Hitotsubashi Journal of Commerce and Management 26 (1991) pp. 15–28. © The Hitotsubashi Academy

IMPORT PRICING UNDER VOLATILITY AND MISALIGNMENTS OF EXCHANGE RATES*

EIJI OGAWA

I. *Introduction*

Exchange rates have shown two distinctive movements under the present floating exchange rate system. One is that the exchange rates are random-walking day by day or week by week. The random fluctuations make it very difficult to forecast the exchange rates even in the nearest future such as tomorrow. The random fluctuations of exchange rates are called volatility.

The other distinctive movement is the longer-run changes in the exchange rates. It often means that the exchange rates deviate from fundamental levels in the longer-run. Such a longer-run deviation from the fundamental levels is called misalignments. A typical misalignment of exchange rates is the overvaluation of the US dollar in the first half of 1980s.

The exchange rates that are misaligned and volatile determine relative prices of traded goods and thus the trade balances. We suspect that the misaligned and volatile exchange rates will affect both the trade prices and the trade balances in a wrong way.[1] This paper considers how the misaligned and volatile exchange rates affect the trade prices and the trade balances. Here we focus on their effects on the import side of trade, but it is esay to analogize their effects on the export side by replacing a home country with a foreign country.

Moreover, this paper focuses on a supply side of import markets to consider the pass-through effect of the exchange rates on the import prices.[2] Especially, we analyze foreign firms' import pricing with their sunk costs of entering our domestic market. The sunk costs will decrease their incentives to enter the market and to exit out of the market. On one hand, the sunk costs will induce the firms to take a pricing to the market[3] rather than to reflect the exchange rate changes in the import prices.

---

* I thank Mr. Law Hin Pong Joe for editing the English. This paper is a part of the research supported by a Grant-in-Aid for Scientific Research from the Ministry of Education, No. 03853011.

[1] Baldwin and Krugman (1986) and Krugman and Baldwin (1987) emphasized persistent effects of these changes in the exchange rates on trade balances. They attributed the persistent U.S. trade deficits to the problem.

[2] The pass-through effects of the exchange rate on the prices are analyzed from both the supply and demand sides of the markets (Krugman (1987)). See Froot and Klemperer (1989), Dohner (1984), Ogawa (1987) for the demand side.

[3] The pass-throughs of the exchange rate and the pricing to market should be distinguished. The pricing to market will lead to an imperfect pass-through effect. However, other factors such as imported raw materials will lead to the imperfect pass-through effect. See Marston (1990) for distinguishing them.

In the next chapter, we consider how the sunk costs of entering the market affect the import pricing. In chapter 3, we introduce volatility of the exchange rates into the import pricing with the sunk costs. And we consider how the volatility affects the foreign firms' pricing. In chapter 4, we consider how the import prices are set by the foreign firms when the exchange rates are misaligned and then are realigned. In chapter 5, we summarize and conclude our analysis.

II. *Import Pricing with Sunk Costs of Entering the Market*

(1) Sunk Costs of Entering the Market

When foreign firms enter our domestic market, they may have to form visible or invisible capitals for entering the market and operating in it at the first stage. For example, new foreign firms need to advertise or to set up a distribution network at the first stage when they enter the domestic market and sell their commodities in the market. After they have exited out of the market, they can't use such capitals in another country's market. Therefore, the costs which they have paid in entering the market should be sunk. The costs can't be recovered in exiting out of the market.

Given the sunk costs of entering the domestic market, it is not easy for the firms to enter the market and to exit out of the market repeatedly. They must decide to enter the market by taking the sunk costs into account. And they must decide to exit out of the market by taking the sunk costs into account once they have entered the market. Changes in the exchange rate would change the foreign firms' profits in terms of their own foreign currency. However, small and short-run changes in the exchange rate might not change their profits enough to cover the sunk costs. In this case they would not enter the market nor the existing firms would exit out of the market even if the exchange rate changes.

Baldwin (1988, 1990) and Dixit (1989) focused on the sunk costs of entering the market to analyze the pass-through effect of the exchange rate. According to them, we examine their pricing in the case when the sunk costs of entering the market exist.

We suppose the case of foreign firms exporting their commodities to our domestic market. The foreign firms produce their commodities in their own country subject to a cost function $C(\cdot)$. And they face a demand function $f(\cdot)$ in the domestic market.

