degree of substitutability in domestic markets is partly due to the narrowness of Japanese markets, a criticism often levelled by other nations, it is a problem not only from the standpoint of improving the trade imbalance

but also from the viewpoint of price stability and fairness. In this case, we should make Japanese markets more open and promote price lowering. (iii) While adjustment of exchange rate levels is a necessary and effective macroeconomic measure to improve the huge trade imbalance, bearing in mind that the influence of the exchange rate depends on the industry, careful policy consideration at a microeconomic level is required for implementation.

B. Future problems

(1) The theoretical model applied in this paper was based on the short-term production behavior of corporations in coping with the fluctuation of relative prices. Accordingly, the process of structural changes, including changes in investment behavior and ensuing permeation effects (changes in capital stock volume and labor productivity), has not been analyzed in detail. Thus, it cannot be denied that other inferences could be drawn. In order to analyze changes in the production structure more strictly, it would be necessary to include the medium- and long-term behavior of corporations, including investment behavior, in the model.

(2) We analyzed exchange rate influences from two aspects—short-term cyclical effects and structural influence—but they do not cover all exchange rate effects. In this paper, we regarded explanatory variables, including raw material prices and real income, as exogenous variables and consideration was not given to the process of determining them. Actually, however, exchange rates must also have an effect on these independent variables (for instance, an improvement in the terms of trade parallel with the yen's appreciation brings about an increase in real income). Furthermore, there is feedback from production to explanatory variables (in particular, domestic real income). In order to measure the overall influence of exchange rates, a theoretical model should be more general and dynamic.

(3) In the latest phase of the yen's appreciation, the relaxation of restrictions and innovation in information technology advanced simultaneously and in a parallel fashion. Bearing this in mind, more strict analysis is required in order to judge whether or not all the structural changes observed were occasioned by the yen's appreciation.

Appendix I. Theoretical Model and Estimation Equation

Here, we will give a simple theoretical model, which is the basis of the observation equation applied in this paper, and derive a reduced form used in the estimation. As for structure, we utilized Branson and Love (1986) and Bruno and Sachs (1988).

Assumptions for the model are as follows:

(1) Two sectors—domestic and external

(2) Two kinds of goods—domestically-manufactured goods and externally-manufactured ones.

(3) There is substitutability between domestic and external goods, but not 100%.
(4) Demand for domestically-manufactured goods is determined depending on the relative prices of domestic and external goods as well as the real income of consumers.
(5) Corporations aim at profit maximization in competitive markets.
(6) Production stems from raw materials (N), labor (L), and capital (K), according to a linear and homogeneous CES-type production function.
(7) Raw materials are all imported. The price of each production factor is given exogenously.
(8) Capital stock is constant in the short run. With the above assumptions, the demand function is expressed as follows:

$$Q_d = D\,(P\,E/P^F,\ Y,\ Y^F), \tag{A-1}$$

where Q_d = demand volume for domestically-manufactured goods; P = yen-denominated price of domestic goods; E = foreign currency-denominated nominal exchange rate; P^F = foreign currency-denominated price of external goods; Y = domestic real income; and Y^F = external real income. Accordingly, PE/P^F depicts the relative price between domestic and external goods.

When equation(A-1) is depicted in logarithmic form,

$$q^d = a_1(p + e - p^F) + a_2 y + a_3\, y^F \tag{A-2}$$

where q^d, p, e, p^F, y, y^F are logarithms of Q^d, P, E, P^F, Y, Y^F, respectively. a_1, a_2, a_3 are parameters showing the elasticity of demand for respective variables.

If prices of domestic goods become relatively higher than those of external goods, demand for domestic goods decreases. Accordingly, a_1 is obviously negative ($a_1<0$). On the other hand, a_2 and a_3, which depict the elasticity of demand, are indefinite since they depend on the character of goods. If a good is inferior, there is also a likelihood that demand decreases with an increase in consumers' income. Concerning Japanese-made goods, however, it would be appropriate to think they are positive ($a_2<0$, $a_3<0$).

