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Contagion: Monsoonal Effects, Spillovers, and Jumps Between Multiple Equilibria

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Abstract

Several concepts of contagion are distinguished. It is argued that only models that admit of multiple equilibria are capable of producing true contagion. A simple balance of payments model is presented to illustrate that phenomenon, and some back-of-the-envelope calculations assess its relevance to the coincidence of emerging market crises in 1994–95 and in 1997.

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SUMMARY

The currency crises in Mexico and Thailand were associated with strong pressures on exchange rates and asset prices in other emerging market countries. There may be several reasons for expecting crises to be contemporaneous in time. First, they may be due to a common cause, for instance policies undertaken by industrial countries that have similar effects on emerging markets. Second, a crisis in one emerging market may affect the macroeconomic fundamentals in other emerging markets, for instance because a devaluation reduces the price competitiveness of other countries. Third, a crisis in one country may conceivably trigger a crisis elsewhere for reasons unexplained by macroeconomic fundamentals, perhaps because it leads to shifts in market sentiment or changes the interpretation given to existing information.

The paper distinguishes between these various reasons and applies the term contagion only to the third category—those that cannot be identified with observed changes in macroeconomic fundamentals. In contrast, the first category are called "monsoonal effects," and the second, "spillovers."

As defined here, pure contagion involves changes in expectations that are self-fulfilling, with financial markets subject to multiple (or "sunspot") equilibria, for given values of a country's macroeconomic fundamentals. A simple balance of payments model is specific that allows for the possibility of sunspot equilibria, as well as the monsoonal and spillover channels. This model implies that only for certain ranges of the fundamentals are countries vulnerable to contagion.

After applying the model to the data, the results suggest that the first two factors cannot explain the coincidence of speculative pressures felt by a number of emerging market economies at the time of the Mexican and Thai crises. However, the values for key variables in many emerging markets were consistent with the existence of multiple equilibria, and hence these countries were potentially exposed to contagion.

I. Introduction

Since the crisis in Mexico in late 1994 and early 1995, which was accompanied by speculative pressures in other countries of Latin America and elsewhere, there has been much discussion of contagion effects. Studies by Gerlach and Smets (1995), Sachs, Tornell, and Velasco (1996), Valdés (1995), and Agénor and Aizenman (1997) present explanations of why a crisis in one country might trigger a crisis in another. Eichengreen, Rose, and Wyplosz (1996), using data for 20 industrial countries from 1959 through 1993, show that the occurrence of crises elsewhere increases the probability of a crisis occurring in a given country, after allowing for the standard set of macroeconomic fundamentals. They also attempt to identify what features of countries explain such contagion effects, finding that it is trade linkages, rather than similarity of macroeconomic fundamentals, that have the greatest explanatory power. We will follow them in defining exchange rate crises broadly, to include not only devaluations but also successful defense of a peg that involves substantial increases in interest rates and losses of reserves.

The recent crisis in Thailand and other emerging market economies has once again raised the question of contagion effects. The Thai economy had experienced for several years a period of strong domestic demand associated with an appreciating real exchange rate and large current account deficits, as well as financial sector problems linked to overexposure to a property market whose prices had fallen sharply. After long resisting pressures on the baht through measures that included capital controls and massive forward intervention, the Thai authorities were eventually forced to abandon the dollar exchange rate peg. The depreciation (and the lead up to it) were associated with pressures on the currencies of neighboring countries which also attempted to keep their exchange rates against the dollar in a narrow range, especially Indonesia, Malaysia, and the Philippines. These countries shared some features (including current account deficits) with Thailand and were quickly forced to accept more exchange rate flexibility, their currencies depreciating by about the same amount as the Thai baht. More curiously, Hong Kong and Singapore, with strong current account and fiscal positions, were also briefly exposed to downward pressure on their currencies, and Korea, which was spared for several months, succumbed to contagion effects in November. More generally, the currency turmoil seems to have triggered plunges in stock markets of the region and elsewhere.

Clearly there may be many reasons for expecting crises to be contemporaneous in time. First, they may be due to a common cause, for instance policies undertaken by industrial countries which have similar effects on emerging markets. Second, a crisis in one emerging market may affect the macroeconomic fundamentals in other emerging markets, for instance because a devaluation reduces the price competitiveness of other countries, or because lack of liquidity in one market leads financial intermediaries to liquidate other emerging market assets (Valdés (1996)). Third, a crisis in one country may conceivably trigger a crisis elsewhere for reasons unexplained by macroeconomic fundamentals, perhaps because it leads to shifts in market sentiment or changes the interpretation given to existing information. For instance, a crisis might lead investors to reassess the fundamentals of other countries, even if they had not changed, or lead to a change in the risk tolerance of investors.