The firms are assumed to have an infinite horizon and to maximize a discounted present value of profits from their exports over time. We should notice that the firms are operating with taking the sunk costs of entering the market into account. The net return in terms of the foreign currency which firm j in industry i gets from producing and exporting its own commodities in our domestic market at time t is π_{ijt}:

$$(1) \qquad \pi_{ijt}=\left(\frac{P_{it}}{E_t}-C'_{ij}\right)f\left(\frac{P_{it}}{P_t}\right)$$

where E: an exchange rate of a foreign currency in terms of the home currency, P_i: a price of the foreign commodity in terms of the home currency, P: a domestic price index, C': the marginal costs of production in terms of the foreign currency. For simplicity, we as-

sume that the domestic price index is constant and normalized at a unity and that the marginal costs are constant.

The foreign firms must make initial investments K_0 for setting up their exporting when they enter the market. Thus, they must pay the sunk cost K_0. Suppose that the fixed capital for entering the market depreciate at a rate of δ every period and that the firms need maintenance activities to keep the initial capital K_0. They must pay maintenance costs δK_0 every period. On the other hand, we assume that the firms need to pay no costs when they exit out of the market. Both the entry costs and the maintenance costs are termed in the foreign currency, and thus they are independent from the exchange rate.

When the potential foreign firms enter the market, the discounted present value of profits from their exports V_0^I is

$$V_0^I=\int_0^\infty\left\{\left(\frac{P_{it}}{E_t}-C'_{ij}\right)f(P_{it})-\delta K_0\right\}e^{-rt}dt-K_0 \tag{2a}$$

And when the existing firms stay in the market, the discounted present value of profits from their exports V_I^I is

$$V_I^I=\int_0^\infty\left\{\left(\frac{P_{it}}{E_t}-C'_{ij}\right)f(P_{it})-\delta K_0\right\}e^{-rt}dt \tag{2b}$$

On one hand, when the potential firms do not enter the market and when the existing firms exit out of the market, both the discounted present values of profits from their exports are equal to zero.

$$V_0^O=V_I^O=0 \tag{2c}$$

Whether the potential foreign firms enter the market or not is decided by comparing the present value of profits in the case of entering the market V_0^I and the present value of profits in the case of staying outside the market V_0^O. If $V_0^I>V_0^O$, the potential firms enter the market, while they stay outside the market if $V_0^I<V_0^O$. Whether the existing firms exit out of the market or not is decided by comparing the present value of profits in the case of staying in the market V_I^I and the present value of profits on the case of exiting out of the market V_I^O. If $V_I^I<V_I^O$, they stay in the market while they exit out of the market if $V_I^I<V_I^O$.

Thus, critical conditions for entering the market and for exiting out of the market are following:

$$\left(\frac{P_{it}}{E_t}-C'_{ij}\right)f(P_{it})-(\delta+r)K_0=0 \tag{3a}$$

$$\left(\frac{P_{it}}{E_t}-C'_{ij}\right)f(P_{it})-\delta K_0=0 \tag{3b}$$

We can derive a critical entry price $P^I{}_{it}$ and a critical exit price $P^O{}_{it}$ from eqs. (3).

$$P^I{}_{it}=E_t\{C'_{ij}+(\delta+r)k_0\} \tag{4a}$$

(4b) $$P^{o}_{it}=E_t\{C'_{ij}+\delta k_0\}$$

where $k_0(=K_0/f(\cdot))$: the sunk costs per commodity.

Some potential foreign firms enter the domestic market when an actual market price is higher than the critical entry price. On one hand, some existing firms exit out of the market when an actual price is lower than the critical exit price. And there exists a gap of rk_0E_t between the critical entry price and the critical exit price. No firms enter the market nor exit of the market in a price band between both the critical prices. Thus, the number of foreign firms exporting their commodities into the domestic market is unchanged independently from the exchange rate in the price band. On the other hand, if changes in the exchange rate make their prices go beyond the price band, some foreign firms will enter the market or exit out of the market. Thus, the number of foreign firms in the market is changed.

(2) Pass-through Effects of the Exchange Rate with the Sunk Costs

Given the price band where the number of foreign firms in the domestic market is unchanged, we find that there are discontinuities in a supply function of the whole market or a competitive condition in the market. Moreover, they bring the discontinuities into pass-through effects of the exchange rate.

