INDUSTRY AND ENERGY DEPARTMENT WORKING PAPER
INDUSTRY SERIES PAPER No. 26

Cost Reduction, Product Development and the Real Exchange Rate

Why Do Successful Industrializing Countries Experience Real Exchange Rate Appreciation?

April 1990

COST REDUCTION, PRODUCT DEVELOPMENT AND THE REAL EXCHANGE RATE

Why Do Successfully Industrializing Countries Experience Real Exchange Rate Appreciation?

Sadao Nagaoka
April 1990

Industry Development Division
Industry and Energy Department
Policy, Research and External Affairs

TABLE OF CONTENTS

		Page No.
ABSTRACT		i
I.	INTRODUCTION	1
II.	PRICE ELASTICITY OF DEMAND AND COST REDUCTION	5
III.	A MONOPOLISTIC COMPETITION MODEL OF A SMALL OPEN ECONOMY	8
IV.	BIASES IN PRODUCTIVITY CHANGE AND REAL EXCHANGE RATE	12
	A. Productivity Gain Biased toward Product Development and Real Exchange Rate	12
	B. Sectoral Bias in Productivity Change and Real Exchange Rate - General Formula	14
	C. Applications of General Formula	16
V.	CONCLUDING COMMENTS	18

FIGURES AND TABLES

REFERENCES

This paper is one of the background papers for the IENIN research project on Productivity, Competitiveness and Economic Policy.

ABSTRACT

Countries with successful industrial development records tend to experience real appreciation of their currencies not only in terms of the economy-wide price index but also in terms of the price index of the industrial sector. This has certainly been the case for Korea and Japan.

However, this is exactly the opposite of what we generally expect from conventional trade theory, which holds that a fast-growth economy generally experiences terms-of-trade losses. Instead, it looks as though successful industrialization prevents the tradeoff between growth and terms-of-trade gains. This finding may have important implications for exchange rate policies as well as for industrial policy. Nagaoka conducts theoretical investigations of the possible causes of this puzzle, based on a monopolistic competition model. He has found that:

- Equilibrium real exchange rates must appreciate when a positive correlation exists between price elasticity of demand and changes in competitive positions across industrial sectors. If a country gains competitiveness mainly in highly competitive sectors, it can expand its market significantly so that the external balance requires a real appreciation of the domestic currency.

- A positive correlation between price elasticity and the speed of cost reduction may arise naturally in the technological "catchup" process since high price elasticity of demand is conducive to cost reduction. First, high price elasticity makes each firm in the sector more aggressive in expanding output, due to the smaller perceived effect on prices in individual firms. Second, low price-cost margins necessitate a large output from each firm for it to break even. Large output, in turn, makes the appropriability from cost reduction high.

- Another potential source for real appreciation of domestic currency is productivity gain biased toward adopting new products and against cost reduction. The real exchange rate appreciates in proportion to the excess of productivity gain for product development over that for cost reduction.

- Real exchange rate flexibility is essential in order to accommodate these changes without causing macro imbalances. One additional lesson at this stage may be the importance of conducting a disaggregated analysis of industrial performance with a focus on product development capability in evaluating the competitiveness position of a country's external trade.

I. INTRODUCTION

1.01 Countries with successful development records in industrialization tend to experience real appreciation of their currencies not only in terms of the economy-wide price index but also in terms of the price index of the industrial sector. As shown in Figure 1 for Japan, the yen has appreciated substantially over time, not only in terms of the economy-wide price index, such as the GDP deflator, but also in terms of the manufacturing value-added deflator or the unit labor cost of the manufacturing sector. Figure 2 tells the same story for Korea. The opposite story holds for those countries experiencing stagnant industrialization and growth. In fact, it appears that successful industrialization may preclude the tradeoff between growth and terms of trade gains, which is implied by conventional trade theory.

1.02 The tendency for the appreciation of the real exchange rate in high growth economies in terms of the broad price index is not surprising. It has been well known since Balassa (1964) and Samuelson (1964) that the exchange rate diverges from purchasing power parity (PPP) if the productivity differential between tradable and nontradable sectors differs across countries. Generally there is more opportunity for technological catchup in the tradable sector than in the nontradable sector, such as for some services, in developing countries. Thus, we expect that the real exchange rate, in terms of the price index in the nontradable sector, or the economy-wide price indexes, would appreciate in successfully developing countries.

1.03 However, the puzzling part is the appreciation of the real exchange rate even in terms of the price index of the industrial sector in successfully industrializing countries. Actually, this is exactly the opposite of what we generally expect from conventional trade theory. Unless growth has a strong import-substituting bias, so that the import-income ratio declines steadily over time, high-growth countries have to expand their exports faster than the income growth of the rest of the world. This is possible only when these economies lessen the prices of their exports. Consequently we are led to expect high-growth countries generally to experience real depreciation in terms of the price index of the tradable sector, i.e., there exists a tradeoff between growth and the terms of trade.

1.04 This puzzle gives rise to some policy questions, too. First, it may have implications for exchange rate policy. In successfully industrializing countries, substantial real appreciation of their currencies may be necessary in order to prevent inflationary developments in their economies. This is certainly suggested by Japan's experience in the early 1970s and Korea's in the late 1980s. On the other hand, continuous real depreciation may be necessary for those economies beset with stagnant industry in order just to keep the economy competitive. Second, the exchange rate puzzle may have implications for industrial

policy. If government can assist the pattern of industrialization leading to terms of trade gains or to avoid terms of trade loss, such an intervention would be welfare improving. Dornbush and Park (1987) suggest that Korea's active industrial policy contributed to its high growth accompanied by improving terms of trade.

1.05 To understand this puzzle it is useful to examine changes in industrial structure or the absence of change after growth. The idea is most elegantly developed by Krugman (1989). He proposes considering the growth of an economy not as a homogeneous expansion of existing industries but as a continuous addition of new industries. He has demonstrated that growth does not affect the real exchange rate at all in the Dixit-Stigliz (1977) monopolistic competition model. He also has presented evidence from industrialized countries supporting this view of growth. Evidence shows that rapidly growing developed countries show a systematically high income elasticity for their exports ("45-degree rule"), thus more or less exactly offsetting the pressure for devaluation in these economies, which comes from rapidly growing imports. He regards high income elasticity of exports as reflecting the speed of adding new industries. Since product differentiation opportunities seem to be more abundant for industrial activities than for agricultural or mining activities, Krugman's analysis is also consistent with the observation that terms of trade loss due to growth often has been the concern of primary commodity-based developing countries rather than the developing countries with successful industrialization records. However, his analysis, at least in its original form, cannot explain why successfully industrializing economies experience terms of trade gains rather than constant terms of trade.

