Exchange Rate Overshooting in Thailand

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Abstract

This paper investigates the exchange rate overshooting phenomenon for Thailand over the period 1987-2000 using Autoregressive Distributed Lag (ARDL) regression method introduced by Pesaran and Shin (1998). The study is based on the sticky-price monetary model introduced by Dornbusch (1976), that asserts that an increase in money supply causes currency to depreciate in the long run with some short run rigidity caused by price stickiness. The results of the study support the exchange rate overshooting hypothesis for Thailand and it is in line with the findings of Bahmani-Oskooee and Kara (2000).

1. Introduction

In the wake of the turmoil in East Asian currency markets, several East Asian countries - Thailand, Indonesia, Philippines, Malaysia and Korea - allowed their currencies to float relatively free after July 1997. Their moves represented a substantial departure from the previous practice of tightly managing, or "pegging" currencies against either the U.S. dollar or a basket of currencies. Since ten, the exchange rates of these studies have gradually become more obviously determined by market forces.

In an effort to explain the abnormal fluctuations in an exchange rate, Dornbusch (1976) introduced his "sticky-price" monetary model, which contained an "overshooting" hypothesis. The main feature of his model was that since prices are sticky in the short run, an increase in the money supply (which result in lower interest rates and thus capital outflow) causes currency depreciation. The currency actually depreciates beyond its long-run value. In other words, in the short run it "overshoot" itself. However, over time, commodity prices rise, which result in a decrease in the real money supply. This in turn, causes the interest rates to rise and the currency to appreciate (although the currency was found still be below its value prior to the increase in money supply).

Dornbusch's exchange rate overshooting model is found to be an obvious phenomenon for this study and his work has remained at the core of international finance theory. Dornbusch predicted that the exchange rate would initially overshoot its long-run level in adjusting to a monetary shock, which owes much of its huge appeal to two factors. First, it provides hope of explaining why the exchange rates in the post-Bretton Woods era were more volatile than were macroeconomic fundamental variables such as money supply, output and interest rates. Second, the overshooting phenomenon conclusion relies on shocks on nominal interest rate, uncovered interest rate parity (UIP), and long-run purchasing power parity (PPP).

While overshooting is a dominant theory in international finance, its reliance on UIP means that when confronted with data, the

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theory is enmeshed into a dominant empirical puzzle in international finance. It remains an open question as to whether the exchange rate overshooting hypothesis applies in response to the monetary shocks in these particular five countries. It is an empirical question what happens to the long-run value of the currency in Thailand. This paper focuses on two questions:

1) Does the exchange rate overshoot in Thailand? More specifically, in what time lag does the exchange rate peak after a monetary shock?

2) Is exchange rate overshooting a short-run phenomenon, or is there evidence that it may continue over longer time-periods?

Most previous studies have investigated exchange rate overshooting in developed countries. A few studies applied Dornbusch's overshooting model for developing countries, especially for East Asian countries. Among others, Chin (1997) tested a sticky-price model of the exchange rate using quarterly data on seven currencies: the Indonesian *rupiah*, the Malaysian *ringgit*, the Philippine peso, the Singapore dollar, the Taiwanese dollar and the Thai *baht* before the crisis from 1970 to 1996. The model proved empirically unsuccessful, except in the cases of Thailand and Singapore.

Hence, the objective of this paper is to empirically measure the effect of shocks in the exchange rate, money supply, output, interest and inflation rate by applying Dornbusch's exchange rate overshooting model to Thailand that encountered both external and internal shocks during the 1997 economic crisis. This paper will look at how these macroeconomic models behaved by using the monthly data from 1987 to 2000 for Thailand.

This paper applies Pesaran and Shin's (1998) techniques, which introduced yet another model of testing cointegration. The approach, known as the "Autoregressive Distributed Lag" (ARDL) approach, has the advantage of avoiding the classification of variables that are integrated of order one [i.e., $I(1)$] or order zero [i.e., $I(0)$]. Unlike the standard cointegration tests, there is no need for unit root pre-testing.

The purpose of this paper is to extend the literature on the dynamics of the exchange rate overshooting hypothesis by considering Thailand in the light of recent advances in applied research. Thailand is the first country experienced currency devaluation during the Asian economic crisis of 1997.

This paper is divided as follows. Section 1 discusses the exchange rate monetary model. Section 2 presents the econometric methodology. Section 3 describes the empirical results. Finally, section 4 provides a summary and conclusion. Data definitions and sources are givem in Appendix B.

2. The Model

This section focuses on a fundamentals-based approach to understanding the vast literature on exchange rate determination theory, which evolved largely in the early 1970s. The three monetary approaches integral to this theory's evolution are-flexible-price, sticky-price and the real interest differential approach (further discussion, see Frankel (1979, 1993).

