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Nominal Anchor Exchange Rate Policy and Equilibrium Real Exchange Rate: The Case of Thai Baht

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Abstract

Until June 1997, the Thai government maintained a currency basket exchange rate system, under which Thai baht was tied to a basket of major foreign currencies with a weight assigned to each currency. Although the weighting method was claimed to be a trade-weighing scheme, our econometric estimates reveal that a significantly large weight was given to the US dollar, which was not proportional to the USA's trade weight with Thailand among the major trading countries. In fact, Thai baht was nominally anchored to the US dollar under the currency basket system. There are some researches claiming that Thai baht was overvalued in real terms before the currency crisis, which might be associated with the increasing current account deficits, and that in particular the US dollar-pegged currency–weighted method was responsible for such real overvaluation of Thai baht. In order to examine these claims, we studied whether the real effective exchange rate under the currency basket system was misaligned with a long-run equilibrium value of real effective exchange rate. Using a theoretical model of the long-run equilibrium real exchange rate, we estimated an error correction model encompassing the observed real effective exchange rate and the fundamental macroeconomic variables that may determine the long-run equilibrium rate. We find that there surely exits a long-run relation between the realized real effective exchange rate and the fundamental macroeconomic variables that determine it. When an equilibrium error occurs in their long-run relation, an equilibrating force to correct the equilibrium error is found to work. Furthermore, we find evidence that the nominal anchor based, observed real effective exchange rate tends to narrow the gap with a hypothetical pure trade-weighted real effective exchange rate, toward the long-run equilibrium exchange rate, in a dynamic context.

1. Introduction

In July 1997, the Thai government abandoned the fixed exchange rate system, which had been implemented as the currency basket exchange rate scheme, and switched to a managed floating exchange rate system. The currency basket exchange rate system had been maintained for twelve-and-half years since November 1984, before which a pure fixed exchange rate system with Thai baht pegged to a single currency, the US dollar, had been the exchange rate scheme. The main reason of abolishing the currency basket exchange rate system, which was a version of the adjustable fixed exchange rate system, is that foreign exchange reserves held by the Bank of Thailand was about to be depleted just before the incidence of the currency crisis. The crisis of near depletion of the central bank's foreign exchange reserves resulted from their efforts to defend the fixed exchange rate under the currency basket scheme in the foreign exchange market, in face of big and precipitous net outflows of foreign short-term capital from the Thailand's capital markets. Such sudden withdrawal of short-term capital stemmed from the fear by some international investors and foreign banks about possible devaluation of Thai baht in the near future. As a main factor causing such international investors and banks to suspect near-future devaluation, and thus to withdraw their short-term capital from the financial market, some researchers pointed out that Thai baht had been overvalued for some periods before the currency crisis in July 1997, for example Sachs and Woo (2000), Flatters (2000), Roubini, Corsetti and Pesenti (1998), among others. They pointed out the possibility of Thai baht's overvaluation preceding the currency crisis by examining rapid and increasing current account deficits; the current account deficits, at 1988 constant price, of 183.3 billion baht in 1994 jumped to 280.9 billion baht in 1995 and 296.6 billion baht in 1996. The switch to the floating exchange rate system and subsequent rapid depreciation of Thai baht gave rise to epidemic panics among the international investors and foreign banks, which led to further massive withdrawal of their short-term capital invested in the Thailand's capital market. As a result of such risk-avoiding movement, Thai baht collapsed from 25 baht per US dollar on June 30, 1997, to 55 baht per dollar in mid-January (Flatters, 2000).

Some researchers analyzed that the currency basket exchange rate system was in fact a US dollar-pegged exchange rate system, so that as the US dollar appreciated against major currencies like Japanese yen and German mark since the 3rd quarter of 1995, Thai baht was dragged to appreciate against the currencies of her major trading countries, which might have exerted negative effects on the current account deficits (Higashi, 2001). Some researchers further suggested that if the currency basket exchange rate system had been implemented exactly as the name implied, i.e. if appropriate weights had been given to each currency in the basket based on trade-value weights, the overvaluation of real exchange rate, and hence the increasing current account deficits might have been avoided. We consider the validities of these arguments.

Under the currency basket exchange rate system, Thai baht was pegged to a basket of currencies of major trading partner countries with an officially determined weight assigned to each currency. It was officially announced as a system using trade-value weights as the weighting scheme for each currency in the basket, although the actual weight on each currency was not publicized (Chaiyawat and Tanwanich, 1993). As the bilateral exchange rate fluctuates among any pairs of currencies under the floating exchange rate system, Thai baht should also have exhibited some fluctuations with each of the currency in the basket. The exchange rates data shows, however, that the baht-US dollar exchange rate stayed fairly constant throughout the period, despite fluctuations of the US dollar's bilateral exchange rate with other major currencies. On the other hand, the baht-Japanese yen rate showed fluctuations that mimicked the movement of the yen-US dollar rate. Therefore, it was generally conjectured by the economists and market participants that the Thai authority assigned a large weight to the US dollar that was not proportional to the US's trade weight with Thailand in the basket[1]. In this sense, Thai baht has a nominal anchor to the US dollar. The acclaimed reasons for such nominal anchor policy are first the dominance of the US dollar as the international currency for transaction settlement. Second reason is the potential capital loss, caused by the fluctuation of the baht-US dollar rate, on the part of borrowers of foreign capital, most of which was denominated in the US dollar. With the USA's share in total trade with the countries in the basket being only 20%, the nominal anchor of Thai baht to the US dollar could result in potentially large fluctuations of bilateral exchange rate with other currencies. These fluctuations of the bilateral rates, in turn, might have influenced the current account of Thailand. We may call this de facto US dollar-pegged exchange rate policy "currency-weighted basket system", in comparison to the conventional "trade-weighted basket system".

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[1] Trade with the USA accounted for only 20% of the total trade with fourteen countries in the basket I constructed. For the list of the fourteen countries, see section 2.2.

The purpose of this paper is to examine whether the nominal anchor foreign exchange rate policy, with baht tied to the US dollar, during the period of the currency basket system in fact led to some misalignments of Thai baht's real exchange rate. The real exchange rate is an important macroeconomic variable, determined endogenously within the economic system, that is associated with international competitiveness of home country's goods, and thus with the evolution of the current account. If the nominal anchor foreign exchange rate policy generated actual real exchange rates that were misaligned with some equilibrium values consistent with macroeconomic equilibrium, such foreign exchange policy may be judged as an inappropriate one. As such an equilibrium value of real exchange rate, we consider the concept of long-run equilibrium real exchange rate. The long-run equilibrium real exchange rate is defined as the value of the real exchange rate that is consistent with the dual objectives of internal and external balance, for specified values of other variables that may influence these objectives (Nurkse, 1945). The internal balance refers to a situation in which the market for nontraded goods is in a sustainable equilibrium at full employment level (Montiel, 1999a). The external balance refers to a situation in which the value of the current account deficit is equal to the net capital inflow necessary to sustain the steady-state value of the net international creditor position (Montiel, 1999a).

Focusing on the entire period of the currency basket exchange rate system between November 1984 and June 1997, we estimated a model of long-run equilibrium real exchange rate with the data of actual real exchange rate and some fundamental macroeconomic variables associated with the long-run equilibrium real exchange rate. The rationale of this research agenda is whether we can statistically identify, from the data, the long-run equilibrium real exchange rates that are consistent with the fundamental macroeconomic variables determining them. If such long-run equilibrium real exchange rates are identified from the data, then we may be allowed to judge that the nominal anchor exchange rate system, tied mainly to US dollar, did not lead to misalignments of the real exchange rates. It must be noted, however, that because this is a statistical analysis of the long-run equilibrium real exchange rates taking the full period of currency basket exchange system as the sample period, we may not be able to preclude the possibility of short-run misalignment of the real exchange rate, such as the real exchange rate overvaluation during six months before the currency crisis. In our econometric analysis, such short-run deviation from the long-run equilibrium level is tested for the existence of an adjustment movement (error correction) toward the long-run equilibrium level.

The equilibrium real exchange rate and actual real exchange rate's misalignment have been studied theoretically and empirically by several researchers, who include Edwards (1989, 1994), Montiel (1997, 1999), and Baffes, Elbadawi and O'Connell (1999), among others. Based on these previous studies, this paper focuses on the case of Thai baht, using the methodologies in line with such previous researches about the long-run equilibrium real exchange rates. As the theoretical model of the long-run equilibrium real exchange rate, we follow the model of Montiel (1999b), which is a modified version of the standard dependent economy model à la Dornbusch (1983). With regard to the econometric model, we estimated an error correction model for nonstationary variables to identify the long-run equilibrium real exchange rate and its long-run equilibrium relation with the fundamental macroeconomic variables that determine the equilibrium rate. However, we made one important extension to the base empirical model. We tried to assess the effect, toward the equilibrium real exchange rate, of the deviation of the real exchange rate realized under the nominal anchor policy from that obtained under a theoretical pure trade-weighted exchange rate scheme. For this purpose, we computed hypothetical real effective exchange rates that would have evolved if the Thai authority had followed a strict trade-weighted currency basket policy in determining the bilateral exchange rates in the currency basket. The construction method of such hypothetical real effective real exchange rate is somewhat complicated, and therefore explained in detail in the Appendices and in section 2.3. Instead, we briefly outline the main idea here. Starting with November 1984 as the base year when the currency basket exchange system was initiated, we compute the quarterly change of the value of national currency per SDR for each currency in the basket, and use trade-weight for each currency to compute real effective exchange rate. We call this hypothetical real effective exchange rate "SDR-based trade-weighted real effective exchange rate", and use a notation $REER^{SDRTW}$. In contrast to this, the observed real effective exchange rate, termed as $REER^{CW}$, is computed based on the observed bilateral nominal exchange rates with major foreign currencies in the basket. That is, it is computed as $REER^{CW} = (NEER^{CW} \cdot P_f) / P_{TH}$, where $NEER^{CW}$ is the trade-weighted nominal effective exchange rate index, P_f is the trade-weighted foreign price index, and P_{TH} is the price index of Thailand. See Appendices for further detail on the construction method of this observed real effective exchange rate index. We name this observed real effective exchange rate "Currency-weighted real effective exchange rate". Note that the name "currency-weighted" refers to the situation in which the observed bilateral nominal exchange rates have reflected the Thai authority's arbitrary weighting scheme for each currency in the basket, but that in constructing the "Currency-weighted real effective exchange rate", we used actual trade weight for each currency in the basket.

Our extension to the econometric experiments is to find the effects of the hypothetical SDR-based trade-weighted real effective exchange rate on the evolution of the long-run equilibrium real exchange rate. In particular, we are interested in testing whether the nominal anchor policy induced difference in the real effective exchange rates, i.e. the difference between $REER^{SDRTW}$ and $REER^{CW}$, has a dynamic adjustment mechanism to pull the observed currency-weighted real effective exchange rate $REER^{CW}$ close to the theoretical SDR-based trade-weighted real effective exchange rate $REER^{SDRTW}$ in the following periods.

We briefly summarize the main econometric findings here. The estimation results of the error correction models reveal that there exists a long-run equilibrium relation between the currency-weighted real effective exchange rate $REER^{CW}$ and such fundamental variables determining the long-run equilibrium real exchange rate as: composition of government's spending, i.e. traded goods or nontraded goods: trade balance: terms of trade: degree of trade intervention: differential productivity growth between traded goods sector and nontraded goods sector - so called, the Harrod-Balassa-Samuelson effect. Moreover, the error correction adjustment parameter indicates that when there occurs an equilibrium error in the real exchange rate in the previous period, a force works to correct the equilibrium error toward achieving the long-run equilibrium real exchange rate in the current period. Furthermore, when we include the one-period lagged difference between $REER^{SDRTW}$ and $REER^{CW}$ as an exogenous variable, it has positive statistical association with current change in the currency-weighted real effective exchange rate. This indicates for example that when the observed currency-weighted real effective exchange rate appreciated relative to the theoretical SDR-based trade-weighted real effective exchange rate in the previous period, the observed real exchange rate tends to depreciate to narrow the gap with the SDR-based real exchange rate in the current period. Thus, both the error correction term and the difference between the two measures of real effective exchange rates will force the observed real exchange rate to move toward the long-run equilibrium real exchange rate.

This paper is organized as follows. In section 2, after briefly reviewing the foreign exchange rate policy of the Thai government, we estimate the weights assigned to each major foreign currency in the basket, and compare the computed currency-weighted real effective exchange rate and SDR-based trade-weighted real effective exchange rate. In section 3, the general equilibrium model of long-run equilibrium real exchange rate is introduced. Section 5 shows estimation results and their analyses. The final section summarizes the findings and draws a conclusion.

2. The foreign exchange rate regimes of the Thai government

2.1 A brief history of the foreign exchange rate policies

The foreign exchange rate regime of Thailand underwent several major revisions during the past thirty years (Suwanmana, 1993). It is classified into five phases. In the first phase from 1963 to 1978, which includes the period of the Bretton-Woods system, Thai baht was fixed to the US dollar and gold with several episodes of devaluation. In March 1978, the fixed link to the US dollar was abolished, and baht was pegged to a basket of major currencies (second phase). This basket method of exchange rate had a short live; in November 1978 the exchange rate began to be determined under a managed floating system. Under this managed floating system (phase 3), the baht-US dollar exchange rate was determined under a managed market mechanism between the Exchange Equalization Fund (EEF)[2] and the representatives of major commercial banks. In July 1981, the exchange rate system returned to the US dollar-pegged system (phase 4). This US dollar-pegged system lasted until November 1984. Because the US dollar was overvalued during this period due to the "Reaganomics" policy, however, Thai baht was also overvalued against major foreign currencies. Consequently, trade balance worsened and international reserves approached the critical minimum level. The Thai government was forced to launch stringent government's expenditure policies as well as measures to increase the revenue. The foreign exchange rate policy was another major policy issue to improve the current account. With this aim, the bilateral exchange rates of baht began to be determined by "Basket method" from November 1984, under which the bilateral exchange rates of baht were determined in

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[2] Exchange Equalization Funds is Thai government's foreign currency deposit at Bank of Thailand. Bank of Thailand uses this fund to stabilize the baht-US dollar exchange rate.

reference to trade weights of the major trading partners (phase 5 until June 1997).

The basket method of exchange rates is, in its official definition, a trade-weighted average of market exchange rates with foreign currencies in the basket. Therefore, if the trade with the USA absolutely dominates the total value of trade, the official baht-US dollar rate under the basket will mimic its market baht-US dollar rate. Although the Thai authority did not reveal the exact weight assigned to each major foreign currency, Tasaka (1996) estimated that about 80~82 percent weight was given to the US dollar in 1992. His estimate shows that the remaining weights are assigned to the Japanese yen (10~13%), German mark (6~8%), and Singapore dollar, Hong-Kong dollar, and other currencies of major trading partner countries of Thailand[3]. On the other hand, the actual trade weights of the major trading partners are 16.5% with the USA, 24.1% with Japan, 4.9% with Germany, and 54.5% with the other countries in 1992 (Tasaka, 1996).

It appears that an excessively large currency-based weight was given to the US dollar, while the Japanese Yen received a much smaller currency weight compared to the trade weight. The plausible reasons for such a US dollar-dominated policy of basket-weight exchange rate determination are two folds. The first is the dominance of the US dollar as the international, transaction settlement currency. Tasaka (1996) shows, from the Bank of Thailand's statistics, that ninety one percent of total export and seventy five percent of total import were settled by the US dollar in 1992, respectively. Second reason is the potential capital loss on the part of borrowers of foreign capital. Since most of the foreign capital inflow was made in terms of the US dollar, swings of the baht-US dollar rate might have discouraged foreign capital inflows.