We consider a supply function of the whole market. Suppose that n foreign firms are exporting to the market. If we represent a profit function of firm j in industry i by $\pi(P_i/E;\ C'_{ij})$, the supply function of the firm is represented by $\pi'(P_i/E;\ C'_{ij})$. Here we assume that each firm's supply elasticity is constant and is equal to $\eta(=P_i\pi''/E\pi')$ and that the demand elasticity in the market is constant and is equal to $\varepsilon(=-f'P_i/f)$.

An equilibrium condition in the market is following:

(5) $$f(P_i)=\sum_{j=1}^{n}\pi'\left(\frac{P_i}{E};\ C'_{ij}\right)$$

Now, we derive a pass-through coefficient, that is an elasticity of the import price with regard to the exchange rate, in the price band of constant number of foreign firms. We totally differentiate eq. (5) with the number of foreign firms constant. Then, we can obtain the following:

(6) $$-\varepsilon f\frac{dP_i}{P_i}=\eta\sum_{j=1}^{n}\pi'\left(\frac{dP_i}{P_i}-\frac{dE}{E}\right)$$

Substituting eq. (5) into eq. (6), the pass-through coefficient β^{U} in the price band of constant number of foreign firms is derived:

(7) $$\beta^{U}=\left(\frac{dP_i}{P_i}\right)\Big/\left(\frac{dE}{E}\right)=\frac{\eta}{\varepsilon+\eta}$$

Outside the price band, some potential firms enter the market or some existing firms exit out of the market in response to the changes in the returns in terms of the foreign currency P_i/E which are caused by the changes in the exchange rate. Given the market price

in terms of the home currency P_t, the number of foreign firms in the market increases through the potential firms' entry when the home currency appreciates. On the other hand, the number decreases through the existing firms' exit when the home currency depreciates. Such a relation between the number of foreign firms in the market and the returns in terms of the foreign currency is represented as follows:

$$(8) \qquad n=n\left(\frac{P_t}{E}\right);\ n'>0$$

where the elasticity of the number of foreign firms with regard to the return in terms of the home currency $\varphi(=P_t n'/En)$ is larger than 0.

For simplicity, we assume that either marginal firms entering the market or marginal firms exiting out of the market are homogeneous. We totally differentiate eq. (5) taking account of changing the number of foreign firms in the market. Then we can obtain the following:

$$(9) \qquad -\varepsilon f\frac{dP_t}{P_t}=\eta\sum_{j=1}^{n}\pi'\left(\frac{dP_t}{P_t}-\frac{dE}{E}\right)+\varphi\pi'\left(\frac{dP_t}{P_t}-\frac{dE}{E}\right)$$

When some firms enter the market or exit out of the market, a pass-through coefficient β^a is:

$$(10) \qquad \beta^a\equiv\left(\frac{dP_t}{P_t}\right)\Big/\left(\frac{dE}{E}\right)\equiv\frac{\eta+\varphi}{\varepsilon+\eta+\varphi}$$

From eqs. (8) and (10), the pass-through coefficient in the case of changing number of foreign firms is larger than that in the case of constant number of foreign firms. For example, suppose that the home currency appreciates not enough for any potential firms to enter the market. As the appreciation increases the returns in terms of the foreign currency, the existing firms lower the price in terms of the home currency to increase their supplies. However, the pass-through coefficient in that case is less than a unity because the lower price increases the demand for the commodity.

If the supplies from the existing firms were completely inelastic ($\eta=0$), they could not lower the price in response to the appreciation to increase their supplies. Therefore, the price would be unchanged and we could find no pass-through effect in this case.

Suppose that the home currency appreciates further beyond the price band of constant number of foreign firms. Then, some potential firms enter the market. As a result, supplies in the whole market become more elastic. The increase in the firms increases the supplies more than the increase in supplies by the existing firms. Thus, the price is lower than that in the case of constant number of foreign firms.

(3) Illustrative Explanation

Next, we explain the effect of the sunk costs on the pass-through of the exchange rate using a figure.

We suppose that a demand function in the domestic market has a constant price elasticity. We specify the demand function as follows:

$$\log P=a-\left(\frac{1}{\varepsilon}\right)\log Q \tag{11}$$

where Q: an import volume of the relevant commodity.