1.06 There exist several distinct (but possibly complementary) potential causes, including the one newly offered in this paper. One explanation is Krugman's (1979), of course. In his paper, industrialization in developing countries is formulated as the relocation of industries from developed countries to developing countries, caused by international technology diffusion. If such diffusion is more rapid than the creation of new industries in developed countries, terms of trade shift in favor of developing countries. This is because the aggregate expenditure pattern shifts in developing countries' favor.[1/] In Krugman's model, technology development in developing countries results only in the introduction of new products or new industries. In this paper I extend this analysis by demonstrating that whether the real exchange rate appreciates depends on the excess of the productivity gain for product development over the productivity gain for cost reduction.

1/ The fast industrial diversification of Korea is considered by Dornbusch and Park (1987) to be a cause for the tendency toward appreciation of Korean unit labor costs in the manufacturing sector relative to the US and Japan.

1.07 A second explanation comes from the extension of the Balassa-Samuelson (1964) model to the "tradable" sector. Some of the manufacturing subsectors do seem to produce "nontradable" products such as consumer goods (e.g., traditional costumes) catered to specific needs of a country. If these subsectors have smaller technological opportunities for productivity improvement than the rest of the manufacturing sector, industrial development leads to real appreciation in the average price of manufactured goods. This paper extends this analysis by demonstrating that real appreciation takes place when a positive correlation exists between the share of domestic industry in world industry and the productivity gain.

1.08 A third potential explanation for the appreciation of the real exchange rate in terms of the price index of the industrial sector in industrialized countries comes from their high export income elasticity. If industries in a particular country produce highly income-elastic goods more systematically than the rest of the world, such a country will grow rapidly and experience terms of trade gain over time. It may be interesting to note in this regard that one of two targeting criteria suggested by a prominent industrial policy adviser in Japan in the 1950s and 1960s was income elasticity. However, this third explanation is close to a tautology and may not be consistent with economic equilibrium. Since all enterprises would like to produce goods for which demand grows fastest, we would expect competition to lead to a situation where no major difference exists in the income elasticities for exports of various countries--unless some systematic bias exists, such as a natural resource advantage for a particular industry or if there are international differences in capital costs.

1.09 A fourth explanation, newly offered in this paper, is the systematic correlation between price elasticity of demand and improvement of price competitiveness.[2/] As will be formally demonstrated later, when productivity gains or improvement in competitive position take place more rapidly in highly price-elastic sectors, output from these sectors expands at a disproportionately high rate. Thus, international trade does not balance unless wages go up more than the economy-wide average productivity gains. Thus, terms of trade improve. Is there economic ground for such a correlation? As is demonstrated in Section II, high price elasticity is conducive to investment toward cost reduction since private appropriability of such investment is high. Since developing countries with high technical capability are likely to have more room for cost reduction than industrialized countries, due to their late-comer advantage, it is not surprising if these countries catch up faster in the price-elastic sectors and experience real appreciation even in terms of tradable goods prices.

2/ This explanation has been suggested by Krugman and Baldwin (1987) as a potential cause for the long-run tendency of the US real exchange rate to depreciate, although they did not articulate a formal model.

1.10 The rest of the paper is organized as follows. Section II demonstrates within the partial equilibri n framework that high price elasticity is conducive to investment for cost reduction. Section III describes a simple general equilibrium model for a small open economy, based on a monopolistic competition model, which is essentially a multi-sector extension of Krugman (1989). Section IV first establishes that productivity gains biased toward introduction of new products lead to real appreciation, based on the model developed in Section III. It also develops a general formula linking sectoral bias in productivity change and real exchange rates. It then discusses various implications. A positive correlation between the price elasticity of demand and the improvement of price competitiveness leads to real appreciation. This section also shows that the Balassa-Samuelson effect (the second explanation) can be interpreted as a special case under the general formula. Section V gives concluding comments.

II. PRICE ELASTICITY OF DEMAND AND COST REDUCTION

2.01 This section demonstrates that the high price elasticity of demand is conducive to cost reduction within the framework of a partial or industry equilibrium. I demonstrate this in the monopolistic competition setting.[3] The reason for choosing the imperfect competition framework is a familiar one: perfect competition does not allow enterprises to recover investment for cost reduction when the marginal cost of production is constant or declining. This would be inconsistent with empirical observations that enterprises invest in technology and that they have more or less constant or declining costs of production. I consider the following setting. There exist n firms in an industry. Each firm has a constant marginal cost c, which declines as the firm increases investment for cost reduction f. I assume that $\partial c/\partial f < 0$ and $\partial^2/\partial f^2 > 0$.

2.02 First I regard n as exogenously determined. Each firm produces its own product, differentiated from others. But all firms are identical in other aspects. k is elasticity of substitution among differentiated products.[4] When n is large, k approximates elasticity of demand faced by each firm.[5] If we denote the price set by each enterprise as P, the quantity supplied by x, and the constant marginal cost of investment f as r, the optimal conditions for production and investment decisions by each firm are given by

$$(1) \qquad P = C(f)/(1 - 1/k)$$

$$(2) \qquad - C'(f)x = r$$

Equation (1) determines the price for a given cost, and equation (2) gives the investment for a given output. A larger output increases the private appropriability from cost reduction and thereby encourages investment for cost reduction.

3/ See Helpman and Krugman (1985 and 1989) for an excellent discussion of the recent developments in applying the monopolistic competition model to international trade theory and policy.

4/ The utility function is assumed to be approximated by constant elasticity of the substitution function (see Section III).

5/ See Helpman and Krugman (1985).

