

# Exchange Rate Volatility and the Partial Equilibrium Model in the Multinational Company Profit and Production Strategy

Chris J. Czerkawski\*

(Received on January 16, 2004)

## 1. Introduction

The amplitude of changes of nominal exchange rates in the years since 1973–75 when the major international currencies began to float has been largely unexpected. While it is known that efficient asset markets are likely to display variable prices, the level of volatility seems to have been more than can be logically explained with conventional models relating exchange rates to economic fundamentals. Furthermore, exchange rate volatility has changed with time and the related models failed to provide a satisfactory framework for a constructive analysis of this phenomenon.

Exchange rate volatility could be expected to affect many other economic variables and business decisions. One such set of decisions has been the strategy of pricing of goods and services. Early theories predicted that in competitive markets, exchange rate fluctuations would be passed quickly on to prices of goods and services sold. Empirically, however, the pass-through effects have been more complex. They appear to depend on the market structure, the ways in which firms set their prices, and the size of exchange rate variations over time. These observations have resulted in an expansion of literature examining models and theories of how firms may incorporate exchange rate variations in their pricing decisions (Krugman, 1989; Baldwin, 1989; Bodnar *et al.*, 2000; Aristotelous, 2001).

It is generally assumed that real investment decisions by firms to respond to exchange rate fluctuations. Less theoretical work has emerged to date to link exchange rate movements with real investment; but what there is seems to have followed one of two main channels. One takes a macroeconomic view and focuses on the real interest rate as the borrowing cost for real investment. The connections between real interest rates and real exchange rates are then investigated. Empirically, the links among rates appear to have been weak (Meese and

---

\* Professor, Graduate School of Economics, Hiroshima Shudo University

Rogoff, 1988; Tarditi and Menzies, 1992; Flood and Taylor, 1996). This may lead to conclusion that exchange rate movements will have little direct impact on real investment because they do not interact strongly with real interest rates.

The other approach has argued from a microeconomic approach that exchange rate changes should be considered as components of the net present value calculations for investment projects. Changes in exchange rates ‘normally’ affect real investment decisions through the cost of capital or through measures of cash flow used in discounted cash flow analysis. Here, the insertion of anticipated exchange rate changes in the net present value formula is argued but the overall impacts on firms’ investment decisions are not really emphasized. Further, changes in the exchange rate are usually included in the cost of capital measures as a “once off” adjustment, or as a constant rate of change. Also, the impact of exchange rate volatility, that is, changes that may be random in occurrence but whose variability is adequately described by a measure such as variance can also be investigated. If exchange rate variability can be positively (or negatively) correlated with investment decisions, one can explore how the firm reacts not only to the volatility itself but also to changes in the volatility.

There is a contrary viewpoint arguing that there should be no impact at all from movements of exchange rates on the real capital decisions of the firm. If we a world of perfect goods and capital markets with no transactions costs or uncertainty is assumed here, one would expect the “parity” theorems — purchasing power, covered, and uncovered — to hold (Solnik, 1996). A firm’s operations decisions would be “risk-neutral” in that they would not be adjusted as financing costs changed. This is similar to the Modigliani- Miller framework of corporate finance. We believe, however, that strong empirical and theoretical evidence does not support the assumptions that generate such neutrality, and therefore it is appropriate to attempt to model real impacts of financial variables (Stanley, 1989; Arndt and Richardson, 1987).

The purpose of this paper is to present a partial equilibrium model which may be used for empirical verification of tests with regard to the impact of currency crisis or other foreign exchange shocks on multinational company’s long-term strategic decisions, show its methodological limitations and offer a critique in view of the most recent phenomena. The current extensions of the fundamental model of currency crisis (i.e. uncontrolled depreciation of domestic currency) have been derived from the recent developments following the Asian currency crisis of 1997.

## 2. Partial Equilibrium Model — Definition and Development

This model will present demand as well as supply side and define the general equilibrium for a company engaged in multinational business under the conditions of foreign exchange shocks caused by extensive economic, transaction and translation exposure. Following the Krugman's methodology this model assumes exchange rates and wages to be exogenous variables i.e. company's strategic decisions are made before any wages adjustments). In extension to this model currency rate variable is a proxy (representative) for multinational company's (MNC's) profit objective.

### 2.1. *Demand Side of the Model*

The relationship between the real exchange rate and the level of output is an important and still a controversial issue for transitional economies. There are two principal issues: firstly, the level and determinants of the real exchange rate; and secondly, the effects of changes in the real exchange rate on the level of output of the economy. The first issue has been considered for transition economies by Halpern and Wyplosz (1997). They found that, following liberalization of financial markets, the real exchange rate usually first depreciates sharply and then appreciates, with the most important determinant of real exchange rate appreciation being increases in labor productivity. The second issue concerning the output effect of real exchange rate movements has yet to be addressed in the context of transition economies, and is also discussed in this paper.

