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Sources of Exchange Rate Fluctuations: The Cases of Mexico and Thailand in the Aftermaths of their Recent Currency Crises*

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We construct a sticky-price open macro model in the spirit of Clarida and Gali (1994), and use it to motivate a structural VAR analysis of the real and nominal exchange rates for Mexico and Thailand in the aftermaths of their currency crises in 1994 and 1997. We identify the model's structural shocks to demand, supply, money, and capital flow using the long-run restriction method pioneered by Blanchard and Quah (1989). Our structural estimates suggest that demand shocks explain a bulk of the variance in real and nominal exchange rate fluctuations, supply and money shocks explain more for Mexico than for Thailand, and transitory shocks to capital flow explain nearly 10 percent for Thailand but virtually none for Mexico. To the extent that transitory shocks to capital flow may reflect shifts in investor sentiment about near-term country risk, our results suggest that exchange rate volatility during a post-crisis period may in part be attributable to variations in country-risk premia in the case of Thailand, but not in the case of Mexico.

Key Words: Exchange rates; Structural shocks; Capital flows; Country risk.
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1. INTRODUCTION

The currency crises in Mexico during 1994-95 and in Thailand and other East Asian countries during 1997-98 have been the subjects of a large body of research. The existing studies have mostly focused on the causes, symptoms, and consequences of the crises and tended to emphasize the periods leading to the currency collapses. By far economists have learned much about what might have led to these crises,[1] their contagion effects,[2] the appropriateness of these countries' exchange rate regimes,[3] and the roles of alternative monetary policies and regimes.[4] Among other findings, a general observation is that some country-specific risk factors might have played important roles in shaping the behaviors of the countries' macro variables, particularly their exchange rates, at the onset and during their currency crises.

In contrast, the sources of the fluctuations in the countries' macro variables in the aftermaths of their currency crises have received much less attention.[5] In particular, little is known whether country-specific risk factors may have played any important roles in accounting for the exchange rate fluctuations in the aftermaths. Naturally, such an understanding can better be achieved through investigating the joint behaviors of the countries' real and nominal exchange rates in their post-crisis periods of floating nominal exchange rate regimes. The present paper takes up this task for Mexico and Thailand.

Our focus on Mexico and Thailand stems in part from the availability of Data. Further, and more importantly, Thailand is often considered featuring a more similar economic environment as to that of Mexico than do the other East Asian countries around the time of their currency crises, both faced with somewhat overheated economic conditions and aggregate

[1] See, among others, Sachs et al. (1996), Martinez (1998), Lipsky (1998), Corsetti, et al. (1998a, b), Roubini et al. (1998), Radelet and Sachs (1998), and Edward (2001).

[2] See Glick and Rose (1998), Kaminsky and Reinhart (1998, 2000), and Masahiro et al. (2001), among others.

[3] See, for example, Edward and Savastano (1998), Jose Antonio (1998), Ogawa and Ito (2000), Devereux and Lane (2001), and Edward (2001).

[4] For example, Ghironi and Rebucci (2001) compare three different monetary policies, a currency board, inflation targeting, and dollarization, while Gali and Monacelli (2000) analyze three alternative monetary regimes, an exchange rate peg, a Taylor rule, and an optimal monetary policy rule.

[5] A notable exception is the work by Edwards and Savastano (1998) that deals with both the road leading to the 1994 Mexican crisis and the three years of its aftermath. To the extent that it is related to our study at presence, the paper analyzes the forces behind the apparent stability of the peso-dollar nominal exchange rate during 1996-97. The authors find that throughout most of the 1995-97 periods the peso-dollar rate behaved in a manner largely consistent with a (quasi) floating exchange rate regime.

demand restraint.[6] For example, Martinez (1998) finds that there were similar external imbalances around the two crises, though they were associated with somewhat different patterns in domestic saving and investment — while the external deficit masked high levels of investment and saving rates in Thailand, that in Mexico was caused by high domestic demand due to over consumption by private sectors that were not met by domestic production. In both countries, there were concerns about the sustainability of a large current account deficit, losses in competitiveness associated with real exchange rate appreciation, and the weakness of the banking system. They both ended up with sudden large capital outflows due to sharp changes in investors' attitude toward their country-specific risks, reversing the course of marked increases in capital inflows prior to the crises.[7] Thus our focus on the two countries may help to minimize differences in initial conditions and extract, if any, common factors influencing the post-crisis exchange rate fluctuations in Mexico and Thailand.

Our theoretical framework builds on the sticky-price open macro model outlined in Clarida and Gali (1994), which takes its root in Dornbusch (1976) and Obstfeld (1985). To investigate whether country-specific risk factors may have played important roles in accounting for the exchange rate fluctuations in the aftermaths of the currency crises in Mexico and Thailand, we extend Clarida and Gali's model by including a transitory shock to capital flow, in addition to shocks to demand, supply, and money. Many studies suggest that capital flow shocks may be of particular importance for small open economies that depend critically on foreign capital.[8] Such a shock is represented here by shifts in investor sentiment about the near-term risk associated with investment in the home country (Mexico or Thailand) relative to that in the foreign country (the United States). In reflection of this risk, short-run interest parity features a premium term.[9]

[6] While, as in the immediate aftermath of the Mexican crisis, hyperinflation was considered a genuine threat during the Indonesian crisis, political factors played a dominant role in Indonesia around that time.

[7] Though some studies suggest that a high degree of capital mobility and financial globalization contributed to Mexico's balance-of-payments crisis while fundamental instability, such as rapid growth of bank credit to private sectors, political events, and criminal acts that generated considerable uncertainty were the major cause of the Mexican crisis, Mishkin (2000) suggests that capital flows were a symptom rather than a cause of the crises. In fact, Radelet and Sachs (1998) propose that policy mistakes and poorly designed international rescue programs, rather than the reversal of capital flows itself, were the causes of the deepened crisis in Thailand. In particular, tightened monetary and fiscal policies halted the growth of the Thai economy and caused its exchange rate to slip further than expected. On the other hand, Sachs et al. (1996) suggests that fiscal and monetary policies of the Mexican economy were not tightened enough to improve the credibility of Mexican exchange rate.

[8] See, for example,, Kim (2000), Edwards (2001), and Osakwe and Schembri (2002).

[9] In retrospect, the capital outflows from Mexico and Thailand in the face of the countries' rising interest rates following their crises might have been caused more by

By contrast, interest parity holds in the standard version in the long run to reflect the long-run fundamental productivities and preferences in the home and the foreign countries.

This feature of our theoretical model is consistent with our empirical finding that uncovered interest parity condition holds in the long run, though not in the short run, for the Mexican peso and for the Thai baht relative to the U.S. dollar in the periods after the collapses of the fixed nominal exchange rate regimes in Mexico in December 1994 and in Thailand in July 1997. It also stands in line with the empirical finding by Kumhof (2001) that covered interest parity holds in the long run but not in the short run for the two countries in the aftermaths of their currency crises.[10]

Our objective is to investigate the roles of the four types of the model's structural shocks in accounting for the peso-dollar and the baht-dollar real and nominal exchange rate fluctuations in the periods following the crises. To the extent that transitory capital flow shocks may cause short-term deviations from the standard interest parity condition through varying country-risk premia, our analysis also helps to examine whether it may apply to the post-crisis Mexico or Thailand the notion of Obstfeld and Rogoff (1998) that exchange rate volatility may in part be explained by fluctuations in risk premia.

