CHAPTER 3

THEORETICAL FRAMEWORK

3.1 Theoretical Background

3.1.1 The Law of One Price

The Law of One Price (LOP) is the definition of market integration: identical goods sell for the same common-currency price in different countries. LOP holds on the assumption of profit maximization and costless transportation, distribution, and resale (Goldberg and Knetter, 1997). Let $P_{i,t}$ be the price of good *i* in terms of the domestic currency at time *t*, $P^*_{i,t}$ be the price of good *i* in terms of the foreign currency at time *t*, and S_t be the nominal exchange rate expressed as the domestic price of the foreign currency at time *t*, the LOP in its *absolute* version can be written as:

$$P_{i,t} = S_t P^*_{i,t} \qquad i = 1,\ 2, \ldots,\ N. \tag{3.1.1}$$

The *absolute* version of the LOP posits that identical good should have the same price across countries if prices are expressed in a common currency. That the LOP holds implies that markets are integrated. The LOP relates to the common-currency prices of similar goods at a disaggregated level. In an aggregate level, if the LOP held for all individual goods between two countries then the price levels between these two countries would be equal and the *absolute* purchasing power parity (PPP) would hold. Formally, by summing all the traded goods in each country, the *absolute* version of the PPP can be written as:

$$\sum_{i=1}^{N} \alpha_i P_{i,t} = S_t \sum_{i=1}^{N} \alpha_i P^*_{i,t}, \tag{3.1.2}$$

where the weights in the summation satisfy $\sum_{i=1}^{N} \alpha_i = 1$.

Actually, the absolute versions of the LOP and PPP are not likely to hold because the assumptions of costless transportation, distribution, and resale are not realistic. A less restrictive version of the LOP and PPP is proposed: the *relative* LOP and PPP. In this version, prices between two countries are not equal due to frictions from transport costs, tariffs and other non-tariff barriers. These frictions, however, create constant price differential across the two countries. The relationship can be expressed in the following equations.

$$\frac{P^*_{i,t+1.}S_{t+1}}{P_{i,t+1}} = \frac{P^*_{i,t}S_t}{P_{i,t}} = \varphi \qquad i = 1, 2,..., N. \qquad (3.1.3)$$

$$\frac{S_{t+1}\sum_{i=1}^{N}\alpha_i P^*_{i,t+1}}{\sum_{i=1}^{N}\alpha_i P_{i,t+1}} = \frac{S_t\sum_{i=1}^{N}\alpha_i P^*_{i,t}}{\sum_{i=1}^{N}\alpha_i P_{i,t}} = \varphi \qquad (3.1.4)$$

where equation (3.1.3) and (3.1.4) represent the *relative* LOP and PPP respectively and φ is constant.

Obviously, the absolute LOP (PPP) implies the relative LOP (PPP), but not vice versa.

3.1.2 <u>Exchange Rate Pass-Through</u>

1) <u>Definition</u>

Apart from verifying the validity of the LOP and PPP, another strand of research focuses on the relationship between exchange rates and traded goods prices, i.e. how traded goods prices respond to exchange rate changes. Exchange rate pass-through (ERPT) is defined as the transmission of exchange rate changes to import prices in the destination market currency[1]. The degree of pass-through is measured by the percentage change in import prices in the destination market currency with respect to one percentage change in the exchange rate between the importing and exporting countries. The pass-through relationship can be formally explained as the following.

Consider two countries, Home (H) and Foreign (F) trading goods, with country H being the exporting country and country F the importer. For any goods exported from country H,

$$P^X_H \equiv EP^X_F \qquad (3.1.5)$$

[1] This is the most widely used definition of ERPT. However, ERPT also refers to the degree to which exchange rate changes are reflected in the export prices and domestic prices as used in many studies in this area.

where P_H^X is the export price expressed in H's currency, P_F^X is the export price paid by buyers in country F in F's currency, and E is the bilateral exchange rate expressed in terms of units of H's currency per unit of F's currency.