The traditional literature suggests that a real exchange rate depreciation will lead to a rise in the demand for domestic output as the gain in competitiveness improves the trade balance, assuming that the sum of the import and export net elasticities of demand exceed unity. On the other hand, there are several theoretical reasons why, contrary to the traditional view, devaluation can be effectively contractionary and generate a decline in economic activity. First, a nominal devaluation can result in certain contractionary pressures on aggregate demand, which could more than offset the traditional expenditure-switching effect. For example, a devaluation will raise the price level, generating a negative real balance effect (Alexander, 1952), which will, in turn, lower aggregate demand and output. Another channel through which devaluation can lower aggregate demand relates to its effect on income distribution. A devaluation can redistribute net income from sectors and groups with a low

marginal propensity to save to sectors and groups with a high net marginal propensity to save, resulting in a decline in demand and output (see Krugman and Taylor, 1978). Second, in addition to these demand-side effects there are a number of supply-side channels through which devaluation can be in effect contractionary. For example, a devaluation may reduce aggregate supply because the increased costs of imported inputs may reduce the effective demand for them and hence of domestic production (Hanson, 1983). Argy and Salop (1983) and Lizondo and Montiel (1989) also suggest that reduced profits in the non-traded sector, caused by the higher real costs of imported inputs, especially oil, lead to a contraction in output after a devaluation.

The demand function in this study has been extrapolated from a symmetric total net expenditure function in translog form (Bergin and Feenstra (2000, 2001)). The advantage of using this functional form is that it generates curvature on both the average as well as weighted price elasticity of demand, which leads to non-constant markup, and allows for changes in multinational company's output volume. Here weighted price elasticity of demand is fixed which in turn will lead to constant level of output when the number of varieties is sufficiently (stochastically) large. In consequence MNC's output would not normally respond to external currency shocks. The expenditure function is defined as:

$$\ln E(P, u) = \ln u + \sum_{i=1}^{\bar{N}} \alpha \ln P_i + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln P_i \ln P_j$$

where  $\bar{N} = N + N^*$ .  $N$  is the number of domestically produced varieties and  $N^*$  is the number of imported varieties. Assume that all goods in this economy are tradable so that the number of imported goods and services varieties is equal to that of foreign producers. In Bergin and Feenstra (2000, 2001) research, the number of unit varieties entering the utility function is assumed to be fixed to keep the translog expenditure function sufficiently yet not totally manageable. However, once the number of unit varieties is allowed to vary, some goods may not be purchased and their prices have to be set at their reserve prices i.e. non market-prices. Keeping track of reserve prices adds difficulty for using translog expenditure function under the framework of monopolistic competition and increasing returns to scale (see Dornbusch's law of diminished returns under non-monopolistic scenario). On the other hand, Feenstra (2001) shows that the symmetric translog expenditure function is still valid when the number of unit varieties changes. He gives sufficient evidence that one can solve for the reserve prices of goods with zero quantity demanded and substitute them back to the expenditure function to obtain a reduced form expenditure function. This reduced form total net expenditure

function is fully calculable even when the number of unit varieties changes.

The demand function derived is:  $C_i = s_i E/P_i$ , where  $\Phi_a$  denotes the aggregate expenditure and  $s_i$  denotes the expenditure share on good  $i$ .  $s_i$  can be further specified as:

$$s_i = P_i C_i / E = \{\sigma \ln \Phi_a(P, u)\} / \sigma \ln P_i = \alpha_i + \sum \gamma_{ij} \ln P_j \quad (1)$$

Since the expenditure function is homogenous of degree one, the following restrictions have to be imposed:

$$\sum \alpha_i = 1 \text{ and } \sum \gamma_{ij} = \sum \gamma_{ji} = 0 \quad (2)$$

Therefore, the price elasticity of demand (in absolute value)  $\varepsilon_i$  can be simplified as:

$$\varepsilon_i = 1 - \{\sigma \ln s_i\} / \sigma P_i = 1 - \gamma_{ij} / s_i \quad (3)$$

where  $\gamma_{ij}$  needs to be negative to ensure the demand to be elastic.

Assume that all domestic goods, as well as imported goods, enter the expenditure function symmetrically. However, the price of domestic goods does not have to be symmetric to that of imported goods. That is,

$P_{i,d} = P_d;$	$C_{i,d}$ , if $i$ is $D$
$P_{i,f} = P_f;$	$C_{i,f}^*$ , if $i$ is $F$

where  $(P_d, P_f)$  denote the home currency price of representative domestic and imported goods respectively. Goods in this economy are composed of two groups: representative domestic ( $D$ ) and foreign ( $F$ ) goods, and their prices are allowed to deviate from each other.