In this paper, we attempt to distinguish between these various reasons and to apply the term contagion only to the third category, those that cannot be identified with observed changes in macroeconomic fundamentals. In contrast, the first category will be called "monsoonal effects" (see Masson and Mussa (1995)), defined as major economic shifts in industrial countries that trigger crises in emerging markets. Though not primarily the fault of those countries' policies, the extent of their vulnerability will be importantly affected by their previous exposure to foreign currency borrowing, the size of government debt, and problems in their banking system. The debt crisis in the early 1980s was to a substantial extent a common response to the sharp increase in interest rates in the United States relative to their very low levels (in real terms) of the late 1970s.[2] The appreciation of the U.S. dollar against the yen in 1995–96 was an important factor contributing to the recent weakening of net exports of Southeast Asian countries. The second category is termed "spillovers," rather than contagion, because it results from interdependence among developing countries themselves. A crisis in one country may have a substantial effect on the macroeconomic fundamentals of its neighbors. An example from advanced countries illustrates this point: the devaluations of several EMS currencies in 1992–93 made the parities of the remaining ones more fragile, since those countries' real effective exchange rates had appreciated.[3]

As defined here, pure contagion involves changes in expectations that are not related to changes in a country's macroeconomic fundamentals. It is most natural to think of this in a context where financial markets are subject to multiple equilibria, or self-fulfilling expectations. There is an extensive literature on exchange rate crises which involve multiple equilibria, but these models have so far been developed only for countries considered in isolation, e.g., Obstfeld (1986, 1994), Cole and Kehoe (1996), Sachs, Tornell, and Velasco (1996), Jeanne (1997), and Jeanne and Masson (1996).[4] However, by analogy to the literature on bank runs (Diamond and Dybvig (1983)), attacks on countries which involve a simultaneous move from a nonrun to a run equilibrium seem to be relevant for recent experience in emerging market countries. In this paper, a simple balance of payments model

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[2]However, overborrowing for nonproductive uses was also a large contributor to the debt crisis in many developing countries.

[3]The crisis itself had an important monsoonal component due to German unification, however, as the high interest rates in Germany and the tendency for the deutsche mark to appreciate put pressures on the ERM parities of many European currencies. Drazen (1998) points to other spillovers among these countries, which he calls "political contagion."

[4]Eaton and Gersovitz (1988) show that the existence of public debt (which needs to be serviced through taxation) and of decentralized private investment decisions can lead to an equilibrium with no investment as well as the social optimum, with positive investment.

will be used to describe the relationship between fundamentals and currency crises, in a form that allows for the possibility of multiple equilibria, as well as the monsoonal and spillover channels. While the model does not explain the timing of jumps between equilibria or of contagion, it is not inconsistent with various micro theories that explain how expectations are formed in a context of imperfect and asymmetric information. For instance, one view concerning contagion operating through changes in expectations for unchanged values of a country's fundamentals is that a crisis in another country constituted a "wake up call" (Goldstein (1998)). In this view, the true fundamentals were really poor, but investors did not realize this until problems elsewhere made it manifest—for instance, banking sector problems were quickly seen to be pervasive in East Asia after the devaluation of the Thai baht. It could further be argued that there was just a single (bad) equilibrium, but that the true fundamentals were at first incorrectly perceived to be good. However, the fact that an optimistic view about East Asian economies prevailed for so long (in the face of some reports of banking sector problems), the rapidity of the change in view, and the suddenness and severity of the resulting crisis all argue in favor of the multiple equilibrium story (even if the appeal to unobservable fundamentals could conceivably make the two explanations observationally equivalent).

A criticism of models with multiple equilibria or sunspots is that they seem to disculpate policymakers from any blame for the speculative crises (Garber (1997)). However, this is not really the case. A clear implication of most such models is that multiple equilibria are only possible in a certain range for the fundamentals (Jeanne (1997)). An implication is that policymakers should try to ensure that they avoid that range, for instance, by reducing their exposure to short-maturity, foreign currency debt (Kehoe (1997)). The model presented here does produce predictions concerning the vulnerability to contagion: only in certain ranges of the fundamentals and for certain parameter values are multiple equilibria possible.