To undertake the investigation, we use our theoretical framework to motivate a four-equation structural VAR analysis. We use the long-run restriction method pioneered by Blanchard and Quah (1989) to identify the impacts of the four structural shocks on the peso-dollar and the baht-dollar real and nominal exchange rates in the aftermaths of the currency crises in Mexico in 1994 and in Thailand in 1997. Restrictions on the long-run effects of supply, demand, and money shocks in our model are similar to those in Clarida and Gali (1994).[11] In the long run, only supply shocks

fears of their rising default risks than by concerns about their future inflations and depreciations. As Gould and Kamin (2000) argue, the rises in the domestic interest rates in these cases might have further strengthened perceptions about the countries' near-term default risks on debts. It is for this reason that we also choose to ignore in this study causes of capital flows associated with fluctuations in world interest rates and world economic conditions.

[10]Deviations of bilateral nominal exchange rates from uncovered interest parity condition have been observed between other currencies, and explanations for such deviations include missing term premia [e.g., Fatemi and Tavakkol (1992) and Bansal (1997)], liquidity premia [e.g., Engel (1992)], and, in most research, risk premia [e.g., Bomhoff and Koedijk (1988), Domowitz and Hakkio (1992), McCallum (1994), and Engel (1996)] in the standard specification of interest parity condition. Here, as in Kumhof (2001), we emphasize changing country-risk premia in explaining the short-term deviations from (uncovered) interest parity of the peso-dollar and the baht-dollar nominal exchange rates in the aftermaths of the currency crises in Mexico and Thailand.

[11]For more recent studies based on Clarida and Gali's theoretical framework and Blanchard and Quah's empirical method, see, among others, Lee and Chinn (1998), and Kim, Ogaki and Yang (1999). See, also, Lastrapes (1992) for an earlier contribution. Ng

are expected to influence relative output, only supply and demand shocks are expected to influence real exchange rate, and only shocks to supply, demand, and money are expected to influence nominal exchange rate and relative price level. We impose an additional restriction that transitory shocks in capital flow are expected not to influence the long-run value of any of these variables, since interest parity holds in the long run though not in the short run. We show that these restrictions are sufficient to make our VAR system identified.

To preview the results, our estimated VAR impulse response functions are largely consistent with the model's predictions. A permanent supply shock that boosts home output relative to foreign output produces modest real and small nominal depreciations in home currency relative to foreign currency in the long run. For Thailand, the long-run depreciations in the baht against the dollar are preceded by some initial appreciations of the baht-dollar rates. In the case of Mexico, the depreciations of the peso relative to the dollar start on the impact of the shock and continue throughout the forecast horizon. A demand shock in favor of foreign output against home output generates substantial real and nominal depreciations in home currency against foreign currency. To the extent that the shock is permanent, the depreciations are also permanent. A permanent shock that raises home nominal money supply or reduces home nominal money demand relative to foreign nominal money supply or demand causes considerable nominal depreciations in home currency relative to foreign currency in both the short run and the long run, and moderate real depreciations in the short run but no variations of real exchange rates in the long run. While exchange rates are invariant to a transitory capital flow shock in the long run and for Mexico in the short run as well, a transitory shock to capital flow in favor of the United States against Thailand generates significant real and nominal depreciations in the baht relative to the dollar in the short run.

The paper's main empirical results, our structural VAR estimates of the variance decompositions of the baht-dollar and the peso-dollar exchange rates, stand much in line with the impulse-response indications. We find that demand shocks explain the majority of the error variance in forecasting the real and nominal exchange rates in both the short run and the long run. To be specific, shocks in demand account for more than 81 and 75 percent of the variance in the real and nominal baht-dollar exchange rates, and more than 69 and 56 percent of the variance in the real and nominal peso-dollar exchange rates. We also find that supply and money shocks explain more forecast error variance for Mexico than for Thailand: while shocks to supply and money explain less than 6 and 5 percent of the variance in

(2002) extends Clarida and Gali's model but employs an identification strategy different from Blanchard and Quah's decomposition approach.

the real exchange rate and only about 7 and 9 percent of the variance in the nominal exchange rate in the case of Thailand, they explain more than 16 and 13 percent of the variance in the real exchange rate and about 32 and 12 percent of the variance in the nominal exchange rate in the case of Mexico.

More strikingly, we find that there exists a sharp contrast between the impacts of capital flow shocks on the peso-dollar and the baht-dollar exchange rates, just as the impulse response functions indicate. On the one hand, shocks to capital flow play the second largest role in accounting for the error variance in forecasting the baht-dollar real and nominal exchange rates, with more than 8 percent of the forecast variance attributable to the shocks in both the short run and the long run. On the other hand, virtually none of the variance of the changes in the peso-dollar real or nominal exchange rates is attributable to capital flow shocks at any forecast horizon. To the extent that transitory shocks to capital flow may reflect changes in investor appraisal of near-term country risk, our results suggest that exchange rate volatility during the period following a crisis may in part be attributable to variations in country-risk premium in the case of Thailand, but not in the case of Mexico. We suspect that this difference may have much to do with the fact that the Banco de Mexico had a policy of selling exchange rate options and adopted a policy of inflation targeting, which might have served as a buffer to absorb much of its capital flow shock, while the Bank of Thailand in repose to its currency crisis appealed to capital controls on local banks, which turned out to be ineffective and were eventually removed in January 1998.

The rest of the paper will be organized as follows. In Section 2, we present our theoretical open macro model and solve for the model's short-run and long-run equilibria. In Section 3, we apply the theoretical framework to motivate a four-equation structural VAR analysis. We shall describe there in much detail our data and identification strategy. In Section 4, we report our main empirical results. We conclude in Section 5.

2. A STICKY PRICE OPEN MACRO MODEL

We present in this section a sticky-price open macro model that extends Clarida and Gali (1994) by including a transitory capital flow shock, besides shocks to demand, supply, and money. The motivation for this extension is in part to allow for the incorporation and thus the examination of the notion that shocks to capital flow may be of particular importance for small open economies, such as Mexico and Thailand, which are critically dependent on foreign capital. Such a shock is represented in our model by shifts in investor sentiment about the near-term risk associated with investment in the home country relative to that in the foreign country, and accordingly the model features a premium term in its short-run interest parity condition in reflection of this country risk.