Under this symmetry assumption, the parameters can be further specified as:

$$\gamma_{ij} = -\{\gamma / \bar{N}\}, \gamma_{ij} = \gamma / N(\bar{N} - 1), \text{ and } \alpha = 1 / \bar{N} \text{ for } j \neq i \quad (4)$$

where  $\gamma > 0$  in order to ensure the demand to be elastic. In this special case, the representative consumer's expenditure shares and demand elasticities can be simplified as:

$$\begin{aligned} s_d &= 1 / \bar{N} \{1 - N^* \gamma / (\bar{N} - 1) \ln P_d + \bar{N}^* \gamma / (\bar{N} - 1) \ln P_f\}; \\ s_f &= 1 / \bar{N} \{1 - N \gamma / (\bar{N} - 1) \ln P_f + N \gamma / (\bar{N} - 1) \ln P_d\}; \\ \varepsilon_d &= 1 + (\gamma / \bar{N}) / s_d = 1 + \gamma \{1 - N^* \gamma / (N - 1) \ln P_d + N^* \gamma / (\bar{N} - 1) \ln P_f\}^{-1}; \\ \varepsilon_f &= 1 + (\gamma / \bar{N}) / s_f = 1 + \gamma \{1 - N \gamma / (\bar{N} - 1) \ln P_f + N \gamma / (\bar{N} - 1) \ln P_d\} P_d^{-1} \end{aligned}$$

where  $(s_d, s_f)$  denote expenditure shares on domestic and imported goods and  $(\varepsilon_d, \varepsilon_f)$  denote their elasticities.

Equation (5) demonstrates the effects of competition between the domestic and foreign goods. The price elasticity of demand is positively related to own price but negatively related to rival's price. Higher own price or lower rival's price exposes this good to more severe competition which leads to a lower expenditure share and higher demand elasticity.

In the special case where all goods are symmetric, the demand elasticities become constant ( $\epsilon_d = \epsilon_f = 1 + \gamma$ ) and the expenditure shares of all goods become equal ( $s_d = s_f = 1 / \bar{N}$ ).

## 2.2 *Supply Side of the Model*

This side takes into account three observations. First, not all consumers in a country have the same preferences or tastes. Second, the structure and the volume of the produced goods and services exhibits what is called economies of scale. And third, there are a variety of different types of the same manufactured good. Combining the first and third observation, typically a country's market can be segmented along the lines of different preferences. These different preferences provide incentives to producers to create a variety of manufactured goods with different attributes to service the different market segments.

The second observation, economies of scale in manufacturing, means that the larger the firm's operations, the more efficient it becomes. Large-scale output leads to a lower cost per unit. Moving from left to right along the average cost curve in the Krugman model, the size of the firms operations is increasing. At the same time, the average cost curve's height is decreasing, meaning that the cost per unit output is falling. Under these conditions, it is more efficient to have only a handful of large firms producing the good. These efficiency gains are obtained from specialization and diversification of inputs, e.g., assembly lines, or high capital costs in the form of sophisticated equipment best paid for by large output units.

With strong economies of scale, only large output units make economic sense. If firms respond primarily to their domestic markets, then in the US we would have only a few firms specializing in the manufacturing of large units. These firms would enjoy low average costs via large volumes. With economies of scale, the European manufacturers would have a lower cost per unit. The same argument applies to European manufacturing of large output units. For example the US and Europe import and export large house appliances such as washing machines and refrigerators but each with differing technical characteristics. The importance of this theory is that it introduces conditions of imperfect competition into international trade. With economies of scale, industries will tend to have fewer firms. In some sectors and industries, airline manufacturers for example, world demand can be met by only one or two firms (Boeing and Airbus). Under these conditions strategic behavior on the parts of firms and governments can influence the location, growth, and competition within industries.

The government's role in industry differs greatly between the different industrial countries under different industrial policies. In the US, the government tends to be much less involved

than in the other industrial countries. Japan was for many years an example of high government involvement in shaping industry. Japan's Ministry of International Trade and Industry (MITI) has played an influential coordinating role in formulating Japan's industrial policy. Conventional wisdom at the beginning of the 1990s believed that MITI had been successful in stimulating industrial growth in the Japanese economy with such examples as consumer electronics and automotive industries. Many influential economists and business leaders in the US ( Galbright, Rosen, Peters) have advocated that the US also implement more assertive industrial policies

According to the basic assumption of Krugman's model – producers are monopolistically competitive firms producing differentiated products. When firm  $i$  produces quantity  $X_i$ , its production cost in terms of labor unit is:  $l_i = \alpha + \beta X_i$ , which consists of a fixed overhead cost  $\alpha$  and a variable cost  $\beta$ .