Frankel (1979) developed a monetary model that combined the magnification effect on the flexible-price monetary model and the overshooting effect of Dornbusch's sticky-price model. This combination makes Frankel's model a more general monetary model of exchange rate determination. Frankel's model has been termed the "real interest rate differential monetary model" because it is identical to the flexible-price model with the real interest rate differential added as an additional explanatory variable in the flexible-price equation.

Frankel's real interest rate differential model draws upon Dornbusch's sticky-price model by assuming that PPP fails to hold in the short run but is valid in the long run. The only difference between the two models involves the factors influencing exchange rate expectations. In the Dornbusch model, the expected change in the exchange rate is determined by the anticipated speed with which the gap between the spot exchange rate and its long-run equilibrium level could be closed. That specification of the exchange rate expectations implies that once the gap is closed, the expected change in the spot exchange rate is zero. This, in turn, implies that the market's expectation of future inflation would be zero once the gap is closed. Frankel suggested an alternative equation of the exchange rate expectations formation. He proposed one in which the expected change in the exchange rate is influenced both by the gap between the spot and the long-run equilibrium exchange rates (similar to Dornbusch's sticky-price model) and by the long-term expected inflation differential (similar to the flexible-price monetary model).

Frankel's real interest rate differential model is a more general model of the exchange rate determination in three fundamental ways. First, it illustrates the immediate direct impact of money growth on the exchange rate embodied in all monetary models. Second, it highlights the indirect effect of the expectations of higher or lower inflation on the exchange rates embodied in the flexible-price model. And, third, Frankel's model shows the liquidity-induced effect on real interest rates, capital movements and, therefore, on the exchange rate embodied in the sticky-price model.

The model adopted in this study closely follows Frankel's "real interest rate differential monetary model". The model can be expressed using the following equation:

$$s_t = a + bm_t + cy_t + di_t + e\pi_t + \varepsilon_t \quad (1)$$

where

s = log S: where S is defined as the number of units of each country's currency per U.S. dollar.

m = (log M_T - log M_{US}): where M_T is each country's money supply and M_{US} is the U.S. money supply.

y = (log Y_T - log Y_{US}): where Y_T is each country's output and Y_{US} is the U.S. output.

i = (i_T - i_{US}): where i_T is each country's interest rate and i_{US} is the U.S. interest rate.

π = (π_T - π_{US}): where π_T is each country's price level and π_{US} is the U.S. price level.

a = constant

ε = error term

From equation (1), the expected sign of money variable (m) will respond when a domestic country has a faster monetary growth than the United States, causing depreciation in its domestic currency. Thus, b is expected to be positive ($b > 0$). In general, it is expected that b is equal to 1.

Following the monetarist prediction, a faster growth of output in a domestic country than the U.S., will appreciate the domestic currency. Thus c is expected to be negative ($c < 0$). Estimates of e are expected to be positive ($e > 0$), indicating a depreciation of domestic currency due to an increase in the domestic inflation rate. However, the sign of d is unclear. The standard Keynesian assumption of the rise in the domestic interest rate leading to currency appreciation, implies that d is less than zero ($d < 0$). While Frankel and Bilson's (Frankel 1993) Chicago theory of the exchange rate states that a rise in the domestic interest rate due to inflationary expectations, thus implying that d is greater than zero ($d > 0$). Dornbusch's (1976) sticky-price model stated that the estimate of d is equal to zero ($d = 0$) (Baillie and Selover 1987)

3. The methodology

Equation (1) outlines the long-run relationships among variables of the monetary exchange rate model. To examine the overshooting hypothesis, which describes a short-run effect, the short-run dynamics must be included in the equation (1). Following Pesaran and Shin (1998) and Bahmani-Oskooee and Kara (2000), this paper tests the existence of a linear long-run relationship and closely adopts the methodology of these seminal studies. To specify the error correction versions in equation (1), the following ARDL form is used:

$$\Delta s_t = a_0 + \sum_{j=1}^{n} b_j \Delta s_{t-j} + \sum_{j=0}^{n} c_j \Delta m_{t-j} + \sum_{j=0}^{n} d_j \Delta y_{t-j} + \sum_{j=0}^{n} f_j \Delta i_{t-j} + \sum_{j=0}^{n} g_i \Delta \pi_{t-j}$$

$$+ \delta_1 s_{t-1} + \delta_2 m_{t-1} + \delta_3 y_{t-1} + \delta_4 i_{t-1} + \delta_5 \pi_{t-1} + \varepsilon_t \qquad (2)$$

In accounting for the short-run dynamics in the convergence of the exchange rate over time, the error correction terms (EC_{t-1}) are also included. This captures the speed of adjustment that measures the response of the exchange rate per period against any deviations between the actual exchange rate and its long-run equilibrium level. Specifically, if there is a shock to the exchange rate, this will raise its value relative to the equilibrium relationship with other series belonging to the cointegration vectors. Then, the coefficient on EC_{t-1} measures how much of the divergence is eliminated in the following period. Convergence of the cointegrating system in its long-run equilibrium is assured when $-1 < EC_{t-1} < 0$.

