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The Interest Rate-Exchange Rate Nexus in the Asian Crisis Countries

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Abstract

Sharp exchange rate depreciations in the East Asian crisis countries (Indonesia, Korea, and Thailand) raised doubts about the efficacy of increasing interest rates to defend the currency. Using a standard monetary model of exchange rate determination, this paper shows that tighter monetary policy was in fact associated with an appreciation of the exchange rate. Moreover, there is little evidence of higher real interest rates contributing to a widening of the risk premium.

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I. Introduction

One of the more controversial elements of the stabilization programs in the East Asian crisis countries (Indonesia, Korea, and Thailand) was the stance of monetary policy. With the sharp exchange rate depreciations experienced at the onset of the crises, standard policy prescriptions called for an immediate tightening of monetary policy.

But continued depreciation of the exchange rates—well into the stabilization programs—began to raise doubts about the efficacy of raising interest rates to defend the currency.[2] Some commentators, indeed, started suggesting that raising interest rates, far from stabilizing the exchange rate, could actually prove counter-productive: further *de*preciating the exchange rate instead of appreciating it. The mechanism of this "perverse" effect is straightforward: high (presumably, real) interest rates, by causing widespread bankruptcies (or the expectation thereof), result in larger country risk premia—so much so, that the expected return to investors actually declines as interest rates increase, thus prompting even greater capital flight, and generating more downward pressure on the exchange rate.[3]

Establishing whether tighter monetary policy—often taken to mean an increase in nominal interest rates—appreciates or depreciates the currency turns out to be a surprisingly difficult task. Such studies as do exist typically use regressions or VARs to correlate exchange rate movements to changes in nominal interest rates. This approach, however, runs into two main problems.[4]

First, the level of nominal interest rate is simply not a good measure of the monetary stance. To give but the starkest example, in January 1998 interest rates in Indonesia reached almost 60 percent per year (far higher than the interest rates witnessed in the other Asian crisis countries), at a time when the money supply was expanding at a *monthly* rate of 30

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[2] IMF-supported programs began in August 1997 in Thailand, November 1997 in Indonesia, and December 1997 in Korea, while the most depreciated exchange rates were in January 1998 in Korea and Thailand, and in July 1998 in Indonesia; Lane et al. (1999) provides a useful summary.

[3] An important proponent of this school of thought is Joseph Stiglitz; see, e.g., Furman and Stiglitz 1998.

[4] A third problem is that of policy endogeneity and causality. Interest rates were raised in East Asia precisely *because* the exchange rate was depreciating. The issue goes beyond finding appropriate instruments for interest rate policy (itself no mean task): in an environment in which policies are being set in anticipation of reactions of the exchange market, and the market determined exchange rate embodies expectations of future policy, it becomes virtually impossible to disentangle cause from effect. Kraay (1999) reports results using an instrumental variable technique.

percent—scarcely a tight monetary stance. Second, simple time series correlations or vector autoregressions provide very little structure on the model, and their empirical performance in explaining exchange rate movements—even in the absence of a crisis—is, at best, limited. It is difficult to know what to make of a statement such as "higher interest rates are not correlated with exchange rate appreciations during the East Asian crisis" when the model is mute on what *is* driving the exchange rate.

In this paper, we propose an alternative approach to examining whether high real interest rates resulted in exchange rate depreciations. We start from the simple proposition that, as the relative price of two monies, the exchange rate should appreciate in response to a contraction of the domestic money supply. This, together with the empirical observation that in the Asian crisis countries there is a somewhat better correspondence between the exchange rate and the money supply (than between the exchange rate and the interest rates), suggests that a standard monetary model may be useful for explaining the bulk of the exchange rate dynamics. This allows us to isolate the risk premium, controlling for changes in monetary policy, and permits a direct test of whether higher real interest rates are associated with a larger risk premium—and thus, *ceteris paribus*, downward pressure on the exchange rate.

By measuring the monetary stance by the money supply, and by using an explicit model of exchange rate determination, our approach goes at least part of the way in addressing the methodological problems identified above. Of course, even if higher real interest rates are correlated with a larger risk premium, it does not necessarily follow that tightening monetary policy is counterproductive in stabilizing the exchange rate. The magnitude of the effect on the risk premium may be small. And, of course, there may be third factors (such as adverse political news) affecting both the real interest rate and the risk premium on the exchange rate. Nonetheless, if the findings suggest no correlation between real interest rates and the risk premium, then the possibility of the perverse effect (of tight monetary policy causing an exchange rate depreciation) is ruled out.

Our results may be summarized briefly. We find that the pure monetary model does credibly well in explaining much of the observed exchange rate movements (though the stringent cross-equation constraints are rejected). Augmenting this framework to allow for a time varying risk premium, we find little evidence that high real interest rates are correlated with a larger risk premium (except in the case of Korea). Once a simple contagion variable is added to the explanatory variables of the risk premium, moreover, the significance of the real interest rate diminishes even in the case of Korea. We conclude that there is little evidence of a "perverse" effect of a monetary tightening on the exchange rate.

The remainder of the paper is organized as follows. Section 2 provides a brief review of the literature and an overview of exchange rate developments during the crisis. Section 3 lays out the methodology. Section 4 turns to the empirical results, first on the pure monetary model, and then on the behavior of the risk premium. Section 5 concludes.

II. Background

Perhaps the most dramatic aspect of the East Asian crises were the sharp exchange rate depreciations. Prior to the crises, nominal exchange rates in these countries had, to varying degrees, been *de facto* fixed against the U.S. dollar. In July 1997, the Thai Baht depreciated by 18 percent, eventually going from Baht 25 to Baht 54 per U.S. dollar (at its most depreciated rate, in January 1998). The initial depreciations in Indonesia and Korea were somewhat smaller, around 12 percent (in August 1997 and November 1997 respectively), though the maximum depreciations—from Won 850 to Won 1,700 per U.S. dollar (January 1998), and Rp 2,400 to Rp 15,000 (July 1998)—were, if anything, even more spectacular.

Confronted by sharply depreciating exchange rates, monetary policy had to tread warily between two objectives. Under the assumption that tighter monetary policy would stabilize the exchange rate, there was an obvious need to limit the currency depreciation, not least because of the large foreign currency debt exposures of the banking and corporate sectors (particularly in Thailand and Indonesia). Against this, was the danger of an excessive contraction that could severely weaken economic activity. In the event, this dilemma resulted in stop-go policies, with significant declines in money growth rates occurring only in early 1998 in Korea and Thailand. In Indonesia, a deepening banking sector crisis necessitated massive liquidity injections, and the money supply grew rapidly until mid-1998.

The continued exchange rate depreciations despite (generally) rising interest rates began to raise doubts about the efficacy of raising interest rates to defend the currency. On the other hand, at least to date, direct evidence that higher interest rates—by raising risk premia—resulted in further depreciation of the exchange rate (whether in East Asia or elsewhere) has been scant.

Furman and Stiglitz (1998) identify a set of 13 episodes, in nine emerging markets, of "temporarily high" interest rates. Using a simple regression analysis, they find that both the magnitude and duration of such interest rate hikes are associated with exchange rate *depreciation*. Though they caution that this evidence is not definitive, and its interpretation is fraught with difficulties concerning endogeneity, they conclude that it at least questions the usefulness of raising interest rates to defend the exchange rate. Conversely, Goldfajn and Baig (1998), using daily data to analyze the relationship between nominal interest rates and nominal exchange rates during the Asian crisis find no evidence that higher interest rates resulted in weaker exchange rates—if anything, they find support for the "orthodox" relationship. Finally, Kraay (1999) uses a large panel data set to examine whether higher interest rates helped stave-off speculative attacks. Importantly, he instruments for the policy endogeneity of interest rates, though he notes the difficulties in finding adequate instruments.