2.2 Estimating the currency weights

We estimated the unobserved weight assigned to each foreign currency in the basket from the exchange rate data between November 1984 and June 1997. Since it is unlikely that the Thai authority put all foreign currencies in the basket, we first selected the

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[3] He made estimates of the weights based on interviews with the staffs of local and foreign commercial banks. Frankel and Wei (1994) estimated the weights with monthly data from January 1991 to May 1992. They found estimated weights of about 80% on the US dollar, 10% on Japanese yen, and 10% on German mark. See also Warr and Nidhipraba (1996).

currencies of the major trading partners of Thailand from values of external trade. During the sample period, the following fourteen countries accounted for 70.4%, on average, of Thailand's total value of trade (export plus import) with the world; Japan, USA, Germany, UK, France, Italy, Netherlands, Australia, Singapore, Malaysia, South Korea, China, Hong Kong and Taiwan. We assume that the currencies of these fourteen countries comprise the currency basket operated by the Thai authority. Among this fourteen countries' group, the share of trade of Japan within the group was 29.9%, followed by USA (20.1%), Singapore (10.6%), Germany (6.2%) and UK (3.7%). The other nine countries accounted for the rest 29.5% of the total value of trade within the group. We, therefore, picked up the above major five countries' currency for direct estimation of their weights in the basket, and combined the other nine countries' currencies into a composite foreign exchange index by the geometric mean method.

Let $USD_t, JPY_t, GRM_t, UKP_t, SPD_t$ *and* $OTHER_t$ be the value of SDR (Special Drawing Right) in terms of the US dollar, Japanese yen, German mark, UK pounds, Singapore dollar and the composite of other nine currencies, respectively. By assumption, these five major currencies and a composite of other nine currencies are put into the basket. Let $\beta_1, \beta_2, \beta_3, \beta_4$ *and* β_5 be the weight assigned to logarithm of the exchange rate vs. SDR of each of the major five currencies: $USD_t, JPY_t, GRM_t, UKP_t,$ *and* SPD_t. It follows that the weight assigned to logarithm of the exchange rate of the composite nine currencies β_6 is

$$\beta_6 = 1 - (\beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5). \tag{2.1}$$

Assuming a linear relationship between the value of SDR in terms of Thai baht (THB_t) and the exchange rates of major six currencies, we may estimate the following equation by OLS.

$$\begin{aligned}\ln(THB_t) = \alpha_0 + \alpha_1 \cdot T + \beta_1 \cdot \ln(USD_t) + \beta_2 \cdot \ln(JPY_t) + \beta_3 \cdot \ln(GRM_t) \\ + \beta_4 \cdot \ln(UKP_t) + \beta_5 \cdot \ln(SPD_t) + \beta_6 \ln(OTHER_t) + \varepsilon_t.\end{aligned} \tag{2.2}$$

In equation (2), we added an intercept and a time trend term T.

In order to impose the share restriction, we substitute equation (2.1) into equation (2.2) to obtain the following equation for estimation,

$$\begin{aligned}\ln(thb_t) = \alpha_0 + \alpha_1 \cdot T + \beta_1 \cdot \ln(usd_t) + \beta_2 \cdot \ln(jpy_t) + \beta_3 \cdot \ln(grm_t) \\ + \beta_4 \cdot \ln(ukp_t) + \beta_5 \cdot \ln(spd_t) + \varepsilon_t,\end{aligned} \tag{2.3}$$

where the lower letter variable measures the difference between logarithm of the exchange rate of a major currency (for example, $\ln(USD_t)$) and logarithm of the exchange rate of the composite nine currencies ($\ln(OTHER_t)$). The estimated coefficient on each major currency, normalized by the composite exchange rate of the other nine currencies, shows the estimated currency weight that the Thai government assigned to each currency in the basket.

Warr and Nidhipraba (1996) estimated a similar equation by OLS with the data of the US dollar, Japanese yen and Singapore dollar as the major currencies, and a composite exchange rate index of seven other currencies during the time period from November 1984 to December 1992. Their estimated weights on major currencies in the sample period are 66% on the US dollar, 9% on Japanese yen, and 16% on Singapore dollar. They further decomposed the OLS estimate of each currency into a currency intercept term using a currency dummy variable, and a currency slope term, by assuming a linear trend of the weights on major currencies. They found that the Thai authority put increasingly larger weights to the US dollar over time in the basket.

Since there is no a-priori reason to believe that the weight to each currency changes linearly over time, we simply divide the whole sample period into two sub-periods to see whether the weight to each major currency changed significantly during the sample period.[4] Our full sample covers monthly data spanning from November 1984 to June 1997. We further divide the full sample period into two sub-periods: the first period from November 1984 to May 1992, and the second period from June 1992 to June 1997. The rationale to divide the full sample period this way rests on the Thai government's deregulation of foreign exchange controls. In response to IMF's guidance on financial market and foreign exchange market liberalization, coupled with the private sector's demand for demolition of foreign exchange controls, the Thai government started to deregulate the foreign exchange control gradually since May 1990. A series of revisions of the Foreign Exchange Act, which include May 1990, April 1991, May 1992, February 1994 and creation of Bangkok International Banking Facilities (BIBF) –the off shore market- in 1993, led to a large influx of foreign short-term capital since 1992. Because inflow of foreign capital, most of which is denominated in the US dollar, is likely to influence the

[4] As an alternative method, we may be able to use the state-space model with Kalman filter algorithm to estimate time varying coefficients (see Hamilton, 1994).

Table 1. Estimation of Currency Weights

Variables	Full sample period: 1984/11–1997/6 Coefficients	Sub-sample period (1) 1984/11– 1992/5 Coefficients	Sub-sample period (2) 1992/6– 1997/6 Coefficients
Constant	2.7460*** (0.0406)	2.7588*** (0.0639)	2.7306*** (0.0583)
$\ln(usd_t)$	0.7561*** (0.0158)	0.7395*** (0.0264)	0.8217*** (0.0251)
$\ln(jpy_t)$	0.1048*** (0.0043)	0.1111*** (0.0078)	0.1027*** (0.0061)
$\ln(grm_t)$	0.0263*** (0.0081)	0.0196* (0.0115)	0.0512*** (0.0125)
$\ln(ukp_t)$	0.0202*** (0.0054)	0.0182* (0.0102)	0.0163** (0.0070)
$\ln(spd_t)$	0.0380** (0.0168)	0.0487** (0.0233)	-0.0073 (0.0284)
Trend	0.0003*** (0.00006)	0.0003** (0.0001)	0.00028** (0.0001)
Adjusted R^2	0.9989	0.9984	0.9988
Durbin-Watson statistics	2.1289	2.3957	1.8530
F-statistics (probability)	18600.3 (0.0000)	6949.4 (0.0000)	7215.6 (0.0000)

Note: 1. Monthly data

2. OLS estimation results adjusted for first-order serial correlation by Cochrane-Orcutt method.

3. Figures in parenthesis are standard errors. Asterisks ***, **, * stand for 1% significance level, 5% level and 10% level, respectively.

4. Dependent variable is $\ln(thb_t)$. thb_t: Thai Baht per SDR, usd_t: US Dollar per SDR, jpy_t: Japanese Yen per SDR, grm_t: German Mark per SDR, ukp_t: UK Pounds per SDR, spd_t: Singapore Dollar per SDR. Each exchange rate is divided by a composite of exchange rates per SDR of other currencies ($OTHER_t$); France Franc, Italy Lira, Netherlands Guilder, Australia Dollar, South Korea Won, China Yuan, Hong Kong Dollar, Taiwan Dollar, and Malaysia Ringgit.

baht-US dollar rate, we need to split the sample period for estimation to reflect a possible structural change. In order to gain a statistical ground for how to split the sample period, we experimented the Chow test for a structural change after estimating the full sample equation (Chow, 1960). By successively conducting the Chow test starting from January 1988, we obtain insignificant F statistic for the first time in June 1992. The F statistic is 1.4956 whose probability is 0.1655. We cannot reject the null hypothesis of a structural break in June 1992. Thus, we divide the sample period into two sub-periods with June 1992 being the time of the structural break.

The estimation results are shown in Table 1. All data are taken from the International Financial Statistics of IMF. The estimation result of the full sample period shows that the currency weight on the US dollar is 75.6%, while those on Japanese yen, German mark, UK pounds, and Singapore dollar are 10.5%, 2.6%, 2.0% and 3.8%, respectively. During the same sample period, the shares of trade of each country within the major trading partners group are 20.1% (USA), 29.9% (Japan), 6.2% (West Germany), 3.7% (UK) and 10.6% (Singapore). Obviously, an unparalleled large weight was given to the US dollar in the basket, while Japanese yen was assigned the least weight relative to the trade weight. The currency weight on the US dollar increased between the two sub-sample periods: in the second sub-period (June 1992 ~ June 1997) it is 82.2%, which is larger than the weight of 73.9% in the first sub-period (July 1984 ~ May 1992). The currency weight on Japanese yen remains relatively constant: 10.3% in the second period in comparison to 11.1% in the first period. Another gain comes for German mark: the second period's weight increased to 5.1% from the weight of 2.0% in the first period. This is probably due to the increasing involvement of German companies' transactions with Thai economy in terms of direct investment and foreign trade. On the other hand, Singapore dollar's weight dropped significantly from 4.9% in the first sub-period, to close to zero in the second sub-period, although the latter estimate is not statistically significant.

2.3 Currency-weighted real exchange rates vs. SDR-based trade-weighted real exchange rates

As explained in the introduction section, we computed two measures of real effective exchange rates: the currency-weighted real effective exchange rate $REER^{CW}$ and the SDR-based trade-weighted real effective exchange rate $REER^{SDRTW}$. The currency-weighted real effective exchange rate is the trade-weighted, observed real effective exchange rate computed, using the realized bilateral nominal exchange rate with the major foreign currencies in the currency basket, and price indices of the trading partner countries. We included the bilateral nominal exchange rates of major fourteen trading partner countries of Thailand, which are listed in section 2.2.

The SDR-based trade-weighted real effective exchange rate, on the other hand, is a hypothetical real effective exchange rate constructed, using the value of national currency per SDR for major currencies in the basket. We first computed a series of hypothetical baht per SDR ratios $Basket\left(\frac{baht}{SDR}\right)_t$ under the foreign currency basket scheme, which was computed using a trade-weighted average of the national currency-SDR rates of the major fourteen trading partner countries in the basket. The computation method is as follows. Let the base period t_0 be November 1984. Index the realized baht per SDR in the base period by 100;

$$\left(\frac{baht}{SDR}\right)_{t_0=1984/11} = 100 .$$

For the succeeding period $t_0 + h,\ h = 1,2,3,---$, define $Basket\left(\frac{baht}{SDR}\right)_{t_0+h}$ by

$$Basket\left(\frac{baht}{SDR}\right)_{t_0+h} = \left(\frac{baht}{SDR}\right)_{t_0+h-1} \cdot \left[1 - \sum_i TW^i_{t_0+h} \cdot \frac{\Delta\left(\frac{NC_i}{SDR}\right)_{t_0+h}}{\left(\frac{NC_i}{SDR}\right)_{t_0+h-1}}\right], \qquad (2.4)$$

where the term $\left(\frac{NC_i}{SDR}\right)_{t_0+h-1}$ is the value of national currency i per SDR at the end of period $t_0 + h - 1$, the term $\Delta\left(\frac{NC_i}{SDR}\right)_{t_0+h}$ is the change in the value of currency i per SDR during the period $t_0 + h$, and the term $TW^i_{t_0+h}$ is country i's trade weight with Thailand in the total trade of fourteen countries in the basket. The second term in the bracket of equation (2.4) measures a trade-weighted average of the percentage changes of depreciation, or appreciation, of the foreign currencies per SDR in the basket. Suppose that the trade-weighted average of the changes in the foreign currency values per SDR exhibits depreciation. Then, Thai baht is assumed to have appreciated, on average, against the currencies in the basket, which is captured by the appreciation of $Basket\left(\frac{baht}{SDR}\right)_{t_0+h}$. We recursively computed the series $Basket\left(\frac{baht}{SDR}\right)_{t_0+h}$ for $h = 1,2,3,---$, during the period between November 1984 and June 1997. After computing it, we constructed the SDR-based trade-weighted real effective exchange rate index which is shown in equation (2.5)

$$REER_t^{SDRTW} = \sum_i \left(\frac{ESDR_t^{Thai}}{ESDR_t^i} \cdot \frac{P_t^i}{P_t^{Thai}} \right) \cdot TW_t^i . \qquad (2.5)$$

In equation (2.5), we set $ESDR_t^{Thai} \equiv Basket\left(\frac{baht}{SDR}\right)_t$. The variable $ESDR_t^i \equiv \left(\frac{NC_i}{SDR}\right)_t$ is the indexed value of national currency i per SDR at period t, and the variables P_t^{Thai}, P_t^i are price index of Thailand, and that of country i, respectively. The variable TW_t^i is the trade weight of country i.

The normalized series of $REER^{CW}$ and $REER^{SDRTW}$, with the value on November 1984 set equal to 100, are plotted in Figure 1. First, take a look at the observed real effective exchange rate $REER^{CW}$ - the thick line in the figure. Reflecting the US dollar's sharp nominal depreciation against the major foreign currencies since September 1985, the real effective exchange rate $REER^{CW}$ first exhibited a sharp real depreciation trend until the end of 1988. Since the first quarter of 1989, however, $REER^{CW}$ appears to be relatively stable until the second quarter of 1995, although we can observe a slightly depreciating trend between second quarter of 1991 and second quarter of 1995. After recording the highest value of 128.1 in the second quarter of 1995, $REER^{CW}$ continued to appreciate sharply until the second quarter of 1997. The real effective exchange rate appreciated by 15.8 percent in two years from the second quarter of 1995 with the value 128.1, to the second quarter of 1997 with the value 107.9. This is the reason why some researchers suspected the overvaluation of the real exchange rate since 1995. However, if we compare the average real effective exchange rates between two periods, one from the second quarter of 1991 to the first quarter of 1995, and the other from the second quarter of 1995 to the second quarter of 1997, the real appreciation in the latter period does not appear to be much profound. The average real effective exchange rate in the latter period is 114.6, which is only 4.3 percent smaller than the average value (119.7) in the former period.

Next, take a look at the graph of the SDR-based trade-weighted real effective exchange rate index $REER^{SDRTW}$ - the dotted line in Figure 1. Because unlike the currency-weighted real effective exchange rate $REER^{CW}$, the share of US dollars in the basket is much smaller, $REER^{SDRTW}$ did not show a depreciation trend since September 1985. It stayed fairy constant between November 1984 and the second quarter 1989, then appreciated about 14.6 percent between the second quarter 1989 and the third quarter 1990. Between the fourth quarter of 1990 and the second quarter of 1995, it remained relatively stable with small magnitude of ups and downs. Starting at the third quarter in 1995, $REER^{SDRTW}$ continued to appreciate until the second quarter of 1997. The percent of real appreciation in terms of $REER^{SDRTW}$ is 16.2 percent in two years between the second quarter of 1995 and the second quarter of 1997, which is similar to the magnitude of real appreciation in terms of $REER^{CW}$ during the same period.

We compared the two real exchange rate series by taking difference;

$$DIFFRER \equiv REER^{SDRTW} - REER^{CW}. \qquad (2.6)$$

The real exchange rates differential $DIFFRER$ is plotted in Figure 2, where we normalized the series by setting the value of the first quarter of 1989 equal to zero. Apart from the first two years when the observed real effective exchange rate sharply depreciated, the differentials indicate consistent under-valuation of the observed real effective exchange rate compared to the SDR-based trade-weighted real effective exchange rate, except for a short period between the second quarter and third quarter of 1989. The average differential between the fourth quarter of 1989 and the first quarter of 1995 is –6.81, whereas the average between the second quarter of 1995 and the second quarter of 1997 is –11.35. Hence, the SDR-based trade-weighted real effective exchange rate appreciated more than the observed real effective exchange rate since the second quarter of 1995.