Taking the logarithm of (1):

$$\ln P_H^X = \ln E + \ln P_F^X \qquad (3.1.6)$$

and differentiating:

$$d \ln P_H^X = d \ln E + d \ln P_F^X \qquad (3.1.7)$$

and dividing by $d \ln E$ on both sides:

$$\frac{d \ln P_H^X}{d \ln E} = 1 + \frac{d \ln P_F^X}{d \ln E} \qquad (3.1.8)$$

equivalently:

$$\frac{d \ln P_H^X}{d \ln E} - \frac{d \ln P_F^X}{d \ln E} = 1. \qquad (3.1.9)$$

From the above equation, the first term of the left hand side represents the degree to which exporters from country H absorb the exchange rate changes into their export price in H's currency, while the second term represents the degree to which the exporters pass-through the exchange rate changes to import price in F's currency, or the degree of ERPT. The absolute values of the two terms must sum to one.

If $\frac{d \ln P_F^X}{d \ln E} = -1$, there is *complete* ERPT by exporters in country H to F's currency denominated prices.

If $\frac{d \ln P_F^X}{d \ln E} = 0$, there is *zero* ERPT by exporters in country H to F's currency denominated prices.

If $-1 < \frac{d \ln P_F^X}{d \ln E} < 0$, there is *incomplete* ERPT by exporters in country H to F's currency denominated prices.

ERPT involves directly to the pricing behavior of exporters. The degree of ERPT is thus usually measured by an estimation of pass-through equation which is based on the export pricing equation. Generally, the regression model for pass-through takes the following form:

$$p_t \;=\; \mu + \delta X_t + \xi E_t + \lambda Z_t + \varepsilon_t \qquad (3.1.10)$$

where all variables are in logs and p_t is import price in destination market currency, X_t is the exporter's cost, E_t is the exchange rate expressed in terms of units of importer's currency per unit of exporter's currency, Z_t denotes other variables that may shift import demand (e.g. income and competitor's price) and ε_t is an error term.

If $\xi = 1$, then ERPT is complete. If $\xi = 0$, then there is no ERPT (zero pass-through). And if $0 < \xi < 1$, then ERPT is incomplete.

The connection between ERPT and the LOP can be explained in the following way (Swift, 2001). Consider the case of any products which is sold both in the domestic market (country H) and in the foreign market (country F). Assume that the LOP holds. Thus, at any given exchange rate,

$$P_D^X \;=\; P_H^X \;=\; EP_F^X \qquad (3.1.11)$$

where P_D^X is the domestic price paid by domestic buyers in H's currency, and P_H^X, P_F^X and E are defined previously.

Taking the logarithm of (7) and differentiating:

$$\frac{dP_D^X}{P_D^X} \;=\; \frac{dP_H^X}{P_H^X} \;=\; \frac{dE}{E} + \frac{dP_F^X}{P_F^X}. \qquad (3.1.12)$$

If the exchange rate changes are completely pass-through to export price in F's currency so that export price in H's currency remains constant $\left(\frac{dP_H^X}{P_H^X} = 0\right)$, then P_D^X stills equals P_H^X. This implies that the LOP still holds. However, if the exchange rate changes are not completely passed-through so that there are some adjustments in export price in H's currency $\left(\frac{dP_H^X}{P_H^X} \neq 0\right)$, then P_D^X does not equal P_H^X. This implies that the LOP is violated.

The above interpretation implicitly assumes that in the presence of incomplete ERPT, the domestic price paid by domestic buyers (P_D^X) does not change. Nevertheless, if the price of the good paid by domestic buyers (P_D^X) changes by an amount equivalent to the change in the price paid by buyers in country F in H's currency (P_H^X) so that $\frac{dP_D^X}{P_D^X} = \frac{dP_H^X}{P_H^X}$, the LOP still holds, whatever the degree of pass-through.

To conclude, the connection between ERPT and the LOP seems ambiguous. It is interesting to state that incomplete ERPT is not necessarily evidence of the violation of the LOP.