The parameters δ_i; i = 1, 2, 3, 4, 5 function as the long-run multipliers, while the a_j, b_j, c_j, d_j, f_j, g_j parameters function as the short-run dynamic coefficients of the underlying ARDL.

Two steps are involved in the ARDL procedure noted in equation (2). In the first step, one needs to compute the usual F-statistic for testing the null of non-cointegration defined by H_0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$ to examine there is a long-run relationship between the levels of the included variables. However, the asymptotic distribution of this *F*-statistic for testing the significance of the lagged levels of the variables is non-standard (Pesaran et al. 2001). Pesaran and Shin's (1998) autoregressive distributed lag model is used to test for the existence of a long-run relationship between the domestic nominal exchange rate and the monetary model in (2).

The two-step residual-based procedure of Engle-Granger (1987) and the system-based reduced rank regression approach of Johansen (1988) both concentrate on cases in which the underlying variables are integrated of order 1 [i.e., they are *I*(1)]. However, the ARDL technique does not require the researcher to assume that the underlying regressors are purely *I*(1), purely *I*(0), or mutually cointegrated variables. Instead, the ARDL regression yields a test statistic that can be compared to two asymptotic critical values. One set assumes that all variables are *I*(1) and another assumes that they are all *I*(0). These two sets of critical values provide a band covering all possible classifications of the variables into *I*(1) or *I*(0) or even a fractionally integrated variable. To classify the variables, the *F*-statistic computed in the second step can be compared with the upper and lower 95% or 99% critical value bounds (F_U and F_L). If the calculated *F*-statistic lies above the upper level, $F > F_U$, the null is rejected, indicating cointegration. If the calculated *F*-statistic lies below the lower level, $F < F_L$, the null cannot be rejected, indicating lack of cointegration. Finally, if $F_L < F < F_U$, falls within the band, the inference has to be regarded as inconclusive. In an inconclusive case, the error-correction model is a useful way of establishing cointegration (Kremers et al. 1992).

When estimating the long-run relationship, one of the most important issues is the choice of the order of the distributed lag function in the unrestricted ECM model. One possibility is to carry out the two-step ARDL estimation approach advanced by Pesaran and Shin (1998), where first the lag orders are selected by either the Akaike information criterion, the Schwarz information criterion, the Hannan-Quinn criterion or by Theil's (1971) R-Bar Square criterion.

From equation (2) [following from Bahmani-Oskooee and Kara (2000)], short-run overshooting is supported if estimates of $c_j > 0$ for initial values of *j*, since it must be determined whether exchange rate overshooting in each country occurs in the long run. When equation (2) is re-estimated, the long-run overshooting is detected if the lagged error-correction term, EC_{t-1} in the following model carries a positive and significant coefficient:

$$\Delta s_t = a_0 + \sum_{j=1}^{n} b_j \Delta s_{t-j} + \sum_{j=1}^{n} c_j \Delta m_{t-j} + \sum_{j=1}^{n} d_j \Delta y_{t-j} + \sum_{j=1}^{n} f_j \Delta i_{t-j} + \sum_{j=1}^{n} g_i \Delta \pi_{t-j} + \delta EC_{t-1}$$

$$EC_{t-1} = \hat{\delta}_1 s_{t-1} + \hat{\delta}_2 m_{t-1} + \hat{\delta}_3 y_{t-1} + \hat{\delta}_4 i_{t-1} + \hat{\delta}_5 \pi_{t-1} \qquad (3)$$

where

4. The Results

Since most variables used in this paper are strongly trend, their mean values change over time. Figures 1 through 10 plot the log of each variable and its first difference for Thailand. The first series of figures is obviously nonstationary, but the first *difference* series appears to be stationary for Thailand. In general, the error correction model and cointegration techniques usually require unit root pre-tests in order to identify the size and location of the autoregressive roots. Determining whether unit roots characterize the variables in the model requires the application of one of many possible tests (Bahmani-Oskooee and Brooks 1999). Bahmani-Oskooee (1998) argued that the existing test for unit roots can at times yield different outcomes. Due to this uncertainty, Pesaran and Shin (1998) and Pesaran et al. (1996) introduced the latest techniques of testing for cointegration. The approach, known as the Autoregressive Distributed Lag (ARDL), has the advantage of avoiding the classification of variables into $I(1)$ or $I(0)$, Therefore, unlike standard cointegration tests there is no need for unit root pre-testing.