He finds very little association (positive or negative) between raising interest rates and the outcome of the speculative attack.[5]

Overall, perhaps the most robust finding of these papers is that the interest rate-exchange rate nexus does not lend itself very easily to econometric analysis, particularly in the East Asian crisis context. Figures 1-3 show why.

Take the case of Thailand (Figure 1a). Until May 1997, interest rates hovered between 8 and 15 percent, while the exchange rate remained virtually constant (the currency was *de facto* pegged against the US dollar). From May 1997 till September 1997, higher interest rates were generally associated with continual exchange rate depreciation (the "perverse" effect), but from September 1997 to December 1997, interest rates *fell* and the exchange rate depreciated (the "orthodox" relationship). Interest rates then rose (with continued exchange rate depreciation) till January 1998, and from January to March 1998, higher interest rates were associated with an exchange rate appreciation (the orthodox effect). Finally, since June 1998, interest rates have fallen steadily—with few ill effects on the exchange rate.

It is hard to know what to make of all this, with neither the orthodox school ("high interest rates appreciates the exchange rate") nor the "perverse" school ("high interest rates depreciate the exchange rate") receiving unequivocal support. A quick check of Korea or Indonesia (Figures 2a and 3a) likewise shows periods during which interest rate and exchange rate movements were positively correlated, but also periods when higher interest rates were associated with exchange rate appreciations.

Of course, it is always difficult to know the counterfactual, and many factors other than interest rates—the availability of official external financing, debt deals with creditors, and political uncertainty—must have been impinging on the exchange rate as well. A further difficulty, alluded to above, lies in that interest rates often reflect risk premia and

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[5] Goldfajn and Gupta (1998) take another tack, and study the behavior of nominal exchange rates in the *aftermath* of a speculative attack, and in particular, whether higher interest rates are associated with the reversal of the overshooting of the real exchange rate taking place through a nominal exchange rate appreciation rather than through higher inflation. They find that higher interest rates are indeed associated with the real appreciation taking place through the nominal exchange rate, with the important caveat that this result does not apply in countries that also suffered a banking crisis.

expectations of inflation and/or depreciation and inflation and, as such, do not provide a very clear indication of the monetary stance of the country.[6]

Do monetary aggregates tell a better story? Figures 1(b)-3(b) show corresponding time plots for the exchange rate and broad money supplies in these countries. For Thailand and Indonesia, the orthodox relationship—greater monetary expansion is associated with an exchange rate depreciation—comes through reasonably clearly. For Korea, the time plot is more difficult to interpret: the exchange rate obviously overshot in late 1997, and then appreciated back, but again, taking the period as a whole, looser monetary policy is associated with an exchange rate depreciation.

This (comparatively) stronger relationship between monetary aggregates and the exchange rate suggests an alternative approach to studying whether higher interest rates contributed to an exchange rate weakening via the risk premium, using an explicit monetary model of exchange rate determination.

III. Methodology

The basic idea, which follows Ghosh (1992) in a similar context, is to calculate a "theoretical" exchange rate, based on a pure monetary model that abstracts from any (non-constant) risk premium.[7] The difference between the actual exchange rate and this theoretically defined exchange rate therefore captures the risk premium. The risk premium thus identified can then be correlated to explanatory variables, such as those capturing political events, contagion from other countries, and, in particular, the level of real interest rates. If indeed high real interest rates are expected to cause widespread bankruptcies—and through this mechanism to exert downward pressure on the exchange rate—then they should be positively correlated with the risk premium.

Two points bear noting. First, the risk premium that this methodology identifies probably comes close to the "credit" risk premium emphasized by Furman and Stiglitz. In particular, and as explained below, under the null hypothesis that the model is correct, the risk premium identified here controls for expectations of future monetary growth based on agents' *entire* information set. For instance, if there is an expectation of looser monetary policy (perhaps because of adverse political news or the onset of the banking crisis), this is

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[6] In fact, finding pure "policy" interest rates in these countries is not easy. In Korea, for instance, the so-called Bank of Korea discount rate barely moved during the crisis, and actually fell from 5.0 percent to 3.0 percent. In Indonesia, market determined interest rate rose to 60 percent even as broad money was expanding at a monthly rate of 30 percent, while Bank Indonesia's discount rate remained constant at 20 percent per year.

[7] The essential econometric methodology was developed by Campbell and Shiller (1987) in a somewhat different context.