A short-run supply function (with an assumption that capital stock is constant) is depicted as follows:

$$Q_s = S(\,P_N^F,\ W/P,\ K) \tag{A-3}$$

where Q_s = supply volume; P_N^F = price of imported raw materials (foreign currency-denominated); W = nominal wages; and K = capital stock volume.

The supply volume is a function of the real price of raw materials and labor for producers, and of existing capital stock volume.

(A-3) is depicted by logarithmic form as:

$$q^s = b_1\,(p_N^F - p - e) + b_2(w - p) + b_3 k \tag{A-4}$$

Since b_1 and b_2 are the elasticity of supply to the real production factor price, both are negative ($b_1<0$, $b_2<0$). On the other hand, b_3, which is the capital stock volume parameter, is positive ($b_3<0$).

Suppose production volume Q is an equilibrium of demand and supply, we can produce the following reduced form equation from (A-2) and (A-4) by eliminating P from $Q^d=Q^s$.

$$q = a_1A[(b_1+b_2)^{-1}\{b_1(p_N{}^F-e) + b_2w\} - (p^F-e)] + a_2Ay + a_3Ay^F + (a_1+b_1+b_2)^{-1}a_1k \quad \text{(A-5)}$$

where $A = (a_1+a_2+a_3)^{-1}(b_1+b_2)$

Appendix II. Test of Structural Changes (using a kind of Chow test)

First, we will briefly explain methodology. For details, see Moriguchi (1977).

To assume structural change in the relationship between a dependent variable and a specified explanatory variable is to consider that the parameter of the explanatory variable changes when structural change occurs. In the case of the following regression model,

$$Yt = a_0 + a_1X_{1t} + a_2X_{2t} + \ldots\ldots + a_iX_{it} + e_t,\ t=1,2,\ldots,n, \quad \text{(A-6)}$$

suppose that at t=k+1, the relationship between the dependent variable Y and the specified independent variable X_1 (or variables) i.e. the parameter of $X_1(=a_1)$, changes, equation (A-6) will be

$$Yt = a_0 + (a_1+b_1D_{1t})X_{1t} + a_2X_{2t} + \ldots\ldots + a_iX_{it} + e_t. \quad \text{(A-7)}$$

$$D_{1t} = \begin{cases} 0\ (t=1,2,\ \ldots\ ,k) \\ 1\ (t=k+1,\ \ldots\ ,n) \end{cases}$$

Structural change can be tested by testing a null hypothesis H0 : $b_1=0$. Equation (A-7) can be rewritten as:

$$Yt = a_0 + a_1X_{1t} + a_2X_{2t} + \ldots + a_iX_{it} + b_1D_{1t}X_{1t} + e_t. \quad \text{(A-8)}$$

This is equal to adding a new independent variable ($D_{1t}X_{1t}$). Accordingly, in order to test structural change, we will estimate equation (A-8) and, conduct an F-test using estimation results for equations (A-6) and (A-8).

Procedural details and results of the test (mentioned in Section III) are follows. (1) At first, a constant dummy, which is 1 after the period that was supposed to be the time when structural changes occurred (the first quarter of 1986), is produced. (2) An additional explanatory variable depicting structural changes is produced by multiplying an independent variable (which is assumed to have experienced structural changes) by

the constant dummy mentioned in (1). (3) A regression equation in which the additional independent variable is included is estimated. (4) Based on the estimation result of equation (A-8) and that of the equation without an additional independent variable, the value of F is calculated according to the following equation and the F-test is performed.

$$F = (R_1^2 - R_0^2)(1-R_1^2)^{-1}(n - Q)(Q - H)^{-1}$$

where R_1^2 and R_0^2 are coefficients of determinants before adjustment for the degree of freedom in the case of adding an additional variable and in the case of no additional variable, respectively. n = the number of obserbations. Q = the number of explanatory variables including additional ones. H = the number of original explanatory variables.

We tested structural change in relation to the exchange rate factor and the domestic real income factor in accordance with the above-mentioned method. The value of F was 66.3, far exceeding the critical value 5.2 of the significant level of 1%. That is, a substantial improvement in determinancy could be discerned. In order words, there is a strong likelihood that structural change with respect to the exchange rate factor and the domestic real income factor occurred.