2.03 I further assume that total expenditure E for this industry's products is fixed.[6] In this case

$$(3) \quad n P x = E$$

When price goes down, real expenditure (nx) goes up, but nominal expenditure stays the same. Substituting equation (3) for equation (1) we have

$$(4) \quad x = (E/n)\ (1 - 1/k)/C(f)$$

We can regard this equation as determining output x for a given level of production cost.

2.04 Industry equilibrium (f,x) is given in equations (2) and (4). Its determination is illustrated in Figure 3. The line xx corresponds to equation (4), while the line ff corresponds to equation (2). Both lines have positive slopes. Higher output expands the benefit of cost reduction and thereby increases investment for such purpose, while high investment for cost reduction reduces price and thereby expands demand. It also can be shown that the line ff is steeper than the line xx given the second-order condition of profit maximization.

2.05 Now higher price elasticity of demand k shifts up xx line. Higher price elasticity of demand implies that each enterprise can expand output without worrying about its price-depressing effect. Consequently, industry prices are low and industry output is high for a given level of investment. Since larger output is in turn conducive to investment, both output and investment are larger for highly price elastic sectors, (the equilibrium shifts from s to s' in Figure 3). More cost reduction takes place in highly price-elastic sectors.

2.06 In the free entry case, n is determined endogenously by the zero profit condition. If we denote operating profit by π, such a condition is given by

$$(5) \quad \pi = Px/k = E/(kn) = fr$$

given equation (3). Equation (4) determining output now becomes modified into

---

6/ When the upper-tier utility function can be approximated by the Cobb-Douglas function, this relationship holds (see Section III).

(4') $x = r(k - 1)f/C(f)$

Consequently, the line xx becomes steeper.

2.07 The high price elasticity of demand shifts up xx line as before. Assuming that the line ff is still steeper than the line xx (unless industry equilibrium becomes unstable), we can derive the same conclusion as above. The economic mechanism in this case is the following: the high price elasticity of demand reduces the price-cost margin and therefore the price for a given level of cost-reducing investment f from equation (1). Only a firm with large output can break even when a low price-cost margin, as well as low prices, prevails in the industry (equation (5). Large output is in turn conducive to cost reduction, which reduces price further and invites expansion of demand and output.

III. A MONOPOLISTIC COMPETITION MODEL OF A SMALL OPEN ECONOMY

3.01 This section presents a simple general equilibrium model of a small open economy based on the framework of monopolistic competition. To simplify the analysis, this section takes technical progress as exogenous. This model serves as an analytical framework for the next section.

3.02 The economy consists of N industries. It is assumed that there exist Dixit-Stiglitz type product differentiation opportunities within each industry. In industry i there exist n_i domestic enterprises and n_{if} foreign enterprises, each of which produces only one variety of product.

3.03 The utility function of a representative individual is assumed to have a two-tier structure, Cobb-Douglas in the upper tier and CES in the second tier:

$$(6)\quad U = \Pi_{i=1\sim N}\, U_i^{w_i},\quad \Sigma_{i=1\sim N}\, w_i = 1$$

$$(7)\quad U_i = [\Sigma_{j=1\sim ni}\, d_{ij}^{(1-1/ki)} + \Sigma_{j=1\sim nif}\, d_{ijf}^{(1-1/ki)}]^{ki/(ki-1)},\quad k_i > 1$$

where w_i is the expenditure share for industry i, d_{ij} is consumption of the domestically produced variety j of industry i, d_{ijf} is consumption of imported variety j of industry i, and k_i is the elasticity of substitution for each pair of products in industry i.

3.04 Industry price P_{ai} is then derived as follows:

$$(8)\quad P_{ai} = [\Sigma P_{ij}^{1-ki} + \Sigma P_{ijf}^{1-ki}]^{1/(1-ki)}$$

where P_{ij} is the price of the domestically produced variety j of industry i, and P_{ijf} is the price of the imported variety j of industry i. We measure all prices in a common currency.

3.05 It is well known that the demand function for each differentiated product can then be given by

$$(9)\quad \log d_{ij} = -k_i \log(P_{ij}/P_{ai}) + \log(w_i E/P_{ai})$$

where E is the country's total spending.

3.06 I further assume that the home country is small so that foreign spending, a number of foreign varieties of differentiated products in each industry, and foreign prices of the products are taken as exogenous. If we denote foreign spending for industry i products as E_{if}, the foreign demand for home variety j in industry i is given by

$$(10)\quad \log d_{ijf} = -k_i \log(P_{ijf}/P_{ai}) + \log(E_{if}/P_{ai})$$

3.07 For the production side, I assume a constant marginal cost of production. For simplicity, I assume one composite factor of production (call it labor). Total cost function is then

$$(11)\quad f_{ij}\, w + C_{ij} w x_{ij} \quad \text{with } df_{ij}/d\theta_{pij} = dC_{ij}/d\theta_{cij} = -1$$

where f_{ij} w is fixed cost and C_{ij} w is marginal cost, and w is wage, θ_{pij} is efficiency for product development, and θ_{cij} is production efficiency. It is natural for us to assume that both f_{ij} w and C_{ij} w are proportional to w since there is only one composite factor of production.

3.08 It is well known that when each industry is occupied by many firms producing different varieties of a product, the perceived elasticity of demand for the product j in industry i is given by k_i. Consequently, firms that engage in monopolistic competition will set the prices so as to allow for constant markups.

$$(12)\quad P_{ij}\,(1 - 1/k_i) = C_{ij} w$$

The operating profit, defined as revenue minus variable production cost, is given by

$$(13)\quad \pi_{ij} = (P_{ij} - C_{ij} w)\, x_{ij}$$

3.09 In the case where free entry exists, operating profits must be equal to fixed cost in equilibrium.

$$(14)\quad \pi_{ij} = f_{ij} w$$

3.10 The equilibrium condition of the factor market is given by

(15) $\Sigma f_{ij} + \Sigma C_{ij} x_{ij} = L$

where L is total labor supply.