In what follows, all variables, except for interest rates and net capital flow, are in logs and represent home relative to foreign levels except for exchange rates. For example, p_t denotes $(p_t^h - p_t^f)$, where p_t^h and p_t^f represent the logs of home and foreign price levels, respectively. Net capital flow, on the other hand, is measured as a percentage of home GDP. The model contains the following system of equations:

IS Equation:

$$y_t^d = d_t + \eta(s_t - p_t) - \sigma[i_t - E_t(p_{t+1} - p_t)], \quad \eta > 0, \quad \sigma > 0, \tag{1}$$

Price-Setting Equation:

$$p_t = (1-\theta)E_{t-1}p_t^e + \theta p_t^e, \quad 0 \leq \theta \leq 1, \tag{2}$$

LM Equation:

$$m_t^s - p_t = y_t - \lambda i_t, \quad \lambda > 0, \tag{3}$$

Interest Parity in the Long Run:

$$i_t = E_t(s_{t+1} - s_t), \tag{4}$$

Interest Parity in the Short Run:

$$i_t = E_t(s_{t+1} - s_t) + \beta\omega_t, \quad \beta < 0 \tag{5}$$

Net Capital Flow:

$$nf_t = \mu(i_t - E_t\Delta p_{t+1}) + \omega_t, \quad \mu > 0, \tag{6}$$

where y_t^d = the demand for home output relative to foreign output,
d_t = the shock to relative demand,
s_t = the logarithm of nominal exchange rate,
p_t = the log-difference between home and foreign price levels,
p_t^e = the equilibrium value of the log level of relative price,
i_t = the nominal interest rate differential,
m_t^s = the logarithm of relative money supply,
nf_t = the net capital flow as a percentage of home GDP,
E_t = the expectation operator conditional on time t information,
where $\eta, \sigma, \theta, \lambda, \beta$, and μ are parameters.

The IS equation (1) says that the demand for home output relative to foreign output y_t^d is positively related to the real exchange rate $(s_t - p_t)$, negatively related to the real interest rate differential $[i_t - E_t(p_{t+1} - p_t)]$ that is in favor of home currency, and positively related to the relative demand shock d_t that is in favor of home output. The price-setting equation (2) prescribes that the relative pricep_t adjusts towards its long-run equilibrium level p_t^e gradually, with the speed of adjustment given by θ. Prices are fully flexible if $\theta = 1$, and are predetermined if $\theta = 0$. The LM equation (3) relates the relative demand for real money balances, which in equilibrium equals the relative real money supply $(m_t^s - p_t)$, with the relative output y_t and the nominal interest rate differential i_t. Equation (4) is the standard uncovered interest parity condition in the long run, which asserts that the nominal interest rate differential i_t tends to equal the expected appreciation in the spot exchange rate $E_t(s_{t+1} - s_t)$, as the long-run equilibrium is determined by the long-run fundamental productivities and preferences in the home and the foreign countries. By contrast, a premium term $\beta\omega_t$ appears in the short-run interest parity condition (5) in reflection of a transitory capital flow shock ω_t that captures shifts in investor perception of near-term home-country risk. Equation (6) says that the net capital flow nf_t depends linearly on the real interest rate differential subject to the transitory shock ω_t.

The following three equations close our model by specifying the stochastic processes governing y_t^s, d_t, and m_t:

$$y_t^s = y_{t-1}^s + z_t, \tag{7}$$

$$d_t = d_{t-1} + \delta_t - \gamma\delta_{t-1}, \tag{8}$$

$$m_t = m_{t-1} + \upsilon_t. \tag{9}$$

Thus, as in Clarida and Gali, the relative supply of output y_t^s and money m_t are simple random walks, and the relative demand shock d_t has both a transitory and a permanent component. We assume that the disturbance terms z_t, δ_t, υ_t, and ω_t are uncorrelated contemporaneously, and at all leads and lags.

2.1. Solving for the Long-Run Equilibrium

The long-run equilibrium can be obtained by setting$\theta = 1$, that is, by assuming full flexibility of the prices. In the long-run equilibrium, uncovered interest rate parity condition holds in the standard version (4), and the relative output is supply determined. Denoting the real exchange rate by $r_t = s_t - p_t$, we can then characterize the long-run equilibrium by the following system of equations:

$$y_t^e = y_t^s = y_t^d, \tag{10}$$

$$r_t^e = (y_t^s - d_t)\eta^{-1} + [\eta(\eta+\sigma)]^{-1}\sigma\gamma\delta_t, \tag{11}$$

$$p_t^e = m_t - y_t^s + \lambda(1+\lambda)^{-1}(\eta+\sigma)^{-1}\gamma\delta_t, \tag{12}$$

$$s_t^e = (y_t^s - d_t)\eta^{-1} + m_t - y_t^s + [\eta(1+\lambda)(\eta+\sigma)]^{-1}(\sigma+\lambda\sigma+\lambda\eta)\gamma\delta_t, \tag{13}$$

$$nf_t^e = \mu(\eta+\sigma)^{-1}\gamma\delta_t + \omega_t, \tag{14}$$

where all variables with the super index $e$denote the long-run equilibrium values of the corresponding variables without super index. Inspecting (10) through (14) reveals that, in the long run, only supply shocks are expected to affect the relative output, only supply and demand shocks are expected to affect the real exchange rate, and only shocks to supply, demand, and money are expected to affect the relative price and the nominal exchange rate. Transitory shocks in capital flow, on the other hand, are expected not to affect the long-run value of any of these variables.

2.2. Solving for the Short-Run Equilibrium

In the short run, price adjustments are sluggish and all variables can deviate from their long-run equilibrium values. In the short-run equilibrium, uncovered interest parity condition holds in the modified version (5), and the relative output is demand determined. The short-run equilibrium is characterized by the following system of equations:

$$p_t = p_t^e - (1-\theta)[\upsilon_t - z_t + (1+\lambda)^{-1}(\eta+\sigma)^{-1}\lambda\gamma\delta_t], \tag{15}$$

$$r_t = r_t^e + \psi[(1+\lambda)(1-\theta)(\upsilon_t - z_t) - (\eta+\sigma)^{-1}(\lambda\theta+\sigma)\gamma\delta_t - (\lambda+\sigma)\beta\omega_t], \tag{16}$$

$$y_t = y_t^e + \psi[(\eta+\sigma)(1+\lambda)(1-\theta)(\upsilon_t - z_t) - (\sigma+\theta\lambda)\gamma\delta_t - (\eta\lambda+2\sigma\psi^{-1})\beta\omega_t], \tag{17}$$

$$\begin{aligned} s_t &= s_t^e + \psi[(1-\sigma-\eta-\lambda)(1+\lambda)(1-\theta)(\upsilon_t - z_t) \\ &+ (\eta+\sigma)^{-1}(1+\lambda)^{-1}\kappa\gamma\delta_t - (\lambda+\sigma)\beta\omega_t], \end{aligned} \tag{18}$$

$$\begin{aligned} nf_t &= nf_t^e - \mu\psi(1+\lambda)(1-\theta)(\upsilon_t - z_t) \\ &- (\eta+\sigma)^{-1}\sigma^{-1}\psi(\sigma+\theta\lambda)(\mu\eta - \sigma\eta - \sigma^2)\gamma\delta_t \\ &- [(\psi\eta - 2)\mu\beta + 1]\omega_t, \end{aligned} \tag{19}$$

where $\psi = (\lambda+\sigma+\eta)^{-1}$ and $\kappa = [\sigma(1+2\lambda-\theta\lambda) + \lambda(\theta+\eta+\lambda-\theta\eta)]$.