2) Exchange Rate Pass-Through in the Short-Run

Complete ERPT is seen as a long-run phenomenon. Traditional theories concerning the effects of exchange rate changes on external adjustment implicitly assumes that ERPT is complete. However, the fact that the U.S. external balance did not respond to exchange rate changes brought about the question of whether ERPT is really complete. Early studies have found incomplete pass-through (Kreinin, 1977; Froot and Klemperer, 1989 and Hooper and Mann, 1989). Departures from complete pass-through may be considered as a short-run phenomenon. Several explanations for these short-run deviations are stated in Menon (1996).

First, exporting firms face the costs of changing prices. Such kind of price is known as the "menu" costs. In an environment where exchange rates are highly volatile, changes in the exchange rates can be seen as temporary. Exporters may prefer not to change prices in order to secure the benefits of price stability and to avoid the menu costs. The menu costs can be in terms of "informational" costs to the exporter if the change in prices makes buyers inconvenient and thus leads to loss of sales. In addition, the exporter faces "administrative" menu costs in setting new prices and notifying buyers (Ghosh and Wolf, 1994).

Second, exporting firms face the costs associated with changing supply to the foreign market. In the case of temporary depreciation of the exporter's currency, the importer may not fully benefits from reduced prices in local currency. This is possible when the exporter needs more marketing and distribution infrastructures to increase sales to meet the expanded demand in the foreign market. Such costs may be high and sunk. Firms are, therefore, reluctant to pass-through all the exporter currency's depreciation to local import prices. In case that the depreciation of the exporter's currency is perceived to be relatively permanent, firms are likely to incur such costs. The decision to pass-through exchange rate changes so that local import prices will be lower, however, depends on firms' capacity to meet the expanded demand.

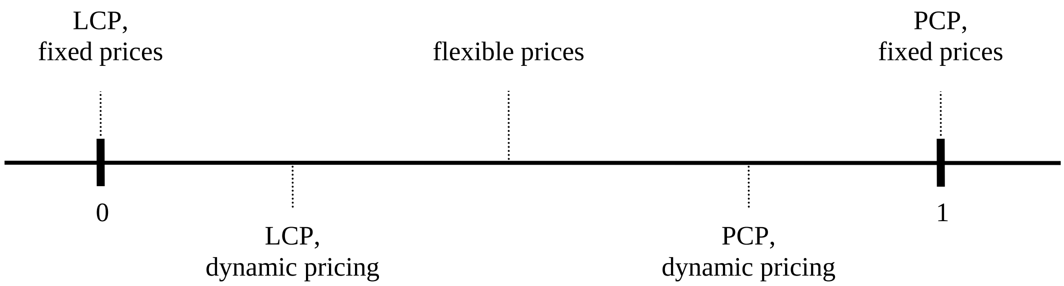
Third, incomplete ERPT can also be explained by demand-side factors. Normally, firms completely passing on a depreciation of the exporter's currency in the long-run to protect their market share from increased arbitrage opportunities of rival firms and entry of new firms into the market. But in the short-run, deviations from complete pass-through occur. One reason is that exporting firms concern less about arbitrage opportunities of rival firms. There may be lags of demand response to price differences because buyers are not instantaneously aware of information about prices. Also, strong relationship between existing firms and their buyers might impede new establishments of new contracts between the buyers and new rival firms. The degree of incomplete pass-through depends also on timing factors. Price differentials which exist for a long time potentially induce rival firms to be aware of the arbitrage opportunity. Additionally, firms contemplating entry into the market are able to recover their fixed costs of entry which are seen as firm's irreversible investment.

Fourth, international transactions are subject to normal lags between placement of the order and payment. If the exchange rate moves during the order-delivery period, the importers will be affected by this exchange rate movement.