Suppose that each firm has to allocate sales between domestic and foreign markets ( $X_i$  and  $X_i^*$  respectively). When a firm sells abroad, an extra fixed cost ( $\alpha_x$ ) occurs. The representative firm's profit function can be written as:

$$\begin{aligned} \pi_i(X_i, X_i^*) &= \pi_i(X_i) + \pi_i^*(X_i^*) = \\ &= P_i X_i - \omega(\alpha + \beta X_i) + e P_i^* X_i^* - \omega(\alpha_x + \beta X_i), \quad X_i, X_i^* \geq 0 \end{aligned} \quad (6)$$

Here  $e$  denotes the exchange rate expressed as the amount of domestic currency per unit of foreign currency. The existence of the fixed export cost enables the representative firm to choose between selling products only domestically and serving both foreign and domestic markets. Since firms are monopolistically competitive, their equilibrium production and sales allocation decisions have to satisfy both the profit maximizing condition (PMC) and the zero-profit condition (ZPC, condition for long-term equilibrium see also Stolper-Samuelson accounting for profit criteria). The profit maximizing pricing rules are:

$$\left. \begin{aligned} P_i &= \varepsilon_i / (\varepsilon_i - 1) \beta \omega \\ e P_i^* &= \varepsilon_i^* / (\varepsilon_i^* - 1) \beta \omega; \end{aligned} \right\} \quad (7)$$

and the zero-profit condition is satisfied when:

$$\begin{aligned} P_i X_i + e P_i^* X_i^* &= \omega[\alpha + \alpha_x + \beta(X_i + X_i^*)], \quad X_i, X_i^* \geq 0 \\ P_i / \beta \omega &= \varepsilon_i / (\varepsilon_i - 1) = 1 + 1 / (\varepsilon_i - 1) \geq 0 \end{aligned} \quad (8)$$

where  $1 / (\varepsilon_i - 1)$  is this firm's mark-up margin.

When the markets are highly competitive, the mark-up margin should be small, therefore, the logarithm of equation (7) can be approximated by:

$$\ln P_i = \ln \varepsilon_i / (\varepsilon_i - 1) + \ln(1 + 1 / (\varepsilon_i - 1)) + \ln(\beta\omega) / (\varepsilon_i - 1) + \ln(\beta\omega) \quad (9)$$

$$\ln eP_i^* = \ln \varepsilon_i^* / (\varepsilon_i^* - 1) + \ln(\beta\omega) = \ln(1 + 1 / (\varepsilon_i - 1)) + \ln(\beta\omega) / (\varepsilon_i^* - 1) + \ln(\beta\omega)$$

### 3. Model Equilibrium

After introducing exogenous comparative advantage in production and exogenous comparative advantage in transactions into the model with monopolistic competition and endogenous comparative advantage, Krugman shows that a country may export goods in which it has exogenous comparative disadvantage in production if its endogenous comparative advantages in production and exogenous comparative advantage in transactions dominate its exogenous comparative disadvantage. Also, final manufactured goods may become increasingly more capital intensive, as the number of capital goods increases in response to parameter changes. A country can export capital intensive goods even if it has exogenous comparative disadvantage in producing this good.

Further extension of the Krugman model will show that a country will trade goods in which it has net comprehensive exogenous and endogenous comparative advantage in production as well as in transactions. It will exploit substitution between trades of different types of goods to avoid trade that involves high transaction costs. Various possible substitutions between endogenous and exogenous comparative advantages and between comparative advantages in production and in transactions generate much more convincing model of equilibrium trade and development patterns than in neoclassical trade models.

In line with the Krugman model it is assumed here that exchange rates ( $e$ ), wages ( $w$ ), and aggregate expenditure ( $\Phi$ ) are fixed in this partial equilibrium. Besides, both the total number of varieties ( $\bar{N}$ ) and the number domestic varieties ( $N$ ) are endogenous in this system while the number of foreign varieties ( $N^*$ ) is fixed.