3.11 I analyze only the symmetric equilibrium in each industry, so that

$$
\begin{array}{llll}
P_{ij} = P_i & , & P_{nij} = P_{ni} & \\
x_{ij} = x_i & & & \\
d_{ij} = d_i & , & d_{nij} = d_{ni} & \\
C_{ij} = C_i & , & \theta_{pij} = \theta_{pi} \quad , & \theta_{cij} = \theta_{ci} \\
f_{ij} = f_i & & &
\end{array}
$$

I also define

(16) $M_i = 1 - 1/k_i$ and

(17) $X_i = n_i x_i$

3.12 Given the symmetry, the equilibrium condition in labor markets is

(18) $\Sigma f_i n_i + \Sigma C_i X_i = L$

Pricing and profit equations can be also simplified to

(19) $P_i = C_i w/M_i$

(20) $P_{ai} = (n_i P_i^{1-ki} + n_{ni} P_{ni}^{1-ki})^{1/(1-ki)}$

(21) $\pi_i = (p_i x_i)/k_i = f_i w$ if free entry.

3.13 The national budget constraint is, therefore, given by

$$(22)\quad E = \Sigma(M_i P_i X_i + n_i \pi_i) = \Sigma(M_i + 1/k_i) P_i X_i = \Sigma P_i X_i = Y$$

where Y is the domestic product.

The product market equilibrium condition is given by

$$(23)\quad x_i = (P_i/P_{ai})^{-ki} (w_i E/P_{ai}) + (P_i/P_{ai})^{-ki} (E_{if}/P_{ai})$$

$$= (P_i/P_{ai})^{-ki} (w_i E + E_{if})/P_{ai}$$

since domestic output is equal to the sum of domestic sales and exports.
$w_i E + E_{if}$ is the world spending on industry i products.

3.14 Welfare can be measured by the indirect utility function as follows:

$$(24)\quad \log U = \text{constant} + \log E - \Sigma_{i=1\sim N}\, w_i/(1-k_i) \log(n_i p_i^{1-ki} + n_{if} P_{if}^{1-ki})$$

It is clear from this equation that higher prices reduce welfare while larger product variety increases welfare.

IV. BIASES IN PRODUCTIVITY CHANGE AND THE REAL EXCHANGE RATE

4.01 This section first presents an analysis of how the bias in productivity gains between cost reduction and product development causes the change in the equilibrium exchange rate. Then it presents an analysis of how the productivity gain from cost reduction causes change in the real exchange rate, if it is sectorally biased in terms of price elasticity of demand and shares of domestic industries.

A. Productivity Gain Biased toward Product Development and the Real Exchange Rate

4.02 I first describe the response of the economic model set up in the last section to technical progress and changes in foreign prices and expenditures. Equations (11) and (19) give the following price-setting equation:

$$(25) \quad dP_i/P_i = dw/w - d\theta_{Ci}$$

Equations (8) and (23) give the following demand function for each product of domestic industry i:

$$(26) \quad dx_i/x_i = -(k_i + t_i - k_i t_i)\, dP_i/P_i + (k_i - 1)(1 - t_i)\, dP_{fi}/P_{fi} - t_i\, dn_i/n_i + e_i\, dE/E + (1 - e_i)\, dE_f/E_f$$

where t_i is domestic industry's share of the world industry in sector i, and e_i is the share of domestic demand in the total sales of domestic industry i. The zero profit condition (21) becomes

$$(27) \quad dP_i/P_i + dx_i/x_i = dw/w - d\theta_{pi}$$

These three equations give the industry equilibrium for given dE/E and dw/w, which in turn are determined by budget constraints and by the labor market equilibrium as follows.

4.03 Budget constraint (22) becomes

$$(28) \quad dE/E = \Sigma s_i\, (dx_i/x_i + dn_i/n_i + dP_i/P_i)$$

where s_i is the share of domestic industry i in the domestic economy. The labor market equilibrium condition (18) becomes

(29) $\Sigma s_{Li0} (dn_i/n_i - d\theta_{pi}) + \Sigma s_{Li} (dx_i/x_i + dn_i/n_i - d\theta_{ci})$
$= 0$ (free entry case)

(29') $\Sigma s_{Li} dx_i/x_i = 0$ (restricted entry case)

where s_{Li0} (s_{Li}) is the share of the fixed-cost (variable-cost) component of employment in the domestic industry i in the domestic economy.

4.04 In the rest of this section I show that whether the real exchange rate appreciates depends on whether the productivity gain favors cost reduction or product development. For simplicity, I assume the symmetry of all industries and focus on the response to productivity gain. Productivity gain is assumed to improve opportunities for cost reduction and for product development for all industries in the same manner:

(25') $dP/P = dw/w - d\theta_c$ and

(27') $dP/P + dx/x = dw/w - d\theta_p$

If $d\theta_c < d\theta_p$, then technical progress is biased toward product development.

The budget constraint (28) gives

$dE/E = dw/w - d\theta_p + (1/t)(d\theta_p - d\theta_c) - (k+t-kt)(dw/w-d\theta_c)/t+dE/E,$
since t = e. Simplifying this equation, we get a concise formula:

(30) $dw/w = d\theta_c + (d\theta_p - d\theta_c)/k$

From equation (25) we have

(31) $dp/p = (d\theta_p - d\theta_c)/k$

Therefore, if the productivity gain is biased toward cost reduction ($d\theta_p < d\theta_c$), the real exchange rate depreciates. Conversely, if technical progress is biased toward new products or new industry developments ($d\theta_p > d\theta_c$), the real exchange rate appreciates.

B. Sectoral Bias in Productivity Change and the Real Exchange Rate--General Formula

4.05 I first analyze the case characterized by restricted entry. It is possible to rewrite the budget constraint and the labor market equilibrium condition as follows:

$$\begin{array}{l} (32) \\ (33) \end{array} \begin{vmatrix} 1-e^V & (k+t-kt-1)^V \\ e^L & -(k+t-kt)^L \end{vmatrix} * \begin{vmatrix} dE/E \\ dw/w \end{vmatrix}$$

$$= \begin{vmatrix} (k+t-kt-1)^V\{(d\theta)'+(dp_f/P_f)'\}+(1-e)^V dE_f/E_f \\ -(k+t-kt)^L\{(d\theta)''+(dP_f/P_f)''\}+(d\theta)^L+(dP_f/P_f)^L-(1-e)^L dE_f/E_f \end{vmatrix}$$

where superscript V(L) represents the variable, with that superscript as the economy-wide average, with weights $s_i(s_{Li})$,[7] $(d\theta)'$ and $(dP_f/P_f)'$ representing average productivity gain and foreign price changes and with weights s_i normalized by $(k_i + t_i - k_i t_i - 1)$; and $(d\theta)''$ is average technical progress with weights s_{Li} normalized by $(k_i + t_i - k_i t_i - 1)$.[8]