4.1 Model without trend

After imposing a maximum of 12 lags on (2), Table 1 reports the short-run coefficient estimates obtained for the lagged values of the first difference variables in equation (2) for Thailand. This follows Kremers et al. (1992) who argued that the significant lagged error correction term is a more efficient way of establishing cointegration. Thus, it is justified to retain the lagged value of all five variables (a linear combination of which has been denoted by the error correction term, EC_{t-1}) in the ARDL model. The model can now be re-estimated using an appropriate lag selection of AIC. Only an appropriate lag selection criterion will be able to identify the true dynamics of the model. The full information estimate of this step is reported in Table 2.

From Table 2, it is obvious that EC_{t-1} carries its expected negative sign but is not significant, even when imposing 12 lags maximum on each of the first difference variables. The error correction coefficient estimated at -.01176 is statistically insignificant, has the correct sign.

Concentrating on the sign of lagged coefficient estimates of the relative money supply (Δm) variable, it appears that the Thai *baht* depreciates immediately (as indicated by the one positive coefficient). It also appears to generate a persistent depreciation for three months before it converges to its new equilibrium, thus supporting the exchange rate overshooting hypothesis in the short run. The other variables all carry significant coefficient estimates that are in line with this paper's prediction.

None of the reported results could be used to infer the long-run impact of the exchange rate unless estimates of $\delta_1, \delta_2, \delta_3, \delta_4, \delta_5$ that were used to form the error-correction term in Table 2 were also reported. These results can be found in Table 4.

It appears that the coefficient of the relative money supply (m) was supposed to be positive, but in fact is negative. This result is inconsistent with this paper's hypothesis. The relative output coefficient (y) also carries a wrong sign. However, the interest rate (i) and inflation rate (π) coefficients are both in line with the predictions. Therefore, the sign of and coefficient on money supply and output show that money supply and output seem to have an unfavorable effect on the Thailand spot exchange rate in the long run.

4.2 Model with time trend

The results of the estimation for Thailand are reported in Table 3. The inclusion of the time trend in the model displays satisfying informational contents, same as the model without time trend. The magnitude of EC_{t-1} also carries a negative sign as expected (-.20003) and highly significanct (-4.145). The signs of lagged coefficients of Δm indicate that domestic currency depreciates (as noted by the positive sign) in the first four months, and also appreciates in alternative months (as indicated by a negative coefficient). This supports the overshooting hypothesis in the short run. All other variables reveal a significant short-run impact upon Thailand's spot exchange rate. As observed throughout Table 6-3, the short-term impact of all coefficients stays quite obvious. In the long run m carries a negative sign, which is insignificant, but not for the expected result. The full information is reported in Table 4.

5. Summary and Conclusion

This paper is an examination of Dornbusch's exchange rate overshooting phenomenon as applied to Thailand that experienced a financial crises in 1997. This paper employs time-series data to investigate the short-run and long-run responses of the spot exchange rates in Thailand. The current methodology has employed a new technique in econometrics; namely, autoregressive distributed lag, which has had little application in previous studies.

In summary, this study found that in the short run, evidence supports the classic "exchange rate overshooting" model for Thailand. These subsequent results confirm the findings of the other researchers, especially Bahmani-Oskooee and Kara (2000). This paper also provides evidence that Dornbusch's overshooting model is still useful and robust for East Asian countries.

More significantly, it has been shown in this paper that imposing the monetary model as a long-run equilibrium condition on a dynamic error-correction, using the ARDL model, proved fruitful for Thailand - even though some of the results in certain coefficient parameters proved inconclusive in the long run. Therefore, this is a facet of the study that is well worth future research.

Figure 1 The log of Thailand spot exchange rate log s_t (LE)