Figure 1(a): Thailand -- Interest Rate and Exchange Rate

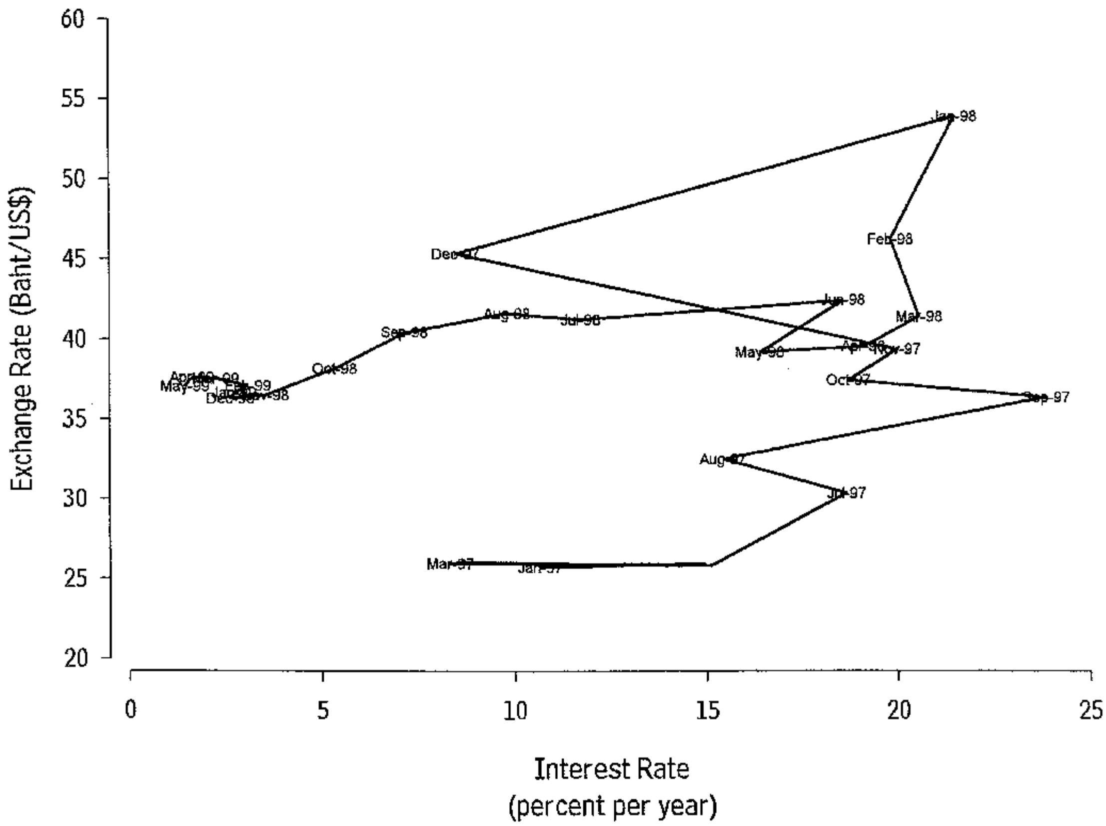


Figure 1(b): Thailand -- Broad Money and Exchange Rate

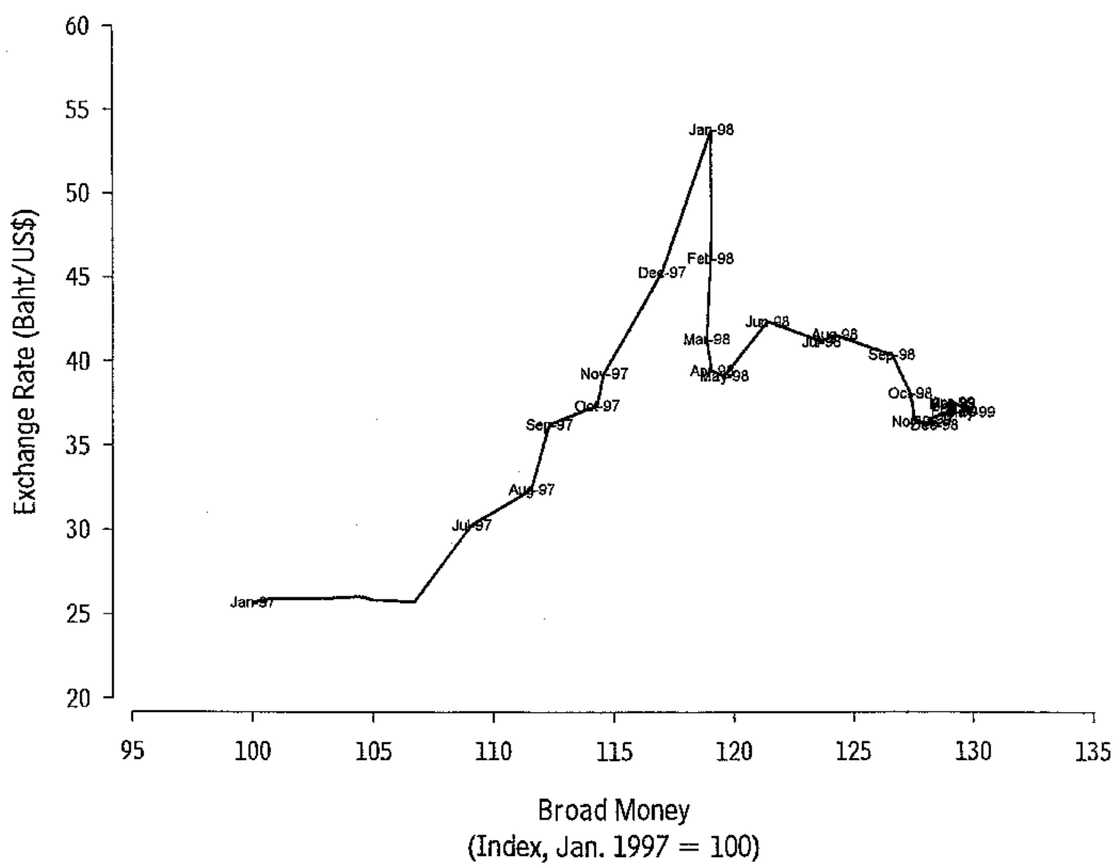


Figure 2(a) Indonesia--Interest Rate and Exchange Rate

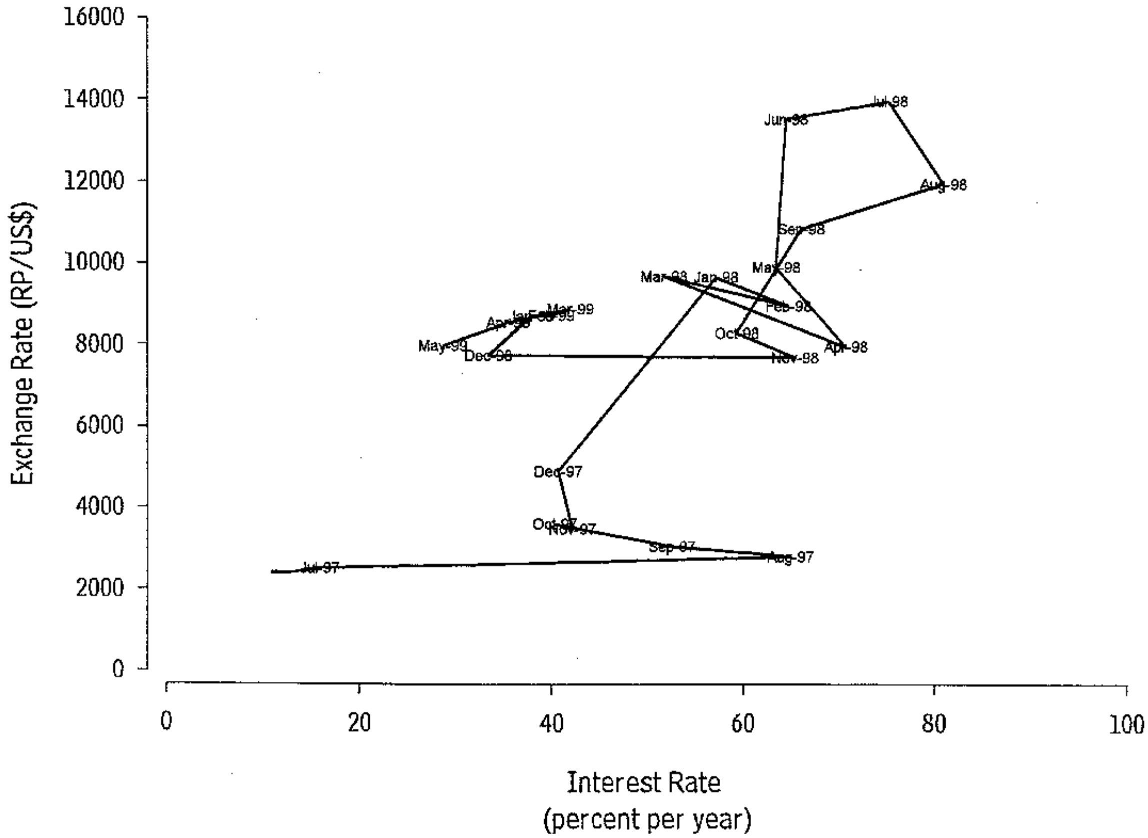


Figure 2(b): Indonesia -- Broad Money and Exchange Rate

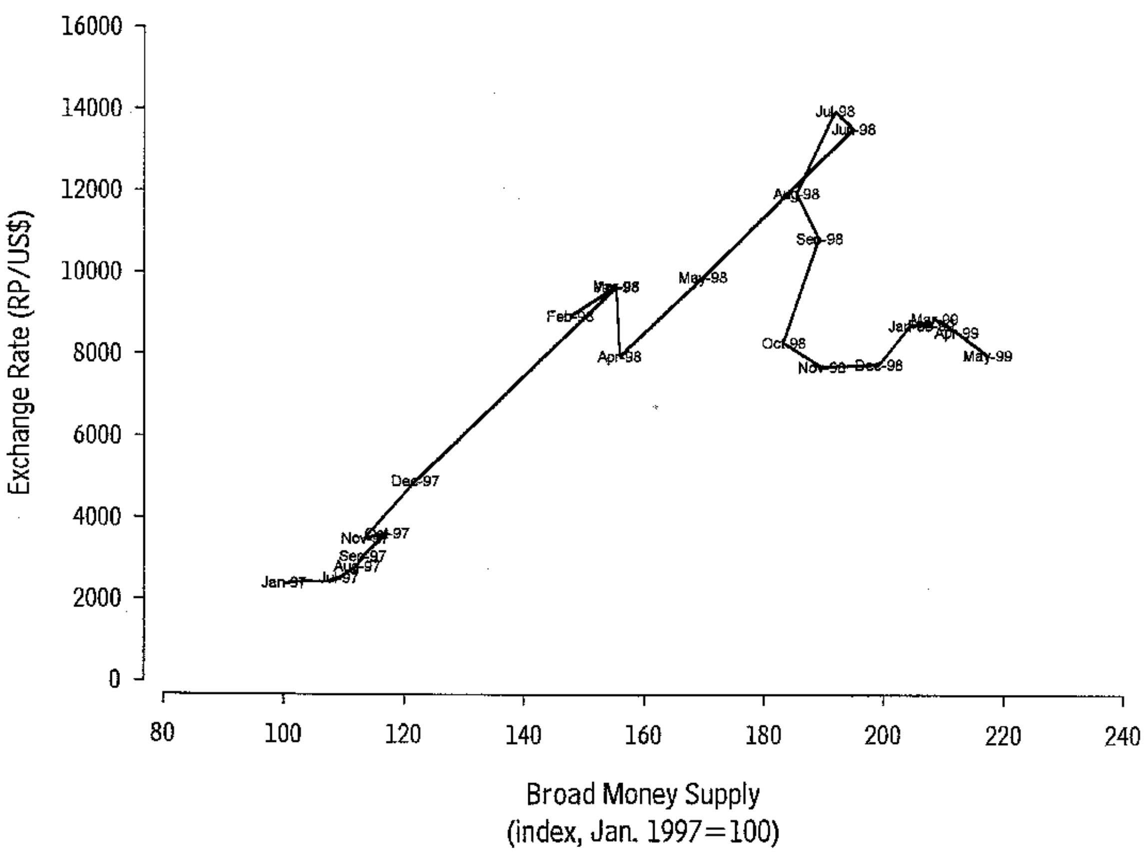
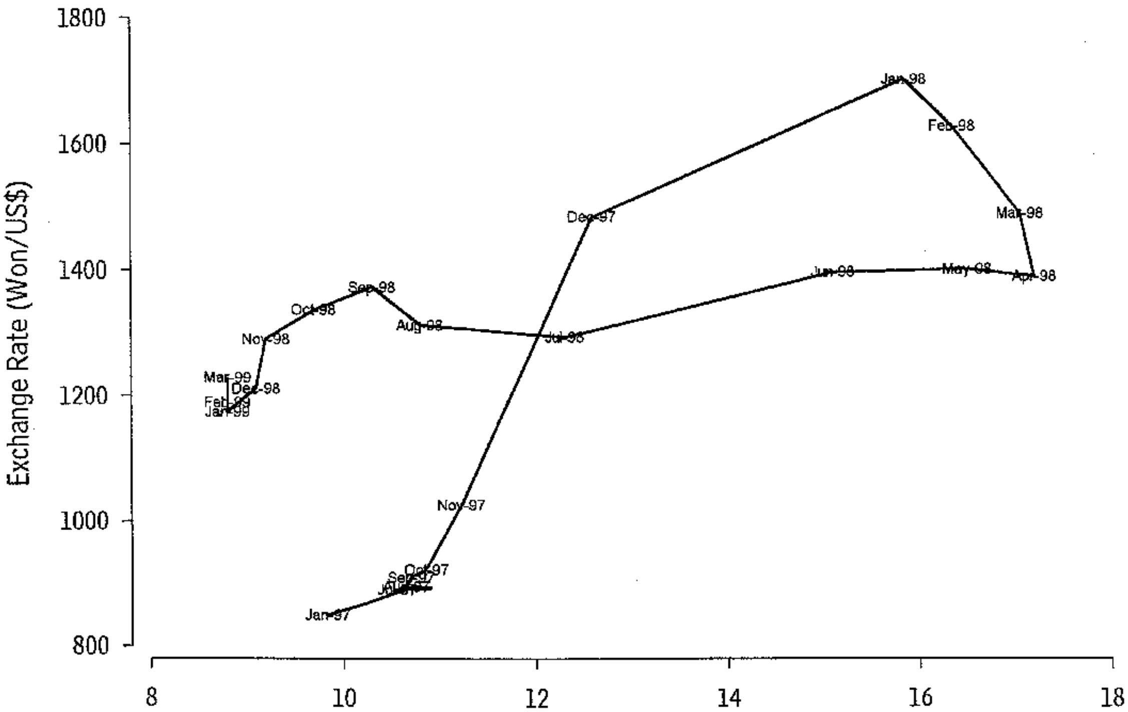