4.06 If we assume that $dE_f/E_f = (dP_f/P_f)^L$, we arrive at the following simplified equation for dw/w:

$$(34) \quad dw/w = \Sigma s_i\,(g_i/g^V)(d\theta_i + dP_{if}/P_{if}) - (1-e^V)/g^V d\theta^L$$

where $g_i = e^L(k_i+t_i-k_i t_i-1) + (1-e^V)(s_{Li}/s_i)(k_i+t_i-k_i t_i)$ and $g^V = \Sigma s_i\, g_i$

It is natural to define the domestic price index P_v as follows:
$dP_v/P_v = \Sigma\, s_i\, dP_i/P_i$, which is equivalent to the GDP deflator. Given any general foreign price index dP_f/P_f, the real exchange rate index can be given by

$$(35) \quad dP_f/P_f - dP_v/P_v = -\Sigma s_i\, dP_i/P_i + dP_f/P_f$$

$$= -\Sigma s_i\,(dw/w - d\theta_i) + dP_f/P_f$$

7/ For example, $e^V = \Sigma_{i=1-N}\, s_i e_i$.

8/ For example, $(d\theta)' = \Sigma s_i(k_i+t_i-k_i t_i-1)d\theta_i/(k+t-kt-1)^V$

$$= -dw/w + d\theta^v + dP_f/P_f$$

$$= -\Sigma(s_i/g^v)(g_i-g^v)\{(d\theta_i-d\theta^v)+(dP_{if}/P_{if}-dP_f/P_f)\}+(1-e^v)/g^v d\theta^L$$

where $d\theta^v = \Sigma s_i\, d\theta_i$. The last term in this formula is a familiar terms of trade effect of growth. A productivity gain leads to real depreciation since the expansion of domestic income does not create sufficient demand for increased output. Markets abroad can accommodate a larger quantity only when the relative price of domestic products falls, unless elasticity of demand is infinite. I name this effect of the productivity gain on the real exchange rate as the **elasticity effect.**

4.07 The first term represents the effect of the sectoral bias from productivity and competitiveness changes on the real exchange rate. If there exists a correlation between g_i and $d\theta_i$ - dP_{if}/P_{if}, the equilibrium real exchange rate changes. I name this the **correlation effect.**

4.08 Next I briefly consider the case where there is free entry and where any productivity gain improves the opportunities for cost reduction and for product development equally. The budget constraint now becomes simplified into

$$(36)\quad dw/w = \Sigma s_i(g_i/g^v)(d\theta_i + dP_{if})$$

where $g_i = (k_i - k_i t_i)/t_i$ and $g^v = \Sigma s_i g_i$, if we assume that foreign expenditure changes homogeneously with foreign prices so that $dE_f/E_f = \Sigma s_i(1-1/t_i)$
$dP_{fi}/P_{fi}/\Sigma s_i(1-1/t_i)$. dE/E has disappeared from equation (34) since $e_i/t_i = W_i/s_i$.

4.09 Consequently, the real exchange rate index can be given by

$$(37)\quad dP_f/P_f - dP_v/P_v = dP_f/P_f - (dw/w - d\theta)$$
$$= -\Sigma s_i(g_i/g)\{(d\theta_i - d\theta) + (dP_{if}/P_{if} - dP_f/P_f)\}$$

The elasticity effect has disappeared, since uniform productivity growth does not cause the expansion of the output of each firm but leads instead to increased variety of products. Consequently, a productivity gain does not depress prices if it improves opportunities for product development and for cost reduction equally, as we saw in Section IV A.

4.10 The correlation effect remains. The major difference for the correlation effect is that the real exchange rate effect of the sectoral bias of the productivity change generally becomes larger in a free entry situation, since the supply response to a productivity change becomes amplified.

C. Applications of the General Formula

Assuming that the elasticity effect is negligible, we can derive the following four *ceteris-paribus* propositions from equations (35) and (37):

Proposition 1: Real exchange rate appreciates when a positive correlation exists between price elasticity of demand and productivity gain.

Proposition 2: Real exchange rate depreciates when a positive correlation exists between the share of domestic industry in world industry and productivity gain.

Proposition 3: Real exchange rate depreciates when a negative correlation exists between price elasticity of demand and the change in foreign prices (i.e., foreign prices fall more in high-elasticity sectors).

Proposition 4: Real exchange rate appreciates when a negative correlation exists between the share of domestic industry in world industry and the change in foreign prices (i.e., domestic prices fall more in those sectors where shares of foreign enterprises are high).

4.11 The first proposition is intuitively clear. When the productivity gain is concentrated in sectors that are highly price elastic, output from these sectors expands disproportionately. Thus trade does not balance unless real wages go up more than average industrial productivity growth. Since high price elasticity in turn is conducive to productivity gains (cost reduction), as demonstrated in Section II, and developing countries with high technical capability are likely to have more room for productivity gain, it is not surprising if these countries experience real appreciation over time, even in terms of tradable prices.

4.12 The second proposition is also straightforward. For a domestic industry with a large share in the world industry, the productivity gains of each enterprise offset each other so that the market expansion effect of the productivity gain is diluted. If the productivity gain is biased toward such industries, real wages go up less than the industry's average productivity growth. Real depreciation takes place. This proposition is a close parallel to the well-known proposition in a perfect competition model that technical progress biased toward export sectors causes terms of trade loss.

4.13 The third and fourth propositions also should be clear. Combining the first and third propositions, we can say that the real exchange rate must depreciate if the home country loses more of its competitiveness ($d\theta_i$ - dP_{if}/P_{if}) in highly price elastic sectors. Similarly, combining the second and fourth propositions, we can say that the real exchange rate has to depreciate if the home country gains its competitiveness mostly in those sectors where the shares of the domestic industries in the world market are high.