From (11), we derive a marginal revenue:

$$\log P=\log\left\{1-\left(\frac{1}{\varepsilon}\right)\right\}+a-\left(\frac{1}{\varepsilon}\right)\log Q \tag{12}$$

The first term in eq. (12) is negative with $\varepsilon>1$.

As for a supply function of the whole market, we apply the results of the above analysis. We assume that the price elasticity of supply is a constant η in the price band of constant number of foreign firms and that the price elasticity of supply is a constant $\eta+\varphi$ outside the price band. Thus, we specify the supply function in the price band as follows:

$$\log P=b_0+\left(\frac{1}{\eta}\right)\log Q+\log E \tag{13a}$$

On the other hand, we specify the supply function outside the price band as follows:

$$\log P=b_1+\left(\frac{1}{\eta+\varphi}\right)\log Q+\log E \tag{13b}$$

In Fig. 1, we depict a demand line D, the corresponding marginal revenue line MR, and a supply line S in the plane with logarithms of an import price and an import volume. We should notice that a size of their changes represents a rate of changes in the relevant variables by using logarithms as a measure in the figure.

The demand line is a line with a slope of $-1/\varepsilon$. The marginal revenue line is related with the demand line because the marginal revenue is derived from the demand function. The marginal revenue line is a line which has the same slope with the demand line. On the

FIG. 1

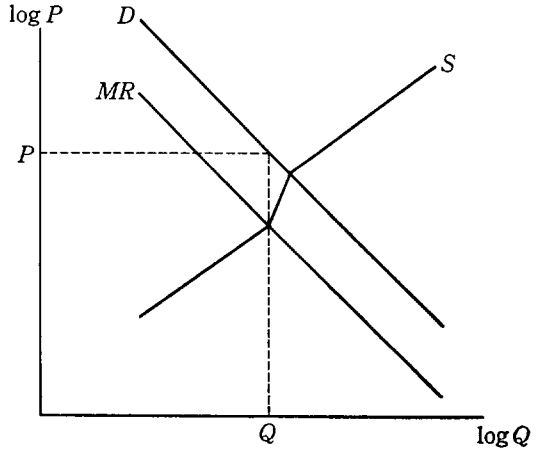
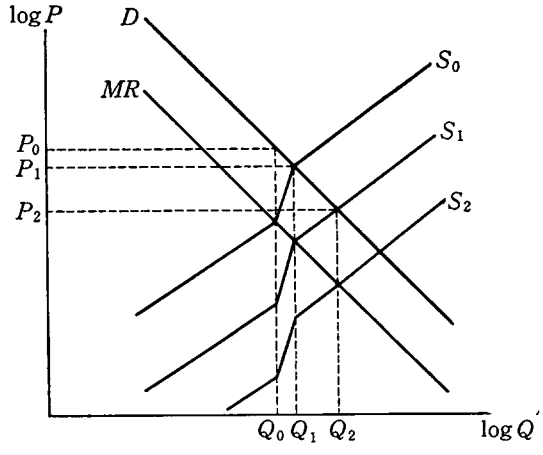


FIG. 2



other hand, the supply line is a line which has a slope of $1/\eta$ in the price band of constant number of foreign firms and a slope of $1/(\eta+\varphi)$ outside the price band.

We use Fig. 2 to compare a pass-through effect of an exchange rate changes on the import price in the price band with the pass-through effect outside the price band. Suppose that the home currency appreciates from E_0 to E_1 ($E_0>E_1$). We assume that the appreciation changes the import price to a critical entry level where no potential foreign firms can enter the market yet. So such appreciation makes no potential foreign firms to enter the market. However, as supplies by the existing firms are elastic, they increase their supplies and lower the import price from P_0 to P_1.

Suppose that the home currency appreciates further from E_1 to E_2 by the same rate of appreciation with the former appreciation ($\log E_1-\log E_2=\log E_0-\log E_1$). As the further appreciation makes a return in terms of the foreign currency go beyond a critical entry level, it induces some potential foreign firms to enter the market. Then, they must pay the sunk costs to enter the market. The elasticity of supply increases as more potential firms enter the market. As a result, they lower the import price from P_1 to P_2. The change in the import price is larger than the former change with no entry ($\log P_1-\log P_2>\log P_0-\log P_1$).

Thus, if the exchange rate goes beyond the critical entry level, the pass-through effect is larger than that in the price band. Depreciations of the home currency have similar effects on the pass-through in the price band and outside it.