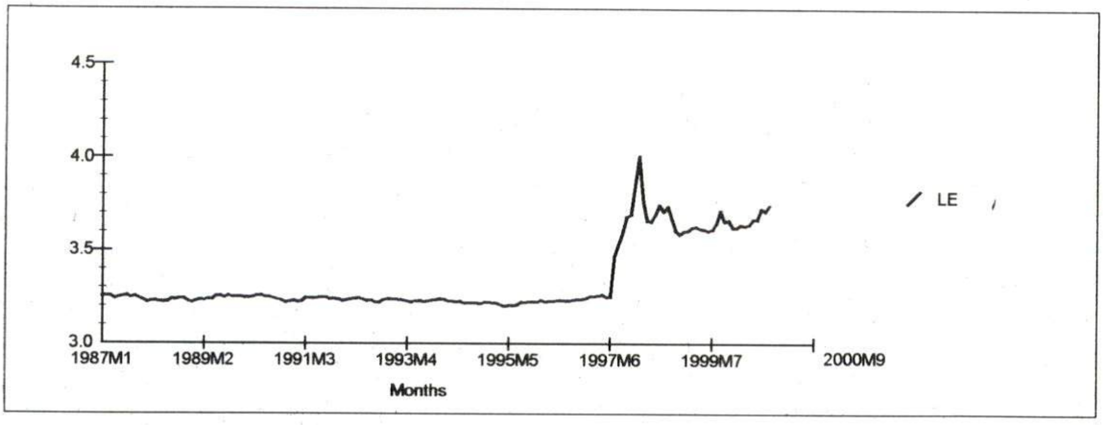

Figure 2 The first difference of the log of Thailand spot exchange rate d log s_t (DLE)

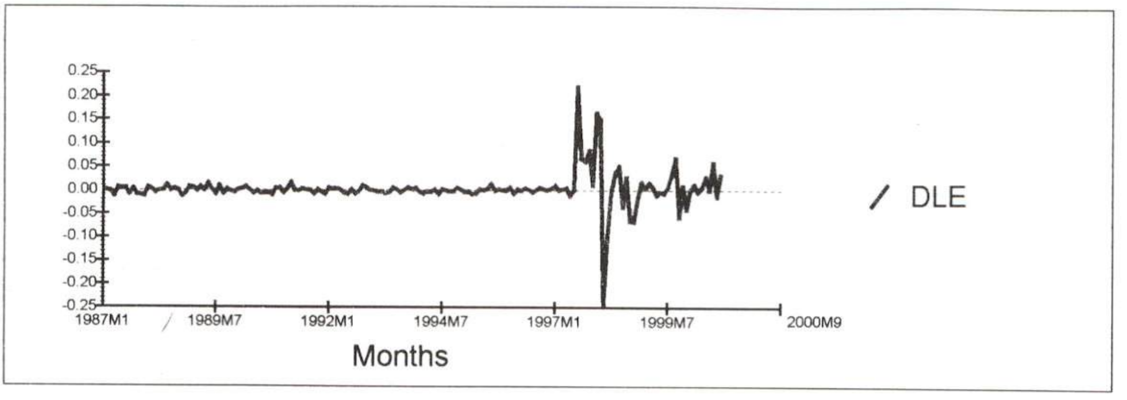

Figure 3 The log of Thailand money supply log m_t (LM)

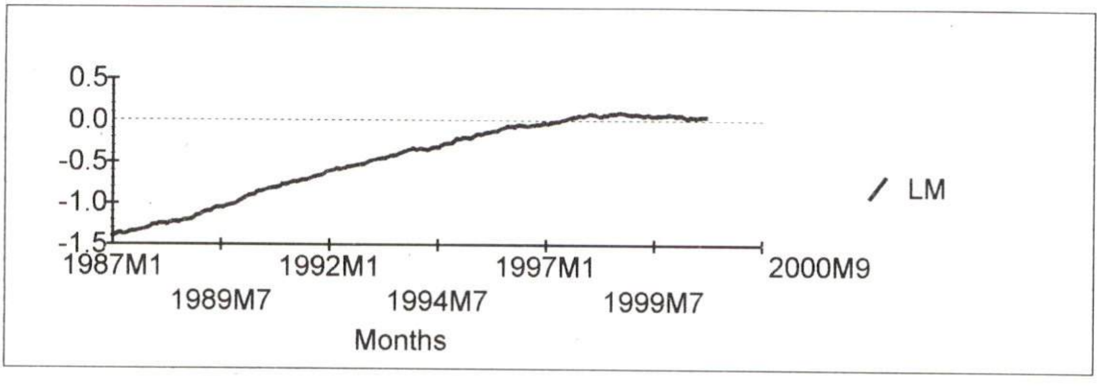

Figure 4 The first difference of the log of Thailand's money supply d log m_t (DLM)