According to equations (15) through (18), in the short run, only three out of the four shocks — to supply, demand, and money — can affect the relative price, while all the four shocks can influence the relative output, the real and nominal exchange rates, and the net capital flow. Since the system (15)-(18) is expected to converge to (10)-(14) in the long run, the long-run restrictions derived in Section 2.1 can be used in helping identify the four-equation structural VARs to be presented in the following sections.

3. EMPIRICAL APPROACH

In this section we apply the theoretical model developed in Section 2 to motivate a structural VAR analysis that will use the Blanchard and Quah's (1989) decomposition method to identify the impacts of the four structural shocks on the peso-dollar and the baht-dollar real and nominal exchange rates in the aftermaths of the currency crises in Mexico in 1994 and in Thailand in 1997. In what follows, we shall describe first the data and then the empirical strategy to be used in our analysis.

3.1. Data

Throughout the paper, we treat Mexico or Thailand as the home country and the United States as the foreign country. The data for Mexico and Thailand are obtained from the Bank of Thailand and the Banco de Mexico, respectively, whereas the U.S. data are extracted from the Bureau of Labor Statistics, the Federal Reserve Bank of St. Louis, and the International Financial Statistics. Our analysis is based on data of monthly frequency. Monthly data are collected for Mexico from January 1995 to June 2003, and for Thailand from July 1997 to June 2003. Since monthly data for output are not readily available, the monthly manufacturing production index is used instead as a proxy. The sum of the monthly net flow of portfolio investment in equity securities and the monthly net foreign direct investment is used to represent the monthly net capital flow for Thailand. Since the same type of data is not available for Mexico, its quarterly data of net foreign investment are used instead, which are transformed into monthly data using the DISTRIB procedure in the RATS program.

As in Eichenbaum and Evans (1995), we use both the nominal three-month Treasury bill rate and the federal funds rate, measured by the monthly average of the daily rates, to represent the monthly nominal interest rate for the United States. Since our empirical results are fairly robust to which of the two rates is used, only the result using the three-month T-bill rate is reported. The monthly average of the overnight inter-bank rates and of the twenty-eight days Cetes rates is used to represent the monthly interest rate for Thailand and Mexico, respectively. The nominal exchange rate is expressed in the units of home currency per unit of the U.S. dollar, with the monthly rate defined as the monthly average of the daily rates. The monthly real exchange rate is taken to be the monthly nominal exchange rate adjusted for the difference between foreign and home price indices.

Before proceeding further, we shall recall that the theoretical model presented in Section 2 suggests that the variables involved in our study are non-stationary in levels but stationary in first differences. Table 1 reports our empirical results from the augmented Dickey-Fuller (ADF) test and the Phillips-Perron test based on the data described above. As the table shows, indeed, the hypothesis that the level data are $I(1)$ and their first differences are$I(0)$ cannot be rejected at either 1% or 5% significance level. Therefore, the data conform to our model's indication that the variables under concern are non-stationary in levels but stationary in their first differences. In accordance, their first differences will be included in our VAR analysis.

Regression Equation (Level):$\Delta E_t = \beta_1 + \delta E_{t-1} + \beta_2 t + \sum_{i=1}^{p} \gamma_i \Delta E_{t-i} + \varepsilon_t$

Regression Equation (First Difference): $\Delta E_{t,2} = \mu_1 + \alpha \Delta E_t + \mu_2 t + \sum_{i=1}^{p} \eta_i \Delta E_{t+1-i,2} + \varepsilon_t$

Corresponding to these unit root tests, we also find that, for Mexico and Thailand, both the mean and the mean absolute value of the uncovered interest rate differential $[i_t - E_t(s_{t+1} - s_t)]$ implied by the data differ significantly from zero with low p-values computed from autocorrelation-robust standard errors. This suggests that the standard version of uncovered interest parity does not hold in the short run for either of these two countries. To examine whether uncovered interest parity holds in the standard version in the long run, we apply Johansen's co-integration test to determine whether there exists a long-run relationship among the three $I(1)$-variables i_t, $E_t(s_{t+1})$, and s_t, for Mexico or Thailand, and if so, what may qualify as an underlying co-integrating vector. Our test results are reported in Tables 2 and 3.

TABLE 1.

Tests for Unit Roots

Variables		Mexico/US				Thailand/US				
		ADF		PP		ADF			PP	
	No. of lags (ADF)	δ	α			No. of lags (ADF)	δ	α	δ	α
s_t	6	−0.159 (−2.551)	-1.270^{*} (−3.891)	–	–	8	−0.216 (−2.204)	−1.314 (−2.687)	−0.260 (−2.997)	-0.686^{**} (−4.454)
r_t	6	−0.131 (−1.366)	1.758^{**} (−5.263)	–	–	7	−0.122 (−1.643)	−0.941 (−1.950)	−0.180 (−2.054)	-0.667^{**} (−4.335)
y_t	11	−0.513 (−1.884)	7.106^{**} (−4.212)	–	–	6	−0.500 (−2.932)	−1.209 (−2.213)	0.233 (−3.066)	-1.167^{**} (−7.316)
nf_t	12	−0.132 (−2.656)	−0.384 (−1.584)	−0.137 (−2.242)	-0.546^{**} (−6.252)	1	−0.479 (−2.520)	-1.288^{**} (−4.852)	–	–
i_t	8	−0.158 (−2.044)	1.257 (−2.776)	−0.204 (−2.789)	-0.745^{**} (−6.341)	9	−0.231 (−2.698)	−1.459 (−2.743)	−0.137 (−1.530)	-1.414^{**} (−9.673)
$E_t s_{t+1}$	6	−0.154 (−2.181)	-1.325^{*} (−4.084)	–	–	7	−0.137 (−1.269)	−1.349 (−2.227)	−0.264 (−2.658)	-0.759^{*} (−4.738)

1. A * or ** indicates, respectively, that the null hypothesis of a unit root cannot be rejected at 5% or 1% significance level. The length of the lags for the ADF test was based on the T-statistics and the Schwartz Bayesian Criterion. 2. The T-statistics are in the parentheses.

TABLE 2.

Johansen's Co-integration Test

Country	Null Hypothesis	Alternative Hypothesis	
	λ_{trace} tests		λ_{trace} values
Thailand	$r = 0$	$r > 1$	33.69^{**}
	$r \leq 1$	$r > 2$	5.89
Mexico	$r = 0$	$r > 1$	36.23^{**}
	$r \leq 1$	$r > 2$	13.09^{*}

1. The critical values for the rejection of the null hypothesis ($r = 0$) at 1% and 5% significance levels are 35.65 and 29.68, respectively. 2. The critical values for the rejection of the null hypothesis ($r = 1$)at 1% and 5% significance levels are 20.04 and 15.41, respectively. 3. A * or ** denotes that the null hypothesis can be rejected at 5% or 1% significance level, respectively.