Estimation results after adding independent variables are as in the chart below.

In short, as a result of structural change, the influence of both the exchange rate factor and the domestic real income factor on production increased (increase in the absolute value of the parameter).

	Coefficient (t-value)
Constant	−5.13 (3.4)
Exchange rate factor	−0.13 (2.3)
Domestic real income factor	0.38 (3.8)
Overseas real income factor	0.70 (11.1)
Time trend factor	0.01 (40.2)
Additional explanatory variable (Exchange rate)	−0.42 (4.1)
Additional explanatory variable (Domestic real income)	0.16 (3.9)
Coefficient of determinant (R^2)	0.9939
Coefficient of determinant adjusted by degrees of freedom ($\bar{R}^2$)	0.9929
Durbin-Watson ratio	2.11
Degrees of freedom	38

Appendix III. Comparison with Estimation Results of Branson and Love

As for sectoral differences in the influence of the real effective exchange rate on production mentioned in Section V, W.H. Branson and J.P. Love (B & L) conducted similar estimations on the influence of the dollar's appreciation on U.S. manufacturing industry in the first half of the 1980s. Several papers have been forthcoming since 1986 and one published in January 1988 also covered Japan's manufacturers.

These papers are an important reference source for this paper. As for estimation equation specifications, there is a common denominator between our paper and theirs, i.e. the real effective exchange rate and real income are dealt with as major independent variables. For reference, Table A-1 shows a comparison of our estimation results with theirs concerning sectoral parameter differentials for the real effective exchange rate.

Specifications for the estimation equation are not, of course, completely the same.[21] In addition, the period of estimation, the variable applied as an alternative variable, and the method of estimation are different. Therefore, it would not be proper to compare the level of the parameter, but it seems to be meaningful to compare the sectoral ranking of the influence of the exchange rate.

A. Comparison of B & L and our estimation results regarding Japan

Comparing the estimation results of the two papers (Table A-1), the value for the parameter of the entire manufacturing industry was the same, coincidentally, but considerable differences were discerned by sector. That is, in B & L estimation results, contrary to the sign condition theoretically expected, the parameters are significantly positive for many sectors. In particular, it is questionable that the value of the parameter for industries with a heavy reliance on exports, including the iron and steel sector and the transportation equipment sector, was positive.

The difference between the estimation results of the two papers may be due in part to the fact that B & L used annual data for the National Acccounts in the estimation

[21] The main differences between the estimation methods in this paper and in Branson and Love(1988) are as follows (their estimation method is that used for the U.S. manufacturers industry):

(a) The estimation method in this paper is an ordinary least squares method, while B & L used the Beach-Mackinnon maximum likelihood procedure for correcting first order autocorrelation.

(b) We calculated the real exchange rate factor using domestic production costs and prices overseas (wholesale prices), while B & L applied the real effective exchange rate index based on a unit labor cost-basis (in accordance with IMF's *IFS*).

(c) The real income factor of consumers is classified into a time trend factor and a cyclical factor in both papers. Regarding the cyclical factor, however, this paper introduced a domestic factor (real domestic expenditures) and an external one (real world imports). B & L applied the unemployment rate in the United States as an alternative variable and only this was considered as a cyclical factor.

(d) B & L's estimation period included the first oil crisis and the initial phase of the latest yen appreciation period (dollar depreciation). The structural effect of the first oil crisis was dealt with by adding real energy prices (ratio of the energy component of CPI to total CPI) to explanatory variables as a structural change factor.