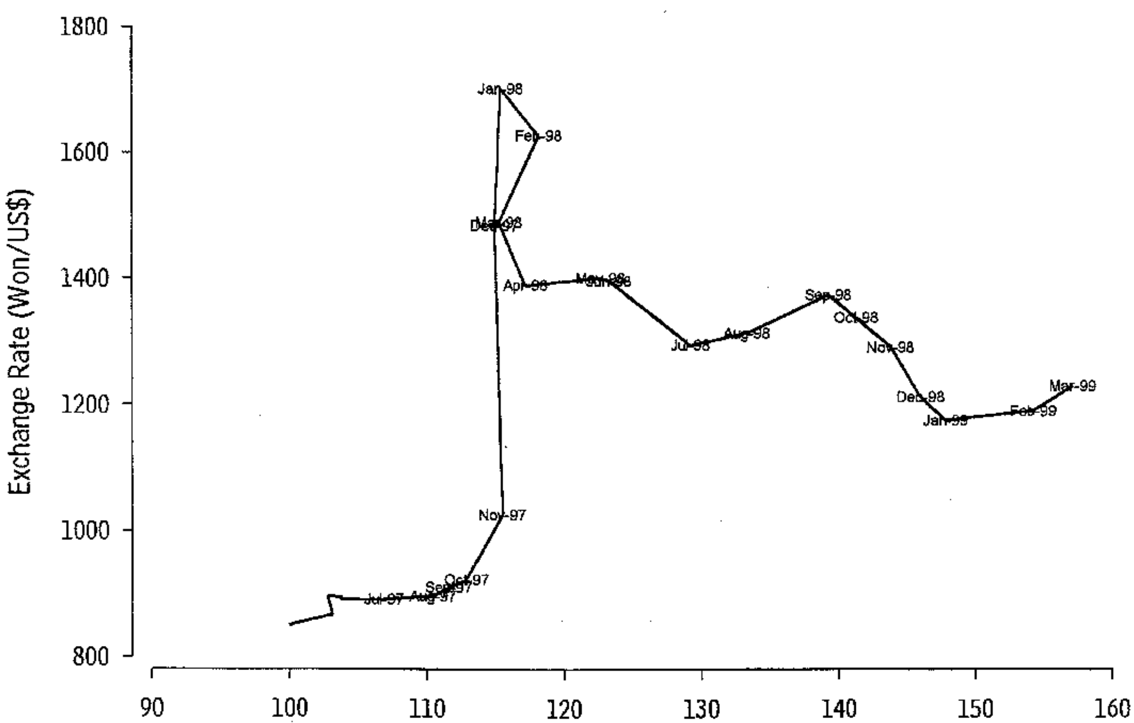


Figure 3(a): Korea -- Interest Rate and Exchange Rate



Interest Rate
(percent per year)

Figure 3(b): Korea -- Broad Money and Exchange Rate



Broad Money
(Index, Jan. 1997=100)

controlled for in identifying the risk premium. What remains for the risk premium term to capture should therefore largely reflect credit risk, and in particular, whether higher interest rates result in greater credit risk.