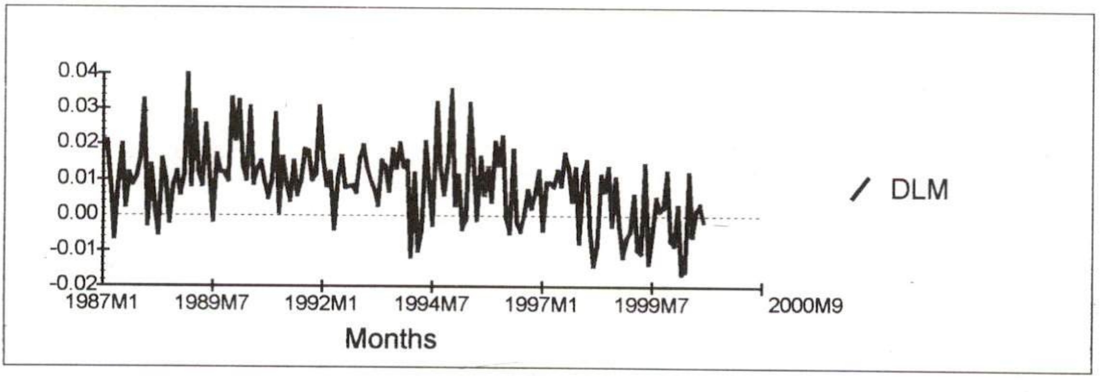

Figure 5 The log of Thailand output log y_t (LY)

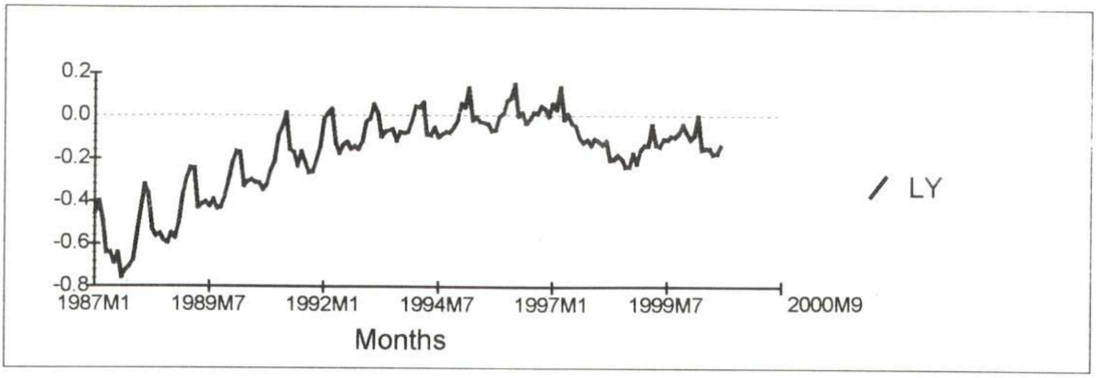

Figure 6 The first difference of the log of Thailand's output d log y_t (DLY)

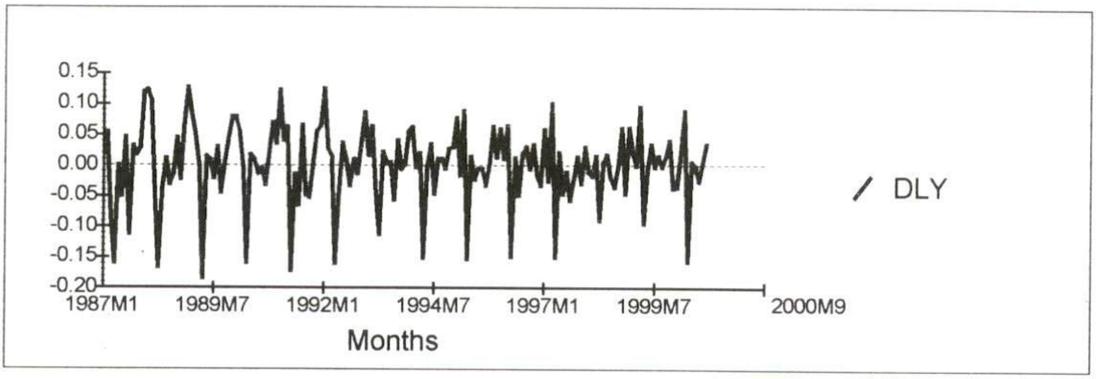

Figure 7 The log of Thailand interest rate i_t (I)

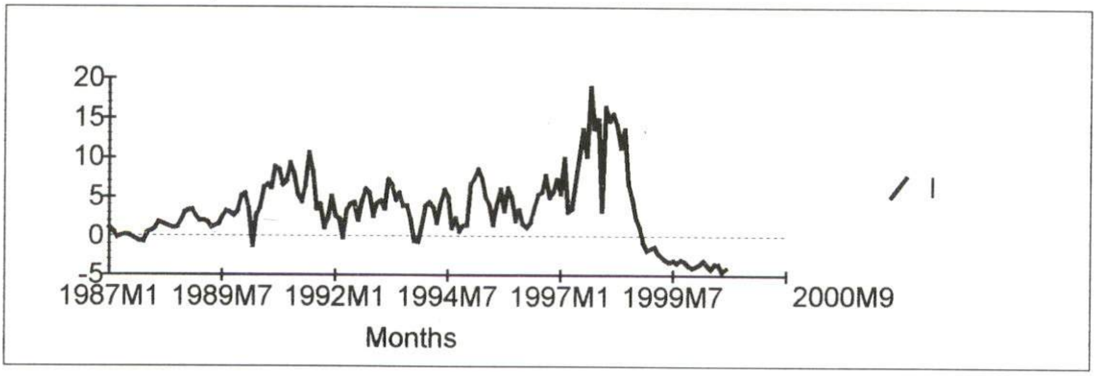

Figure 8 The first difference of the log of Thailand's interest rate d i_t (DI)