In equilibrium, the quantity of production equals to the quantity of consumption, that is,

$$X_i = X_d = C_d = s_d \omega \varphi / P_d = s_d (\varepsilon_d - 1) \varphi / (\varepsilon_d \beta) = \gamma \varphi / (\bar{N} \varepsilon_d \beta) \text{ and} \quad (10)$$

$$X_i^* = X_d^* = C_d^* = s_d^* \omega^* \varphi^* / P_d^* = s_d^* \omega^* (\varepsilon_d^* - 1) \varphi^* \varepsilon / \varepsilon_d^* \beta \omega = \gamma^* \omega^* \varphi^* e / (\bar{N} \varepsilon_d^* \beta \omega) \quad (11)$$

where

( $\varphi$ ,  $\varphi^*$ ) denote the total labor units in the domestic and foreign economies, and ( $w\varphi$ ,  $w^*\varphi^*$ ) are the aggregate incomes (expenditures).

Consequently, the PMC and ZPC for the representative domestic producer can be rewrit-



ten as:

$$\begin{aligned}
 \ln P_d &\cong 1 / \varepsilon_d - 1 + \ln(\beta\omega) \\
 \ln eP_d^* &\cong 1 / (\varepsilon_d - 1) + \ln(\beta\omega) \\
 s_d(\varphi\omega / \varepsilon_d) + (\varepsilon s_d^* \varphi^* \omega^*) / \varepsilon_d^* &= (\alpha + \alpha_x)\omega
 \end{aligned} \tag{12}$$

The representative foreign producer's PMC and ZPC are:

$$\begin{aligned}
 \ln P_f^* &\cong 1 / (\varepsilon_f^* - 1) + \ln(\beta^* \omega^*) \\
 \ln P_f / \varepsilon &\cong 1 / (\varepsilon_f - 1) + \ln(\beta^* \omega^*) \\
 (s_f \varphi\omega / e) / e_f + s_f^* \varphi^* \omega^* / \varepsilon_f^* &= (\alpha^* + \alpha_x^*) \omega^*
 \end{aligned} \tag{13}$$

To increase the flexibility of this system, foreign parameters ( $\alpha^*$ ,  $\alpha_x^*$ ,  $\beta^*$ ,  $\gamma^*$ ) are allowed to differ from domestic ones.

#### 4. Foreign Expenditures — Consumption and Output

If the foreign market is symmetric to the domestic market, then the foreign consumer's expenditure shares and price elasticity of demand can be specified as:

$$\left. \begin{aligned}
 s_d^* &= 1 / N [1 - N^* \gamma^* / (N-1) \ln P_d^* + N^* \gamma^* / (N-1) \ln P_f^*], \\
 s_f^* &= 1 / n [1 - N \gamma^* / (N-1) \ln P_f^* + N \gamma^* / (N-1) \ln P_d^*] \\
 \varepsilon^* d &= 1 + \{\gamma^* / N\} / s_d^* = 1 + \gamma^* [1 - N^* \gamma^* / (N-1) \ln P_d^* + N^* \gamma^* / (N-1) \ln P_f^*] \\
 \varepsilon^* f &= 1 + (\gamma^* / N) / s_f^* = 1 + \gamma^* [1 - (N \gamma^* / N) / (N-1) \ln P_f^* + N^* \gamma^* / (N-1) \ln P_d^*]
 \end{aligned} \right\} \tag{14}$$

Where ( $P_d^*$ ,  $P_f^*$ ,  $s_d^*$ ,  $s_f^*$ ,  $\varepsilon_d^*$ ,  $\varepsilon_f^*$ ) denote the foreign currency prices, expenditure shares, and demand elasticities of domestically and foreign produced goods respectively. The underlying assumption is that all goods and services are tradable between home and foreign markets, thus, the volume of goods consumed at home and foreign is identical ( $\bar{N}$ ).

The representative foreign producer's cost of producing quantity  $X_i^*$  in terms of labor unit is:  $\varphi_i^* = \alpha^* + \beta^* X_i^*$ , which consists of a fixed overhead cost  $\alpha^*$  and a variable cost  $\beta^*$ . Like the domestic producer, foreign firm has to decide to allocate total sales between domestic and foreign markets ( $X_{i,f}$  and  $X_{i,f}^*$  respectively), and an extra fixed cost ( $\alpha_x$ ) occurs when selling abroad. The representative firm's profit maximizing and zero-profit conditions can be written as:

$$\begin{aligned}
 \ln P_{i,f} / \varepsilon &= 1 / (\varepsilon_{i,f}) + \ln(\beta^* \omega^*) \\
 \ln P_{i,f}^* &= 1 / (\varepsilon_{i,f}^* + \ln(\beta^* \omega^*)) \\
 P_{i,f} / \varepsilon X_{i,f} + P_{i,f}^* X_{i,f}^* &= \omega^* \{\alpha^* + \alpha_x^* + \beta^* (X_{i,f} + X_{i,f}^*), X_{i,f}^* \geq 0\}
 \end{aligned} \tag{15}$$