Second, the underlying framework is in the spirit of the monetary model of exchange rate determination. This model, a workhorse of exchange rate economics, fell into disuse after its relatively poor predictive performance in the 1970s and 1980s (Meese and Rogoff (1983)). In fact, however, the model has generally performed well in times of high nominal volatility (indeed, much of the early work on this model is based on the high inflation experience of the 1920s and 1930s), and in its modern incarnation, actually performs rather well even for low inflation, industrialized countries (as documented in Woo (1985) and Ghosh (1992), among others). Ultimately, of course, the proof of the model lies in its empirical fit, and as shown in Section IV(a) below, for the Asian crisis countries the simplicity of the model notwithstanding, its fit is remarkably good.

The model consists of three basic building blocks. Real money demand is assumed to depend positively on income and negatively on the nominal interest rate:

$$m - p = \alpha y - \beta i$$

where m is the log of money, p the log of the domestic price index, y the log of output, and i the domestic interest rate. Domestic and foreign interest rates are linked by an interest parity condition:

$$i_t = i_t^* + s_{t+1}^e - s_t + \pi_t$$

where s is the log of the exchange rate (an increase in s is a depreciation), and π the risk premium. Finally, the real exchange rate is given by:

$$v_t = p_t - p_t^* - s_t$$

Solving forward for the (first-difference of the) nominal exchange rate yields:[8]

$$\Delta s_t = \frac{1}{1+\beta} \sum_{j=0}^{\infty} \left(\frac{1}{1+\beta} \right)^j E_t \{ \Delta x_{t+j} + \Delta \pi_{t+j} | \Omega_t \} \qquad (1)$$

where $x_{t+j} = m_{t+j} - m^*_{t+j} - v_{t+j} - \alpha(y_{t+j} - y^*_{t+j})$.

[8] Ghosh (1992) works with a lagged adjustment money demand function and shows that the quasi-first difference, $s_t - \lambda s_{t-1}$ should be stationary. Since the estimated value of λ is 0.98, however, as a simplifying approximation here we work with the first difference directly.

Equation (1) is merely a statement of the monetary model of exchange rate determination. According to (1), faster money growth in the home country (relative to the rest of the world) leads to a depreciation of the exchange rate, while faster output growth, by raising money demand, results in an appreciation. (A widening risk premium, of course, depreciates the exchange rate.) Current movements of (any component of) x_t affect the exchange rate directly, while expected future movements are discounted at the rate $(1+\beta)^{-j}$.

Notice that, in this model, a monetary contraction in the home country necessarily appreciates the exchange rate (via the first term in x_t)—unless higher real interest rates happen to cause a sufficiently large increase in the (present-value) risk premium, π.

It is useful to define the theoretical exchange rate (excluding the risk premium) by:

$$\Delta s_t^* = \frac{1}{1+\beta}\sum_{j=0}^{\infty}\left(\frac{1}{1+\beta}\right)^j E_t\{\Delta x_{t+j}|\Theta_t\} \qquad (2)$$

then, *conceptually*, our test consists of correlating the difference between Δs-Δs^* to the variable of interest, w_t, such as the level of real interest rates (as suggested by Furman and Stiglitz).

The actual test is somewhat different, and follows Campbell and Shiller (1987) who study such present value relations extensively in a somewhat different context, and Ghosh (1992) who studies the risk premium in a monetary model of the exchange rate.

The first step in estimating the pure monetary model is to create the projection of the expected future discounted monetary policy, Δx_t. The simplest approach would be to use a univariate autoregression. However, in general, agents have much more information about the evolution of future monetary policy than would be contained in past values of Δx_t. For instance, agents may be expecting looser monetary policy based on news about political events or adverse developments in the banking sector.

In general, it is difficult to identify and capture the additional information that is being used by agents to determine the exchange rate, and the econometrician's information set, Θ will be only a small subset of agent's information set, Ω. As shown by Campbell and Shiller (1987), however, it is possible to include *all* the relevant information in the econometrician's information set because, under the null, the exchange rate itself embodies this additional information.[9] (As discussed by Campbell and Shiller, one implication of this is that Δs should Granger cause Δx.).Therefore, rather than use a univariate autoregression in

[9] The issue is important because otherwise expectations of looser monetary policy are shifted to the risk premium term (since it is the residual), and the risk premium would be capturing not only credit risk, but also the risk associated with looser monetary policy.

Δx_t, a vector autoregression (VAR) in is estimated in $z = \{\Delta x_t, \Delta s_t\}$: $z_t = \Phi z_{t-1} + \varepsilon_t$. This turns out to be particularly convenient for computing the infinite sum on the RHS of (2) since $Et(z_{t+k}) = \Phi^k z_t$, so that the cross-equation constraint (2) becomes:

$$g' z_t = \frac{1}{1+\beta}\sum_{j=0}^{\infty}\left(\frac{1}{1+\beta}\right)^j h'\Phi^j z$$

and the theoretical exchange rate may be computed as:[10]

$$\Delta s_t^* = [1 \quad 0]' \frac{1}{1+\beta}\left(I - \frac{\beta}{1+\beta}\Phi\right)^{-1}\begin{pmatrix}\Delta x_t \\ \Delta s\end{pmatrix} \tag{3}$$

Writing out (3) explicitly yields: $\Delta s_t^* = \Gamma_1 \Delta x_t + \Gamma_2 \Delta s_t$. Under the null hypothesis that the pure monetary model (i.e. without the risk premium) is correct, $\Gamma_1 = 0$, $\Gamma_2 = 1$, and this can be tested using the appropriate Wald statistic. Beyond the formal statistical test, the overall fit of the model may be assessed by comparing the fitted, Δs^*, and actual, Δs, exchange rates.

Next, in order to examine whether the risk premium depends on some variable Δw (such as real interest rates), the VAR is augmented to include it: $z = \{\Delta x_t, \Delta s_t, \Delta w_t\}$. Proceeding exactly as above:

$$\Delta s_t^* = [1 \quad 0 \quad 0]' \frac{1}{1+\beta}\left(I - \frac{\beta}{1+\beta}\Phi\right)^{-1}\begin{pmatrix}\Delta x_t \\ \Delta s \\ \Delta w\end{pmatrix} \tag{4}$$

Again, writing out (4) explicitly yields: $\Delta s_t^* = \Gamma_1 \Delta x_t + \Gamma_2 \Delta s_t - \Gamma_3 \Delta w_t$. Under the null hypothesis that the pure monetary model (i.e. without the risk premium) is correct, $\Gamma_1 = 0$, $\Gamma_2 = 1$, and $\Gamma_3 = 0$. Under the alternative, that w_t is (positively) correlated with a currency depreciation, $\Gamma_3 > 0$.