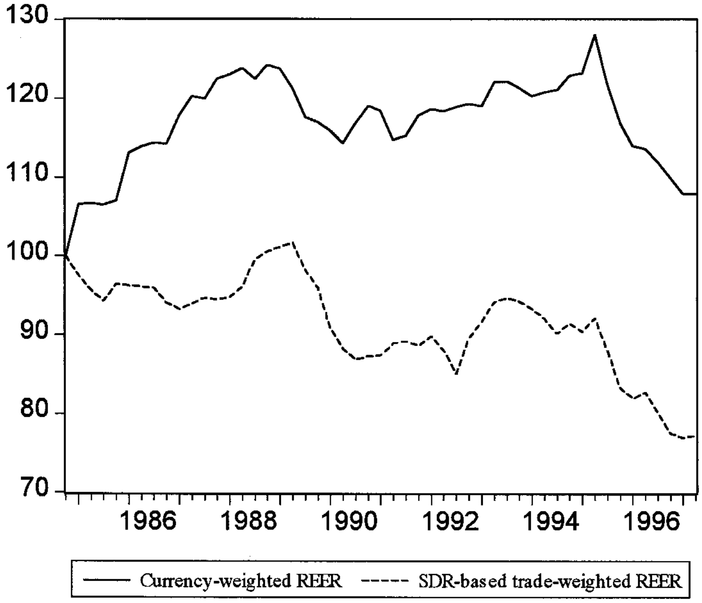
From the observation of the two figures, we may draw a few remarks. First, although the observed, currency-weighted real effective exchange rate did appreciate since the third quarter of 1995 until the time of the currency crisis, the average magnitude of $REER^{CW}$ during that period does not appear to be significantly low, compared to the average magnitude between the second quarter of 1991 and the second quarter of 1995. Second, because the value of currency-weighted real effective exchange rate consistently exceeded the value of SDR-based trade-weighted real effective exchange rate in the 1990s when the real exchange rate differential in the first quarter of 1989 set equal to zero, we may not be able to conclude that the nominal anchor exchange rate policy with baht pegged mainly to the US dollar caused appreciation of the real exchange rate in the 1990s. If the Thai government instead had used strict trade-weighting scheme as the basket method, the realized real effective exchange rate might have appreciated at a larger extent than the case of the nominal anchor currency basket method.

3 The model of the long-run equilibrium real exchange rate

The base theoretical model we use for laying out the econometric specification of the long-run equilibrium real exchange rate is the model developed by Montiel (1999b). Montiel's model is an extension of the dependent economy model of Dornbusch (1983) that studied two-sector dependent economy structure of a developing economy. In Montiel's model, the economy is characterized as a two-sector dependent economy where traded goods and nontraded goods are produced, and as having a crawling peg exchange rate system with the domestic financial market open to the international market. Wages and prices are assumed to be flexible.

The long-run equilibrium real exchange rate is defined as the value of the real exchange rate that emerges when the economy attains both external balance and internal balance for sustainable values of policy and exogenous variables (Montiel, 1999a). The external balance may be defined as the economy's maintaining either the sustainable net capital flows or maintaining sustainable stock of external liabilities. We follow the Montiel's approach that the economy's external balance obtains when capital account balance is in the steady-state equilibrium at the sustainable level in the long run (see also Edwards, 1989). The internal balance refers to the macroeconomic condition that demand for and supply of the non-traded goods is in the equilibrium (Dornbusch, 1983, and others). Such long-run equilibrium real exchange rate is determined by the long-run fundamental variables that consist of policy variables and exogenous variables.

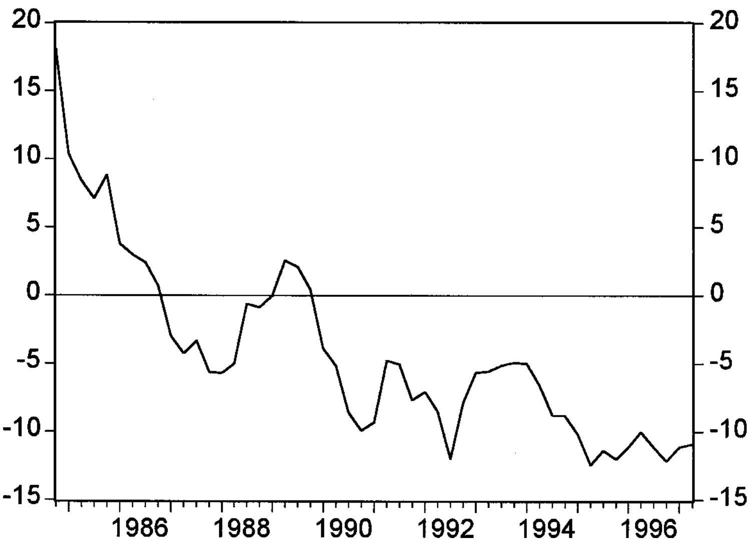
Figure 1 Real Effective Exchange Rates: $REER^{CW}$ *vs.* $REER^{SDRTW}$



Note: Index numbers with 4th quarter of 1984 set equal to 100.

$REER^{CW}$ = Currency-weighted REER; $REER^{SDRTW}$ =SDR-based trade-weighted REER

Figure 2 Real Exchange Rates Differential: $REER^{SDRTW} - REER^{CW}$



Note: Index number with 1st quarter of 1989 set equal to 100

3.1 The production structure

Assume that the country is a small open economy with two production sectors; traded goods sector and nontraded goods sector. We use subscript T to stand for traded goods, and subscript NT to stand for nontraded goods. Output in each sector is produced with labors that are mobile across sectors, and fixed sector-specific capital. We assume that households own firms and supply labor service for production. Therefore, households are assumed to earn all the income from production.

Let y_T stand for output of traded goods measured in terms of traded goods, and y_{NT} stand for output of nontraded goods measured in terms of nontraded goods. With sector-specific fixed capital, the output is a function of labor input and productivity. We assume that there is a difference in productivity growth between the traded goods sector and the nontraded goods sector. In particular, the production function of each sector is written as follows:

$$y_T = y_T(L_T, \alpha); \ \frac{dy_T}{dL_T} > 0, \ \frac{dy_T}{d\alpha} > 0,$$

$$y_{NT} = y_{NT}(L_{NT}); \ \frac{dy_{NT}}{dL_{NT}} > 0,$$

where L_T is labor input in the traded goods production, L_{NT} is labor input in the nontraded goods production, and α is the exogenous productivity parameter which captures differential productivity level between traded goods and nontraded goods sectors.

Denote the real exchange rate by ε, which measures relative price of traded goods in terms of nontraded goods, i.e., $\varepsilon \equiv \frac{P_T}{P_{NT}}$, where P_T is the price of traded goods, and P_{NT} is the price of nontraded goods. Increase in the value of ε means real depreciation, and its decrease corresponds to real appreciation. Let ω be real wage measured in terms of traded goods. Then, $\omega\varepsilon$ is real wage measured in terms of nontraded goods.

A firm minimizes its costs for a given output level by choosing variable labor input such that marginal product of labor equals the real wage rate; $\frac{\partial y_T}{\partial L_T} = \omega$, and $\frac{\partial y_{NT}}{\partial L_{NT}} = \omega\varepsilon$. These first order conditions define the labor demand, $L_T = L_T(\omega, \alpha)$ in the traded goods sector, and $L_{NT} = L_{NT}(\omega\varepsilon)$ in the nontraded goods sector. Let L be the fixed amount of labor supply. Then, the labor market equilibrium requires

$$L = L_T(\omega,\alpha) + L_{NT}(\omega\varepsilon). \tag{3.1}$$

From this equilibrium condition, we obtain the following relation between the real wage and real exchange rate;

$$\omega = \omega(\varepsilon,\alpha), \text{ with } \frac{d\omega(\varepsilon,\alpha)}{d\varepsilon} < 0, \text{ and } \frac{d\omega(\varepsilon,\alpha)}{d\alpha} > 0. \tag{3.2}$$

When the productivity of the traded goods sector increases, demand for labor in the trade goods sector increases, raising the real wage in that sector, while the nontraded goods sector reduces demand for labor. Overall effect is a rise in the equilibrium real wage.

Total output of the economy, measured in terms of traded goods, denoted by y, is

$$\begin{aligned} y &= y_T + y_{NT} = y_T\left[L_T(\omega(\varepsilon,\alpha),\alpha),\alpha\right] + \frac{y_{NT}\left[L_{NT}(\omega(\varepsilon,\alpha)\cdot\varepsilon)\right]}{\varepsilon} \\ &= y(\varepsilon,\alpha), \text{ with } \frac{dy(\varepsilon,\alpha)}{d\varepsilon} < 0. \end{aligned} \tag{3.3}$$

When real exchange rate depreciates, total output measured in terms of traded goods declines. The effects of productivity growth in the traded goods sector on the sectoral production will be analyzed in section 3.5 in relation to the Harrod-Balassa-Samuelson effect on the real exchange rate.

3.2 The household's behavior

(1) Utility function

A representative household derives their utility from consuming both traded goods and nontraded goods. They maximize their intertemporal, instantaneous utility subject to the budget constraint. Assume the utility function takes the form of the constant relative risk aversion (CRRA) type;

$$u(c_T, c_{NT}) \equiv \frac{\left(c_T^{\theta}\cdot c_{NT}^{1-\theta}\right)^{1-\sigma}}{1-\sigma} \tag{3.4}$$

where c_T is consumption of traded goods measured in terms of traded goods, and c_{NT} is consumption of nontraded goods measured in terms of nontraded goods. The parameter θ represents the share of consumption of traded goods in the consumer's total consumption. Let c stand for a consumer's total consumption quantity, measured in terms of traded goods. Then, c_T and c_{NT} are expressed as

$$c_T = \theta \cdot c$$
$$c_{NT} = (1-\theta)\cdot c \cdot \varepsilon \tag{3.5}$$

Using equations (3.5), the instantaneous utility function (3.4) can be written as a function of total consumption c, real exchange rate ε, and parameters;

$$u(c_T, c_{NT}) \equiv \frac{\left(\kappa \cdot \varepsilon^{1-\theta} \cdot c\right)^{1-\sigma}}{1-\sigma}, \tag{3.6}$$

where κ is a constant.

(2) Assets holdings and budget constraint

By assumption, a household earns income from firms producing traded goods and nontraded goods. Out of the households' total income y, they pay tax t to the government, consume both goods, and save. They invest saved income into two types of assets, foreign bonds and domestic money. Assume that, as a portfolio selection strategy, the households allocate total assets, denoted by a, into foreign bonds f_H and domestic money m, all of which are measured in terms of traded goods.

$$a = f_H + m \tag{3.7}$$

Foreign bonds may be denominated in foreign currency, in which case they yield the nominal interest rate i^*, or they may be denominated in domestic currency that yield the nominal interest rate i. The interest rate on domestic currency-denominated bonds and that on foreign currency-denominated bonds are related to each other by uncovered interest parity condition,

$$i = i^* + e, \tag{3.8}$$

where e is the rate of depreciation of the domestic currency.

The households are assumed to hold a part of their assets in the form of domestic money, because they try to minimize the transaction costs associated with spending on consumption. Montiel (1999b) modeled such transaction costs as follows:

$$T(m,c) \equiv \upsilon\left(\frac{m}{c}\right)\cdot c;\ \upsilon' < 0,\ \upsilon'' > 0, \tag{3.9}$$

where $\upsilon\left(\frac{m}{c}\right)$ is transaction costs per unit of consumption, which is assumed to be a decreasing function of money holdings. He assumes that the transaction costs are incurred in the traded goods only.

Given the household's behavior in assets holdings, the household's asset accumulation equation may be expressed by the following.

$$\begin{aligned}\dot{a} &= y + i\cdot f_H - \tau - (1+\upsilon)\cdot c - \pi\cdot a \\ &= y + (i^* + e)\cdot f_H - \tau - (1+\upsilon)\cdot c - \pi\cdot a\end{aligned} \tag{3.10}$$

where τ is real taxes measured in terms of traded goods, and therefore $y + i\cdot f_H - \tau - (1+\upsilon)\cdot c$ stands for net savings in the current period. The variable π is the rate of increase in the price of traded goods, i.e., $\pi \equiv \frac{\dot{p}_T}{p_T}$, and the term $\pi\cdot a$ captures capital gain or capital loss. Since this economy is a price taker in the world market for traded goods, π is related to the foreign inflation rate in the traded goods, π_W, via,

$$\pi = \pi_W + e \tag{3.11}$$

where e is the rate of depreciation of domestic currency.

Let r be real interest rate earned by domestic residents on the foreign bonds, measured in terms of traded goods,

$$r = i - \pi\ . \tag{3.12}$$

Using the uncovered interest parity condition (3.8) and equation (3.12), real interest rate may be expressed as foreign nominal interest rate i^* faced by the domestic residents minus the foreign currency rate of inflation of the traded goods π_W ;

$$r = i - \pi = \left(i^* + e\right) - \left(\pi_W + e\right) = i^* - \pi_W . \tag{3.13}$$

With the definition of the real interest rate (3.12), and with the definition of asset portfolio (3.7), the assets accumulation equation (3.10) can be written, using the domestic real interest rate, as

$$\dot{a} = y - \tau + r \cdot a - i \cdot m - \left(1 + \upsilon\left(\frac{m}{c}\right)\right) \cdot c . \tag{3.14}$$

(3) Optimal consumption path

A representative household maximizes their instantaneous utility (3.4) over an infinite horizon, subject to the asset accumulation equation (3.14).

$$\max_{\{c_T, c_{NT}\}} \int_0^\infty e^{-\rho \cdot t} \cdot \frac{\left(\kappa \cdot \varepsilon^{1-\theta} \cdot c\right)^{1-\sigma}}{1-\sigma} dt , \tag{3.15}$$

subject to

assets accumulation equation; $\dot{a} = y - \tau + r \cdot a - i \cdot m - \left(1 + \upsilon\left(\frac{m}{c}\right)\right) \cdot c$,

transversality condition; $\lim a^{-\int r dt} \geq 0$,

where σ is inverse of intertemporal elasticity of substitution, and time script is omitted for notational simplicity.

Solving the intertemporal maximization problem (3.15) by Hamiltonian optimization method, we obtain first order conditions describing the optimal consumption and saving behavior, and the optimal portfolio selection behavior, from which the optimal consumption path and the money demand equation can be derived as the following equations.

Money demand equation; $m = h(i) \cdot c$, with $\dfrac{dh(i)}{di} < 0$ (3.16)

Consumption; $\dot{c} = \dfrac{1}{\sigma} \cdot \left[r + (1-\sigma) \cdot (1-\theta) \cdot \dfrac{\dot{\varepsilon}}{\varepsilon} - \dfrac{h(i) \cdot i}{1 + \tau(h(i)) + i \cdot h(i)} - \rho \right] \cdot c$ (3.17)

In equation (3.16), the function $h(i)$ represents the inverse relationship between the nominal interest rate and demand for money.

From equation (3.17), we see that expected real depreciation leads to future consumption growth. As real exchange rate depreciate in the future, relative price of nontraded goods will decrease,

3.3 The public sector

The public sector is comprised of the government and the central bank. The government levies lump-sum tax on the private sector, receives credit from the central bank, and spends the revenue on traded goods and nontraded goods. The central bank tries to maintain the nominal exchange rate, which is subject to crawling peg adjustments by the government, and provides credit to the government by money creation, i.e., by seignorage. The budget constraint of the consolidated public sector is

$$\dot{f}_G = \tau + r \cdot f_G + (\dot{m} + \pi \cdot m) - \left(g_T + \frac{g_N}{\varepsilon} \right), \quad (3.18)$$

where f_G is the stock of the foreign bonds, possibly negative, held by the consolidated public sector, and g_T and g_{NT} are government's expenditure on traded goods and nontraded goods, respectively. The term $\dot{m} + \pi \cdot m$ represents the credit from the central bank after taking into account price increases. Montiel (1999b) assumes that the amount of tax is determined such that a change in stock of bond $\dot{f}_G$ is equal to a change in credit from the central bank by money creation, $\dot{m}$.