TABLE 3.

Normalized Co-integrating Coefficients

Country	No. of lags (in the level)	i_t	$E_t(s_{t+1})$	s_t
Thailand	1	1.00	−1.14 (0.22)	1.14 (0.22)
Mexico	1	1.00	−0.916 (0.108)	0.915 (0.109)

Asymptotic standard errors are in parentheses.

These tables do indicate the existence of a long-run relationship among the three $I(1)$-variables i_t, $E_t(s_{t+1})$, and s_t, regardless of which country's data are used. There is one co-integrating vector for Thailand and two for Mexico. In particular, the nominal interest rate differential, the expected future spot exchange rate, and the current spot exchange rate are co-integrated at an order near $(1, -1, 1)$ for each country. This suggests that uncovered interest parity holds in the standard version in the long run, though not in the short run, for both Mexico and Thailand. Thus our empirical results are consistent with the findings by Kumhof (2001) based on daily data.

3.2. Empirical Methodology

It should be recalled that, among the four types of structural shocks present in our open macro model, only supply shocks are expected to have a long-run effect on relative output, both supply and demand shocks are expected to have long-run effects on real and nominal exchange rates, money shocks are expected to have a long-run effect on nominal but not real exchange rate or relative output, and transitory capital flow shocks are expected not to influence the value of any of these variables in the long run. In this section, we invoke these long-run restrictions to help identify a four-equation VAR system in relative output, real and nominal exchange rates, and net capital flow.

We start by recalling that the variables y_t, r_t, s_t, and nf_t are non-stationary in levels but stationary in first differences. Therefore, we will include their first differences, $\Delta y_t, \Delta r_t, \Delta s_t$, and Δnf_t in our VAR analysis. We next note that, in our theoretical model, these first-differenced variables can be written as functions of the four structural shocks:

$$\begin{bmatrix} \Delta y_t \\ \Delta r_t \\ \Delta s_t \\ \Delta nf_t \end{bmatrix} = \begin{bmatrix} C_{11}(L) & C_{12}(L) & C_{13}(L) & C_{14}(L) \\ C_{21}(L) & C_{22}(L) & C_{23}(L) & C_{24}(L) \\ C_{31}(L) & C_{32}(L) & C_{33}(L) & C_{34}(L) \\ C_{41}(L) & C_{42}(L) & C_{43}(L) & C_{44}(L) \end{bmatrix} \begin{bmatrix} z_t \\ \delta_t \\ \upsilon_t \\ \omega_t \end{bmatrix}, \qquad (20)$$

where $C_{ij}(L)$ is an infinite-order polynomial in the lag operator L, for $i, j = 1, 2, 3, 4$. The restriction that demand, money, and capital flow shocks are expected to have no long-run effect on relative output can then be represented by the restriction that the sum of the coefficients in $C_{12}(L)$, $C_{13}(L)$, and $C_{14}(L)$ is each equal to zero, that is, by

$$C_{12}(L) \equiv \sum_{j=0}^{\infty} c_{12}(j) L^j \quad , \quad \sum_{j=0}^{\infty} c_{12}(j) = C_{12}(1) = 0, \qquad (21)$$

$$C_{13}(L) \equiv \sum_{j=0}^{\infty} c_{13}(j) L^j \quad , \quad \sum_{j=0}^{\infty} c_{13}(j) = C_{13}(1) = 0, \qquad (22)$$

$$C_{14}(L) \equiv \sum_{j=0}^{\infty} c_{14}(j) L^j \quad , \quad \sum_{j=0}^{\infty} c_{14}(j) = C_{14}(1) = 0, \qquad (23)$$

where $\sum_{j=0}^{\infty} c_{12}(j)$, $\sum_{j=0}^{\infty} c_{13}(j)$, and $\sum_{j=0}^{\infty} c_{14}(j)$ measure the long-run effect on y_t of the demand shock δ_t, the money shock υ_t, and the capital flow shock ω_t, respectively.

Further, the restriction that money and capital flow shocks are expected to have no long-run effect on real exchange rate can be represented by the restriction that the sum of coefficients in $C_{23}(L)$ and $C_{24}(L)$ is each equal to zero, that is, by

$$C_{23}(L) \equiv \sum_{j=0}^{\infty} c_{23}(j)L^j \quad , \quad \sum_{j=0}^{\infty} c_{23}(j) = C_{23}(1) = 0, \tag{24}$$

$$C_{24}(L) \equiv \sum_{j=0}^{\infty} c_{24}(j)L^j \quad , \quad \sum_{j=0}^{\infty} c_{24}(j) = C_{24}(1) = 0. \tag{25}$$

Finally, the restriction that capital flow shocks are expected to have no long-run effect on nominal exchange rate can be represented by the restriction that the sum of coefficients in $C_{34}(L)$ is equal to zero, that is, by

$$C_{34}(L) \equiv \sum_{j=0}^{\infty} c_{34}(j)L^j \quad , \quad \sum_{j=0}^{\infty} c_{34}(j) = C_{34}(1) = 0. \tag{26}$$

We are now ready to show that these long-run restrictions can be used to help identify the structure matrix C_0, and to recover the four structural shocks and thus the structural system dynamics defined by $C_1, C_2, \ldots\ldots$. To proceed, we note that, since those first-differenced variables are stationary, there exists a VAR representation of our model in the following form:

$$\begin{aligned} b_t &\equiv \begin{bmatrix} \Delta y_t \\ \Delta r_t \\ \Delta s_t \\ \Delta nf_t \end{bmatrix} = A(L)b_{t-1} + u_t \\ &\equiv \begin{bmatrix} A_{11}(L) & A_{12}(L) & A_{13}(L) & A_{14}(L) \\ A_{21}(L) & A_{22}(L) & A_{23}(L) & A_{24}(L) \\ A_{31}(L) & A_{32}(L) & A_{33}(L) & A_{34}(L) \\ A_{41}(L) & A_{42}(L) & A_{43}(L) & A_{44}(L) \end{bmatrix} \begin{bmatrix} \Delta y_{t-1} \\ \Delta r_{t-1} \\ \Delta s_{t-1} \\ \Delta nf_{t-1} \end{bmatrix} + \begin{bmatrix} u_{1t} \\ u_{2t} \\ u_{3t} \\ u_{4t} \end{bmatrix} . \end{aligned} \tag{27}$$

The VAR representation in (26) can be written in a compact form:

$$[I - A(L)L]b_t = u_t. \tag{28}$$

Pre-multiplying both sides of (28) by $[I - A(L)L]^{-1}$, we obtain

$$b_t = [I - A(L)L]^{-1}u_t. \tag{29}$$

We note that the four VAR residuals u_{1t}, u_{2t}, u_{3t}, and u_{4t} are functions of the four structural shocks z_t, δ_t, υ_t, and ω_t, and the one-step ahead forecast errors of b_t are $u_{1t} = \Delta y_t - E_{t-1}\Delta y_t$, $u_{2t} = \Delta r_t - E_{t-1}\Delta r_t$,