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[10] To see this, note that $E_t \Delta x_{t+j} = [1\ 0]'\Phi^j z_t$. Therefore,

$[1/(1+\beta)]\ \Sigma\ E_t \Delta x_{t+j}/(1+\beta)^j = [1/(1+\beta)]\ [1\ 0]'[I-\beta/(1+\beta)\Phi]^{-1}\ z_t$.

IV. Empirical Results

A. The Monetary Model

Our data are monthly, covering the period 1990:1-1998:12.[11] We begin by estimating the "pure" monetary model (2); that is, abstracting from any (time-varying) risk premium. To do so, we first require some preliminary parameter estimates for the money demand function. With high rates of monetization and substantial financial innovation in the years preceding the crises, it is quite difficult to obtain stable parameter estimates for the money demand functions. Fortunately, as discussed in the robustness section below, the main findings turn out not to be terribly sensitive to the exact parameter values of the money demand function. For instance, the interest elasticity (the most difficult parameter to estimate), only enters the expression for the exchange rate as the discount factor.

We therefore proceed on the basis of the estimates given in Table 1, and in the robustness section, test the sensitivity of our main results to variations in the money demand parameter values.

Next, we check the order of integration of s and x. As indicated in the bottom panel of Table 1, the augmented Dickey-Fuller test cannot reject the null hypothesis of a unit root for the levels of s and x, but readily do so for their first differences. As such, it is appropriate to work with Δs_t and Δx_t.[12]

With these preliminary transformations, we estimate the vector autoregression, $z_t = \Phi z_{t-1} + \varepsilon_t$. Table 2 reports the VAR parameters for a first-order system.[13] The Granger-causality tests are mixed: for Korea, Δs_t strongly Granger-causes subsequent movements in Δx_t as the model above would predict; for Indonesia and Thailand, the Granger-causality is much weaker (t-statistics around 1.48), though this presumably reflects, in part, the largely fixed exchange rate regime over much of the sample period.

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[11] Data are taken from IFS: exchange rate (line af); money plus quasi money (lines 34+35); consumer price index (line 64); lending interest rate (line 60p); and industrial production (line 66). For Thailand, industrial production was taken from the Bank of Thailand *Monthly Bulletin* and for Indonesia, quarterly data from *Biropustat Statitistik* were interpolated.

[12] As noted above, it is possible to work with the quasi-first difference, $s_t - \lambda s_{t-1}$, yet given implied parameter estimates of λ (which are very close to unity), we work with the first difference directly.

[13] The order of the VARs was chosen using the Schwartz-Bayes criterion.

Table 1: Money Demand Parameter Estimates and Unit Root Tests

	Indonesia	Korea	Thailand
Parameter Estimates 1/			
α	0.276	0.360	0.151
(t-stat)	4.01	7.51	3.72
β	-0.345	-0.325	-0.461
(t-stat)	-2.01	-1.09	-2.19
R^2	0.95	0.92	0.98
Unit Root Tests 2/			
x	-1.06	1.23	-0.63
s	-2.42	-0.45	-2.23
Δx	-3.38	-5.38	-3.81
Δs	-3.70	-5.24	-4.95

1/ OLS estimates
2/ Augmented Dickey-Fuller tests with 6 lags

Table 2: Vector Autoregression Parameter Estimates

	Indonesia	Korea	Thailand
Dependent Variable: Δx			
Δx(-1)	-0.392	0.035	-0.136
t-stat.	-1.18	0.21	-0.43
Δs(-1) 1/	0.648	0.429	0.504
t-stat.	1.48	2.37	1.45
Const.	0.020	0.009	0.011
t-stat.	1.71	2.09	2.39
Dependent Variable: Δs			
Δx(-1)	-0.284	0.234	-0.084
t-stat.	-1.16	1.63	-0.29
Δs(-1)	0.618	0.280	0.434
t-stat.	1.91	1.78	1.37
Const.	0.011	0.148	0.003
t-stat.	1.27	0.15	0.64

1/ Model implies that Δs(-1) should Granger-cause Δx.

A more formal statistical test of the model is presented in Table 3, based on the implied Γ coefficients from the estimated VAR parameters.[14] Although Γ_2 is significantly different from zero, for all three countries, it is also significantly different from unity. Moreover, Γ_1 is also significantly different from zero.[15] Overall, the χ^2 test of the overidentifying restrictions strongly reject the pure monetary model.

Despite the formal rejection of the stringent cross-equation constraints, the model performs respectably in that the fitted and actual (first-differences of the) exchange rates are highly positively correlated (ranging from +0.85 for Korea, to +0.96 and +0.97 for Thailand and Indonesia), and the simple time series plots given in Figures 4-6 show that the model correctly captures much of the movement in the exchange rate.

These figures are also useful for identifying periods for which the pure monetary model does *not* work—which, in the framework adopted, means periods during which there were changes in the risk premium. In Indonesia, there seems to be little left to explain. Essentially, the massive liquidity injection in December 1997/January 1998 so swamps any other developments that the pure monetary model can account for nearly all of the exchange rate depreciation. In February 1998, however, the small re-appreciation of the actual exchange rate falls short of what the pure monetary model would predict—suggesting that the risk premium widened.

In Thailand, from July 1997-January 1998, the actual exchange rate depreciated more than the monetary model would predict, suggesting a widening risk premium, with a decrease in the risk premium starting in February 1998. Finally, in Korea the story is much the same: a very large increase in the risk premium in December 1997, which starts reversing around April 1998.

To summarize, the pure monetary model seems to characterize movements of the East Asian exchange rates reasonably well, and provides a credible framework to control for the direct impact of monetary aggregates on the exchange rate. However, it is also clear that the risk premium was not constant. In the next section, therefore, we relax this assumption, and in particular, allow the risk premium to depend upon real interest rates.

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[14] That is, we compute $[1 \quad 0]' \frac{1}{1+\beta}\left(I - \frac{\beta}{1+\beta}\Phi\right)^{-1}\begin{pmatrix}\Delta x, \\ \Delta s\end{pmatrix}$, then Γ_1 is the resulting coefficient on Δx, and Γ_2 is the resulting coefficient on Δs.

[15] Recall that the model implies $\Gamma1=0$ and $\Gamma2=1$. Standard errors were computed numerically as $\nabla Q'\Sigma\, \nabla Q$, where ∇Q is the gradient of Γ with respect to the VAR parameters, and Σ are the White-consistent standard errors.

Table 3: Cross-Equation Constraints

	Indonesia	Korea	Thailand
[1] Pure Monetary Model 1/			
Γ1	0.677	0.707	0.630
t-stat.	10.89	19.11	9.71
Γ2	0.129	0.102	0.126
t-stat.	1.49	2.35	1.67
Corr(Δs,Δs*)	0.967	0.884	0.969
[2] Interest Rate Effect on Risk Premium 2/			
Γ3	0.176	0.255	-0.143
t-stat.	1.50	1.96	1.53
[3] Interest Rate and Contagion Effects on Risk Premium 3/			
Γ3	0.035	0.200	-0.127
t-stat.	0.21	1.47	1.36
Γ4	-0.540	0.034	0.043
t-stat.	7.75	1.57	1.78

1/ Pure monetary model, null hypothesis: Γ1=0, Γ2=1
2/ If higher interest rates result in larger risk-premium, Γ3 > 0.
3/ If contagion results in larger risk-premium, Γ4 > 0.