3.4 Characterizing the equilibrium and the equilibrium real exchange rate

The equilibrium of this small open economy is obtained by introducing two more conditions for equilibrium. One is the condition for the equilibrium in the nontraded goods market. The other is the condition relating the domestic capital market to the world capital market, which will then be used to characterize the country's external equilibrium.

(1) Internal balance

The internal balance is obtained by the equilibrium in the market for nontraded goods. From the production structure (3.3), the production of nontraded goods is a function of the real exchange rate ε, and demand for nontraded goods is comprised of household demand and government demand. Therefore, the market clearing condition of the nontraded goods is

$$y_{NT}(\varepsilon) = c_{NT} + g_{NT} . \tag{3.19}$$

Using equation (3.5), this is written as

$$y_{NT}(\varepsilon) = (1-\theta)\cdot c \cdot \varepsilon + g_{NT} . \tag{3.20}$$

The internal equilibrium condition (3.20) shows the real exchange rate that clears the nontraded goods market is a function of total consumption c, and government's expenditure on nontraded goods g_{NT}. This defines the internal balance schedule.

$$\varepsilon = \varepsilon(c, g_{NT}) \tag{3.21}$$

with $\dfrac{d\varepsilon}{dc} < 0$ *and* $\dfrac{d\varepsilon}{dg_{NT}} < 0$.

(2) External balance

It is assumed that although the economy opens its capital market to the world, the interest rate on foreign currency denominated bonds faced by the domestic households, i.e. i^*, is not the same as the world interest rate i_w. The domestic residents can lend and borrow funds in the world financial market by incurring some risk premiums, which are an increasing function of the country's net international liabilities. Thus, the external interest rate i^* is related to the world interest rate i_w with the following relation.

$$i^* = i_w + \varphi(f),\ \varphi(0) > 0,\ \frac{d\varphi(f)}{df} < 0 , \tag{3.22}$$

where f is the country's net international liabilities such that $f = f_H + f_G$, and $\varphi(f)$ is the risk premium that is dependent on the magnitude of f. Having defined the external interest rate with risk premiums, we can write the uncovered interest parity condition (3.8) as follows;

$$i = i_w + \varphi(f) + e = r_w + \pi_w + \varphi(f) + e \quad (3.23)$$

In the second equation, we used the Fisher equation for the world nominal interest rate i_w.

The long-run equilibrium is characterized as the situation that all the endogenous variables do not change. In particular, it must hold that

$$\dot{y} = \dot{c} = \dot{\varepsilon} = \dot{i} = \dot{f} = 0 . \quad (3.24)$$

This implies, from the optimal consumption path equation (3.17), that

$$\rho = r . \quad (3.25)$$

In the long-run equilibrium, real interest rate equals the rate of time preference. Using equations (3.23), (3.11) and (3.12), this is also expressed as

$$\rho = r_w + \varphi(f) \quad (3.26)$$

Since world real interest rate r_w and rate of time preference ρ are exogenous variables for the economy, equation (3.26) determines the equilibrium value of net international liabilities $\tilde{f}$. Given the value of rate of time preference, an increase in world real interest rate implies decrease in the net international liabilities, i.e., an increase in the value of $\tilde{f}$.

The long-run equilibrium value of domestic interest rate $\tilde{i}$ is obtained by substituting equations (3.26) and (3.11) into equation (3.23);

$$\tilde{i} = \rho + \pi . \quad (3.27)$$

With this long-run equilibrium interest rate, we can derive the long-run equilibrium value of transaction costs per unit of consumption $\tilde{\upsilon}$;

$$\tilde{\upsilon} = \upsilon\left(\frac{m}{c}\right) = \upsilon\left(h\left(\tilde{i}\right)\right)$$
$$= \upsilon\left[h(\rho + \pi)\right] \tag{3.28}$$

To obtain an equation representing the external balance, we first need to sum the household's budget constraint (3.10) and the government's budget constraint (3.18). Noting the household's asset allocation $a = f_H + m$, we can write equation (3.10) as

$$\dot{f}_H = y - \tau + r \cdot f_H - (\dot{m} + \pi \cdot m) - \left(1 + \upsilon\left(\frac{m}{c}\right)\right) \cdot c. \tag{3.29}$$

Adding equation (4.18) to equation (4.29) to get

$$\dot{f} = \dot{f}_H + \dot{f}_G = y + r \cdot (f_H + f_G) - \left(1 + \upsilon\left(\frac{m}{c}\right)\right) \cdot c - \left(g_T + \frac{g_{NT}}{\varepsilon}\right)$$
$$= y_T(\varepsilon, \alpha) + \frac{y_{NT}(\varepsilon)}{\varepsilon} + r \cdot f - \left(1 + \upsilon\left(\frac{m}{c}\right)\right) \cdot c - \left(g_T + \frac{g_{NT}}{\varepsilon}\right)$$
$$= y_T(\varepsilon, \alpha) + (1 - \theta) \cdot c + \frac{g_{NT}}{\varepsilon} + r \cdot f - \left(1 + \upsilon\left(\frac{m}{c}\right)\right) \cdot c - \left(g_T + \frac{g_{NT}}{\varepsilon}\right).$$

Simplifying this, we obtain the change in the economy-wide net international liabilities,

$$\dot{f} = y_T(\varepsilon, \alpha) + r \cdot f - \left(\theta + \upsilon\left(\frac{m}{c}\right)\right) \cdot c - g_T. \tag{3.30}$$

Since we assume that the transaction costs are incurred in the traded goods, the term $y_T(\varepsilon, \alpha) - \upsilon\left(\frac{m}{c}\right) \cdot c$ represents domestic supply of traded goods, whereas the term $\theta \cdot c + g_T$ is domestic demand for traded goods. Therefore, with interest payment (receipt) on the net international liabilities $r \cdot f$, the right hand side of equation (3.30) stands for current account. Thus, equation (3.30) determines how the net international liabilities evolve over time.

In the long run, net international liabilities are in a steady state equilibrium in the sense that they do not change; $\dot{f}=0$. In order for the net international liabilities to attain the long-run equilibrium $\tilde{f}$, which is consistent with the equilibrium interest rate $\tilde{i}$, the inflation-adjusted current account balance has to be zero. Therefore, the long-run external balance condition is defined as;

$$\begin{aligned}\dot{f}=0&=y_T(\varepsilon,\alpha)+\rho\cdot\tilde{f}-(\theta+\upsilon[h(\rho+\pi)])\cdot c-g_T\\&\equiv b+\rho\cdot\tilde{f}\end{aligned}\tag{3.31}$$

where $b\equiv y_T(\varepsilon,\alpha)-(\theta+\upsilon[h(\rho+\pi)])\cdot c-g_T$ represents trade balance.

Depreciation of real exchange rate increases production of traded goods. Given the government's spending on traded goods g_T, the household's spending on traded goods $\theta\cdot c$ has to increase to keep the trade balance, which requires an increase in household's total consumption c. Therefore, as shown in Figure 3, the external balance locus in the space of real exchange rate (vertical axis) and total consumption (horizontal axis) is upward sloping.

The locus of internal balance schedule, equation (3.21), is downward sloping. When real exchange rate depreciates, production of nontraded goods decreases. For the market for the traded goods to clear, household's consumption of nontraded goods must decline, given the government's spending on nontraded goods. This is made possible by reducing the household's total consumption from equation (3.20).

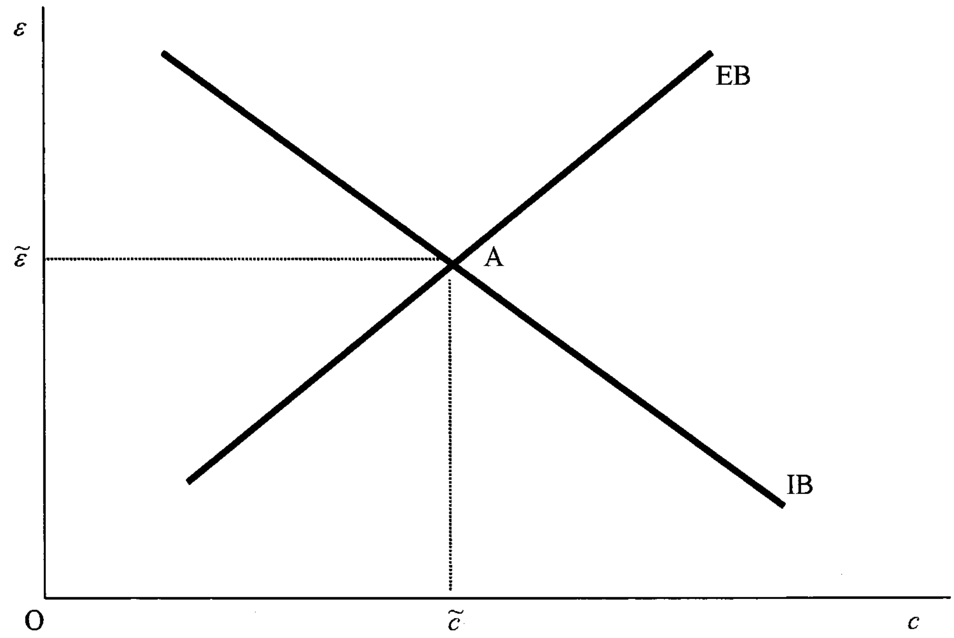
3.5 Determinants of the long-run equilibrium real exchange rate

The long-run equilibrium real exchange rate (*LERER*, for short) will change in response to changes in the fundamental exogenous variables that determine the location of the external balance schedule and the internal balance schedule. These fundamental exogenous variables include variables related to fiscal policy, world interest rates, the Harrod-Balassa-Samuelson effect, terms of trade, and trade policies, among others.

(1) Changes in the composition of the government spending

It has been identified by previous studies, for example Edwards (1989) among others, that a change in the sectoral composition of the government's spending, holding the whole

Figure 3 The Long-run Equilibrium Real Exchange Rate



Note: 1. EB stands for the external balance schedule, equation (3.31), while IB represents the internal balance schedule, equation (3.21).

2. The long-run equilibrium real exchange rate ($\tilde{\varepsilon}$) and the equilibrium consumption, measured in terms of traded goods, ($\tilde{c}$) are determined at the intersection of EB and IB

fiscal position constant, will exercise impacts on the real exchange rate. Given the constant fiscal position, an increase in spending on traded goods will have effect on the long-run equilibrium real exchange rate, which is different from the effect caused by an increase in spending on nontraded goods.

An increase in government spending on traded goods will create excess demand for traded goods and a trade deficit, which requires depreciation of real exchange rate to maintain the external balance. Although depreciation of real exchange rate discourages household's consumption of traded goods, the increase in government spending on traded goods outweighs the reduction of private consumption, which necessitates real depreciation. The excess demand will be met by increased production of traded goods by real depreciation. In Figure 3, an increase in government spending on traded goods shifts the external balance schedule upward, which leads to an increase of the value of *LERER*.

An increase in government spending on nontraded goods, on the other hand, creates excess demand for nontraded goods, which leads to an increase in the price of nontraded goods relative to that of traded goods. Thus, the real exchange rate has to appreciate in order to maintain the internal balance. In Figure 3, the internal balance schedule will shift downward, and the long-run equilibrium real exchange rate will appreciate. As the real exchange rate appreciates, household's total consumption declines because of reduction of consumption of nontraded goods.

In summary, a shift of the government spending from traded goods to nontraded goods, holding the whole fiscal position constant, will appreciate the long-run equilibrium real exchange rate (*LERER*), whereas a shift to spending on traded goods will depreciate the *LERER*.

(2) A reduction in the fiscal deficit

Assume that the government increases tax to cut the fiscal deficit. The tax increase is interpreted as a reduction of seignorage by lowering the money supply growth. The lower money supply growth, on the other hand, implies a reduced rate of depreciation of nominal exchange rate, i.e., smaller value of e. A smaller value of e lowers the domestic nominal interest rate from equation (3.8), which leads to an increase of money demand. The increase of money demand, then, reduces the transaction costs associated with consumption, i.e., $\upsilon\left(\frac{m}{c}\right)$ falls. Since we have assumed that the transaction costs are borne in traded goods, the fall of the transaction costs per unit of consumption implies an increase in total supply of traded goods. This means that the external balance schedule in Figure 3 will shift downwards, resulting in an appreciation of the *LERER*, and an increase in the total consumption. If we assume, instead, that the transaction costs are incurred by nontraded goods, the supply of nontraded goods will increase, which will result in a real depreciation.

(3) Changes in the world real interest rates

Changes in the factors working in the international financial market will affect the long-run equilibrium real exchange rate. Suppose that world real interest rate r_w falls relative to domestic real interest rate r. The difference between the domestic and world real interest rate induces capital inflow into the country. The capital inflow caused by the fall of the world real interest rate shifts the external balance schedule upwards, generating depreciation of the *LERER* and reduction of the total consumption in the new long-run equilibrium.

The reason for the real depreciation may be explained as follows. An increase in capital inflow increases net international liabilities. The increase in net international liabilities creates additional burden of interest payment for the country. For the external balance, shown in equation (3.31), to be maintained in the new long-run equilibrium, the real exchange rate needs to depreciate so that the trade balance can improve by expansion of the production of traded goods, and reduction of the consumption of traded goods. Note that in the long-run equilibrium, the real interest rate faced by the domestic residents does not change since it is equalized with the rate of time preference. And, given the exogenous constant value of rate of time preference, a decline of the world real interest rate is offset by an increase in the value of risk premium associated with the magnitude of net international liabilities; see equation (3.26).

(4) The Harrod-Balassa-Samuelson Effect

The Harrod-Balassa-Samuelson effect (HBS effect) is "a tendency for countries with higher productivity growth in traded goods compared with nontraded goods to have higher average price levels" (Obstfeld and Rogoff, 1996). In terms of the relation between the differential productivity growth and real exchange rate, the HBS effect says that a country will experience appreciation of real exchange rate, if its productivity growth advantage in traded goods over other countries exceeds its productivity growth advantage in nontraded goods.

To understand the HBS effect in the framework of the model of this paper, recall from equation (3.3) that outputs of traded goods and nontraded goods are functions of the equilibrium real wage, and that the equilibrium real wage itself is a function of real exchange rate and productivity parameter of the traded goods sector, $\omega(\varepsilon,\alpha)$. When the productivity in the traded goods sector rises, demand for labor in that sector increases, which raises the real wage of the traded goods sector. On the other hand, the rising real wage will reduce the demand for labor by the nontraded goods sector. Thus, as a result of productivity growth in the traded goods sector, output of traded goods increases, while output of nontraded goods decreases:

$$\frac{dy_T\left[L_T\left(\omega(\varepsilon,\alpha),\alpha\right),\alpha\right]}{d\alpha} > 0, \tag{3.32}$$

$$\frac{dy_{NT}\left[L_{NT}\left(\omega(\varepsilon,\alpha)\right)\cdot\varepsilon\right]}{d\alpha} < 0. \tag{3.33}$$

The decline of output in the nontraded goods sector creates an excess demand for nontraded goods, thereby requiring real appreciation in order to maintain the internal balance. This means that the internal balance schedule shifts downward in response to the productivity growth in the traded goods sector. At the same time, the expansion of output in the traded goods sector generates incipient trade surplus, which requires appreciation of real exchange rate to restore the external balance. Thereby, the external balance schedule will shift downward as well. Thus, both the internal balance schedule and external balance schedule will shift downward to retain the equilibrium in response to the productivity growth in the traded goods sector. The new long-run equilibrium real exchange rate will appreciate from the original equilibrium real exchange rate before the productivity shock.