Table A-1. Comparison with Results of Branson & Love (Exchange rate factor parameter)

Rank	Industries	This study		Branson & Love			
				<Japan>		<U.S.>	Industries
			(t-value)		(t-value)		
Average	Manufacturing industries (total)	−0.22*	3.5	−0.22*	3.4	−0.30*	Manufacturing industries
1	Electrical machinery	−0.58*	3.7	−0.38	1.5	−0.05	Electrical & electronic
2	Transportation equipment	−0.48	1.7	0.18	1.1	−0.22*	Transportation equipment
3	Iron & steel	−0.40*	3.4	0.26*	2.0	−0.55*	Primary metal industries
4	Pulp, paper & paper prod.	−0.28*	2.5	−0.23	1.8	0.08	Paper & allied prod.
5	Precision instrument	−0.26	0.7	−0.04	0.1	−0.29*	Machinery exc. electrical
6	Industrial machinery	−0.25	1.5	−0.81*	4.4	−0.41*	Instrument & related prod.
7	Textiles	−0.06	1.2	−0.20	1.0	−0.04	Textile mill prod.
8	Ceramics, stone & clay	−0.03	0.3	−0.06	0.4	−0.22*	Stone clay & glass prod.
9	Petroleum & coal prod.	0.09	0.8	0.66	1.8	−0.43*	Petroleum & coal prod.
10	Non-ferrous metal prod.	0.10	1.0	0.26*	2.0		
11	Chemicals	0.17	1.4	0.01	0.1	−0.25*	Chemical & allied prod.
12	Food & tabacco	0.18	1.9	0.49*	3.3	0.06*	Food & kindred prod.
13	Fabricated metals	0.37*	3.2	−0.43*	3.2	−0.32*	Fabricated metal prod.

Note: Iron & steel and non-ferrous metal products are grouped in the primary metal industries in the B & L study. * indicates that t-value is significant at 5%.

because of the unavailability of quarterly data. The number of observations, and consequently the degrees of freedom, were rather small.

B. Comparison of sectoral differences between the U.S. (by B & L) and Japan (in this paper)

Comparing the estimation results for the United States by B & L with the estimation results on Japan in this paper, the common ones are that the machinery industry (including transportation equipment and precision instruments) and the iron and steel industry, suffered a relatively serious negative effect when their respective country's currency

Table A-2. Estimation Results as for Sectorial Differences in the United States (by Branson & Love)

	Exchange rate factor [REX(0,6)][a]	Income factors		
		Long-term factor time trend	Cyclical factor [URT(0,4)][b]	Structural factor [RENG(0,4)][c]
Food & kindred prod.	0.06*	0.008*	−0.06*	0.07
Tabacco manufactures	−0.24*	0.000	−0.09*	0.17
Textile mill prod.	−0.04	0.004*	−0.12	0.04
Apparel & other textile	0.04	0.003*	−0.09	0.07
Paper allied prod.	0.08	0.008*	−0.16*	0.04
Print & publishing	0.18*	0.012*	−0.20*	0.02
Chemical & allied prod.	−0.25*	0.012*	−0.13*	−0.30*
Rubber & misc. plastic	−0.43*	0.002	−0.12*	−0.27
Leather & leather goods	−0.16	0.017*	−0.26*	−0.31
Petroleum & coal prod.	−0.14*	−0.012*	−0.08	0.56*
Lumber & wood prod.	0.06	0.008*	−0.15	−0.33
Furniture & fixtures	−0.01	0.013*	−0.23*	−0.40*
Stone clay & glass prod.	−0.22*	0.009*	−0.24*	−0.42*
Primary metal industries	−0.55*	−0.001	−0.51*	−0.23
Fabricated metal prod.	−0.32*	0.007*	−0.35*	−0.32*
Machinery exc. electrical	−0.29*	0.013*	−0.46*	0.14
Electrical & electronic	−0.05	0.016*	−0.34*	0.08
Transportation equipment	−0.22*	0.013*	−0.35*	−0.78*
Instrument & related prod.	−0.41*	0.015*	−0.24*	−0.04
Misc. manufacturing prod.	−0.30*	0.003*	−0.16*	−0.09

Notes: Dependent variables are logarithm of U.S. Industrial Production Indices. Estimation method is the Beach-Mackinnon maximum likelihood procedure for correcting first order autocorrelation. Data frequency is quarterly. Estimation period: 1970/I~1986/I. * indicates that t-value is significant at 5%.