III. *Import Pricing under Volatility of the Exchange Rate*

(1) Exchange Rate Volatility and Firms' Behavior

Next, we introduce volatility of exchange rate into the sunk cost model according to Dixit (1989a, b) and Krugman (1989). They analyzed the effects of the exchange rate vol-

atility on the firms' behavior by applying the option pricing theory. The basic idea is that firms tend to take a cautious attitude in entering the market or in exiting out of the market when the exchange rate is volatile.

Because increased volatility of the exchange rate implies that uncertainty of future exchange rates increases, the firms are more likely to regard changes in the exchange rate as temporal. And the firms have an incentive to take a cautious attitude to respond immediately to the exchange rate changes in the situation where they must pay sunk costs in entering the market. Potential foreign firms wait to enter the market till the exchange rate changes to more profitable level than that under certainty. On one hand, the existing firms stay in the market till the exchange rate changes to less profitable level than that under certainty. They decide to enter the market or not and to exit out of the market or not on the basis of the exchange rate adjusted by a kind of risk premium.

So the uncertainty leads higher critical entry price and lower critical exit price than those under certainty. According to Dixit (1989a, b), we suppose that a logarithm of the exchange rate is random-walking. That is, the exchange rate follows a Brownian motion:

$$\frac{dE_t}{E_t}=\mu dt+\sigma dz \tag{14}$$

where dz is an increment of the standard Wiener process, uncorrelated across time, and at any one instant satisfying that an expectation of dz is equal to zero and an expectation of dz^2 is equal to dt. With the initial price $E_0=E$, $\log E_t$ is normally distributed with mean $\log E_0+(\mu-1/2\ \sigma^2)t$ and variance $\sigma^2 t$.

Let $U_O(E)$ be the expected net present value of starting with the exchange rate E in staying outside the market and $U_I(E)$ be the expected net present value of starting with the exchange rate E in staying in the market. Over the range of the exchange rate where it is optimal for the firm staying outside it to continue staying outside it, the asset of the investment opportunity must be willingly held. Then the only return to this asset is the expected capital gain, $(dU_O(E)/dt)^e$. This must be equal to the normal return $rU_O(E)$.

From Ito's lemma, that is $dU_O=U_O'(E)dE+1/2U_O'(E)\ \sigma^2E_t^2dt$, the expected capital gain of the asset is:

$$dU_O^e=\left\{U_O'(E)\mu E_t+\frac{1}{2}U_O''(E)\sigma^2E_t^2\right\}dt \tag{15}$$

The asset equilibrium condition is:

$$\frac{1}{2}\sigma^2E_t^2U_O''(E)+\mu E_tU_O'(E)-rU_O(E)=0 \tag{16}$$

The return on the asset of staying in the market consists of the flow of operating profit as well as the expected capital gain. Therefore, the value of the asset $U_I(E)$ must satisfy the following:

$$\frac{1}{2}\sigma^2E_t^2U_I''(E)+\mu E_tU_I'(E)-rU_I(E)+\frac{P_{it}}{E_t}-C_{tj}'=0 \tag{17}$$

From eqs. (16) and (17), we obtain the following:

(18a) $$U_O(E)=BE_t^{\beta}$$

(18b) $$U_I(E)=AE_t^{-\alpha}+\frac{1}{r-\mu}\frac{P_{it}}{E_t}-\frac{C''}{r}$$

where

$$\beta=\frac{(1-a)+\sqrt{(1-a)^2+4b}}{2}$$

$$-\alpha=\frac{(1-a)-\sqrt{(1-a)^2+4b}}{2}$$

$$a=2\mu/\sigma^2$$

$$b=2r/\sigma^2$$

The firm pays the sunk cost of entering the market to exercise the option and gets an asset of value $U_I(E)$. Therefore, the critical entry exchange rate E_I must satisfies the value-matching and smooth pasting conditions:

(19a) $$U_O(E_I)=U_I(E_I)-\left[k_0+\frac{\delta k_0}{r}\right]$$

(19b) $$U_O'(E_I)=U_I'(E_I)$$

Similarly, the critical exit exchange rate E_O satisfies the value-matching and smooth pasting conditions:

(20a) $$U_I(E_O)-\frac{\delta k_0}{r}=U_O(E_O)$$

(20b) $$U_I'(E_O)=U_O'(E_O)$$

Here we define

(21) $$X(E)=U_I(E)-U_O(E)$$

From eqs. (18) we obtain

(22) $$X(E)=AE^{-\alpha}-BE^{\beta}+\frac{1}{r-\mu}\frac{P_{it}}{E_t}-\frac{C'_{tj}}{r}$$

The value-matching and smooth pasting conditions can be written in terms of X as

(23) $$X(E_I)=k_0+\frac{\delta k_0}{r},\ X(E_O)=\frac{\delta k_0}{r},\ X'(E_O)=X'(E_I)=0,\ X''(E_I)<0, X''(E_O)>0$$

Subtracting eqs. (16) from eq. (17), we obtain the following equation:

$$\frac{1}{2}\sigma^2 E_t^2 X''(E)+\mu E_t X'(E)-rX(E)=C'_{ij}-\frac{P_{it}}{E_t} \tag{24}$$

(2) Effects of the Exchange Rate Volatility on the Pass-through

Using (23), we evaluate this equation at E_I and E_O to obtain the critical entry price and the critical exit price:

$$P^I{}_{it}=E_t\left\{C'_{ij}+(\delta+r)k_0-\frac{1}{2}\sigma^2 E_t^2 X''\right\} \tag{25a}$$

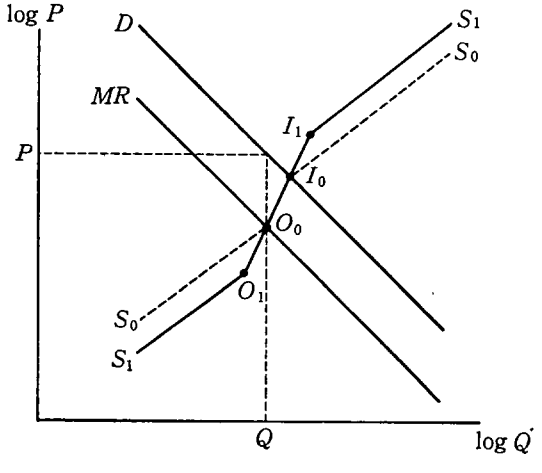
$$P^O{}_{it}=E_t\left\{C'_{ij}+\delta k_0-\frac{1}{2}\sigma^2 E_t^2 X''\right\} \tag{25b}$$

We find the effects of the exchange rate volatility on the critical entry price and the critical exit price by comparing eq. (25) with eq. (4). From (23), X'' in eq. (25a) is less than zero and X'' in eq. (25b) is larger than zero. Therefore, the critical entry price under the volatile exchange rate is higher than that under stable exchange rate. On the other hand, the critical exit price under the volatile exchange rate is lower than that under the stable exchange rate.

Thus, the volatility of the exchange rate makes the price band of constant number of foreign firms wider. The pass-through effects of the exchange rate on the import prices are smaller in the price band than those outside the price band. Therefore, the volatility makes the band of smaller pass-through effects wider.

The effect of the exchange rate volatility on the pass-through of the exchange rate is depicted in Fig. 3. The volatility changes the price band of constant number of foreign firm and thus the shape of supply line as we saw above. A supply function in the whole market

Fig. 3



under certainty is represented by a broken line S_0S_0. When the exchange rate is volatile, the supply line is represented by a solid line S_1S_1.

It is obvious that the exchange rate volatility widens the price band in which the pass-through effect is smaller. When there is no volatility in the movements of exchange rate the pass-through effect is smaller as long as an intersection between the marginal revenue line and the supply line is located between points O_0 and I_0. The pass-through is larger if the intersection goes beyond either of the points. On the other hand, when the exchange rate is volatile, the pass-through effect is smaller if the intersection is located between points O_1 and I_1.

IV. *Misalignments of the Exchange Rate and Hysteresis*

(1) Hysteresis

Baldwin(1990) quoted from the American Heritage Dictionary and defined hysteresis as "failure of a property change by an external agent to return to its original value when the cause of the change is removed." When we use the term, it means that changes in the exchange rate has changed the import price but the import price cannot recover to the initial level even if the exchange rate recover the initial level.