(5) Changes in the terms of trade

The internal terms of trade is defined as the relative price of exportable goods in terms of importable goods $\psi \equiv \frac{p_X}{p_M}$, where ψ is the internal terms of trade, p_X is the domestic price of exportable goods, and p_M is the domestic price of importable goods. Without trade intervention, this internal terms of trade is equivalent to the external terms of trade $\psi^w \equiv \frac{p_X^w}{p_M^w}$, where p_X^w is world price of exportable goods, and p_M^w is the world price of importable goods. When the internal terms of trade changes, we have to analyze its impact on the demand and supply of exportable goods, importable goods, and nontraded goods in the home market. Define the real wage ω in terms of importable goods. The labor market equilibrium condition is

$$L = L_X\left(\frac{\omega}{\psi}\right) + L_M(\omega) + L_{NT}(\omega\cdot\varepsilon), \tag{3.34}$$

and the equilibrium real wage becomes a function of real exchange rate and terms of trade,

$$\omega = \omega(\varepsilon, \psi), \text{ with } \frac{d\omega}{d\psi} > 0. \tag{3.35}$$

From this specification, the outputs of exportable goods, importable goods, and nontraded goods become functions of real exchange rate and terms of trade. Now, for the sake of a simplified analysis, assume that there is no domestic demand for the exportable goods. When the terms of trade improves, labor moves from the importable goods sector and the nontraded goods sector into the exportable goods sector, thereby increasing output of exportable goods. Outputs of importable goods and nontraded goods, on the other hand, contract. There will arise excess demand for nontraded goods, which shifts the internal balance schedule downward to restore the internal equilibrium.

As regard to the effect on the external balance schedule of the terms of trade improvement, divide the traded goods into exportable goods and importable goods. The external balance equation (3.31) is modified into the following equation:

$$\dot{f} = 0 = \psi \cdot y_X(\varepsilon, \psi) + y_M(\varepsilon, \psi) + \rho \cdot \tilde{f} - (\theta + \upsilon[h(\rho + \pi)]) \cdot c - g_M . \tag{3.36}$$

Improvement of the terms of trade leads to expansion of exportable goods and contraction of importable goods. Total effect on the output of traded goods, both exportables and importables, of the terms of trade improvement will be positive (Montiel, 1999b). Therefore, the improvement of the terms of trade will generate trade surplus, thereby shifting the external balance schedule downward to retain the external equilibrium. With both the internal balance schedule and external balance schedule shifting downward, improvement of terms of trade will appreciate the equilibrium real exchange rate.

(6) Changes in trade policy

We consider the effects of the measures of trade liberalization on the long-run equilibrium real exchange rate. With trade intervention measures enforced, the internal terms of trade $\psi \equiv \frac{p_X}{p_M}$ and the external terms of trade $\psi^w \equiv \frac{p_X^w}{p_M^w}$ are not the same, and they are related by the following equation:

$$\psi \equiv \frac{p_X}{p_M} = \frac{\psi^w}{\mu}; \ \mu \equiv \frac{1+t_M}{1-t_X}, \tag{3.37}$$

where μ is a parameter representing the overall trade policy stance, in which t_M and t_X represent import tariff (or, subsidy) and export tax (or, subsidy), respectively.

When the country liberalizes its trade policy by either cutting the import tariff or reducing the export tax or export subsidy, the value of μ decreases, so that given the external terms of trade, the internal terms of trade improves. Montiel (1999b) studies the case of reducing the export subsidy. A subsidy cut to the exportable goods sector draws labor into the importable goods sector and nontraded goods sector. The excess supply created in the nontraded goods sector will shift the internal balance schedule upward, whereas contraction of the output of the exportable goods creates trade deficit that requires real depreciation by shifting the external balance schedule upward. Thus, a subsidy cut for the exportable goods sector makes both the internal balance schedule and the external balance schedule shift upward, resulting in depreciation of the long-run equilibrium real exchange rate.

Trade liberalization in the form of reducing import tariff will produce a similar effect on the long-run equilibrium real exchange rate. Tariff cut on the importable goods will lower the domestic price of the importable goods, which improves the internal terms of trade. Lower price of the importable goods draws labor from the importable goods sector into exportable goods sector and nontraded goods sector. In the nontraded goods sector, excess supply occurs, which requires real depreciation by shifting the internal balance schedule. In the traded goods sector, the substitution effect outweighs the income effect, which causes trade deficits that require depreciation of the real exchange rate. Therefore, the external balance schedule shifts upward as well. Thus, overall effects of cut of import tariff will be depreciation of the long-run equilibrium real exchange rate.

4. Econometric specifications

In this section, we lay out the econometric specifications for estimating the model of the long-run equilibrium real exchange rate. From the theory laid out in the previous section, the long-run equilibrium real exchange rate is expressed as a function of policy and exogenous variables that are sustainable. Since the long-run equilibrium real exchange rate is realized at the intersection of the internal balance schedule (3.21) and the external balance schedule (3.31), the reduced form equilibrium real exchange rate is written as a function of the following fundamental policy and exogenous variables[5], and some additional policy and exogenous variables that we discussed in section 3.5:

$$\underset{}{\tilde{\varepsilon}} = \tilde{\varepsilon}\left(\underset{-}{g_{NT}}, \underset{+}{g_T}, \underset{-}{\alpha}, \underset{-}{r_w}, \underset{+}{\pi}, \underset{-}{\psi^w}, \underset{+}{\mu}\right) \tag{4.1}$$

where g_{NT} and g_T are government spending on nontraded goods and traded goods; α is the differential productivity parameter in favor of the traded goods sector; r_w is world real interest rate; π is domestic inflation rate in terms of traded goods; ψ^w is terms of trade; μ is trade policy instruments. The sign under each variable shows the direction of the change of the long-run equilibrium real exchange rate in response to a positive change in each policy or exogenous variable. Minus sign means real appreciation, whereas plus sign indicates real depreciation. For the trade policy variable μ, its change in positive direction means a liberalized trade policy.

4.1 Extension of the theoretical model for empirical specification

The base theoretical model underlying the long-run equilibrium real exchange rate (4.1) may be modified to take into account some real world situations that developing countries actually face. Following the specifications used by Baffes, Elbadawi and O'Connell (1999), we consider two extensions made on the base theoretical model; one is an assumption that a developing country is obliged to face a credit constraint in the international capital market, and the other extension is to introduce short-run price and wage rigidities in the long-run equilibrium model.

(1) Credit constraint in the international capital market

In the base theoretical model of Montiel (1999b), the sustainable net international liabilities $\tilde{f}$ is determined endogenously by the households' savings and assets allocation decisions, which should be consistent with the external balance. Given the equilibrium net international liabilities, the optimal current account and trade balance are endogenously determined as well. Suppose, instead, that a country faces constraints in borrowing and

[5] To get the reduced form, we also used equation (3.11) $\pi = \pi_w + e$, and equation (3.26) $\rho = r_w + \varphi(\tilde{f})$.

lending in the international capital market such that the net international liabilities have a binding floor $\hat{f}$ such that $|\hat{f}| < |\tilde{f}|$. Then, with the exogenous net interest payments to foreign countries, trade balance becomes an exogenous variable. The domestic real interest rate becomes endogenous, since it has to adjust to equate savings with the exogenous current account. Under the specification of credit constraints in the international capital market, the reduced form long-run equilibrium real exchange rate will be specified as;

$$\tilde{\varepsilon} = \tilde{\varepsilon}\left(\underset{-}{g_{NT}}, \underset{+}{g_T}, \underset{-}{\alpha}, \underset{+}{b}, \underset{-}{\psi^w}, \underset{+}{\mu}\right) \tag{4.2}$$

where $b = -r \cdot \hat{f}$ is trade balance in the long-run equilibrium with credit constraints.

(2) Short-run rigidities in wage and prices, and short-run dynamics

In Montiel (1999b)'s model, it is assumed that wage and prices are flexible so that a disequilibrium created by a shock to the exogenous variables will be adjusted instantaneously toward a new long-run equilibrium through flexible and instantaneous changes of wage and prices, and therefore through flexible changes in the real exchange rate. It is often a case, however, that in reality the wage and prices adjustments are not so flexible in the short-run, but sluggish in a developing economy. As an example presented by Baffes, Elbadawi and O'Connell (1999), a rise in the world real interest rate leads to capital outflow, which requires reduction (or, increase) of trade deficits (or, surplus) under the binding credit constraints in the international financial market. The maintenance of the external balance requires depreciation of the real exchange rate, which implies an upward shift of the external balance schedule instantaneously. If wage and prices are not flexible, however, wage and price of nontraded goods do not change quickly in response to the shift of the external balance schedule. Therefore, in the short-run, it is likely to occur that demand falls short of supply in the nontraded goods sector, while the external balance is maintained. The disequlibrium in the nontraded goods sector will gradually pull down the wage and the price of nontraded goods, thereby depreciating the real exchange rate. As the slow adjustment process continues, the disequilibrium in the nontraded goods sector will be dissolved gradually through real depreciation of the exchange rate, toward the new long-run equilibrium real exchange rate.

Introduction of slow adjustment of the real exchange rate in response to policy and external shocks not only provides the primary role of nominal devaluation in macroeconomic adjustment under an adverse external shock, but also proves to be an important assumption for specifying the error correction model for cointegrated variables in the empirical specification of the long-run equilibrium exchange rate.

4.2 Econometric specifications

In this section, we explain the econometric methodologies used to estimate the equation of the long-run equilibrium real exchange rates, i.e. the equation (4.2). The key concept of the econometric methodologies employed here is the cointegration among the nonstationary variables comprising the determinants of the long-run equilibrium real exchange rate. Since the data of real exchange rates and fundamental variables are likely to be nonstationary, we cannot estimate a simple OLS equation with such nonstationary variables. We instead conducted the cointegration tests to see whether the nonstationary variables of our interest were integrated into a linear equation that is stationary. If such stationary linear combination of the nonstationary variables exists, we may be able to conclude that those variables constitute the determinants of the long-run equilibrium real exchange rate. We used methodologies of the error correction model à la Engle and Granger (1988) and its extensions by Johansen (1988, 1991) and Stock and Watson (1988).

(1) Test for unit roots

Since many macroeconomic variables are characterized as nonstationary random variables containing unit roots, we first tested the presence of unit roots in the data of the real effective exchange rates and the fundamental variables, by carrying out both the Augmented Dickey-Fuller test (ADF test, for short) and the Phillips-Perron test.

The ADF test is an extension of the standard Dickey-Fuller unit root test by controlling for higher-order serial correlations in the data. It assumes that the variable follows an AR(p) process rather than the AR(1) process that the Dickey-Fuller test is based on. The estimation equation for the ADF test is specified as

$$\Delta y_t = c + \gamma y_{t-1} + \sum_{i=1}^{p} \delta_i \Delta y_{t-i} + \eta_t, \qquad (4.3)$$

where c is a constant, and η_t is a white noise random error process. The null hypothesis is presence of a unit root against the alternative hypothesis of no unit root. The test statistic is γ ; when the variable contains a unit root, $\lambda = 0$, as opposed to the case of no unit root $\lambda < 0$. In carrying out the ADF test, we can include, as options, a constant term and/or a linear trend term depending on the time evolution pattern of the variable for testing.

The Phillips-Perron unit root test is a nonparametric method of controlling for higher order serial correlations in the data (Phillips and Perron, 1988). It does not include lagged values of Δy_t as in the ADF test, but it estimates the following equation based on AR(1) process.

$$\Delta y_t = c + \phi y_{t-1} + \eta_t \tag{4.4}$$

The difference from the Dickey-Fuller test which uses AR(1) process is that the Phillips-Perron test makes a nonparametric correction to the t-statistics of the coefficient ϕ by using the Newey-West heteroskedasticity and autocorrelation consistent estimate of the variance-covariance matrix at the frequency zero spectrum of η. However, the asymptotic distribution of the Phillips-Perron t-statistic is the same as the ADF t-statistic. As in the ADF test, we can include a constant term and/or a linear trend term, as options.

(2) Cointegration and Error Correction model

The long-run equilibrium relation between the fundamental variables and the equilibrium real exchange rate may be written as a linear relation as follows:

$$\tilde{\varepsilon}_t = \beta_0 \cdot F_t . \tag{4.5}$$

The variable $\tilde{\varepsilon}_t$ is the long-run equilibrium real exchange rate at time t, and F_t is a $k \times 1$ vector of fundamental variables. The $1 \times k$ vector β_0 is the parameters vector that relates the fundamental variables linearly to the equilibrium real exchange rate. Since the long-run equilibrium real exchange rate $\tilde{\varepsilon}_t$ is unobservable, we may estimate it by the following equation:

$$\varepsilon_t = \beta_0 \cdot F_t + u_t \tag{4.6}$$

where ε_t is a realized, actual real exchange rate, i.e. $REER_t^{CW}$ in this paper, and u_t is a mean-zero, white noise process. However, if ε_t and the variables comprising the vector F_t are not stationary variables, the OLS estimation of equation (4.6) will produce super-consistent estimates of β_0 (Engle and Granger, 1987, and Stock, 1987). In the case that the variables in equation (4.6) contain a unit root in the level variables such that they are $I(1)$ variables, we may instead estimate an error correction model, provided that the variable

$$u_t = \varepsilon_t - \beta_0 \cdot F_t \tag{4.7}$$

in equation (4.6), is a stationary variable. When a linear combination of nonstationary $I(1)$ variables becomes stationary as in (4.7), those nonstationary variables are said to be cointegrated. The equation (4.7) is called a cointegrating equation. The error correction model that includes u_t as a stationary variable may be specified as

$$\Delta\varepsilon_t = \alpha\beta \cdot \Pi_{t-1} + \sum_{j=1}^{p} \gamma_j \cdot \Delta F_{t-j} + \sum_{j=0}^{q} \mu_j \cdot x_{t-j} + \eta_t . \tag{4.8}$$

In equation (4.8), $\Delta\varepsilon_t$ is the first difference on ε_t, the term ΔF_{t-j} is a vector of first difference of the fundamental variables with a lag j, the term x_{t-j} is a vector of exogenous variables outside the equilibrium relation of the real exchange rate with a lag j, γ_j, μ_j are parameters vectors, and η_t is an $i.i.d.$ stationary random error.

The term $\alpha\beta \cdot \Pi_{t-1}$ is the error correction term, in which Π_{t-1} is a $(1+k)\times 1$ vector of variables such that $\Pi'_{t-1} \equiv (\varepsilon_{t-1}, F'_{t-1})$, β is a $1\times(1+k)$ coefficients vector such that $\beta \equiv (1, -\beta_0)$, and α is a scalar parameter that is interpreted as the adjustment parameter toward the equilibrium. The term $\beta \cdot \Pi_{t-1} \equiv \varepsilon_{t-1} - \beta_0 \cdot F_{t-1}$ is equal to the stationary random variable u_{t-1} as shown in equation (4.7), therefore it is the cointegrating equation. The parameters in β are called cointegrating parameters. Since the parameters in the vector β constitute the long-run equilibrium relation, the elements of the vector may be called the long-run parameters. The error correction term $\alpha \cdot (\beta\Pi_{t-1}) = \alpha \cdot u_{t-1}$ is interpreted as follows: If the equilibrium exchange rate could not be obtained in the previous period $t-1$ so that $u_{t-1} \neq 0$, the current real exchange rate at time t will adjust to correct the disequilibrium occurred in the previous period toward the equilibrium exchange rate with the adjustment speed α. In our model, a negative value of the adjustment parameter α corresponds to the dynamic adjustment process to restore the equilibrium in the current period.

The vector of lagged values of first-differenced fundamental variables, ΔF_{t-j}, $j = 1,2,---,q$, captures the effect of changes in each fundamental variable in the previous periods on the evolution of the equilibrium real exchange rate in the succeeding periods. Therefore, the parameters' vector γ_j on ΔF_{t-j} may be interpreted as representing short-run dynamic effects of the fundamental variables on the equilibrium real exchange rate.