$u_{3t} = \Delta s_t - E_{t-1}\Delta s_t$, and $u_{4t} = \Delta nf_t - E_{t-1}\Delta nf_t$. On the other hand, using the structural vector moving average representation of our model, the one-step ahead forecast errors of Δy_t, Δr_t, Δs_t, and Δnf_t can be expressed as

$$c_{11}(0)z_t + c_{12}(0)\delta_t + c_{13}(0)\upsilon_t + c_{14}(0)\omega_t, \tag{30}$$
$$c_{21}(0)z_t + c_{22}(0)\delta_t + c_{23}(0)\upsilon_t^{+} c_{24}(0)\omega_t, \tag{31}$$
$$c_{31}(0)z_t + c_{32}(0)\delta_t + c_{33}(0)\upsilon_t + c_{34}(0)\omega_t, \tag{32}$$
$$c_{41}(0)z_t + c_{42}(0)\delta_t + c_{43}(0)\upsilon_t + c_{44}(0)\omega_t. \tag{33}$$

Since the VAR and the VMA are two equivalent representations of our model, it must be the case that

$$u_{1t} = c_{11}(0)z_t + c_{12}(0)\delta_t + c_{13}(0)\upsilon_t + c_{14}(0)\omega_t, \tag{34}$$
$$u_{2t} = c_{21}(0)z_t + c_{22}(0)\delta_t + c_{23}(0)\upsilon_t + c_{24}(0)\omega_t, \tag{35}$$
$$u_{3t} = c_{31}(0)z_t + c_{32}(0)\delta_t + c_{33}(0)\upsilon_t + c_{34}(0)\omega_t, \tag{36}$$
$$u_{4t} = c_{41}(0)z_t + c_{42}(0)\delta_t + c_{43}(0)\upsilon_t + c_{44}(0)\omega_t. \tag{37}$$

Therefore, we can recover $c_{ij}(0)$ from the variance-covariance matrix of the above system by aid of the aforementioned long-run restrictions. Using these recovered values of $c_{ij}(0)$ and the VAR residuals u_{it}, the entire time series of the structural shocks z_t, δ_t, υ_t, and ω_t can be recovered. In what follows, we will utilize these identified structural shock sequences to obtain the impulse response functions and the variance decompositions of the real and nominal baht-dollar and peso-dollar exchange rates to facilitate our analysis of the dynamic effects of the shocks on these rates.

4. EMPIRICAL RESULTS

This section presents the paper's key empirical results. We shall use our identified VAR system to recover the dynamic effects of the four structural shocks on the real and nominal exchange rates of the Mexican peso and the Thai baht relative to the U.S. dollar in the aftermaths of the countries' currency crises in 1994 and 1997. Our main task is to obtain the impulse response functions (IRFs) and the variance decompositions (VDCs) of the exchange rates using the identified structural shock sequences. The lag-length of the first-differenced variables included in the VARs is two for Mexico and one for Thailand, which are chosen based on the Schwartz Bayesian Criteria.

4.1. Impulse Response Functions

Figures 1 and 2 display, respectively, the impulse response functions of the baht-dollar and the peso-dollar real and nominal exchange rates following one standard deviation shocks to supply, demand, money, and net capital flow over various forecast horizons. A two standard error confidence interval is plotted in each panel of the figures to indicate the precision of the point IRF estimate. Each of the confidence intervals is constructed using the sample standard deviation of the empirical distribution from a bootstrap simulation on the reduced form errors with 500 draws.

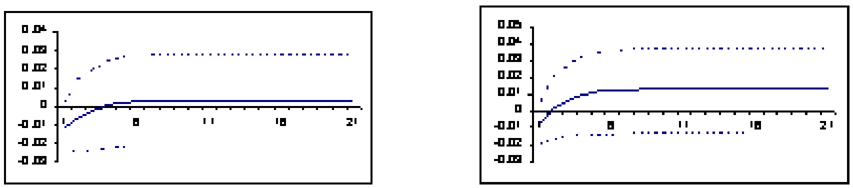
Panels (a) of the figures plot the impulse responses of the real and nominal exchange rates to a one standard deviation shock to supply that boosts home output relative to foreign output. For both Mexico and Thailand, the shock yields long-run depreciations in their currencies relative to the U.S. dollar. In the case of Thailand, the long-run real and nominal depreciations of the baht against the dollar are preceded by some initial appreciations in the baht relative to the dollar, with the maximal responses of the baht-dollar real and nominal exchange rates equal to 1.28 and -1.16 percentage points, respectively. In the case of Mexico, the real and nominal depreciations of the peso against the dollar start on the impact of the shock and continue throughout the forecast horizon, reaching the maximal levels of 1.01 and 0.72 percents in real and nominal terms, respectively.

Panels (b) of the figures reveal that demand shocks in favor of foreign output against home output generate real and nominal depreciations in home currency (the Thai baht or the Mexican peso) against foreign currency (the U.S. dollar). Following a one standard deviation shock to demand, there observes an immediate real depreciation of 4.26 percent in the baht-dollar rate, which climbs to the maximal level of 6.59 percent over the next four months, and then edges down gradually to the long-run level of 6.57 percent. Similarly, a one standard deviation shock to demand causes an immediate real depreciation of 2.07 percent in the peso-dollar rate, which reaches the peak of 2.49 percent in the second month, and then declines to the long-run level of 2.00 percent within seven months. The responses of the nominal exchange rates are smaller than those of the real rates, but display similar patterns of dynamics.

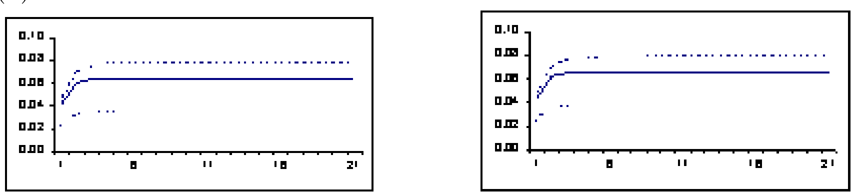
The impulse responses of the baht-dollar and the peso-dollar real and nominal exchange rates to a one standard deviation shock that raises home nominal money supply or reduces home nominal money demand relative to foreign nominal money supply or demand are displayed in Panels (c) of Figures 1 and 2. Clearly, the shock causes larger nominal and smaller real depreciations in the baht-dollar and the peso-dollar exchange rates in the short run, and nominal but not real depreciations in the long run. The real depreciation in the baht relative to the dollar takes on an initial value of 0.82 percentage point, reaches the maximal level of 1.12 percent in

FIG. 1. The Impulse Responses of the Baht-Dollar Real and Nominal Exchange Rates to Shocks in (a) Supply, (b) Demand, (c) Money, and (d) Capital Flow