In equilibrium, the quantity of production has to be equal to the quantity of consumption, that is,  $X_{i,f} = X_f = C_f = s_f \omega^* \varphi \omega / P_f = s_f (\varepsilon_f - 1) \varphi \omega / (\varepsilon_f \beta^* \omega^*)$ , and  $X_{i^*,f} = X_f^* + C_f^* = s_f^* \omega^* \varphi^* / (P_f^*) = s_f^* (\varepsilon_f^* - 1) L^* / \{\varepsilon_f^* \beta^*\}$ . Therefore, the zero-profit condition of equation (14) can be written as:

$$(s_f \varphi \omega / e) / \varepsilon_f + (s_f^* \varphi^* \omega^*) / \varepsilon_f^* = (\alpha^* + \alpha_x^*) \omega^* \quad (16)$$

## 5. Equilibrium Conditions for Firms Engaged in International Trade

In the theoretical part a general equilibrium model is set up to analyze the phenomena of globalization (rising trade, FDI (foreign direct investment) flows and technology transfer) within a unified framework. In this model globalization is driven by decreasing distance costs over time. The model reflects companies' increasing export activities over time which are due to the fall in distance costs. When distance costs have fallen below a certain threshold production abroad becomes profitable and companies engage in FDI. This threshold depends on the degree of product differentiation, the complexity of the production process, the level of fixed inputs and the size of the home market of a MNCs. It can, therefore, explain the observed sectoral clustering of FDI as well as national differences, where companies from larger countries can be seen to internationalize their production earlier, companies based in smaller countries later. The modeling of the adjustment process to an equilibrium with MNCs indicates that FDI of one company increases the profitability of FDI of every domestic company, which explains the often noticed fact that FDI occurs in cycles.

The two-country model may subsequently be extended to a model which reflects globalization as a multilateral process by introducing a third country. By using a three-country model it is possible to examine the influence of one country's FDI in another country on the seemingly unaffected companies which are based in a third country. This model is particularly to analyze the recent FDI flows in the era of globalization which include companies from various countries but only one major host country of their investment, the United States. Substituting equation (11) into equation (5) – one can solve for expenditure shares and demand elasticities:

$$\left. \begin{aligned} s_d &= (2\bar{N} - 1) + N^* (\ln \varepsilon - \ln(\beta \omega) + \ln(\beta^* \omega^*)) / N(2\bar{N} - 1) \\ s_f &= (2\bar{N} - 1) - N (\ln \varepsilon - \ln(\beta \omega) + \ln(\beta^* \omega^*)) / N(2\bar{N} - 1) \\ \varepsilon_d &= 1 + \gamma(2\bar{N} - 1) / (2\bar{N} - 1) + N^* \gamma (\ln \varepsilon - \ln(\beta \omega) + \ln(\beta^* \omega^*)) \\ \varepsilon_f &= 1 + \gamma(2\bar{N} - 1) / (2N - 1) - N\gamma (\ln \varepsilon - \ln(\beta \omega) + \ln(\beta^* \omega^*)) \end{aligned} \right\} \quad (17)$$

Exchange Rate Volatility and the Partial Equilibrium Model in the  
Multinational Company Profit and Production Strategy

$(s_d, s_f, \varepsilon_d, \varepsilon_f)$  are determined by three key elements: 1) marginal cost difference ( $\ln \varepsilon + \ln(\beta^* \omega^*) - \ln(\beta \omega)$ ), 2) the number of variety ( $N$ ), and 3) the taste parameter  $\gamma$ . The foreign counterparts  $(s_d^*, s_f^*, \varepsilon_d^*, \varepsilon_f^*)$  are almost identical, the only difference is that  $\gamma$  is replaced by  $\gamma^*$ . Initially, if the domestic marginal cost is equal to its foreign competitor after converting to the same currency, i.e.  $\varepsilon \beta^* \omega^* = \beta \omega$ , all market shares are equal ( $s_d = s_f = 1/N = s_d^* = s_f^*$ ) and elasticities are solely determined by the taste parameters ( $\varepsilon_d^* = \varepsilon_f^* = 1 + \gamma^*$ ). When exchange rate appreciates, the domestic marginal cost in terms of foreign currency becomes higher. Due to the loss of cost edge, the relative weighted price of domestic goods becomes higher, causing the domestic firm to face a smaller portion of the residual demand. Therefore, the demand elasticity of domestic goods ( $\varepsilon_d, \varepsilon_d^*$ ) become higher. Since  $\varepsilon_d$  and  $\varepsilon_d^*$  increase,  $s_d$  and  $s_d^*$  shrink (less than  $1/eN$ ) while  $s_f$  and  $s_f^*$  are expanding (greater than  $1/N$ ), if  $N$  is kept fixed. However,  $N = N + N^*$  is assumed to be endogenous in this model. The equilibrium condition used to solve for  $N$  is that the expenditure shares on all varieties should sum up to be one, that is:

$$N_{sd} + N_{sf}^* = 1.$$

Even after fixing  $N^*$  the analytical solution of  $N$  is too complicated to present. Instead, the numerical solutions from simulations are used. Based on the numerical solutions,  $N$  decreases when exchange rate appreciates.