The vector x_{t-j}, $j = 0,1,2,---,q$ is a $l \times 1$ vector comprised of exogenous variables that are outside the cointegrating equation (4.7), but may influence the evolution of the equilibrium real exchange rate. In the empirical specification of the model, we include, as an important exogenous variable, the difference between the SDR-based trade-weighted hypothetical real effective exchange rate $REER_t^{SDRTW}$ and the currency-weighted, realized real effective exchange rate $REER_t^{CW}$.

When the nonstationary variables are $I(1)$ variables, the concept of cointegration and that of error correction are equivalent by the Granger Representation Theorem. It must be noted, however, that the cointegration requires that all variables in the cointegrating relation need to be integrated of the same order. If the variables have different orders of integration, we cannot find a cointegrating relation. In the following estimation section, we find that all the fundamental variables and the real exchange rate contain a single unit root, i.e. $I(1)$ variables, so that the cointegration tests can be implemented.

There are two methods to estimate the cointegrating equation, the adjustment parameter α, and the model containing the error correction term, i.e. the equation (4.7). One is the method proposed by Engle and Granger (Engle and Granger, 1987), and the other method is developed by Johansen, and Stock and Watson that use the rank of the coefficient matrix on a vector of one-period lagged variables and its eigenvalue to identify the cointegrating equations and the adjustment parameters, based on a VAR system (Johansen, 1988, Stock and Watson, 1988).

The method of Engle and Granger first estimates the cointegrating relation (4.8) by OLS, provided that all the variables entering into the long-run relation prove to be $I(1)$ variables. If the estimated residuals $\hat{u}_t$ turn out to be stationary under some unit root tests, then, replacing the cointegrating equation in (4.7) by one-period lagged, estimated residuals $\hat{u}_{t-1}$, we estimate the error correction specification as follows:

$$\Delta\varepsilon_t = \alpha\hat{u}_{t-1} + \sum_{j=1}^{p}\gamma_j \cdot \Delta F_{t-j} + \sum_{j=0}^{q}\mu_j \cdot x_{t-j} + \eta_t. \tag{4.9}$$

From the first estimation of the long-run relation, i.e. the cointegrating equation, we can identify the cointegrating parameter vector β, and the estimation of the error correction model (4.9) will produce the adjustment parameter vector α and other parameters of our interest. Although this method is intuitive and simple, it has some shortcomings such as the possibility of getting estimation errors associated with two-step estimations, and the inability to handle the case of multiple cointegrating equations.

The methodology developed in Johansen (1991, 1995) uses VAR-based cointegration tests. Consider a p^{th} order VAR:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + --- + A_p y_{t-p} + \sum_{j=0}^{q}\mu_j x_{t-j} + \eta_t, \tag{4.10}$$

where y_{t-j} is a $k \times 1$ vector of nonstationary $I(1)$ variables, x_{t-j} is a $l \times 1$ vector of exogenous variables, and η_t is a vector of white noise processes. Subtracting y_{t-1} from both sides of equation (4.10) and arranging, we obtain the following equation.

$$\Delta y_t = \Pi y_{t-1} + \sum_{j=1}^{p-1}\Gamma_j \Delta y_{t-j} + \sum_{j=0}^{q}\mu_j x_{t-j} + \eta_t, \tag{4.11}$$

where Π and Γ_j are $k \times k$ matrices such that $\Pi \equiv \sum_{i=1}^{p} A_i - I$, $\Gamma_j \equiv -\sum_{j=i+1}^{p} A_j$ and I is an identity matrix. If the $k \times k$ coefficient matrix Π has reduced rank r such that $r < k$, there exist $k \times r$ matrices α and β such that $\Pi = \alpha \cdot \beta'$, where elements of the $r \times 1$ vector $\beta' \cdot y_t$ are $I(0)$ variables. When the rows of the vector $\beta' \cdot y_t$ are $I(0)$ variable, they are the cointegrating equations, and each column of β is the cointegrating vector. Therefore, r is the number of cointegrating equations. Each element of the $k \times r$ matrix α is the adjustment parameter attached to each cointegrating equation for each variable. Johansen's methodology of cointegrating tests is to identify the reduced rank of the matrix Π, and estimate the matrices α and β .

Johansen (1991) provides two test statistics for testing the rank of the Π matrix, i.e.

the number of cointegrating equations; trace statistic and maximum eigenvalue statistic, both of which are obtained from maximum likelihood estimation. In this paper, we use the trace statistic, which is written as

$$LR_{Trace}(r|k) = -n \cdot \sum_{i=r+1}^{k} \ln(1-\hat{\lambda}_i), \tag{4.12}$$

where $\hat{\lambda}_i$ is the i^{th} largest estimated eigenvalue of the Π matrix, and n is the number of observations. The null hypothesis with the test statistic (4.12) is that there are a total of r cointegrating equations as opposed to the alternative hypothesis of k cointegrating equations. When the rank of the population matrix Π is r, there will be total number of r eigenvalues, each of which takes a non-zero value. On the other hand, the value of other $k-r$ eigenvalues is zero. Therefore, when we test the null hypothesis of r cointegrating equations against the alternative hypothesis of k cointegrating equations, a smaller value of $LR_{Trace}(r|k)$ is likely to reject the null hypothesis. The critical values to test the null hypothesis are provided by Johansen and Juselius (1990), and by Osterwald-Lenum (1992), from which we use the latter critical values in our estimations.

5. Estimation results and interpretations

Following the method of vector error correction (VEC) model by Johansen (1991, 1995), we estimated equation (4.11). Since our empirical interest is the first equation of the VEC, in which the first-differenced currency-weighted, realized real effective exchange rate $\Delta REER_t^{CW}$ is placed in the left-hand side, and the cointegrating equation and lagged first-differenced values of all the variables are placed in the right-hand side. We also included, in an extended specification of the estimated model, the difference between the SDR-based trade-weighted real effective exchange rate $REER_{t-j}^{SDRTW}$, and the currency-weighted, realized real effective exchange rate $REER_{t-j}^{CW}$ as an exogenous variable outside the cointegrating equation.

The specification of the first equation of the VEC is written as:

$$\Delta REER_t^{CW} = \alpha_1 \cdot (c + \hat{\beta} y_{t-1} + T) + \sum_{j=1}^{p} \gamma_j \Delta y_{t-j} + \sum_{j=1}^{q} \delta_j DIFFRER_{t-j} + c_0 + \eta_{1,t}, \tag{5.1}$$

where the term $\sum_{j=1}^{q} \delta_j DIFFRER_{t-j}$ is optional. In equation (5.1), the term in parenthesis is the cointegrating equation:

$$u_{1,t-1} = c + \hat{\beta} y_{t-1} + T, \text{ with } u_{1,t-1} \sim \text{a white noise process,} \tag{5.2}$$

where

$$\begin{aligned} \hat{\beta} y_{t-1} \equiv \hat{\beta}_0 REER_{t-1}^{CW} + \hat{\beta}_1 GVSNT_{t-1} + \hat{\beta}_2 RESGDP_{t-1} + \hat{\beta}_3 TOT_{t-1} \\ + \hat{\beta}_4 TRDPOLICY_{t-1} + \hat{\beta}_5 HBS_{t-1}, \end{aligned} \tag{5.3}$$

and the term c is an intercept, T is a linear trend term, and α_1 is the adjustment parameter. In equation (5.3), the variables stand for the following fundamental determinants of the equilibrium real exchange rate; $GVSNT$ is the ratio of government's spending on nontraded goods to GDP in nominal terms; $RESGDP$ is the resource balance to GDP ratio computed as the ratio of trade balance to GDP in nominal terms; TOT is the terms of trade, computed as the ratio of average export price to average import price, both measured in terms of home currency; $TRDPOLICY$ is a measure of trade restriction policies, defined as the sum of import tariff and export tax divided by the sum of export value and import value; HBS is a measure of the Harrod-Balassa-Samuelson (HBS) effect, i.e. the measure of the effect of differential productivity growth between traded goods sector and nontraded goods sector on real exchange rate, computed, as a proxy variable, by the ratio of Thailand's GDP per worker to the average GDP per worker in the Thailand's major trading partner countries in OECD. The variables $REER^{CW}$, $GVSNT$, TOT, $TRDPOLICY$ and HBS are measured in logarithms, while $RESGDP$ is measured as the original level value. Further details of each variable and the data source are given in Appendices.

Back to equation (5.1), the lagged first-differenced variables with parameters

$\gamma_j \Delta y_{t-j}$, $j = 1,2,---,p$ are

$$\gamma_j \Delta y_{t-j} \equiv \gamma_{1j} \Delta REER^{CW}_{t-j} + \gamma_{2j} \Delta GVSNT_{t-j} + \gamma_{3j} \Delta TOT_{t-j} + \gamma_{4j} \Delta TRDPOLICY_{t-j} + \gamma_{5j} \Delta HBS_{t-j}. \quad (5.4)$$

The term $DIFFRER_{t-j}$ is the difference between the SDR-based trade-weighted real effective exchange rate and the currency-weighted, realized real effective exchange rate:

$$DIFFRER_{t-j} \equiv REER^{SDRCW}_{t-j} - REER^{CW}_{t-j}. \quad (5.5)$$

This variable is measured in logarithm. The term c_0 is an intercept and $\eta_{1,t}$ is a white noise random error.

5.1 Unit roots tests

The results of the unit root tests for each variable are given in Table 2. Visual inspection of the plotted data of each variable shows that none of the variables has zero mean. Therefore, we included an intercept term in the test of each variable. Furthermore, the variables, $REER^{CW}$, *TRDPOLICY*, and *HBS* appear to have a linear deterministic trend identified from plotted graphs, so that we included a trend term for the test of these variables.

With regard to the ADF test, we selected the number of lag length for the first-differenced series based on Schwarz Information Criterion. The results reveal that we cannot reject the null hypothesis of a unit root in the level variable at 10% significance level for all the variables except *DIFFRER*[6]. The variable *DIFFRER* is a stationary process. We further conducted the ADF test on the first-differenced variables, to reject the null hypothesis of a unit root on all the variables. Hence, we concluded that all the variables except *DIFFRER* are $I(1)$ variable, containing a unit root in the level.

As for the Phillips-Perron unit root test, the variables that include intercept and a trend term are the same as the ADF test. We used the bandwidth for the Newey-West

[6] We used MacKinnon (1994)'s critical value, instead of Dickey-Fuller's τ - statistic.

heteroskedasticity and autocorrelation consistent covariance matrix estimate, using Bartlett Kernel. The critical values are taken from MacKinnon (1991), which are the same as those for the ADF test. The test results in Table 2 shows that we cannot reject the null hypothesis of a unit root for all the level variables except *GVSNT* and *DIFFRER* at 10% significance level, whereas the null of a unit root cannot be rejected at 1% level for *GVSNT*, and the null of a unit root is rejected at any significance level for *DIFFRER*. Again, as with the case of the ADF test, a unit root test for the first-differenced variables show no presence of a unit root. Therefore, we concluded that all the variables except *DIFFRER* included in the VEC estimation model are $I(1)$ variables.

5.2 Cointegration tests

We first tested the cointegration relation among the realized real effective exchange rate and the long-run fundamental variables, which is shown in equation (5.2) and (5.3). In carrying out the Johansen's cointegration test, we included both an intercept and a linear deterministic trend in the cointegration equation, since some fundamental variables appear to have a deterministic trend. The test results are shown in Table 3.

We considered two cases. One is the case to identify the long-run equilibrium relation between the observed, currency-weighted real effective exchange rate and the set of the fundamental variables determining the equilibrium exchange rate, without any influences of exogenous variables other than the fundamental variables. This is a test to find an equilibrium relation in equation (5.1) without any exogenous variables.

The other case is to identify the long-run equilibrium relation between the observed, currency-weighted real effective exchange rate and the set of the fundamental variables, after taking into account the influence of some exogenous variables. This is a test to identify the equilibrium relation (5.1) with influences of some exogenous variables. As such an exogenous variable, we paid a particular attention to the difference between the SDR-based, trade-weighted real effective exchange rate $REER^{SDRTW}$ and the currency-weighted, realized real effective exchange rate $REER^{CW}$, which was termed as *DIFFRER* in equation (5.15). Since the SDR-based, trade-weighted real effective exchange rate $REER^{SDRTW}$ is a hypothetical real exchange rate assuming a non-policy intervention real effective exchange rate, its difference with $REER^{CW}$ does not enter into the cointegrating equation as a fundamental variable determining the long-run equilibrium real exchange rate. If we assume, however, that the actual real exchange rate might adjust toward an equilibrium real exchange rate by eliminating the equilibrium difference between the realized real exchange rate $REER^{CW}$ and the hypothetical trade-weighted real exchange rate $REER^{SDRTW}$, we may be able to include the difference $DIFFRER$ as an exogenous variable to influence the equilibrium real exchange rate. This is the case in Table 3 that is specified as "$DIFFRER_{t-1}$ is included as an exogenous variable". As shown, we included the last period's difference in the two real exchange rates, $DIFFRER_{t-1}$, as influencing the change in the actual real effective exchange rate in current period $\Delta REER^{CW}_{t-1}$. Because the variable $DIFFRER_{t-1}$ is a stationary variable, we can include it in the VEC estimation model.

First, examine the case where the variable $DIFFRER_{t-1}$ is not included as the exogenous variable, i.e. the upper half part of Table 3. The Johansen's cointegration trace test indicates that the null hypothesis of at most one cointegrating equation ($r \leq 1$), as opposed to the alternative hypothesis of $k = 6$ cointegrating equation, is rejected at 1% significance level, but that the null of at most two cointegrating equations ($r \leq 2$), as compared to the same alternative hypothesis, cannot be rejected even at 5% significance level. Therefore, the trace test indicates that there are two cointegrating equations among the variables. We show one cointegrating equation, which is our research interest, and the adjustment parameter α as a reference in Table 3, which will be fully analyzed in the following section.

Next, the other case that $DIFFRER_{t-1}$ is included as the exogenous variable is shown in the bottom half part of Table 3. In this case too, the null hypothesis of at most one cointegrating equation ($r \leq 1$), as opposed to the alternative hypothesis of $k = 6$ cointegrating equation, is rejected at 1% significance level, but the null of at most two cointegrating equations ($r \leq 2$) cannot be rejected even at 5% significance level. Hence, we conclude that there are two cointegrating equations when we include $DIFFRER_{t-1}$ as the exogenous variable. Again, the particular cointegrating equation of our interest and the adjustment parameter are shown as a reference in Table 3.

5.3 Estimation results of the error correction model

The estimation results of the vector error correction (VEC) model, equation (5.1), are shown in Table 4. We paid a particular attention to the first equation of the VEC model, whose estimation results are shown in the table. As in the case of the cointegration tests, we set up two specifications; one specification is the case where the one-period lagged difference between the two real exchange rates, $DIFFRER_{t-1}$, is not included as the exogenous variable, and the other specification is the case where it is included. The estimation result of the first specification is shown in the second column of Table 4, and that of the second specification is given in the third column.

When estimating the VEC model, we included one-period lagged first-differenced variables in the equation, in addition to the cointegrating equation. That is, our estimated model is specified as

$$\Delta REER_t^{CW} = \alpha_1 \cdot (c + \hat{\beta} y_{t-1} + T) + \gamma_1 \Delta y_{t-1} + \delta_1 DIFFRER_{t-1} + c_0 + \eta_{1,t}, \quad (5.6)$$

where the equation $u_{1,t-1} = c + \hat{\beta} y_{t-1} + T$ is the cointegrating equation estimated within the model; the term $\gamma_1 \Delta y_{t-1}$ is the equation (5.4) with $j = 1$; the term $DIFFRER_{t-1}$ is optional, depending on the specification of the model. Although one of the reasons to include only one-period lagged first-differenced variables, Δy_{t-1}, is that the number of observations is relatively small, i.e. 50, the estimated residual $\hat{\eta}_{1,t}$ in equation (5.6) appears to be a white noise process. On testing the estimated residual for a unit root by the ADF test, we obtained the ADF test statistic of -7.0263 for the case without $DIFFRER_{t-1}$ and -6.6254 for the case with $DIFFRER_{t-1}$, in both of which the null hypothesis of a unit root is rejected at 1% significance level. Hence, inclusion of only one-period lagged first-differenced variables in the estimation model seems to be validated[7].