A cause of occurring the hysteresis is said to be the sunk costs of entering the market. As we analyzed above, once a new firm has paid the sunk costs for the initial capital in entering the market, it should decide to exit out of the market with taking the sunk costs into account. As a result, the firm may not exit out of the market even if a condition recovers to the initial one. It is because the costs of entering the market are sunk and the whole of them may not be covered by the changed condition.

Thus, the hysteresis effect is affected on the import price. Moreover, the hysteresis effect will be extended to the trade balance because it depends on relative price of importable goods in terms of domestic goods. Therefore, the hysteresis is an important cause why the trade imbalances have been not improving so well in response to a realignments of the exchange rate.

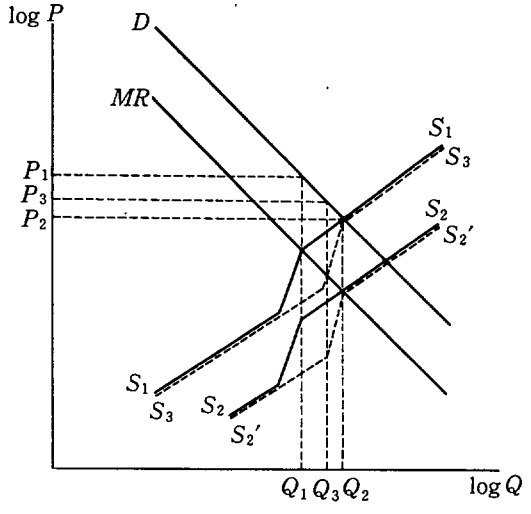
(2) Misalignments of the Exchange Rate and Imperfect Recovery of the Import Price

We use our model to examine the hysteresis effects of misalignments of the exchange rate. Suppose that a misalignment of the exchange rate occurred at first and then the exchange rate realign to the initial level. We analyze how the import price and the import volume change in response to the misalignment and the realignment of the exchange rate.

We suppose an appreciation of the home currency as analyzed in Fig. 2. The initial situation is that the import price and the import volume are P_1 and Q_1 respectively under the exchange rate E_1 in Fig. 4. We assume that the exchange rate E_0 corresponds to the critical enter level beyond which some potential foreign firms begin to enter our domestic market.

Suppose that the home currency appreciates from E_1 to E_2. As the appreciation goes

Fig. 4



beyond a critical level, it induces some potential foreign firms to enter the market. Then, they pay the sunk costs to enter the market. The elasticity of supply in the whole market increases as more potential firms enter the market. As a result, they lower the import price from P_1 to P_2 and increase the import volume from Q_1 to Q_2.

Here we should remember that the new foreign firms have paid the sunk costs to enter the market. They have no incentive to exit out of the market as long as a depreciation of the home currency is not large enough to cover the sunk costs. The supply line slides northeastward until the marginal revenue line and the supply line intersect at the critical entry point. A new supply curve is represented by a broken line $S_2'S_2'$.

Now, suppose that the exchange rate depreciates back to the initial level E_1. The supply line shifts upward to a line S_3S_3 as the exchange rate depreciates from E_2 to E_1. The new foreign firms should not exit out of the market supposing that the depreciation is not enough to cover the sunk costs of entering the market. As a result, the supply in the whole market is less elastic. They can increase the import price no higher than P_3.

The pass-through effect of the exchange rate on the import price is smaller in the first change in the exchange rate than the recovery change in the exchange rate. The import price cannot recover to the initial level even if the exchange rate recovers to the initial level. This phenomenon is called hysteresis. The cause is that the new firms which have entered the market in response to the misalignment must have paid the sunk costs for entering the market and that the realignment is not enough to cover the sunk costs.

Also, the misalignment has a hysteresis effect on the import volume as the pass-through effect in the realignment is smaller than that in the misalignment. The import volume increases from Q_1 to Q_2 in the misalignment. However, the realignment, which is the same rate of change in the exchange rate in the other direction, decreases the import volume from Q_2 to Q_3. The rate of change in the import volume in the realignment is smaller than that in the misalignment.

V. *Summary and Conclusion*

This paper considered the foreign firms' pricing under volatility and misalignments of the exchange rates. Here we focus on the supply side of market, that is, the sunk costs of entering the market.

The sunk costs of entering the market induce the firm not to enter the market nor to exit out of the market as long as the sunk costs are not sufficiently covered by the changes in the exchange rates. The sunk costs bring forth a price band where a number of foreign firms is unchanged. As a result, pass-through effects of the exchange rate on the import price are smaller in the price band.