4.14 The celebrated Balassa-Samuelson (1964) effect can be interpreted in this framework as a special case of proposition 2. As Table 1 suggests, if the nontradable sector ($t_i = 1$) experiences slower technical progress than the tradable sector ($t_i < 1$), the real exchange rate must appreciate. This is because since a positive correlation exists between $d\theta_i$ and g_i unless the elasticity effect dominates the correlation effect. As an illustration, let us assume that $s_T = 0.4$, $e_T = t_T = 0.1$, $d\theta = 3\%$, and $k = 10$.[9/] Then there is a correlation effect or the Balassa-Samuelson effect, amounting to 2.81% and an elasticity effect amounting to -0.3%. Consequently, the economy experiences net real appreciation amounting to 2.5%.

4.15 Next I illustrate the effect of the sectoral bias in productivity change on real exchange rates. Let us assume that the tradable sector can be further divided into a high elasticity sector and a low-elasticity sector with equal weights as described in Table 2. The exchange rate appreciates more than the Balassa-Samuelson effect predicts. Assuming the same parameter values, we get a correlation effect amounting to 3.6% and an elasticity effect amounting to -0.3%. Consequently, the real exchange rate appreciates 3.3%. The difference from the case above (i.e., 0.8% = 3.3% - 2.5%) can be regarded as a real exchange rate effect of the sectoral bias in productivity change.

9/ In the following illustrations I assume $S_i \simeq S_{Li}$. This approximation is good when k_i is large or k_i is uniform across sectors.

V. CONCLUDING COMMENTS

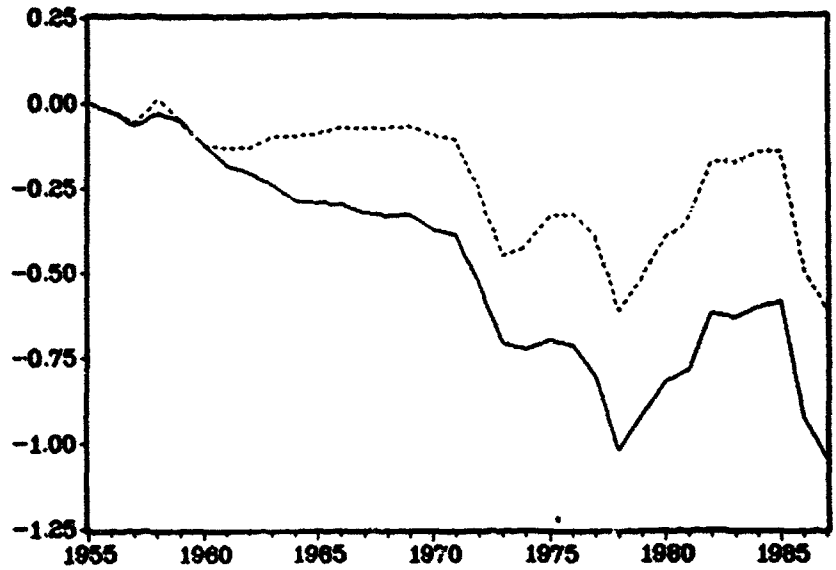
5.01 This paper has demonstrated how biases in productivity changes--either between cost reduction and product development or between sectors with different price elasticities of demand and world market shares--can cause the change in the equilibrium real exchange rate. It has also demonstrated how cost reduction's bias in favor of highly price-elastic sectors may naturally arise.

5.02 Whether the theoretical possibilities elaborated in this paper can contribute to explaining the puzzle referred to in the introduction is an empirical issue. The positive correlation between cost reduction and price elasticity of demand would seem to allow empirical testing relatively easily.

5.03 The analysis clearly suggests the importance of real exchange rate flexibility in order to accommodate the biases of productivity changes without causing macro imbalances. It is too early for us to derive industrial policy implications since empirical testing is still to be done and this paper has not conducted a welfare analysis. Although one may think that some targeted support to technical progress, especially in product development, is welfare improving, such a conclusion is not guaranteed. One practical next step would be to conduct a disaggregated analysis of industrial performance with a special focus on product development capability in evaluating the competitiveness position of external trade.

(A) GDP DEFLATOR vs. MANUFACTURING VALUE ADDED DEFLATOR

(—— RPVD) (..... RPVM)



(B) GDP DEFLATOR vs. RELATIVE UNIT LABOR COST

(—— RPVD) OF THE MANUFACTURING SECTOR

..... RULCT)

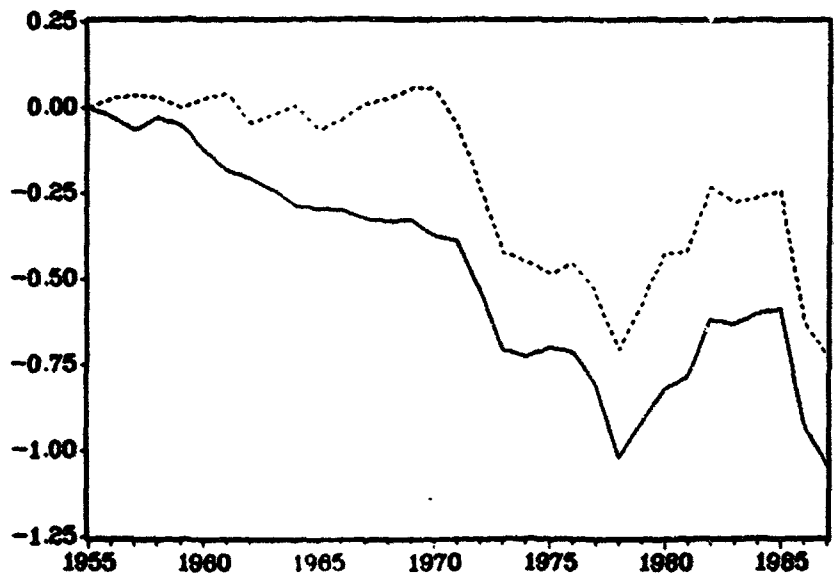
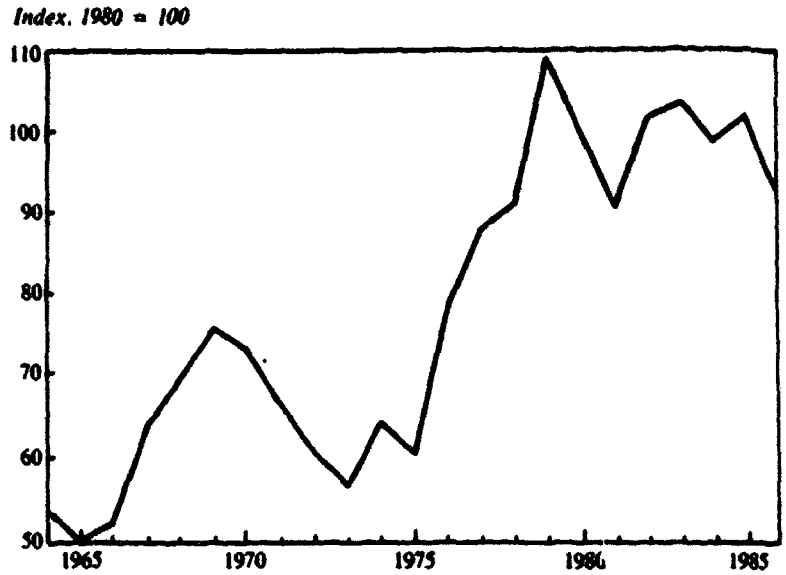