The parameters of the estimated cointegrating equations, which are the same as those obtained in the cointegrating tests, are shown in the upper half of Table 4 under the heading of "Parameters on cointegrating equation". On the other hand, the estimated parameters on the one-period lagged first-differenced variables are shown in the lower half of Table 4 under the heading of "Parameters on short-run dynamics". The estimated parameter on the exogenous variable $DIFFRER_{t-1}$ is given in the last row.

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[7] The Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC) obtained from estimation of equation (5.1) without $DIFFRER_{t-1}$ are -5.14 and -4.84. On the other hand, the AIC and SIC with two-periods lagged first-differenced variables included are -4.63 and -4.10, respectively. Hence, the specification of one-period lagged variables included seems to be better.

The theory of long-run equilibrium real exchange rate laid out in sections 3.5 and 4.1 predicts that when we move the terms other than $REER^{CW}_{t-1}$ in the cointegrating equation to the left-hand side, the signs of parameters are as shown in equation (5.7) below.

$$\begin{aligned} REER^{CW}_{t-1} = \underset{(-)}{b_1}\, GVSNT_{t-1} + \underset{(+)}{b_2}\, RESGDP_{t-1} + \underset{(-)}{b_3}\, TOT_{t-1} \\ + \underset{(+)}{b_4}\, TRDPOLICY_{t-1} + \underset{(-)}{b_5}\, HBS_{t-1} - TREND + C + u_{t-1}. \end{aligned} \tag{5.7}$$

We first examine the case without the exogenous variable $DIFFRER_{t-1}$. For analytical ease, we copy the estimated cointegrating equation from Table 4, shown in (5.8)[8].

$$\begin{aligned} u_{t-1} = REER^{CW}_{t-1} + \underset{(0.0625)}{0.4568} GVSNT_{t-1} - \underset{(0.0022)}{0.0146} RESGDP_{t-1} + \underset{(0.1398)}{0.2963} TOT_{t-1} \\ - \underset{(0.0583)}{0.1069} TRDPOLICY_{t-1} + \underset{(0.1688)}{0.1574} HBS_{t-1} - \underset{(0.0022)}{0.0025} TREND - 7.1132 \end{aligned} \tag{5.8}$$

Note that signs of the long-run parameters in equation (5.8) that are consistent with the theory are just the opposite of the signs of the parameters in equation (5.7). The estimated results in (5.8) reveal that all of the estimated long-run parameters have the correct sign that the theory predicts. First, when the ratio of government's spending on nontraded goods to GDP ($GVTSNT_{t-1}$) increases, real exchange rate tends to appreciate. Since both $REER^{CW}_{t-1}$ and $GVTSNT_{t-1}$ are measured in logarithm, we may interpret the relation such that a one percent increase in the ratio of government's spending on nontraded goods to GDP will lead to about 0.46 percent appreciation of real exchange rate. Second, when trade balance, measured by the ratio of resource balance to GDP ($RESGDP_{t-1}$), improves, real exchange rate tends to depreciate[9]. Third, when terms of trade (TOT_{t-1}) improves by one percent, real exchange rate appreciate by about 0.3 percent. Fourth, trade restriction policies, measured by the ratio of import tariff plus export tax to total value of trade ($TRDPOLICY_{t-1}$), have a positive statistical association with real exchange rate; when trade restriction policies are liberalized such that the ratio $TRDPOLICY_{t-1}$ decreases by one percent, real exchange rate will appreciate approximately by 0.1 percent. The long-run parameters on $GVTSNT_{t-1}$

[8] The figure in parenthesis is standard error.

[9] The variable $RESGDP_{t-1}$ is not measured in logarithm, but in level.

and $RESGDP_{t-1}$ are statistically significant at one percent level, while the parameters on TOT_{t-1} and $TRDPOLICY_{t-1}$ are statistically significant at five percent and ten percent level, respectively. The last fundamental variable is HBS_{t-1} that captures the Harrod - Balassa - Samuelson effect. The coefficient on HBS_{t-1} is not statistically significant at any conventional significance level. Its negative sign, however, corresponds to the theoretical prediction; when productivity of traded goods sector relative to that of nontraded goods sector increases, real exchange rate tends to appreciate.

The value of the adjustment parameter α is -0.3710 and statistically significant at one percent level. The negative value calls for the following interpretation. When there occurs a positive equilibrium error in the previous period represented by $u_{t-1} > 0$, that is, when the real exchange rate in the previous period overshoot the equilibrium real exchange rate that is explained by the fundamental variables, the real exchange rate in current period will decline, i.e. appreciate, to approach the equilibrium real exchange rate. In other words, the equilibrium error in the previous period tends to be corrected in the current period, when the adjustment parameter has a negative value.

On the other hand, the parameters on short-run dynamic terms are a little difficult to interpret, since many of them have a different sign from that predicted by the theory of long-run equilibrium real exchange rate. For example, the one-period lagged, first-differenced value of the ratio of government's spending on nontraded goods to GDP ($\Delta GVSNT_{t-1}$) has a positive statistical association with the change in real effective exchange rate in current period ($\Delta REER_t^{CW}$) in the short-run. Thus, one-period lagged short-run impact, on the evolution of real exchange rate, of the change in government's spending on nontraded goods appears to be different from the long-run equilibrium relation between those two variables as revealed in the cointegrating equation. Since each parameter of a VAR system is sometimes difficult to interpret (Enders, 1995), we emphasize the analyses of the long-run equilibrium relation between real exchange rate and its fundamental determinants without analyzing the short-run dynamics.

Next, turn to the second specification that includes the exogenous variable $DIFFRER_{t-1}$. The estimated cointegrating equation is given below:

$$\begin{aligned} u_{t-1} = REER_{t-1}^{CW} &+ \underset{(0.0645)}{0.5744} GVSNT_{t-1} - \underset{(0.0024)}{0.0138} RESGDP_{t-1} + \underset{(0.1470)}{0.3853} TOT_{t-1} \\ &- \underset{(0.0604)}{0.0903} TRDPOLICY_{t-1} + \underset{(0.2258)}{0.4490} HBS_{t-1} - \underset{(0.0033)}{0.0060} TREND - 8.1604. \end{aligned} \tag{5.9}$$

The estimated long-run parameters in the cointegrating equation are essentially similar to those of equation (5.7) in terms of sign and magnitude. All the parameters have the correct sign that is consistent with the theory of the equilibrium real exchange rate. The estimated parameters on $GVSNT_{t-1}$, $RESGDP_{t-1}$ and TOT_{t-1} are significant at one percent level. The main differences from the model without the exogenous term $DIFFRER_{t-1}$ are: the parameter on HBS_{t-1} turns significant at ten percent level, whereas the parameter on $TRDPOLICY_{t-1}$ becomes insignificant even at ten percent level. The value of the adjustment parameter α is -0.2597, which is significant at one percent level. The equilibrium error occurred in the previous period tends to be corrected toward attaining the equilibrium real exchange rate in the current period.

The speed of adjustment, that is, the absolute value of α, becomes a little smaller compared with the model without the term $DIFFRER_{t-1}$. This may be explained by examining the estimated parameter δ_1 on $DIFFRER_{t-1}$. Recall that the real exchange rate differential $DIFFRER_{t-1}$ is computed by subtracting the currency-weighted, realized real effective exchange rate $REER_{t-1}^{CW}$ from the hypothetical SDR-based trade-weighted real effective exchange rate $REER_{t-1}^{SDRTW}$. Therefore, a negative value of $DIFFRER_{t-1}$ means that the realized real exchange rate depreciated relative to the theoretical SDR-based trade-weighted real exchange rate in the previous period. Its positive value, on the other hand, indicates appreciation of the realized real exchange rate, relative to the theoretical trade-weighted real exchange rate[10]. An increase in the positive magnitude of $DIFFRER_{t-1}$ measures a widening gap between the theoretical exchange rate and actual real exchange rate, that is, a further real appreciation relative to the theoretical rate in the previous period. Likewise, an increase in the negative number of $DIFFRER_{t-1}$ indicates a narrowing gap between $REER_{t-1}^{SDRTW}$ and $REER_{t-1}^{CW}$.

The estimated parameter δ_1 on $DIFFRER_{t-1}$ has a positive value of 0.0933, which is significant at one percent level. Suppose that the real exchange rates differential $DIFFRER_{t-1}$ took a positive value in period $t-1$, meaning that the actual real exchange rate appreciated relative to the theoretical SDR-based trade-weighted real exchange rate in that

[10] We normalized the values of $REER_{t-1}^{CW}$ and $REER_{t-1}^{SDRTW}$ by setting the average value in 1990 equal to 100 for each variable. Therefore, in contrast to Figure 1 where the value of $REER_t^{CW}$ always exceeds the value of $REER_t^{SDRTW}$ since November 1984, the computed differential $DIFFRER_{t-1}$ may take a positive value or a negative value in each period.

period. Then, a positive value of δ_1 indicates that the actual real exchange rate tends toward depreciation in the current period. If, instead, actual real exchange rate depreciated relative to the theoretical rate in the previous period, then the current real exchange rate moves toward appreciation. Since the variable $DIFFRER_{t-1}$ is measured in logarithm, we may interpret the value of δ_1 such that a one percent increase in real appreciation of the actual real exchange rate relative to the theoretical rate in the previous period is associated with 0.093 percent depreciation of the actual real exchange rate in the current period. Likewise, a one percent increase in real depreciation of the actual real exchange rate relative to the theoretical rate in the previous period is associated with 0.093 percent appreciation of the actual real exchange rate in the current period. Thus, the real exchange rates differential $DIFFRER_{t-1}$ plays a role in attaining the equilibrium real exchange rate that is similar to the role played by the cointegrating equation (the equilibrium error) and the adjustment parameter.

Table 2 Unit Root Tests

Variable	ADF test			Phillips-Perron test		
	Include:	Lag length	Test statistics (p-value)	Include:	Band-width	Test statistics (p-value)
$REER^{CW}$	Intercept Trend	0	-2.5952* (0.2842)	Intercept Trend	4	-2.594* (0.2846)
$REER^{SDRTW}$	Intercept Trend	0	-2.0910* (0.5380)	Intercept Trend	1	-2.1693* (0.4957)
DIFFRER	Intercept	0	-3.6825 (0.0073)	Intercept	1	-3.5798 (0.0097)
GVSNT	Intercept	4	-1.3479* (0.6003)	Intercept	2	-3.4319*** (0.0143)
RESGDP	Intercept	0	-2.4482* (0.1341)	Intercept	0	-2.4482* (0.1341)
TOT	Intercept	1	-2.4095* (0.1442)	Intercept	4	-1.9094* (0.3256)
TRDPOLICY	Intercept Trend	0	-2.2571* (0.449)	Intercept Trend	4	-2.3340* (0.4087)
HBS	Intercept Trend	2	-2.4719* (0.3402)	Intercept Trend	5	-2.7266* (0.2308)

Note: 1. Sample period: 1984, 4th quarter – 1997, 2nd quarter

2. Null hypothesis: The variable has a unit root.

3. The p-values in parentheses are MacKinnon's one-sided p-values (MacKinnon, 1991).

4. The lag length in ADF test is selected based on the Schwarz Information Criterion.

5. Asterisks *, **, *** stand for "Not reject the null hypothesis", at 10% significance level, 5% level and 1% level, respectively.

Table 3 Johansen's Cointegration Tests (Trace test)

r : No. of cointegrating equations	Largest Eigenvalue for $r < i$	Trace statistic: $LR_{Trace}(r\|k)$	5% critical value	1%critical value
(1) $DIFFRER_{t-1}$ is not included as an exogenous variable.				
$r = 0^{**}$	0.6833	158.39	114.90	124.75
$r \le 1^{**}$	0.6039	99.75	87.31	96.58
$r \le 2$	0.4323	52.52	62.99	70.05
Cointegrating equation: $CIEQ_{t-1}$	$CIEQ_{t-1} \equiv u_{t-1} = REER^{CW} - 7.1132 + 0.4568GVSNT_{t-1} - 0.0146RESGDP_{t-1} + 0.2963TOT_{t-1} - 0.1069TRDPOLICY_{t-1} + 0.1574HBS_{t-1} - 0.025TREND$			
Adjustment parameter on $CIEQ_{t-1}$: α	$\alpha = -0.3710$ (0.0714)			
(2) $DIFFRER_{t-1}$ is included as an exogenous variable.				
$r = 0^{**}$	0.6487	155.28	114.90	124.75
$r \le 1^{**}$	0.6348	102.97	87.31	96.58
$r \le 2$	0.4515	52.61	62.99	70.05
Cointegrating equation: $CIEQ_{t-1}$	$CIEQ_{t-1} \equiv u_{t-1} = REER^{CW} - 8.1604 + 0.5744GVSNT_{t-1} - 0.0138RESGDP_{t-1} + 0.3853TOT_{t-1} - 0.0903TRDPOLICY_{t-1} + 0.4490HBS_{t-1} - 0.0060TREND$			
Adjustment parameter on $CIEQ_{t-1}$: α	$\alpha = -0.2597$ (0.0800)			

Note: 1. Null hypothesis is the number of cointegrating equations in the data. The critical values are taken from Osterwald-Lenum (1992). The figure in parenthesis is standard errors.

2. In both tests, Johansen's trace test indicates two cointegrating equations at both 5% and 1% levels. We use the case of one cointegrating equation in the following analyses.

Table 4 Estimation of Error Correction Models

	$DIFFRER_{t-1}$, not included	$DIFFRER_{t-1}$, included
Cointegrating equation: $CIEQ_{t-1}$	$CIEQ_{t-1} \equiv u_{t-1} = REER^{CW} - C - b_1 GVSNT_{t-1} - b_2 RESGDP_{t-1} - b_3 TOT_{t-1} - b_4 TRDPOLICY_{t-1} - b_5 HBS_{t-1} - TREND$	
Adjustment parameter α on $CIEQ_{t-1}$	-0.3710*** (0.0714)	-0.2597*** (0.0800)
Parameters on cointegrating equation		
$GVSNT_{t-1}$	0.4568*** (0.0625)	0.5744*** (0.0645)
$RESGDP_{t-1}$	-0.0146*** (0.0022)	-0.0138*** (0.0024)
TOT_{t-1}	0.2963** (0.1398)	0.3853*** (0.1470)
$TRDPOLICY_{t-1}$	-0.1069* (0.0583)	-0.0903 (0.0604)
HBS_{t-1}	0.1574 (0.1688)	0.4490* (0.2258)
C	-7.1132	-8.1604
$TREND$	-0.0025 (0.0022)	-0.0060* (0.0033)
Parameters on short-run dynamics		
$\Delta REER^{CW}_{t-1}$	0.3024*** (0.1136)	0.2364* (0.1286)
$\Delta GVSNT_{t-1}$	0.0960*** (0.0275)	0.0841*** (0.0323)
$\Delta RESGDP_{t-1}$	-0.0024 (0.0015)	-0.0016 (0.0015)
ΔTOT_{t-1}	0.0754 (0.0892)	0.0919 (0.0948)
$\Delta TRDPOLICY_{t-1}$	-0.0750* (0.0411)	-0.0742* (0.0429)
ΔHBS_{t-1}	0.4613* (0.2667)	0.3928 (0.2671)
C	-0.0044 (0.0038)	-0.0073* (0.0043)
$DIFFRER_{t-1}$	——	0.0933*** (0.0406)
Adjusted R^2	0.3672	0.3036
Log likelihood	139.09	135.96

Note: 1. n = 50. The dependent variable is $REER^{CW}_t$. The figure in parenthesis is standard errors.