Figure 4: Thailand--Fitted and Actual Exchange Rate
(log first difference)

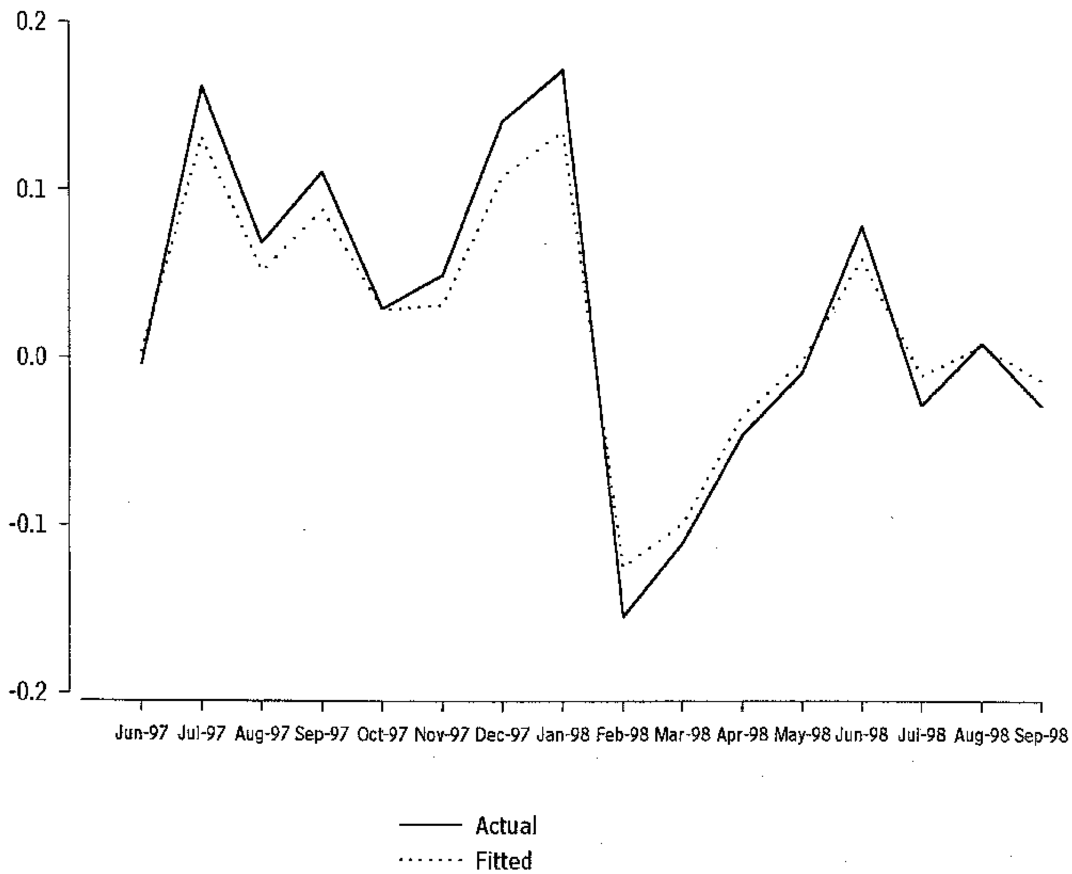


Figure 5: Indonesia--Fitted and Actual Exchange Rate
(log first difference)

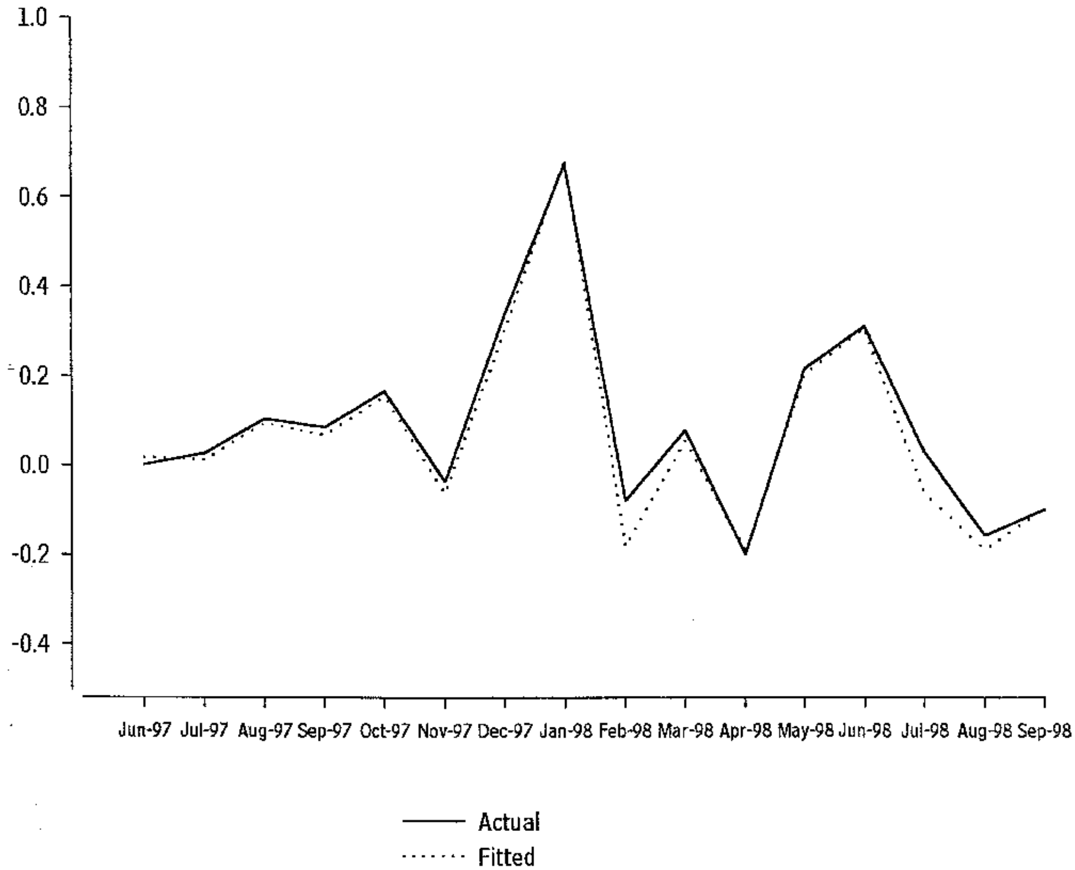
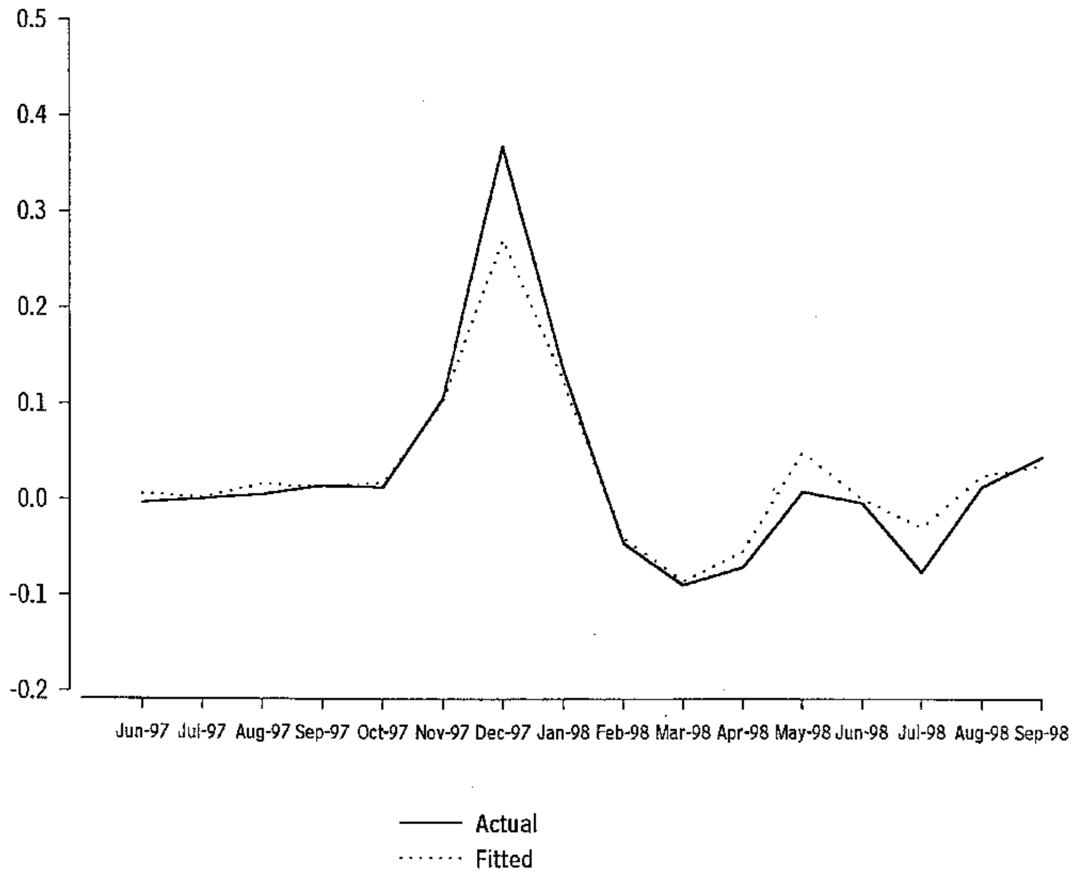