Equation (11) shows that when exchange rate appreciates, the domestic firm responds by charging a higher price for its exports ( $P_d^*$ ). However, the price increment is smaller than the magnitude of exchange rate shock since  $\alpha_d^*$  increases as well, which indicates an incomplete transmission of prices (imperfect market). Such price increase of exports makes the foreign firm face a less competitive market therefore rising its own price. On the contrary, consider the foreign representative firm's profit maximizing pricing decision in equation (15), the appreciation of domestic currency leads to a reduction of  $P_f$ , since it is a depreciation of the foreign representative. In response to its rival's price cut, the representative domestic firm may have to charge a lower price for its product in the domestic market.

While the increase of  $P_d^*$  leads to a fall of the competitive firm's export quantity ( $X_d^*$ ), the falling number of varieties leads to larger market shares of domestic goods in the foreign market ( $s_d^*$ ) and lower level of market competition. However, the latter effect can be considered secondary except in some special cases. The effect of appreciation on representative firm's domestic sales ( $X_d$ ) is determined by the firm's zero-profit condition (equation (9)), which can be rewritten as:

$$P_d X_d / \varepsilon_d + e P_d^* X_d^* / \varepsilon_d^* = \omega(\alpha + \alpha_x), \quad X_d, X_d^* \geq 0$$

where  $1/\varepsilon_d$  and  $1/\varepsilon_d^*$  denote the degree of price modifications. Since appreciation raises the level of competition the domestic firm faces in both markets, its price levels go down. In order to make the equality hold, the firm's profit from domestic sales ( $P_d X_d / \varepsilon_d$ ) has to increase to compensate for the loss of export profit. Since  $P_d / \varepsilon_d$  must go down,  $X_d$  has to increase to make the zero-profit condition hold. When the domestic sales is specified as:

$$X_d = \omega \varphi_{sd} / P_d$$

one can find that the effect of appreciation on  $X_d$  is attributable to the decrease of  $P_d$  and the increase of market share ( $s_d$ ) resulting from the reduction of unit varieties.

To sum up, exchange rate appreciation reduces exports while increasing domestic sales. Therefore, the effect of exchange rate appreciation on a firm's total sales ( $X_d + X_d^*$ ) and labor productivity ( $(X_d + X_d^*) / \alpha^* + \alpha_x^* + \beta (X_d + X_d^*)$ ) is determined by the relative volume (but not its structure) of its impact on  $X_d$  and  $X_d^*$ .

## Conclusion

The question if exchange-rate volatility affects bilateral trade is a very old one. The answer given by economic theory is ambiguous. Depending on the underlying assumptions, different models arrive at opposing conclusions. Thus, the question which of the models explains best the behavior observed in reality has to be empirically answered. Many earlier studies could not find clear empirical evidence. The extension of Krugman's model provides theoretical support that exchange-rate volatility would in effect reduce the volume of bilateral trade. Significantly negative coefficients have been found in empirical studies for the exchange-rate-uncertainty measure in the case of Canada, the United Kingdom and the United States. However, the impact of exchange-rate volatility on trade is only essential and significant if the volatility of the nominal-effective-exchange rate is considerable or trade relations are extremely focused to one country. The results stress the importance of exchange-rate effects via third countries. The econometric studies that focus on this phenomenon differ from those that use other statistical techniques in findings concerning the stationarity and colloraly properties of the time series, e.g. the measure of competitiveness which is integrated of order two, in the elimination of autocorrelation and in the lag structure which exceeds one year. Future research might address the question if there are long-term shifts in the diversification of exports of a country to its trading partners that are caused by exchange-rate volatility.

\* The research of the paper was generously supported by a Grant from Sogo Kenkyu-sho (Institute of Advanced Studies), Hiroshima Shudo University in 2002.