Fifth, the currency of invoicing has some influences on the degree of pass-through in the short-run. According to Magee (1973), evidence of incomplete pass-through in the short-run is attributed to the alternative mixes of invoicing currencies used in international transactions. During the "currency-contract" period, prices are fixed under contracts. If the contract is written in the importer's currency, exchange rate movements during the order-payment period should not matter since the importer does not have to bear this exchange rate risk. Import prices do not reflect current exchange rates since prices will not alter until a new contract is negotiated. As a result, pass-through is zero in the short-run. This is equivalent to the so called "Local Currency Pricing (LCP)". On the contrary, if the constract is written in the exporter's currency, short-run pass-through is complete and the exchange rate risk is carried to the importer.

This is equivalent to the so called “Producer Currency Pricing (PCP)”. In general, the currency used in invoicing and the short-run pass-through depends on the relative market power and the risk aversion characteristics of importers and exporters. The discussion so far is relevant to the situation where prices are fixed under contracts. The invoicing currency, however, has little influence on the degree of pass-through if contract prices are flexible. The degree of pass-through between that implied by fixed-price and flexible-price models is illustrated in Figure 3.1.

Figure 3.1
Degree of Pass-Through Implied by Different
Pricing Assumptions



Source: Flodén and Wilander (2006)

From the above figure, it is implied that if prices are fixed, exporters who price (invoice) their exports in exporter’s currency (PCP) completely pass-through exchange rate changes to foreign importers. ERPT equals to one. And exporters who price (invoice) their exports in importer’s currency (LCP) keep their foreign export price constant. Thus, ERPT equals to zero. The flexible-price model implies incomplete ERPT.

However, existing literature (except for example, Goldberg and Tille (2005)) often ignore the possibility that the exporter could choose to invoice in a third “vehicle currency” (VCP), that is neither her currency nor that of her customer. Studies on the role of VCP in ERPT is even more scarce.

Among vehicle currencies, the US dollar is well-known and widely used, possibly due to low transaction costs. In East Asian countries’ trade including

Thailand, US dollar plays an important role as invoicing currency in international transactions. For Thailand, more than 80 percent of exports are invoiced in US dollar. It is therefore necessary to take into account this fact in studying the relationship between exchange rate and export prices.

3.1.3 Pricing-to-Market

Aside from incomplete pass-through and violation of the LOP and PPP in international goods market, another phenomenon known as "pricing-to-market" à la Krugman (1987) has emerged. Pricing-to-market (PTM) occurs when monopolistic export producers with some market power adjust their destination-specific markups in reaction to the exchange rate movements in different markets. PTM behavior is seen as a pricing policy designed to maintain destination-currency export price stability despite changes in exchange rates. Such strategic pricing policy originated in the 1980s when exporting firms in the industrial countries had to cope with large swings of exchange rates and competitive conditions in export markets, particularly the USA. Certainly, PTM implies incomplete pass-through, but not vice versa. PTM and incomplete pass-through are different in that PTM also refers to exporter's price discrimination in different markets in response to the exchange rate changes. Hence, under PTM behavior, the degree of pass-through varies across export markets. This creates price differentials between export markets. According to Krugman (1987), the relative price differences in different markets when the exchange rate changes are important for a situation to be named as PTM. Swift (2001) considers PTM as a sort of third-degree price discrimination, where different groups of buyers pay different prices for the same goods (Pigou, 1920).

This exchange rate induced price discrimination should be evidence against the integrated world market where the LOP holds. Rather, it should be evidence of the segmented world market where products are sold at different prices across countries even though the transaction costs are taken into considerations. To see this more clearly, let us consider the following equations:

$$P_D^X = P_H^X = E_1 P_{F1}^X = E_2 P_{F2}^X \qquad (3.1.13)$$

where P_D^X is the domestic price in H's currency paid by domestic buyers in country H, P_H^X is the export price expressed in H's currency, E_1 and E_2 are the bilateral exchange rates expressed in terms of units of H's currency per unit of F1's and F2's currency, and P_{F1}^X and P_{F2}^X is the foreign currency export prices paid by buyers in country F1 and F2, respectively. Equation (3.1.13) denotes the absolute form of the LOP in multiple foreign markets. The existence of PTM implies that price of exports from country H to country F1 and F2 are not identical in a common currency, i.e.

$$E_1 P_{F1}^X \neq E_2 P_{F2}^X \qquad (3.1.14)$$

Also, if can be inferred that either $E_1 P_{F1}^X$ or $E_2 P_{F2}^X$ (or both) do not equal P_D^X. Exporters in country H vary their export prices in H's currency relative to their domestic prices. All in all, PTM implies that the LOP does not hold and thus the world market is segmented.