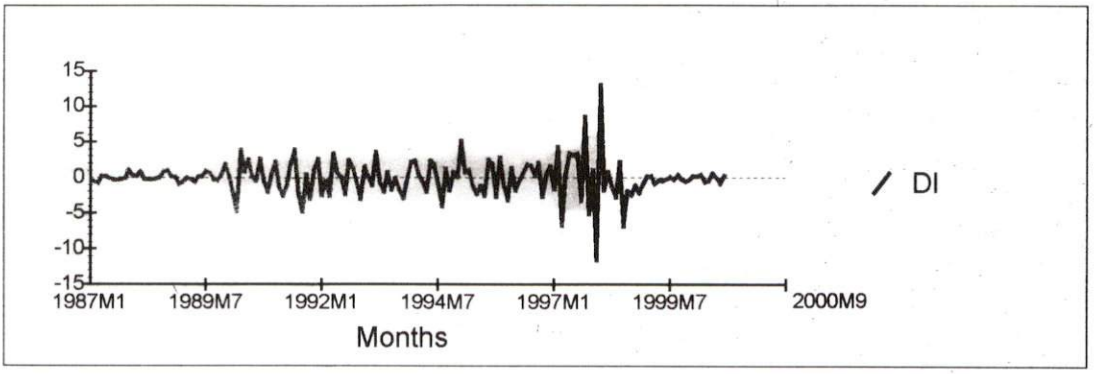

Figure 9 The log of Thailand price level log π_t (LCPI)

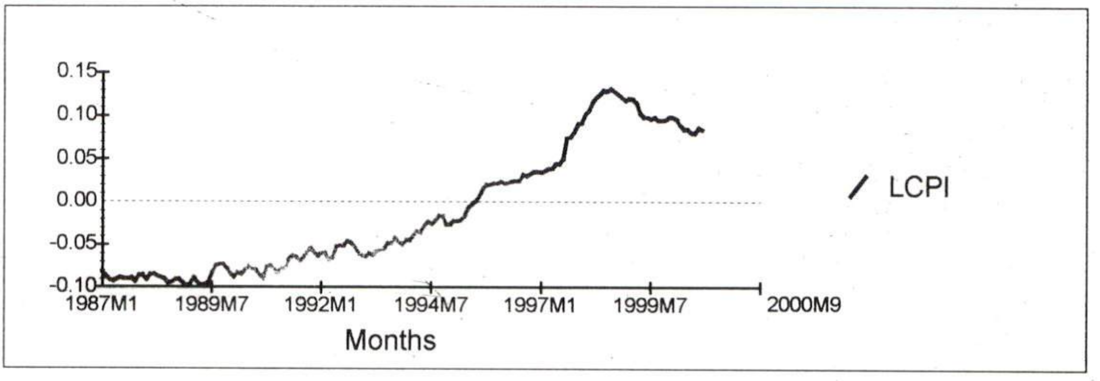

Figure 10 The first difference of the log of Thailand's price level d log π_t (DLCPI)

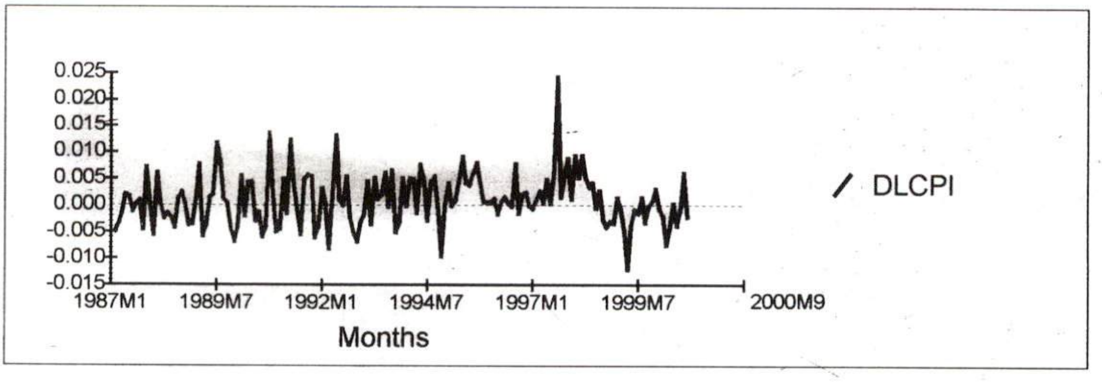

Table 1 The results of the *F*-statistic for cointegration among the variables of exchange rate overshooting for Thailand.