[a] Exchange rate factor [REX(0,6)] is logarithm of IMF's relative unit labor cost index (average of 7 quarters).

[b] Cyclical factor [URT (0,4)] is logarithm of the unemployment rate (average of 5 quarters).

[c] Structural factor [RENG (0,4)] is logarithm of the ratio of real energy price (average of 5 quarters). Real energy price is ratio of energy component of CPI to total CPI (urban).

Table A-3. Estimation Results as for Sectorial Differences in Japan (by Branson and Love)

	Exchange rate factor [REX(−1)][a]		Income factors: Long-term + cyclical factor [RGNP][b]		Income factors: Structural factor [RENG(−1)][c]		$\bar{R}^2$	DW
		(t-value)		(t-value)		(t-value)		
Manufacturing industries (total)	−0.22*	3.4	1.64*	21.5	−0.07*	3.0	0.99	1.0
Food & kindred prod.	0.49*	3.3	0.34	1.9	−0.05	1.0	0.78	1.9
Textile mill prod.	−0.20	1.0	0.46	1.9	0.03	0.4	0.55	1.2
Paper & allied prod.	−0.23	1.8	0.12*	7.9	−0.02	0.4	0.94	2.7
Chemical & allied prod.	0.01	0.1	2.46*	11.0	−0.10	1.6	0.97	2.0
Petroleum & coal prod.	0.66	1.8	−1.14*	2.6	0.37*	3.0	0.40	1.9
Stone clay & glass prod.	−0.06	0.4	0.61*	3.3	−0.17*	3.2	0.36	0.7
Primary metal industries	0.26*	2.0	1.62*	10.7	−0.25*	5.8	0.93	1.9
Fabricated metal prod.	−0.43*	3.2	1.66*	10.3	−0.28*	6.1	0.90	1.7
Instrument & related prod.	−0.81*	4.4	2.21*	10.0	−0.04	0.6	0.96	1.4
Electrical & electronic	−0.38	1.5	5.57*	18.7	−0.14	1.7	0.99	1.3
Transportation equipment	0.18	1.1	1.12*	5.7	0.07	1.3	0.94	2.1
Machinery exc. electrical	−0.04	0.1	3.42*	9.0	−0.16	1.4	0.94	1.7

Note: Dependent variables are logarithm of value-added in the National Accounts. Data frequency is calendar year. Estimation period: 1971~1985. Estimation method is ordinary least squares method. * indicates that t-value is significant at 5%.

[a] Exchange rate factor [REX] is logarithm of IMF's relative unit labor cost index.

[b] Long-term + cyclical factor [RGNP] is logarithm of real GNP.

[c] Structural factor [RENG] is logarithm of real energy price (ratio of yen-denominated world oil price to GNP deflator).

appreciated. These results seem to reflect severe price competition in international markets.

On the other hand, there were considerable differences between the two nations with respect to the raw materials sector that relies on domestic demand, including ceramics, petroleum products and chemicals. While the influence of exchange rates on these industries was not observed significantly in Japan, the relatively serious negative effect of the dollar's appreciation was observed in the United States. This difference might be attributed to the difference in the trade structure between the two nations, in particular the difference in market access from abroad for these industries. That is, since the market is narrow in Japan for petroleum products and cement, domestic demand-led industries might not suffer any serious effect from imported goods. On the other hand, in the United States where trade liberalization has advanced considerably, domestic demand-led industries might suffer from exchange rate effect through imported goods similarly to export-oriented industries. If so, the observation result is quite interesting because we observed a low degree of competitiveness between Japanese goods and imported ones in Japanese markets when analyzing recent business prosperity. As for the outline of the observation results and observation method of B & L, see Tables A-2 and A-3.

C. Regional differences in Japan (estimation results in this paper)

B & L also estimated regional differences in the United States. The method is similar to sectoral estimation, i.e. the same explanatory variables are applied to all regions. Since regional differences with respect to the influence of the exchange rate were often also pointed out in Japan in the latest phase of the yen's appreciation, we examined such differences by dividing the nation into ten regions.[22] The estimation period was from the second quarter of 1976 through the fourth quarter of 1986. The explanatory variables included a dummy variable for the latest phase of the yen's appreciation. Tables A-4 and A-5 show the observation results.