That the world market is segmented is agreed in Goldberg and Knetter (1997). Market segmentation creates market power for the exporters and gives them the opportunity to charge different prices for the same goods in different export markets. In addition, market segmentation implies imperfectly competitive market structures where prices charged are above marginal cost. This provides rooms for the exporters to adjust their markups when the exchange rate fluctuates. Knetter (1989, 1995) and Gagnon and Knetter (1995) provide general frameworks in explanation of PTM.

A firm is assumed to produces goods for sale in *n* separate destination markets, indexed by *i*. Demand in each destination market is given by:

$$q_{it} = f_i(e_{it} p_{it}) v_{it} \qquad \begin{array}{l} i = 1, \ldots, N \\ t = 1, \ldots, T, \end{array} \qquad (3.1.15)$$

where q_{it} is quantity demanded by destination market *i* in period *t*, *p* is price in terms of the exporter's currency, *e* is the exchange rate in units of the destination market currency per unit of the exporter's currency, and v is a random that may shift demand, such as competitors' prices. The exporter's costs in domestic currency units can be written as:

$$C_t = C\left(\sum_{i=1}^{n} q_i\left(e_i p_i; \nu_i\right), w\right), \qquad (3.1.16)$$

where C is the total cost function and w is the input price in units of the exporter's currency. The profits of the firm are given by:

$$\Pi(p_1, \ldots\ldots, p_n) = \sum_{i=1}^{n} p_i q_i(e_i p_i; \nu_i) - C\left(\sum_{i=1}^{n} q_i\left(e_i p_i; \nu_i\right), w\right). \qquad (3.1.17)$$

The first order conditions for profit maximization imply that the firm equates the marginal revenue from sales in each market to the common marginal cost. Alternatively, the export price to each destination is the product of the common marginal cost and a destination-specific markup:

$$p_i = MC\left(\frac{\eta_i(e_i p_i)}{\eta_i(e_i p_i) - 1}\right), \quad i = 1, \ldots\ldots\ldots, n, \qquad (3.1.18)$$

where MC is marginal cost, and η is the absolute value of the elasticity of demand in the foreign market with respect to changes in price.

3.2 <u>Model Specification</u>

The study of exchange rate and export price adjustment is based on pricing behavior of exporters. The theoretical framework adopted in this study builds on the model of export price determination formulated in Hung, Kim and Ohno (1993) and Bowe and Saltvedt (2004) and is modified to focus on the main issue, the predominant role of US dollar as export invoicing currency. Under imperfectly competitive oversea markets, a representative Thai exporting firm employs a constant returns to scale production technology[2] with unit cost of production in domestic currency equals to C_t. The firm maximizes profit, Π_t which is given by

$$\Pi_t = (PX_t - C_t)Q_t. \qquad (3.2.1)$$

where PX_t and Q_t denote export price in domestic currency (Baht) and export quantity, respectively. Standard marginal conditions for profit maximization yield

[2] Unless the returns to scale are constant, unit costs are likely to vary with changes in aggregate demand (Hung, Kim and Ohno, 1993: p.6).

$$PX_t = C_t(\frac{\eta_t}{\eta_t - 1}), \quad (3.2.2)$$

where η_t is equal to $-\left(\frac{\partial Q_t}{\partial PX_t}\right)\left(\frac{PX_t}{Q_t}\right)$ which represents the price elasticity of demand in absolute term.