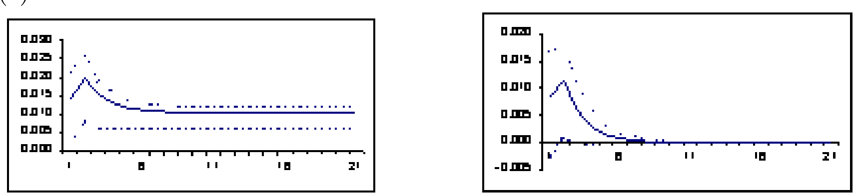
(a)



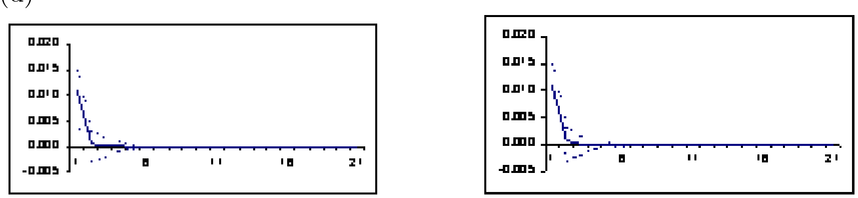
(b)



(c)

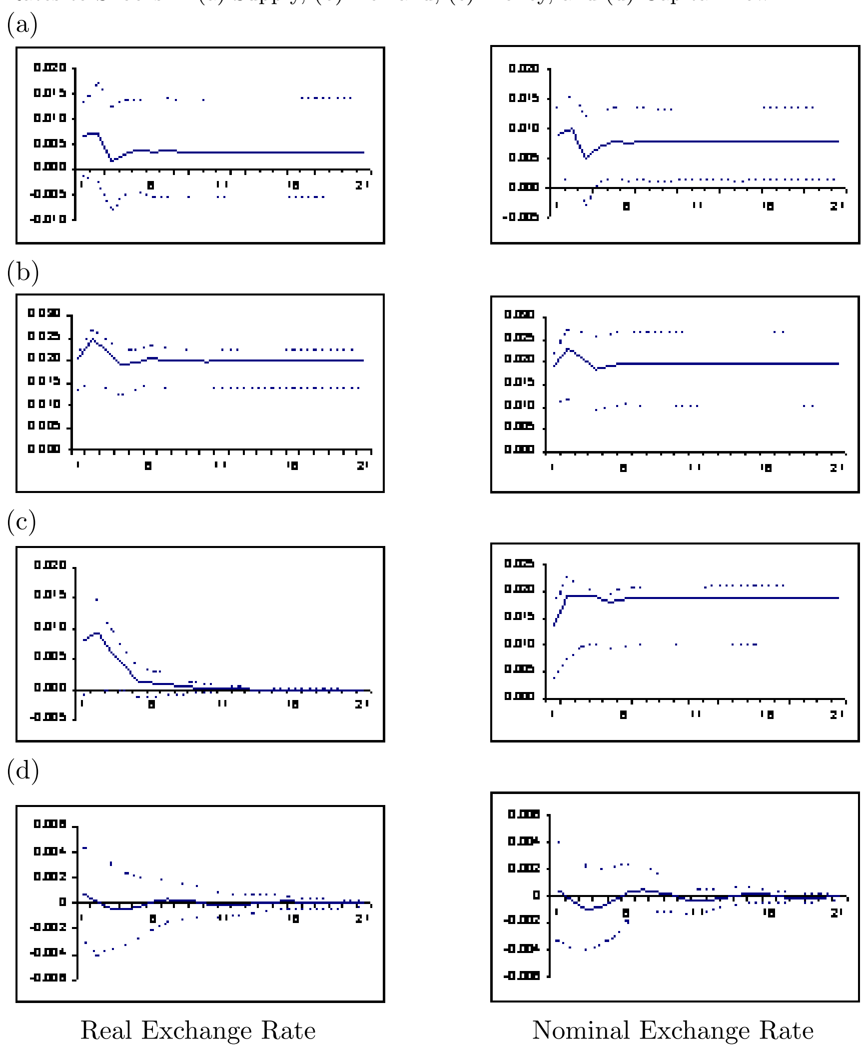


(d)



Real Exchange Rate Nominal Exchange Rate

FIG. 2. The Impulse Responses of the Peso-Dollar Real and Nominal Exchange Rates to Shocks in (a) Supply, (b) Demand, (c) Money, and (d) Capital Flow



the second month, and then gradually declines to zero after seven months; while the nominal depreciation assumes a value of 1.41 percentage point on the impact of the shock, climbs to the maximal level of 1.97 percent in the second month, and then gradually returns to the long-run level of 1.06 percent after eight months. The real depreciation of the peso against the dollar starts with a value of 0.84 percentage point, edges up to the maximal level of 0.98 percent in the second month, and then gradually returns to zero after eleven months; while the nominal depreciation takes on an initial value of 1.37 percentage point, climbs to the peak of 1.93 percent in the second month, and then gradually returns to the long-run level of 1.89 percent after six months.

Finally, Panels (d) of the figures display the impulse responses of the real and nominal baht-dollar and peso-dollar exchange rates to a one standard deviation shock to net capital flow in favor of the foreign country against the home country. While the impact of the shock on the peso-dollar real and nominal exchange rates is negligible, the shock generates significant real and nominal depreciations in the baht against the dollar in the short run. The real and nominal depreciations in the baht relative to the dollar peak to 1.09 percent immediately following the shock, and then return to zero after three months. As in the case for the peso-dollar rates, there is no long-run effect of transitory capital flow shocks on the baht-dollar rates, in either real or nominal terms.

One possible explanation for why there are significant short-run impacts of capital flow shocks on the baht-dollar rates but not on the peso-dollar rates is that, the Banco de Mexico had a policy of selling exchange rate options and adopted a policy of inflation targeting, which could have possibly served as a buffer to absorb much of the capital flow shocks, while the Bank of Thailand in repose to its currency crisis appealed to capital controls on local banks, which turned out to be ineffective and were eventually removed in January 1998.

4.2. Variance Decompositions

The impulse response functions that we have just analyzed paint a general picture about how the baht-dollar and the peso-dollar real and nominal exchange rates would respond to each of the four identified structural shocks in the short run and the long run. The variance decompositions (VDCs) of the real and nominal exchange rates that we are to compute in this section will designate the relative contribution of each of the identified shocks to the error variance in forecasting these rates. The decompositions at various forecast horizons of the variance of the changes in the log levels of the baht-dollar and of the peso-dollar real and nominal exchange rates are displayed in Tables 4 and 5.

TABLE 4.