As in the case of sectoral estimation, let us first look at the exchange rate factor parameter which depicts the short-term cyclical effect (Table A-6a). The value is negative in all ten regions (i.e. the yen's appreciation negatively affects production) and, except for Kinki and Okinawa, is statistically significant (significance level of 5%). Looking at the eight regions which were statistically significant, Shikoku and Kanto suffered from a particularly serious short-term cyclical effect. Although there was a considerable difference between these two regions and the Tokai region which showed the smallest para-

[22] The ten regions are (1) Hokkaido; (2) Tohoku (Aomori, Iwate, Miyagi, Akita, Yamagata and Fukushima prefectures); (3) Kanto (Tokyo, Ibaraki, Tochigi, Gunma, Saitama, Chiba and Kanagawa prefectures); (4) Koshinetsu (Yamanashi, Nagano, Niigata, Toyama, Ishikawa and Fukui prefectures); (5) Tokai (Shizuoka, Gifu, Aichi and Mie prefectures); (6) Kinki (Kyoto, Osaka, Shiga, Hyogo, Nara and Wakayama prefectures); (7) Chugoku (Tottori, Shimane, Okayama, Hiroshima and Yamaguchi prefectures); (8) Shikoku (Tokushima, Kagawa, Ehime and Kochi prefectures); (9) Kyushu (Fukuoka, Saga, Nagasaki, Kumamoto, Oita, Miyazaki and Kagoshima prefectures); and (10) Okinawa.

Table A-4. Estimation Results by Region (Estimation period: 1976/II~1986/IV)

	Exchange rate factor		Domestic real income factor		Overseas real income factor		Time trend factor		Dummy variable for the latest yen's appreciation		Constant				
		(t-value)		(t-value)		(t-value)		(t-value)		(t-value)		(t-value)	$\bar{R}^2$	SE	DW
Hokkaido	−0.29*	3.0	1.21*	5.0	0.04	0.4	0.00*	4.6	−0.01	0.4	−9.02*	3.5	0.41	0.02	1.41
Tohoku	−0.24*	2.4	0.09	0.3	0.47*	4.9	0.01*	23.7	−0.05*	3.5	1.56	0.6	0.98	0.02	1.06
Kanto	−0.38*	4.8	0.43*	2.2	0.64*	8.7	0.02*	34.2	−0.05*	4.1	−3.01	1.4	0.99	0.02	1.75
Koshinetsu	−0.28*	3.1	0.30	1.3	0.70*	8.3	0.01*	26.2	−0.05*	4.3	−2.19	0.9	0.98	0.02	1.56
Tokai	−0.16*	2.2	0.99*	5.5	0.42*	6.2	0.01*	26.8	−0.16*	2.2	−9.51*	5.0	0.98	0.01	1.93
Kinki	−0.06	0.9	0.41*	2.3	0.40*	6.1	0.01*	21.6	−0.06*	6.1	−2.72	1.5	0.97	0.01	1.64
Chugoku	−0.34*	3.6	0.91*	3.9	0.43*	5.0	0.01*	15.1	−0.05*	3.7	−7.63*	3.1	0.93	0.02	1.40
Shikoku	−0.40*	3.4	0.65*	2.2	0.45*	4.0	0.01*	7.8	−0.04*	2.3	−4.23	1.3	0.68	0.02	1.13
Kyushu	−0.32*	4.2	0.00	0.0	0.54*	7.6	0.01*	17.3	−0.04*	3.9	2.73	1.3	0.95	0.02	1.79
Okinawa	−0.14*	0.4	0.61*	3.1	−0.44	1.4	0.01*	6.9	−0.11*	2.4	−24.37*	2.8	0.79	0.07	1.03
National average	−0.18*	2.9	0.57*	3.6	0.58*	9.7	0.01*	35.8	−0.07*	8.1	−5.44*	3.2	0.99	0.01	2.05

Note: Figures listed under each factor are estimated coefficients. * indicates that t-value is significant at 5%.