Since Thai exporters rely heavily on US dollar as the currency of invoicing, the export price in terms of Baht is converted into export price in terms of US dollar using the bilateral Baht/US dollar exchange rate, leading to

$$PXD_t = \frac{C_t}{ERD_t}\left(\frac{\eta_t}{\eta_t - 1}\right), \quad (3.2.3)$$

where PXD_t is export price in US dollar and ERD_t is exchange rate expressed in terms of Baht per unit of US dollar.

As in Hooper and Mann (1989), η_t is assumed to depend on price competitiveness in the world market. Define competitiveness as the relative price between export prices in the world market and prices of exports from Thailand:

$$\frac{PC_t}{PXD_t}, \quad (3.2.4)$$

where PC_t is competitors' price denominated in US dollar. Therefore,

$$\eta_t = \eta(\frac{PC_t}{PXD_t}, Z_t), \quad (3.2.5)$$

where Z_t represents all other factors affecting the elasticity.

Combining (3.2.3) and (3.2.5) yields the result that the pricing behavior of a profit maximizing exporter can be described as a variable markup over the unit cost of production

$$PXD_t = \phi_t \frac{C_t}{ERD_t}, \quad (3.2.6)$$

with markup as a function of relative price and other factors

$$\phi_t = \phi\,(\frac{PC_t}{PXD_t}, \mathrm{Z_t}) = \left(\frac{PC_t}{PXD_t}\right)^{\theta} \phi^{'}(\mathrm{Z_t}). \quad (3.2.7)$$

where $\theta \geq 0$ is the elasticity of markup with respect to relative price. The second equality in (3.2.7) derives from the log-linear approximation of the nonlinear function ϕ.

Substituting (3.2.7) into (3.2.6) gives

$$PXD_t = \left(\frac{PC_t}{PXD_t} \right)^{\theta} \phi^{'}(Z_t) \frac{C_t}{ERD_t}$$

Taking logarithmic transformation (signified by lower case variables) results in

$$pxd_t = \alpha + \theta pc_t - \theta pxd_t + c_t - erd_t + u_t$$

$$pxd_t = \frac{\alpha}{1+\theta} + \frac{\theta}{1+\theta} pc_t + \frac{1}{1+\theta} c_t - \frac{1}{1+\theta} erd_t + u_t$$

Let $\gamma = \frac{1}{1+\theta}$, $0 \leq \gamma \leq 1$.

$$pxd_t = \delta + (1-\gamma) pc_t + \gamma c_t - \gamma erd_t + u_t \qquad (3.2.8)$$

If $\gamma = 1$ or, equivalently, $\theta = 0$, export prices are determined solely on the basis of production cost and exchange rate while competitors' prices are ignored as in a monopolistic market. A large θ or small γ indicates that the exporter follows the competitors' prices as if in a perfectly competitive market. So the markup is expected to be lower for a firm with a higher θ.

The relationship between Baht per US dollar exchange rate and export price in US dollar can be measured by γ, which is the elasticity of US dollar export price with respect to THB/USD exchange rate (the degree of pass-through to US dollar price)[3]. The pass-through elasticity is expected to be negative and range from 0 to -1. The following interpretation is applied in this study.

[3] By definition, the degree of exchange rate pass-through, in fact, is the elasticity of export price in importer's currency with respect to exchange rate between importer's and exporter's currency. Because most of Thailand's exports are invoiced in the US dollar, the degree of pass-through in this study refers to the degree in which Baht per US dollar exchange rate changes are transmitted to the US dollar export prices.

When the exchange rate (*erd*) appreciates (depreciates), exporters offset this change by passing-through the exchange rate change to export price in USD (*pxd*), resulting in an increase (decrease) in export price in dollar term (*pxd*). If exporters are price takers, then $\gamma = 0$. This implies that movements in the exchange rate will be fully reflected in the Baht price (*px*) so that prices in terms of USD (*pxd*) remain unchanged. At the other extreme, if the exporter has significant market power and is a price setter on the world market, then changes in *erd* have no effect on the Baht price (*px*) but will be fully reflected in the USD prices (*pxd*) and thus $\gamma = 1$. Between these extremes is the case of incomplete pass-through, where $0 < \gamma < 1$.