Figure 1: REAL APPRECIATION OF JAPANESE YEN



Source: U.S. Department of Labor, Bureau of Labor Statistics.
a. Korean manufacturing unit labor costs in dollars relative to an average of U.S. and Japanese unit labor costs.

Figure 2: REAL APPRECIATION (Korea Wong)

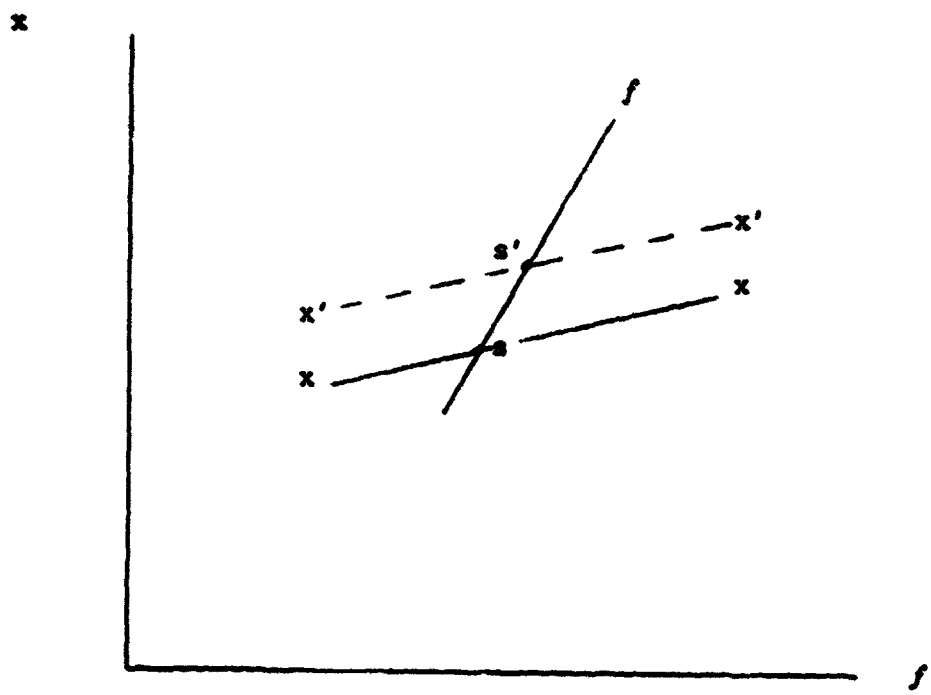


Figure 3: EFFECT OF PRICE ELASTICITY OF DEMAND ON COST REDUCTION

Table 1: BALASSA - SAMUELSON EFFECT ON REAL EXCHANGE RATE

	Tradable Sector ($t_i = 0.1$)	Non-tradable Sector ($t_i = 1$)	Average
$s_i \simeq s_{Li}$ a/	s_T	$1 - s_T$	--
$d\theta_i$	$d\theta$	0	s_T b/ $d\theta$
e_i	e_T	1	$e = s_T e_T + (1 - s_T)$
g_i c/	$k+t-kt-e$ b/	$1-e$	$g = S_T(k+t-kt-1)+(1-e)$
$S_i g_i$	$S_T(k+t-kt-e)$	$(1-S_T)(1-e)$	--

Correlation Effect: $[s_T\ (k+t-kt-e)/g]d\theta > 0$

Elasticity Effect: $-\ [(1-e_T)s_T/g]d\theta < 0$

a/ Approximation is good when k_i is large or uniform across sectors
b/ s_T is the share of tradable sector.
c/ g_i as defined for equation (34). $t = t_i$

Table 2: CORRELATION AND ELASTICITY EFFECTS ON REAL EXCHANGE RATE

	Tradable Sector		Non-tradable Sector	Average
	High Elasticity Sector ($t_i = 0.1$)	Low Elasticity Sector ($t_i = 0.1$)	($t_i = 1$)	
$s_i \simeq s_{Li}$	$1/2\ s_T$	$1/2\ s_T$	$1 - s_T$	-
$d\theta_i$	$3/2\ d\theta$	$1/2\ d\theta$	0	$s_T\ d\theta$
e_i	e_T	e_T	1	$e = s_T e_T + (1 - s_T)$
g_i	$3/2k+t-3/2\ kt-e$	$1/2k+t-1/2kt-e$	$1-e$	$g = s_T(k+t-kt-1)+1-e$

Correlation: Effect $[s_T(5/4k+t-5/4kt-e)/g]d\theta > 0$

Elasticity: Effect $-\ [(1-e_T)s_T/g]d\theta < 0$

REFERENCES

Balassa, B. (1964) "The Purchasing-power Parity Doctrine: A Reappraisal," Journal of Political Economy, 72 (December), 584-96.

Dornbusch, R. and Park Y.C. (1987), "Korean Growth Policy," Brooking Papers on Economic Activity, 2nd volume.