Variance Decompositions of the Baht-Dollar Real and Nominal Exchange Rates

Horizon (In Months)	**Real Exchange Rate**(r_t)			
	Supply	**Demand**	**Money**	**Capital Flow**
1	4.67 (0.56-34.44)	83.87 (41.83-93.27)	3.01 (0.26-23.49)	8.45 (0.53-27.39)
10	5.97 (1.04-34.60)	81.32 (36.89-92.63)	4.53 (0.36-26.69)	8.18 (0.72-27.15)
20	5.97 (1.04-34.60)	81.32 (36.89-92.63)	4.53 (0.36-26.69)	8.18 (0.72-27.15)
	Nominal Exchange Rate (s_t)			
1	6.17 (0.52-37.63)	77.17 (32.49-90.88)	8.40 (0.84-33.91)	8.26 (0.48-27.29)
10	6.91 (1.34-37.60)	75.79 (30.85-90.31)	9.20 (1.05-35.21)	8.09 (0.67-26.06)
20	6.91 (1.34-37.60)	75.80 (30.85-90.31)	9.20 (1.05-35.21)	8.09 (0.67-26.06)

1. The numbers in the table indicate the percentage points of the error variances in forecasting the baht-dollar real and nominal exchange rates that are attributable to shocks in supply, demand, money, and capital flow, respectively. 2. A 95 percent confidence interval is reported in each of the parentheses, which is computed using a bootstrapping method with 500 draws.

As these tables show, demand shocks play the biggest role in explaining the error variance in forecasting the baht-dollar and the peso-dollar exchange rates, in both real and nominal terms, and in both the short run and the long run. Specifically, demand shocks account for, at all forecast horizons, more than 81 and 75 percent of the error variance in forecasting the log levels of the baht-dollar real and nominal exchange rates, and more than 69 and 56 percent of the error variance in forecasting the log levels of the real and nominal peso-dollar exchange rates.

Transitory shocks to capital flow play the second largest role in accounting for the error variance in forecasting the baht-dollar real exchange rate, supply shocks the third, and money shocks the least: at all forecast horizons, more than 8 percent of the forecast error variance is attributable to transitory capital flow shocks, while slightly less than 6 percent is attributable to supply shocks, and only less than 5 percent is attributable to money shocks. On the other hand, both money and capital flow shocks play the second most important role in explaining the error variance in forecasting the nominal baht-dollar exchange rate: at the ten-month and twenty-month forecast horizons, more than 9 and 8 percent of the forecast error variance are attributable to money and capital flow shocks, respec-

TABLE 5.

Variance Decompositions of the Peso-Dollar Real and Nominal Exchange Rates

Horizon (In Months)	**Real Exchange Rate**(r_t)			
	Supply	**Demand**	**Money**	**Capital Flow**
1	13.69 (0.88-42.52)	75.05 (25.98-91.98)	11.09 (0.39-52.27)	0.17 (0.05-10.50)
10	16.78 (3.20-42.61)	69.47 (24.18-83.64)	13.44 (1.48-53.39)	0.31 (0.39-20.33)
20	16.78 (3.19-42.60)	69.46 (24.14-83.52)	13.44 (1.51-53.31)	0.32 (0.41-20.79)
	Nominal Exchange Rate (s_t)			
1	7.36 (0.31-38.37)	58.25 (11.53-85.27)	34.25 (2.65-77.44)	0.14 (0.07-10.82)
10	11.57 (2.33-39.71)	56.02 (11.92-77.11)	32.19 (6.95-71.56)	0.22 (0.32-20.58)
20	11.57 (2.32-20.33)	56.02 (11.94-18.61)	32.19 (6.95-27.27)	0.22 (0.33-20.95)

1. The numbers in the table indicate the percentage points of the error variances in forecasting the peso-dollar real and nominal exchange rates that are attributable to shocks in supply, demand, money, and capital flow, respectively. 2. A 95 percent confidence interval is reported in each of the parentheses, which is computed using a bootstrapping method with 500 draws.

tively. In contrast, only less than 7 percent of the variance of the changes in the nominal baht-dollar exchange rate is attributable to supply shocks. The significant role of capital flow shocks in accounting for the error variance in forecasting the baht-dollar rates manifests the lack of an effective buffer to absorb the shocks, as the capital controls imposed by the Bank of Thailand on May 15,1997, in repose to its currency crisis, turned out to be ineffective and were eventually removed in January 1998.

The results for the peso-dollar exchange rates are somewhat different. Here, supply shocks play the second largest role in explaining the error variance in forecasting the peso-dollar real exchange rate, and money shocks the third: at the ten-month and twenty-month forecast horizons, about 16.78 percent of the forecast error variance is attributable to supply shocks while about 13.44 percent is attributable to money shocks. The orders of relative importance of supply and money shocks are switched in terms of accounting for the error variance in forecasting the peso-dollar nominal exchange rate: at all forecast horizons, money shocks play a much bigger role, accounting for more than 32 percent of the forecast error variance, while only less than 12 percent of the forecast error variance is attributable to supply shocks.

What is in sharp contrast with the case for the baht-dollar rates is that, transitory capital flow shocks almost play no role in accounting for the error variance in forecasting the peso-dollar exchange rates, in either real or nominal terms, and in either the short run or the long run. Indeed, virtually none of the variance of the changes in the peso-dollar real or nominal rates is attributable to capital flow shocks at any forecast horizon. The lack of short-run impacts of capital flow shocks on the peso-dollar rates is a manifestation that, the policy of selling exchange rate options and inflation targeting adopted by the Banco de Mexico might have served as an effective buffer to absorb much of the capital flow shocks.

5. CONCLUDING REMARKS

The Mexican peso crisis of 1994-95 and the Asian currency crises of 1997-98 have attracted much attention from academic researchers and policy makers. Most studies have tended to emphasize the periods leading to these crises and found that country-specific risk factors had played important roles in shaping the behaviors of the countries' macro variables, particularly their exchange rates, at the onset and during the crises. In contrast, little work has been done to analyze the periods following the crises. In particular, little is known whether country-specific risk factors have played important roles in accounting for the exchange rate fluctuations in the aftermaths of the crises. The present paper represents one step toward this direction by examining the sources of real and nominal exchange rate fluctuations in Mexico and Thailand in their post-crisis periods of floating nominal exchange rate regimes.

Our theoretical model is an extension of Clarida and Gali (1994), and our empirical approach is that of Blanchard and Quah (1989). We analyze the impacts of four structural shocks — to demand, supply, money, and capital flow — on the Mexican and Thai exchange rates in the aftermaths of their currency crises. Our structural estimates indicate that demand shocks explain the majority of the variance in real and nominal exchange rate fluctuations, supply and money shocks explain more for Mexico than for Thailand, and transitory capital flow shocks account for almost 10 percent for Thailand but virtually none for Mexico. To the extent that transitory shocks to capital flow may reflect shifts in investor perception of near-term country risk, our results suggest that exchange rate volatility during a post-crisis period may in part be attributable to variations in country-risk premia in the case of Thailand, but not in the case of Mexico. These results suggest that, the policy of selling exchange rate options and inflation targeting adopted by the Banco de Mexico might have served as an effective buffer to absorb much of the capital flow shocks, and there was a lack of such a buffer in Thailand, as the capital controls on local banks imposed by the Bank of Thailand on May 15,1997 turned out to be ineffective and were eventually removed in January 1998. These policy implications of our results should prove useful in the future for designing better policies to deal with currency and financial crises.

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