Next, volatility of the exchange rates implies uncertainty about the future exchange rates. So the volatility induces the firms to take a cautious attitude in entering the market or in exiting out of the market. As a result, the volatility makes the price band of constant number of foreign firms wider. And the band of smaller pass-through effects widens.

Moreover, if the exchange rates are misaligned, the market may be structurally changed through the foreign firms' entry or exit. In these cases, the import price is not recovered to the pre-misalignment level even if the exchange rates are realigned to the pre-misalignment level. There occurs a hysteresis in the import price. The hysteresis implies that trade balances are unable to return to the pre-misalignment level.

If we extend our analysis to include their feedback effects on the exchange rate fluctuations, we can find that the feedback effects will increase the fluctuations (Baldwin and Lyons (1989), Ogawa (1990)). Therefore, the results of this paper may be in fact undervalued.

Here we have two implication for trade adjustments of the exchange rates.

One is that the sunk costs of entering the market should, if possible, be reduced. Initial investments in entering the market include setting up a distribution network. If the distribution network is complicated, costs of setting up it is expensive. Moreover, they would be prohibitively expensive if a domestic distribution system were exclusive of foreign firms.

The other is that the exchange rates had better be stable and aligned for the trade adjustments of the exchange rates. We prefer it rather than reducing the sunk costs since it might be limited to reduce the sunk costs. We know from our experiences and theories that a free floating exchange rate system is unable to exclude the volatility and misalignments of the exchange rates. We should reconsider the present exchange rate system and choose an alternative system which limits fluctuations in the exchange rates to some degree.

HITOTSUBASHI UNIVERSITY

REFERENCES

Baldwin, Richard (1988) "Hysteresis in Import Prices: The Beachhead Effect," *American Economic Review*, vol. 78, no. 4: 773–785.

Baldwin, Richard (1990) "Some Empirical Evidence of Hysteresis in Aggregate U.S. Import Prices," in Stefan Gerlach and Peter A. Petri eds., *The Economics of the Dollar Cycle*, MIT Press: 235–268.

Baldwin, Richard and Paul Krugman (1986) "Persistent Trade Effects of Large Exchange Rate Shocks," *NBER Working Paper*, no. 2017.

Baldwin, Richard and Richard Lyons (1989) "Exchange Rate Hysteresis: The Real Effects of Large VS Small Policy Misalignments," *NBER Working Paper*, no. 2828.

Dixit, Avinash (1989a) "Hysteresis, Import Penetration, and Exchange Rate Pass-through," *Quarterly Journal of Economics*, vol. 54, Issue 2: 205–228.

Dixit, Avinash (1989b) "Entry and Exit Decisions under Uncertainty," *Journal of Political Economy*, vol. 97, no. 3: 620–638.

Dohner, Robert S. (1984) "Exporting Pricing, Flexible Exchange Rates, and Divergence in the Prices of Traded Goods," *Journal of International Economics*, vol. 16, no. 1/2: 79–101.

Froot, Kenneth A. and Paul D. Klemperer (1989) "Exchange Rate Pass-through When Market Share Matters," *American Economic Review*, vol. 79, no. 4: 637–654.

Krugman, Paul (1987) "Pricing to Market When Exchange Rate Changes," in Sven W. Arndt and J. David Richardson, eds., *Real-Financial Linkages Among Open Ecopomies*, MIT Press: 49–70.

Krugman, Paul (1989) *Exchange-Rate Instability*, MIT Press, 1989.

Krugman, Paul and Richard Baldwin (1987) "Persistence of the U.S. Trade Deficit," *Brookings Papers on Economic Activity*, 1: 1–43.

Marston, Richard C. (1990) "Pricing to Market in Japanese Manufacturing," *Journal of International Economics*, vol. 29, no. 3/4: 217–236.

Ogawa, Eiji (1987) "Theories of Exchange Rates Determination: A Review," *Hitotsubashi Journal of Commerce & Management*, vol. 22, no. 1: 27–54.

Ogawa, Eiji (1989) "Importers and Pass-through Effects of Exchange Rares," *Hitotsubashi Journal of Commerce & Management*, vol. 24, no. 1: 13–28.

Ogawa, Eiji (1990) "Imperfect Pass-through Effects, Hysteresis, and Exchange Rate Fluctuations," mimeo.