Lag order	
2	1.1718
3	1.5455
4	1.5038
5	1.7384
6	1.8171
7	1.9462
8	1.3301
9	.64368
10	.97058
11	.81514
12	.99463

*Denotes significant at the 10% level.

Note : At the 10% level of significance the critical value bounds of the *F*-statistic are 2.425-3.574.

Table 2 Full estimation of the error correction coefficient of ARDL model based on AIC for Thailand (*without* time trend).

Variable	Lag order											
	0	1	2	3	4	5	6	7	8	9	10	11
Δs		.26552	-.24906	.070988	-.25855	.079824	.091474	-.30768	-.074438	-.25788	.11498	-.25778
		(2.704)	(-2.349)	(.708)	(-2.489)	(.780)	(.846)	(-2.823)	(-.713)	(-2.489)	(1.194)	(-2.833)
Δm	.35321	.13031	.69407									
	(1.072)	(.378)	(2.099)									
Δy	.090052	-.13782										
	(1.558)	(-2.364)										
Δi	.001333	-.00863	.004826	.004730	.003056	.001064	.002064	.003594	-.0019688	-.00106	.002157	.004264
	(.995)	(-.588)	(3.306)	(3.194)	(2.060)	(.914)	(1.375)	(2.399)	(-1.322)	(-.740)	(1.514)	(3.068)
$\Delta \pi$	.16206	-.31152	1.2356	-1.3962	1.3395							
	(.250)	(-.483)	(1.856)	(-2.190)	(2.073)							
Constant	.026380											
	(.169)											
EC		-.01176										
		(-.252)										

Note : 1) The numbers inside the parenthesis beneath each coefficient represent the value of the *t*-statistic.
2) The adjustment R^2= .34178 and *DW.* = 1.9509.

Table 3 Full estimation of the error correction coefficient of ARDL model based on AIC for Thailand (*with* time trend).

Variable	Lag order									
	0	1	2	3	4	5	6	7	8	9
Δs		.38746	.07401	.16909	-.09803	.23379	.15085			
		(4.290)	(-.749)	(1.809)	(-1.031)	(2.662)	(1.623)			
Δm	.12733	-.02009	.75737	.52011	.48686					
	(.388)	(-.058)	(2.329)	(1.588)	(1.484)					
Δy	.099731	-.09254								
	(1.585)	(-1.563)								
Δi	.009722	-.00730	-.00113	-.00145	-.00125	-.00366	-.002606	-.00580	-.00519	-.00441
	(.764)	(-3.666)	(-.564)	(-.768)	(-.670)	(-2.123)	(-1.537)	(-.389)	(-3.654)	(-3.367)
$\Delta \pi$	.054673	-.53458	1.2242	-1.2897	.82084	.41143	-1.0825			
	(.089)	(-.866)	(1.941)	(-2.040)	(1.277)	(.659)	(-1.777)			
T	.003794									
	(3.784)									
Constant	.16850									
	(1.281)									
EC		-.20003								
		(-4.145)								

Note : 1) The numbers inside the parenthesis beneath each coefficient represent the value of the *t*-statistic.
2) The adjustment R^2= .36294 and *DW.* = 2.0600.

Table 4 Estimated long-run coefficients using the ARDL model for Thailand.

Variable	Without time trend	With time trend
t [1]	-	.018970 (4.384)
constant	2.2426 (.509)	.84240 (1.524)
m	-2.6494 (-.244)	-1.5136 (-4.069)
y	1.4912 (.181)	-.093698 (-.365)
i	.0080122 (.078)	.026472 (3.443)
π	32.1042 (.266)	-.097059 (-.085)

[1] t: Time trend

Note : The numbers inside the parenthesis beneath each coefficient represent the values of the t-statistic.

Appendix: data definition and sources

All data are monthly covering from January 1987-September 2000 and are extracted from both the "International Financial Statistics" (IFS) CD-ROM and the Bank of Thailand's "Index of Industrial Production."

Variables

S	:	Exchange rates are end-of-period units of the spot domestic currency per U.S. dollar
M	:	Money supply (M2): M2 = M1+ quasi money
Y	:	Real output is proxied by industrial production or manufacturing output
i	:	Short-term interest rates or money market rate
π	:	Inflation rate is based on the consumer price index (CPI).

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