### References

- Akhtar, M. A. and Hilton, Spence: Effects of Exchange Rate Uncertainty on German and U.S. Trade, in: *Quarterly Review* 9 (Federal Reserve Bank of New York), 1984, p. 7–16.
- Alexander, Sidney. 1952. “The Effects of Devaluation on a Trade Balance,” *IMF Staff Papers*, (April), pp. 359–373.
- Argy, V.; Salop, J. (1983): “Price and Output Effects of Monetary and Fiscal Expansion in a Two-Country World under Flexible Exchange Rates”, *Oxford Economic Papers*, 35/2: 228–246.
- Aristotelous, Kyriacos, “Exchange-rate volatility, exchange-rate regime, and trade volume: evidence from the UK-US export function (1889–1999)”, *Economics Letters*, 72, 2001, pp. 87–94.
- Arndt, Sven, and Richardson, J. David, “Real-Financial Linkages among Open Economies: An Overview” in Arndt, Sven W., and Richardson, J. David (eds), *Real-Financial Linkages among Open Economies*, Cambridge: MIT Press, 1987, pp. 5–32.
- Baldwin, Richard, “Sunk-cost hysteresis”, National Bureau of Economic Research *Working Paper* No. 2911, March 1989.
- Bergin P., J. C Feenstra., “Staggered Price Setting and Endogenous Persistence,” *Journal of Monetary Economics*, June 2000.
- Bergin P., J. C. Feenstra., “Pricing to Market, Staggered Contracts, and Real Exchange Rate Persistence,” *Journal of International Economics*, March 2001.
- Bernard, Andrew and J. Bradford Jensen (1999), “Exceptional Exporter Performance: Cause, Effect, or Both?” *Journal of International Economics*, 47(1): 1–25.
- Bodnar, Gordon M., Dumas, Bernard, and Marston, Richard C., “Passthrough and Exposure”, Wharton School University of Pennsylvania *Working Paper* September 2000.
- Coes, Donald: The Crawling Peg and Exchange Rate Uncertainty, in Williamson, J. (eds.): *Performance and Prospects for the Crawling Peg*, New York: St. Martin Press, 1981, p. 113–136.
- Flood, Robert P., and Taylor Mark P., “Exchange Rate Economics: What Wrong with the Conventional Macro Approach?” Chapter 8 in Frankel, Jeffrey A., Galli, Giampaolo, and Giovannini, Alberto, (eds), *The Microstructure of Foreign Exchange Markets*, Chicago: University of Chicago Press, 1996, pp. 261–294.
- Fung, L (2001), *Exchange Rate, Firm Dynamics and Productivity Growth*, mimeo, preliminary paper.
- Halpern, L. & Wyplosz, C. (.). (1998). *Hungary: Towards a Market Economy*. Cambridge: Cambridge University Press.
- Hanson, J. (1983), ‘Contractionary devaluation, substitution in production and consumption and the role of the labour market,’ *Journal of International Economics*, 14, 179–189.
- Lizondo, J. Saul, and Peter J. Montiel. 1989. “Contractionary Devaluation in Developing Countries: An Analytical Overview.” *IMF Staff Papers* 36 (March). 182–227.
- Krugman, P. and L. Taylor (1978), “Contractionary Effects of Devaluation”, *Journal of International Economics*, 8(3).
- Krugman, Paul (1979), “Increasing Returns, Monopolistic Competition, and International Trade,” *Journal of International Economics*, 9(4): 469–79.
- Krugman, Paul R., *Exchange-Rate Instability*, Cambridge, Massachusetts: MIT Press, 1989.
- Krugman, Paul R.: *Exchange Rate Instability*, Cambridge: MIT Press, 1989.

- McKenzie, Michael D.: The Impact of Exchange Rate Volatility on International Trade Flows, in: *Journal of Economic Surveys*, Vol. 13, No. 1, 1999, p. 71–106.
- Meese, Richard, and Rogoff, Ken, “Was it real? The exchange rate-interest differential relation over the modern floating-rate period”, *Journal of Finance*, 43, No. 4, September 1988, 933–948.
- Roberts, Mark and James Tybout eds. (1996), *Industrial Evolution in Developing Countries: Micro patterns of Turnover, Productivity, and Market Structure* (Oxford University Press for the World Bank).
- Solnik, B., *International Investments*, 3<sup>rd</sup> ed., Adison-Wesley, New York 1996
- Stanley, Marjorie T., “Capital Structure and Cost-of-Capital for the Multinational Firm”, in Sheth, Jagdish N., and Eshghi, Abdolreza (eds), *Global Financial Perspectives*, Cincinnati: South-Western Publishing Co., 1989, Chapter 8 pp. 94–116.
- Tarditi, Alison, and Menzies, Gordon, “The Australian dollar: do real interest rates matter?” *mimeo*, Reserve Bank of Australia Economic Research Department, 1991.
- Tybout, James and Mark Roberts (1997), “The Decision to Export in Colombia: An Empirical Model of Entry with Sunk Costs,” *American Economic Review*, 87 (4): 545–563.