Table A-5. Number of Regions by Sign of Parameter

	Positive	Negative
Exchange rate factor	0 (0)	10 (8)
Domestic real income factor	10 (7)	0 (0)
Overseas real income factor	9 (8)	1 (0)
Time trend factor	10 (10)	0 (0)
Dummy variable for the latest yen's appreciation	0 (0)	10 (9)

Note: Significance level is 5%. Number of statistically significant regions in parentheses.

Table A-6a.

Exchange rate factor parameter		
1	Shikoku	−0.40*
2	Kanto	−0.38*
3	Chugoku	−0.34*
4	Kyushu	−0.32*
5	Hokkaido	−0.29*
6	Koshinetsu	−0.28*
7	Tohoku	−0.24*
8	Tokai	−0.16*
9	Okinawa	−0.14
10	Kinki	−0.06
	National average	−0.18*

Table A-6b.

Domestic real income factor parameter		
1	Okinawa	2.61*
2	Hokkaido	1.21*
3	Tokai	0.99*
4	Chugoku	0.91*
5	Shikoku	0.65*
6	Kanto	0.43*
7	Kinki	0.41*
8	Koshinetsu	0.30
9	Tohoku	0.09
10	Kyushu	0.00
	National average	0.57*

Table A-6c.

Overseas real income factor parameter		
1	Koshinetsu	0.70*
2	Kanto	0.64*
3	Kyushu	0.54*
4	Tohoku	0.47*
5	Shikoku	0.45*
6	Chugoku	0.43*
7	Tokai	0.42*
8	Kinki	0.40*
9	Hokkaido	0.04
10	Okinawa	−0.44
	National average	0.58*

Table A-6d.

Time trend factor (annual rate, 1980=100)		
1	Kanto	6.3*
2	Tohoku	5.8*
3	Koshinetsu	5.6*
4	Okinawa	5.4*
5	Tokai	4.5*
6	Kinki	3.6*
7	Chugoku	3.3*
8	Kyushu	3.1*
9	Shikoku	2.1*
10	Hokkaido	1.0*
	National average	5.4*

Table A-6e.

Dummy variable for the latest yen's appreciation (1980=100)		
1	Tokai	−14.6*
2	Okinawa	−10.4*
3	Kinki	−5.8*
4	Koshinetsu	−5.3*
5	Tohoku	−4.9*
6	Chugoku	−4.7*
7	Kanto	−4.4*
8	Kyushu	−4.1*
9	Shikoku	−3.8*
10	Hokkaido	−0.6*
	National average	−7.1*

Note: * indicates that t-value is significant at 5%.

Table A-7. Industrial Structure by Region (1980 average; top 10 industries)