Helpman, E. and Krugman, P.R. (1985), Market Structure and Foreign Trade, MIT Press.

_____ (1989), Trade Policy and Market Structure, MIT Press.

Krugman, P. (1989), "Differences in Income Elasticities, and Trends in Real Exchange Rates," European Economic Review, 33, 1031-1054.

Krugman, P. and Baldwin (1987), "The Persistence of the U.S. Trade Deficit," Brooking Papers on Economic Activities, No. 1.

_____ (1979), "A Model of Innovation, Technology Transfer, and the World Distribution of Income," Journal of Political Economy, Vol, 87, 253-266.

Samuelson, P.A. (1964) "Theoretical Notes on Trade Problems," Review of Economics and Statistics, 46 (May), 145-54.

INDUSTRY SERIES PAPERS

No. 1 Japanese Direct Foreign Investment: Patterns and Implications for Developing Countries, February 1989.

No. 2 Emerging Patterns of International Competition in Selected Industrial Product Groups, February 1989.

No. 3 Changing Firm Boundaries: Analysis of Technology-Sharing Alliances, February 1989.

No. 4 Technological Advance and Organizational Innovation in the Engineering Industry, March 1989.

No. 5 Export Catalyst in Low-Income Countries, November 1989.

No. 6 Overview of Japanese Industrial Technology Development, March 1989.

No. 7 Reform of Ownership and Control Mechanisms in Hungary and China, April 1989.

No. 8 The Computer Industry in Industrialized Economies: Lessons for the Newly Industrializing, February 1989.

No. 9 Institutions and Dynamic Comparative Advantage Electronics Industry in South Korea and Taiwan, June 1989

No. 10 New Environments for Intellectual Property, June 1989.

No. 11 Managing Entry Into International Markets: Lessons From the East Asian Experience, June 1989.

No. 12 Impact of Technological Change on Industrial Prospects for the LDCs, June 1989.

No. 13 The Protection of Intellectual Property Rights and Industrial Technology Development in Brazil, September 1989.

No. 14 Regional Integration and Economic Development, November 1989.

No. 15 Specialization, Technical Change and Competitiveness in the Brazilian Electronics Industry, November 1989.

INDUSTRY SERIES PAPERS *cont'd*

No. 16	Small Trading Companies and a Successful Export Response: Lessons From Hong Kong, December 1989.
No. 17	Flowers: Global Subsector Study, December 1989.
No. 18	The Shrimp Industry: Global Subsector Study, December 1989.
No. 19	Garments: Global Subsector Study, December 1989.
No. 20	World Bank Lending for Small and Medium Enterprises: Fifteen Years of Experience, December 1989.
No. 21	Reputation in Manufactured Goods Trade, December 1989.
No. 22	Foreign Direct Investment From the Newly Industrialized Economies, December 1989.
No. 23	Buyer-Seller Links for Export Development, March 1990.
No. 24	Technology Strategy & Policy for Industrial Competitiveness: A Case Study of Thailand, February 1990.
No. 25	Investment, Productivity and Comparative Advantage, April 1990.
No. 26	Cost Reduction, Product Development and the Real Exchange Rate, April 1990.
No. 27	Overcoming Policy Endogeneity: Strategic Role for Domestic Competition in Industrial Policy Reform, April 1990.
No. 28	Conditionality in Adjustment Lending FY80-89: The ALCID Database, May 1990.
No. 29	International Competitiveness: Determinants and Indicators, March 1990.
No. 30	FY89 Sector Review Industry, Trade and Finance, November 1989.

Note: For extra copies of these papers please contact Miss Wendy Young on extension 33618, Room S-4101

ENERGY SERIES PAPERS

No. 1 Energy Issues in the Developing World, February 1988.

No. 2 Review of World Bank Lending for Electric Power, March 1988.

No. 3 Some Considerations in Collecting Data on Household Energy Consumption, March 1988.

No. 4 Improving Power System Efficiency in the Developing Countries through Performance Contracting, May 1988.

No. 5 Impact of Lower Oil Prices on Renewable Energy Technologies, May 1988.

No. 6 A Comparison of Lamps for Domestic Lighting in Developing Countries, June 1988.

No. 7 Recent World Bank Activities in Energy (Revised October 1989).

No. 8 A Visual Overview of the World Oil Markets, July 1988.

No. 9 Current International Gas Trades and Prices, November 1988.

No. 10 Promoting Investment for Natural Gas Exploration and Production in Developing Countries, January 1988.

No. 11 Technology Survey Report on Electric Power Systems, February 1989.

No. 12 Recent Developments in the U.S. Power Sector and Their Relevance for the Developing Countries, February 1989.

No. 13 Domestic Energy Pricing Policies, April 1989.

No. 14 Financing of the Energy Sector in Developing Countries, April 1989.

No. 15 The Future Role of Hydropower in Developing Countries, April 1989.

No. 16 Fuelwood Stumpage: Considerations for Developing Country Energy Planning, June 1989.

No. 17 Incorporating Risk and Uncertainty in Power System Planning, June 1989.

No. 18 Review and Evaluation of Historic Electricity Forecasting Experience, (1960-1985), June 1989.

ENERGY SERIES PAPERS cont'd

No. 19 Woodfuel Supply and Environmental Management, July 1989.

No. 20 The Malawi Charcoal Project - Experience and Lessons, January 1990.

No. 21 Capital Expenditures for Electric Power in the Developing Countries in the 1990s, February, 1990.

No. 22 A Review of Regulation of the Power Sectors in Developing Countries, February 1990.

No. 23 Summary Data Sheets of 1987 Power and Commercial Energy Statistics for 100 Developing Countries, March 1990.

No. 24 A Review of the Treatment of Environmental Aspects of Bank Energy Projects, March 1990.

No. 25 The Status of Liquified Natural Gas Worldwide, March 1990.

No. 26 Population Growth, Wood Fuels, and Resource Problems in Sub-Saharan Africa, March 1990.

No. 27 The Status of Nuclear Power Technology - An Update, April 1990.

No. 28 Decommissioning of Nuclear Power Facilities, April 1990.

Note: For extra copies of these papers please call Ms. Mary Fernandez on extension 33637.