Figure 6: Korea--Fitted and Actual Exchange Rate
(log first difference)



B. Determinants of the Risk Premium

There many factors accounting for the widening risk premia as the crises deepened—political uncertainties, contagion effects, corporate bankruptcies, banking system problems, prospects of possible capital controls, and indeed a seemingly never-ending stream of bad news. Most of these factors are difficult to capture econometrically, but to the extent that rising real interest rates contributed to widespread bankruptcies, part of the widening risk premia may be correlated to higher real interest rates.

As discussed above, conceptually our test simply consists of regressing the difference between the actual and theoretical exchange rates on the real interest rate. Econometrically, however, it is preferable to do the estimation in a single step by augmenting the VAR to include the (change in) the real interest rate and then testing whether $\Gamma_3 = 0$ (the null) , or $\Gamma_3 > 0$ (the alternate hypothesis, that higher real interest rates were associated with a widening premium).

The middle panel of Table 3 reports the results. For Indonesia, there is a positive relation between real interest rates and the risk premium, though the coefficient is not significantly different from zero. For Thailand, the coefficient is actually negative, and statistically insignificant. Only for Korea do we find a positive and statistically significant relationship (essentially because real interest rates started increasing around end-1997, when the risk premium also widened significantly).

But of course, this correlation between real interest rates and the risk premium does not prove that tighter monetary policy caused a widening of the risk premium. One possibility is that some other variable affected the risk premium. An obvious candidate is the contagion effect from other crisis countries in the region. To capture this, for each country, we simply use the unweighted average of the contemporaneous exchange rate movements in the *other* two countries. Once this variable is added to the explanatory variables of the risk premium, the real interest rate loses its significance even in the case of Korea.

Beyond their purely statistical significance, the effects are relatively small in economic terms as well. From Table 3, a 1 percentage point increase in real interest rates would be associated with a 0.2-0.25 percent depreciation of the currency. At their peak, real lending rates by about 10 percentage points in Korea (relative to the pre-crisis levels). Based on these estimates, the rise in real interest rates could account for less than a 3 percent depreciation of the Won—a paltry effect relative to the observed depreciation.

C. Robustness

Finally, it is worth checking whether our main finding—that higher real interest rates are not particularly associated with a widening risk premium—is robust to alternative specifications. Table 4 reports the results of using alternative definitions of the "real interest

Table 4: Robustness Tests 1/

	Indonesia	Korea	Thailand
[1] Lending interest rate, deflated by CPI			
Coefficient Γ3	0.035	0.200	-0.127
t-stat.	0.21	1.47	1.36
[2] Lending interest rate, deflated by WPI			
Coefficient Γ3	0.007	0.172	-0.025
t-stat.	0.12	1.49	0.39
[3] Deposit interest rate, deflated by CPI			
Coefficient Γ3	-0.073	0.150	-0.154
t-stat.	0.67	0.88	1.38
[4] Deposit interest rate, deflated by WPI			
Coefficient Γ3	-0.047	0.151	-0.014
t-stat.	0.66	1.07	0.22
[5] High income elasticity of money demand: $\alpha = \alpha + se(\alpha)$			
Coefficient Γ3	0.039	0.208	-0.130
t-stat.	0.43	1.51	1.39
[6] Low income elasticity of money demand: $\alpha = \alpha - se(\alpha)$			
Coefficient Γ3	0.031	0.192	-0.123
t-stat.	0.34	0.14	1.33
[7] High interest elasticity of money demand: $\beta = \beta + se(\beta)$			
Coefficient Γ3	0.033	0.159	-0.116
t-stat.	0.43	1.51	1.39
[8] Low interest elasticity of money demand: $\beta = \beta - se(\beta)$			
Coefficient Γ3	0.035	0.226	-0.133
t-stat.	0.34	1.44	1.34

1/ Coefficient on real interest rate, Γ3; contagion variable included, but not reported.

rate" (using deposit rates or lending rates, deflating by the CPI or the WPI), or of varying the money demand parameters (to within one standard error of the point estimate).

In general, the findings are not much affected. For Indonesia, where the coefficient on the real interest rate term is positive, it is always wholly insignificant, and for Thailand the coefficient is always negative. For Korea, the point estimate of the coefficient is positive, though the maximum t-statistic is only 1.51.

V. CONCLUSIONS

One of the most controversial elements of the East Asian crises was the stance of monetary policy. With continued depreciation of the exchange rate, some commentators argued that higher nominal interest rates, far from defending the currency, were having a perverse effect by creating the expectation of widespread bankruptcies and thus widening the risk premium.

In this note, we have argued that nominal interest rates are not a good gauge of the monetary stance—particularly in a crisis environment, where the nominal interest more likely reflects fears of inflation and currency depreciation—and that a simple monetary model accounts very well for much of the exchange rate movements witnessed during the crisis. Turning to the determinants of the risk premium, there is little evidence that higher real interest rates contributed to a widening premium and hence, *ceteris paribus*, to a weakening of the exchange rate. Only for Korea is the coefficient consistently positive, and even there, it is statistically and economically insignificant once contagion effects are accounted for. We conclude that the perverse effect of higher interest rates on the exchange rate remains, largely, a theoretical curiosum.

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