	Hokkaido	Share, %	Tohoku	Share, %	Kanto	Share, %	Koshinetsu	Share, %	Tokai	Share, %	Kinki	Share, %	Chugoku	Share, %	Shikoku	Share, %	Kyushu	Share, %	Okinawa	Share, %	National average	Share, %
1	Food & tabacco	27.8	Electrical machinery	19.0	Electrical machinery	18.1	Textiles	14.7	Trans-portation equipment	17.5	Electrical machinery	13.6	Trans-portation equipment	19.2	Industrial machinery	14.8	Food & tabacco	17.2	Food & tabacco	44.2	Electrical machinery	12.9
2	Wood & wood pro-ducts	11.7	Food & tabacco	16.0	Trans-portation equipment	11.4	Industrial machinery	14.1	Industrial machinery	11.7	Industrial machinery	13.4	Industrial machinery	12.5	Textiles	13.9	Iron & steel	15.6	Ceramics, stone & clay	18.8	Industrial machinery	11.1
3	Ceramics, stone & clay	11.3	Ceramics, stone & clay	8.3	Industrial machinery	10.2	Electrical machinery	13.0	Chemicals	8.8	Iron & steel	11.4	Chemicals	12.0	Food & tabacco	9.4	Ceramics, stone & clay	9.8	Fabricated metals	10.5	Trans-portation equipment	10.1
4	Pulp, pap-er & pap-er prod.	10.3	Textiles	8.0	Petroleum & coal prod.	10.0	Fabricated metals	9.6	Electrical machinery	8.8	Textiles	9.9	Textiles	10.2	Petroleum & coal prod.	9.2	Chemicals	9.0	Petroleum & coal prod.	10.3	Food & tabacco	9.1
5	Iron & steel	9.8	Wood & wood pro-ducts	7.2	Chemicals	9.3	Food & tabacco	9.3	Textiles	8.1	Chemicals	9.7	Food & tabacco	9.2	Pulp, pap-er & pap-er prod.	7.8	Industrial machinery	8.5	Wood & wood pro-ducts	4.4	Chemicals	8.7
6	Fabricated metals	6.1	Chemicals	6.2	Food & tabacco	8.0	Misc. manufac-turing	5.9	Misc. manufac-turing	7.5	Fabricated metals	8.1	Ceramics, stone & clay	6.5	Chemicals	7.6	Fabricated metals	6.4	Textiles	4.1	Iron & steel	8.1
7	Petroleum & coal prod.	6.1	Iron & steel	5.5	Misc. manufac-turing	6.5	Chemicals	5.5	Food & tabacco	7.4	Misc. manufac-turing	8.1	Petroleum & coal prod.	6.4	Ceramics, stone & clay	6.8	Electrical machinery	6.2	Chemicals	2.3	Textiles	7.0
8	Industrial machinery	4.2	Fabricated metals	4.8	Iron & steel	6.0	Ceramics, stone & clay	5.4	Ceramics, stone & clay	7.4	Food & tabacco	6.7	Electrical machinery	5.4	Non-ferrous met. prod.	5.8	Trans-portation equipment	5.7	Iron & steel	2.3	Misc. manufac-turing	6.4
9	Chemicals	2.5	Industrial machinery	4.7	Fabricated metals	6.0	Precision instrument	4.5	Iron & steel	6.7	Trans-portation equipment	5.0	Fabricated metals	4.3	Trans-portation equipment	5.2	Textiles	5.7	Pulp, pap-er & pap-er prod.	1.3	Fabricated metals	6.3
10	Electrical machinery	2.2	Pulp, pap-er & pap-er prod.	4.4	Ceramics, stone & clay	3.5	Trans-portation equipment	4.0	Fabricated metals	5.1	Ceramics, stone & clay	4.0	Misc. manufac-turing	4.2	Electrical machinery	4.5	Misc. manufac-turing	5.3	Misc. manufac-turing	1.3	Ceramics, stone & clay	5.5

meter, almost similar effects were observed in other regions. Next, looking at the parameter of the dummy variable which represents the scale of structural effect of the latest phase of the yen's appreciation, all regions, other than Hokkaido, were statistically significant (5%). Excluding Tokai and Okinawa where the effect was considerable, there was no marked difference according to region. Compared with sectoral differences, the variation is rather small in terms of both the short-term cyclical effect and the structural effect. Presumably it partly stems from the fact that each region has multiple sectors within it and the character of each offsets the others. It must be noted, however, that in regions with small short-term cyclical effects, the influence of the latest yen's appreciation was rather serious (i.e. the parameter of the dummy was large), in other words the regional difference was different in terms of short-term cyclical effect and structural influence. We will not analyze details, but will examine the differences in the industrial structure of each region which is considered to be the background for the differences. Table A-7 shows the industrial structure of each region in the base year of the production index (1980). According to this table, the serious short-term cyclical effect on the Kanto and Chugoku regions (Table A-6a) seems to be attributed to the high presence of the machinery industry in these regions (nearly 40%, Table 9a). However, the estimation results which shows that the short-term cyclical effect on the Tokai and Kinki regions was slight and that the structural effect was (Table A-6e) serious do not seem to be explained by respective regional industrial structures. Accordingly, differences among regions cannot be completely attributed to differences in industrial structure. From another point of view, there exist regional differences within each industry.

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