For cost (*c*) and competing prices (*pc*) variables, the model predicts their positive relationship with the USD export price (*pxd*).

The theoretical equation (3.2.8) indicates the identical effects of unit cost and Baht per US dollar exchange rate on export price in US dollar. In practice, this restriction does not necessarily hold. Exchange rate is more variable than cost so exchange rate change may be perceived to be transitory, while cost change is likely to be permanent. Exporters, therefore, are likely to be less sensitive to exchange rate changes than to changes in cost of production.[4] Consequently, the restrictions suggested by the theoretical equation is relaxed, leading to the following estimable equation

$$pxd_t = \delta + \gamma c_t - \beta erd_t + \lambda pc_t + u_t \qquad (3.2.9)$$

The interpretation of (3.2.9) is similar to that of (3.2.8). The only difference is that in (3.2.9) coefficient restrictions are removed.

The above pass-through equation implicitly assumes that directions of exchange rate movements, i.e. appreciation and depreciation have identical influence on the adjustment of export price in USD. Equivalently, exchange rate pass-through is asymmetric during appreciation and depreciation. As already stated, some empirical pass-through literatures have found that exchange rate pass-through is asymmetric. To

[4] This conjecture is concerned in Bache (2002) and Barhoumi (2006). Athukorala and Menon (1995) attributes this to reasons such as the incompatibility of price proxies. However, there exists studies testing for coefficient restrictions in pass-through model. See, for example, Bowe and Saltvedt (2004) and Swift (2004).

fulfill the second objective of this study, the equation (3.2.9) is modified to capture the possible asymmetry in pass-through relationship.

In order to explore the asymmetry in exchange rate pass-through relationship, the empirical method constructed in Webber (2000) is utilized. The advantage of this method is twofold. First, long-run asymmetry is examined, as apposed to short-run asymmetry. Second, the long-run asymmetry effects are not examined using dummy variables, which restrict an analysis to particular time frames that contain continuous appreciation or depreciation episodes. Following Webber (2000), the logarithm of the exchange rate, *erd*, at any point in time *t* can be decomposed into periods of appreciation and depreciation as follows:

$$erd_t = erd_0 + erd_t^A + erd_t^D \qquad (3.2.10)$$

where erd_0 is the initial value of the exchange rate series,

$$erd_t^A \equiv \sum_{i=1}^{t} \psi_i (erd_i - erd_{i-1}),\ \psi_i = 1 \text{ for } erd_i < erd_{i-1} \text{ and } \psi_i = 0 \text{ for } erd_i > erd_{i-1}$$

$$erd_t^D \equiv \sum_{i=1}^{t} \psi_i^* (erd_i - erd_{i-1}),\ \psi_i^* = 1 \text{ for } erd_i > erd_{i-1} \text{ and } \psi_i^* = 0 \text{ for } erd_i < erd_{i-1}$$

Hence, the variable erd_t^A denotes the accumulated sum of the appreciation episodes and erd_t^D the accumulated sum of the depreciation episodes. To test for long-run asymmetry,

only the data series relating to one of the episodes has to be incorporated to the pass-through equation. Here, only the series for depreciation episodes is included in the tests for long-run asymmetry, resulting in the following pass-through equation:

$$pxd_t = \delta + \gamma c_t - \beta_1 erd_t - \beta_2 erd_t^D + \lambda pc_t + u_t \qquad (3.2.11)$$

Relying on erd_t and erd_t^D in the above equation, conclusions about the influence of erd_t^A can be drawn. The pass-through coefficient of depreciation episodes is $-(\beta_1 + \beta_2)$, while that of appreciation episodes is $-\beta_1$. The restriction that the pass-through is symmetric ($\beta_2 = 0$) is tested against the asymmetric pass-through.