2. Asterisks *, **, *** stand for 10% significance level, 5% level, and 1% level, respectively.

6. Summary and conclusion

Until July 2nd 1997 when the currency crisis hit Thailand, the Thai government had maintained the currency basket exchange rate scheme for twelve-and-half years since November 1984. Under the currency basket exchange rate system, Thai baht was pegged to a basket of currencies of major trading partner countries. It was officially described as a trade-weighted average exchange rate of the currencies in the basket, although the actual weight on each currency was not publicized. As the bilateral exchange rate fluctuated for any pairs of currencies under the flexible exchange rate system, Thai baht should also have exhibited some fluctuations with each currency in the basket. The data shows, however, that baht-US dollar exchange rate stayed fairly constant throughout the period, despite the US dollar's fluctuation with other currencies. On the other hand, Japanese yen-baht rate showed fluctuations that mimicked the movement of yen-US dollar rate. Economists and market participants conjectured that the Thai authority assigned a significantly large weight to the US dollar in the basket that was not proportional to the USA's trade weight with Thailand. Our estimation results confirmed this conjecture; while USA's trade share in Thailand's trade with major trading partner countries is 20.1%, the estimated currency weight attached to the US dollar is 75.6%. On the other hand, whereas Japan's trade share stands at 29.9%, Japanese yen's weight in the currency basket is estimated to be 10.5%. Obviously, an unparalleled large weight was given to the US dollar in the currency basket, while Japanese yen was assigned the least weight relative to the trade weight. We may be able to say that Thai baht was nominal anchored to the US dollar under the currency basket exchange rate system.

As a fundamental cause of the large capital flight before the currency crisis, some researchers pointed out the possibility of real overvaluation of Thai baht for some periods preceding the currency crisis, by examining rapid and growing current account deficits during that period. Other researchers ascribed such real overvaluation of Thai baht to the currency basket exchange rate system, in which Thai baht was nominal anchored to the US dollar. In this paper, we examined whether such nominal anchor foreign exchange rate policy, with baht virtually tied to the US dollar, during the period of the currency basket system in fact led to misalignments of the real effective exchange rate of Thai baht.

In order to judge whether the observed real effective exchange rate was misaligned, we need, as a benchmark real exchange rate, a properly defined long-run equilibrium real exchange rate. In this paper, the long-run equilibrium real exchange rate is defined as the value of the real exchange rate that is consistent with the dual objectives of internal and external balance for specified values of fundamental variables that may influence these objectives. The internal balance refers to a situation in which the market for nontraded goods is in a sustainable equilibrium at full employment level, whereas the external balance refers to a situation in which the value of the current account deficit is equal to the net capital inflow necessary to sustain the steady-state value of the net international creditor position. As a reference model of such a long-run equilibrium real exchange rate, we followed the model of Montiel (1999b) with some extensions. We tested the model with the data. As regard to empirical specifications, we selected five fundamental macroeconomic variables that may influence the level and change of the long-run equilibrium real exchange rate. They are: composition of government's spending: trade balance: terms of trade: degree of trade intervention: differential productivity growth between the traded goods sector and the nontraded goods sector to capture the Harrod-Balassa-Samuelson effect.

Focusing on the entire period of the currency basket exchange rate system between November 1984 and June 1997, we estimated the model of the long-run equilibrium real exchange rate. The rationale of this research agenda is whether we can statistically identify, from the data, the long-run equilibrium real exchange rates that are consistent with the fundamental macroeconomic variables determining them. If such long-run equilibrium real exchange rates are identified from the data, then we may be allowed to judge that the nominal anchor exchange rate policy, tied virtually to the US dollar, did not lead to misalignments of the real exchange rates in the long-run, although the possibility of short-run misalignment, such as the real exchange rate overvaluation during six months before the currency crisis, may not be precluded. In our econometric specification, such short-run deviation from the long-run equilibrium level is tested for the existence of an adjustment movement, or the error correction, toward the long-run equilibrium level.

The econometric model we used is an error correction model for nonstationary variables, which is suited for identifying the long-run equilibrium real exchange rate and its long-run equilibrium relation with the fundamental macroeconomic variables that determine the equilibrium rate. We made, however, one important extension to the base empirical model. We tried to assess the effect, toward the equilibrium real exchange rate, of the deviation of the observed currency-weighted real effective exchange rate under the nominal anchor policy $REER^{CW}$ from that obtained under a theoretical pure trade-weighted effective exchange rate scheme. For this purpose, we computed a hypothetical SDR-based, trade-weighted real effective exchange rate $REER^{SDRTW}$ that would have evolved, if the Thai authority had followed a strict trade-weighted currency basket policy in determining the bilateral exchange rates in the currency basket. In particular, we are interested in testing whether the nominal anchor policy-induced difference in the real effective exchange rates in the previous period, i.e. the difference between $REER^{SDRTW}$ and $REER^{CW}$, has a dynamic adjustment mechanism to pull the observed currency-weighted real effective exchange rate $REER^{CW}$ close to the theoretical SDR-based trade-weighted real effective exchange rate $REER^{SDRTW}$ in the following periods.

The estimation results of the error correction models reveal that there exists a long-run equilibrium relation between the currency-weighted real effective exchange rate $REER^{CW}$ and the fundamental macroeconomic variables determining the long-run equilibrium real exchange rate. Moreover, the error correction adjustment parameter indicates that when an equilibrium error in the realized real exchange rate occurs in the previous period, a force will work to correct the equilibrium error toward achieving the long-run equilibrium real exchange rate in the current period. Furthermore, when we include the one-period lagged difference between $REER^{SDRTW}$ and $REER^{CW}$ as an exogenous variable, it has positive statistical association with current change in the currency-weighted real effective exchange rate. This indicates for example that when the observed currency-weighted real effective exchange rate appreciated relative to the theoretical SDR-based trade-weighted real effective exchange rate in the previous period, the observed real exchange rate tends to depreciate to narrow the gap with the SDR-based real exchange rate in the current period. Thus, both the error correction term and the difference between the two measures of real effective exchange rates will force the observed real exchange rate to move toward the long-run equilibrium real exchange rate in a dynamic context.

From theses observations, we conclude that even though there might have been an overvaluation of the real exchange rate of Thai baht for a short period before the currency crisis, the nominal anchor exchange rate policy, which ties Thai baht mainly to the US dollar in the currency basket, was overall consistent with the long-run equilibrium real exchange rate that are determined by the fundamental macroeconomic variables. In addition to this long-run relation, we find evidence that as the nominal anchor-based real effective exchange rate deviated from the theoretical SDR-based trade-weighted real effective exchange rate in the previous period, the actual real exchange rate under the nominal anchor policy tended toward narrowing the gap between the two in the following period.

Appendices

1. Construction of the real effective exchange rate index

(1) Currency-weighted real effective exchange rates: $REER_t^{CW}$

This is the realized, actual real effective exchange rate index. The series $REER_t^{CW}$ is computed by the following method.

- First, compute the trade-weighted nominal effective exchange rate index with the following formula:

$$NEER_t^{TW} = \sum_i w_{i,t} \cdot e_{i,t}\ , \qquad \text{(A1)}$$

where $NEER_t^{TW}$ is a trade-weighted nominal effective exchange rate index at time t;
$w_{i,t}$ is trade weight of i' s trading partner country of Thailand constructed as

$$w_{i,t} \equiv \frac{x_{i,t} + m_{i,t}}{\sum (x_{i,t} + m_{i,t})}, \qquad \text{(A2)}$$

$x_{i,t}$ is value of Thailand's export to country i, and

$m_{i,t}$ is value of Thailand's import from country i;

$e_{i,t}$ is bilateral nominal exchange rate with country i's currency, indexed with January 1990 set at the base period, where the nominal exchange rate is the price of foreign currency in terms of Thai baht, and the countries included in the sample are the following fourteen countries: Japan, USA, Germany, United Kingdom, Singapore, France, Italy, Netherlands, Australia, Malaysia, South Korea, Taiwan, Republic of China, and Hong Kong.

- Second, calculate the foreign consumer prices index

$$CPIF_t = \sum_i w_{i,t} \cdot CPI_{i,t}\ , \qquad \text{(A3)}$$

where $CPIF_t$ is a weighted average foreign consumer prices index, and $CPI_{i,t}$ is the consumer prices index of country i. We used the trade weight $w_{i,t}$ to calculate $CPIF_t$.

- Third, compute the currency-weighted real effective exchange rate index by the following formula

$$REER_t^{CW} = NEER_t^{TW} \cdot \frac{CPIF_t}{CPIT_t}, \tag{A4}$$

where $CPIT_t$ is the consumer price index of Thailand.

As is seen in the above formulas, the currency-weighted real effective exchange rate is simply a trade-weighted average of the bilateral real exchange rates with the major trading partner countries of Thailand. The bilateral nominal exchange rates used to compute the bilateral real exchange rates, however, have already incorporated the effects of the currency specific weights for each foreign currency, which are enforced by the Thai authorities. Therefore, we call the realized, actual trade-weighted real effective exchange rate "*the currency-weighted real effective exchange rate*".

(2) SDR-based trade-weighted real effective exchange rate: $REER_t^{SDRTW}$

This is a hypothetical real effective exchange rate index, which is constructed assuming that the government adopted a rule to adhere to a strict trade-weight scheme in forming bilateral nominal exchange rates in a basket. Starting with the baht-SDR rate in November 1984[11] as the base rate, we created a hypothetical non-policy intervention baht-SDR rate series in the following periods, using a trade-weighted average change in the foreign currencies' value per SDR in the basket. Then, with these non-policy intervention baht-SDR rate series, we constructed real effective exchange rates. Total of export and import with each trading partner country is used as the weighting scheme.

The SDR-based real effective exchange rate is defined as

$$REER_t^{SDRTW} = \sum_i \left(\frac{ESDR_t^{Thai}}{ESDR_t^i} \cdot \frac{P_t^i}{P_t^{Thai}} \right) \cdot TW_t^i. \tag{A5}$$

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[11] Thai government switched to the currency basket method in determining the bilateral exchange rates in November 1984.

The variable $ESDR_t^{Thai} \equiv Basket\left(\frac{baht}{SDR}\right)_t$ is a hypothetical baht-SDR rate under the foreign currency basket scheme, which was computed using a trade-weighted average of the national currency-SDR rates for the major fourteen trading partner countries in the basket (see section (1) of these appendices for the fourteen countries). More precisely, the variable $ESDR_t^{Thai} \equiv Basket\left(\frac{baht}{SDR}\right)_t$ is constructed as follows. Let the base period t_0 be November 1984. Index the realized baht per SDR in the base period as 100;

$$\left(\frac{baht}{SDR}\right)_{t_0=1984/11} = 100.$$

For the succeeding period $t_0 + h$, $h = 1,2,3,---$, define $Basket\left(\frac{baht}{SDR}\right)_{t_0+h}$ by

$$Basket\left(\frac{baht}{SDR}\right)_{t_0+h} = \left(\frac{baht}{SDR}\right)_{t_0+h-1} \cdot \left[1 - \sum_i TW_{t_0+h}^i \cdot \frac{\Delta\left(\frac{NC_i}{SDR}\right)_{t_0+h}}{\left(\frac{NC_i}{SDR}\right)_{t_0+h-1}}\right], \qquad \text{(A6)}$$

where $\left(\frac{NC_i}{SDR}\right)_{t_0+h-1}$ is the value of national currency i per SDR at the end of time $t_0 + h - 1$, indexed as the average value of 1990 to be set at 100, and $\Delta\left(\frac{NC_i}{SDR}\right)_{t_0+h}$ is the change in the value of currency i per SDR during the period $t_0 + h$. The second term in the bracket of equation (A6) measures a trade-weighted average of the percentage changes of depreciation, or appreciation, of the foreign currencies per SDR in the basket. Suppose that the trade-weighted average of the changes in the foreign currency values per SDR exhibits depreciation. Then, Thai baht is assumed to have appreciated on average against the currencies in the basket, which is captured by baht's appreciation against SDR. We recursively computed $Basket\left(\frac{baht}{SDR}\right)_{t_0+h}$ for $h = 1,2,3,---$. After computing $ESDR_{t_0+h}^{Thai} \equiv Basket\left(\frac{baht}{SDR}\right)_{t_0+h}$, we index the series by setting the average value in 1900 at 100.

In equation (A5), the variable $ESDR_t^i \equiv \left(\frac{NC_i}{SDR}\right)_t$ is the value of national currency i per SDR at time t, indexed as its average value in 1990 set at 100.

Thus, the variable $REER_t^{SDRTW}$ measures the hypothetical real effective exchange rates, assuming that starting in November 1984 the government followed a rule of constructing a currency basket and setting bilateral nominal exchange rates under the strict trade-weight scheme.

(3) Difference between the SDR-based trade-weighted real effective exchange rate and the currency-weighted real effective exchange rate: *DIFFRER*

$$DIFFRER \equiv REER^{SDRTW} - REER^{CW} \quad \text{(A7)}$$

The positive value of $DIFFRER$ indicates that the realized real effective exchange rate may be overvalued, as opposed to the hypothetical real effective exchange rate that is assumed to obtain if the trade weighting scheme were strictly observed.

2. Definition of the variables and source of data

(1) Real effective exchange rates: $REER_t^{CW}$ and $REER_t^{SDRTW}$

Definitions of $REER_t^{CW}$ and $REER_t^{SDRTW}$ are given in section 1 of appendices. These two variables are measured in logarithms. The sources of data are as follows.

Exchange rates:

- The value of national currency per SDR: International Financial Statistics, IMF
- Bilateral nominal exchange rates - price of foreign currency in terms of Thai baht: Quarterly Bulletin, Bank of Thailand

Trade data:

- Values of Thailand's export and import with the countries in the basket: Quarterly Bulletin, Bank of Thailand
- Current account: Quarterly Bulletin, Bank of Thailand

(2) Government's spending on nontraded goods: *GVSNT*

The variable *GVSNT* is ratio of government's spending on nontraded goods to GDP, both in nominal terms. We assume that the government's spending on nontraded goods is comprised of payments for social services, costs of general administration and service, and costs for unclassified spending items, which are reported in the Quarterly Bulletin of Bank of Thailand from which the data is taken. This variable is measured in terms of logarithm.

(3) Resource balance to GDP ratio: *RESGDP*

This variable measures the ratio of trade balance to GDP, both computed in nominal terms. Since this variable becomes a negative number under the trade deficits, we use the original data without taking logarithm. The data is taken from Quarterly Bulletin of Bank of Thailand.

(4) Terms of trade: *TOT*

We use the concept of terms of trade defined as the ratio of average export price to average import price, both measured in terms of home currency. This variable is measured in terms of logarithm. The data is taken from Quarterly Bulletin of Bank of Thailand.

(5) Trade restrictions: *TRDPOLICY*

This variable is computed such that sum of import tariff and export tax divided by sum of export value and import value. A larger value of *TRDPOLICY* indicates more restrictive trade policy. This variable is measured in terms of logarithm. The data comes from Quarterly Bulletin of Bank of Thailand.

(6) The Harrod-Balassa-Samuelson effect: *HBS*

The Harrod-Balassa-Samuelson effect (HBS effect) measures the effect of differential productivity growth between traded goods sector and nontraded goods sector on real exchange rate. When the productivity growth of traded goods sector exceeds that of nontraded goods sector in home country, compared to a foreign country, the home country's real exchange rate will appreciate. We use, as a proxy variable to capture the H-B-S effect, the ratio of Thailand's GDP per worker to the average GDP per worker in the Thailand's major trading partner countries in OECD. Since the data, taken from the PENN World Table version 6, records only the yearly data, we first computed simple quarterly average, and constructed a smooth moving average quarterly data series. The data was converted into a logarithm form.

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