The paper then looks at some of the symptoms of monsoonal effects, spillovers, and contagion. At least on the face of it, the first two factors do not seem to explain the coincidence of speculative pressures felt by a number of emerging market economies in two periods: end 1994-early 1995 (associated with the Mexican crisis), and the second half of 1997 and early 1998 (associated, at least initially, with a crisis in Thailand). The paper then examines the values for key variables in emerging markets that influence the regions where multiple equilibria can occur, both at the time of the Mexican crisis in late 1994 and at the time of the more recent Asian currency crises. The countries for which the balance of payments model implies multiple equilibria were possible, and hence were potentially exposed to contagion, are highlighted.

II. A Simple Balance of Payments Model

In what follows, a simple two-country model is developed to illustrate the role of multiple equilibria and contagion, as well as monsoonal and spillover effects. In this model, a devaluation occurs when foreign exchange reserves approach a certain critical level (as in Krugman (1979) or Flood and Garber (1984)). In this very simple model, there may be no trend for the fundamentals, but if the foreign debt that needs to be serviced exceeds a certain level, then shocks to the current account can be large enough to provoke a crisis. Expectations of a crisis show up in the borrowing cost paid to foreigners. Thus, the size of the stock of external debt (assumed, for simplicity, to be exogenous) is a crucial variable for the possibility of multiple equilibria, since higher interest rates by increasing debt service costs can push reserves below the level that triggers a devaluation.

A. The Home Country

The model includes two emerging-market countries; the external environment (in particular, interest rates in industrial countries, r^*) are given to them. Consider first the home country (later on we will use superscript ^{a} to distinguish it from the other emerging market country, b). It has accumulated external indebtedness D incurred in domestic currency, paying a floating interest rate, but for simplicity there are assumed to be no new net capital flows. Up to a point that triggers a crisis, the authorities finance any current account deficit (or surplus) through changes in reserves. The source of uncertainty is shocks to the trade balance, T.[5] If they are large enough to cause reserves R_t to fall below a critical level $\bar{R}$, then a devaluation occurs.[6] Algebraically, for liabilities in local currency, where S_t is today's spot exchange rate (price of foreign exchange), and S^d_{t+1} is its value next period in the event of a devaluation (otherwise S_{t+1}=S_t), the ex ante (ln) return on the asset is

$$\begin{aligned} E_t \ln[(1+r_t)/(S_{t+1}/S_t)] &\approx r_t - \pi_t \ln(S^d_{t+1}/S_t) - (1-\pi_t)\ln 1 \\ &= r_t - \pi_t \ln(1+\delta) \\ &\approx r_t - \pi_t \delta \end{aligned}$$

Thus, risk-neutral investors demand to be compensated by an amount equal to the risk-free (foreign) rate, r^*, which we will assume is constant, plus the probability of a devaluation occurring, π_t, times the extent of the expected devaluation, δ (in percent).[7] Moreover, as we will see below the probability of a crisis will also be influenced by those very same expectations, leading to the possibility of multiple equilibriB

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[5]However, an easy extension is to make r^* stochastic, so that the risk of a rise in world interest rates raises the probability of a crisis.

[6]It can be argued that the model also applies to risk of default on liabilities issued in foreign currency. In practice, risks of devaluation and default are linked. Devaluation increases the domestic value of foreign currency debts and makes them more difficult to repay, provoking defaults. Conversely, a default on foreign debt (as in the debt crisis of the 1980s) leads to devaluation, as the country needs to adjust to a sharp fall in capital inflows by increasing net exports.

[7]Implicitly, there is a market among nonresidents for these bonds that equalizes their expected return with the foreign interest rate.

The change in reserves is therefore given by the following equation:

$$R_{t+1} - R_t = T_{t+1} - (r^* + \pi_t \delta) D \tag{1}$$

A crisis occurs at t+1 if:

$$R_{t+1} - \bar{R} < 0$$

Therefore, the probability, formed at t, of a crisis in period t+1 is

$$\pi_t = Pr_t[T_{t+1} - (r^* + \pi_t \delta) D + R_t - \bar{R} < 0] \tag{2}$$

Letting

$$b_t \equiv T_t - r^* D + R_{t-1} - \bar{R}$$

$$\alpha \equiv \delta D$$

and

$$\phi_t \equiv E_t b_{t+1}$$

then the model is formally identical to the one in Jeanne (1997), with

$$\pi_t = Pr_t[T_{t+1} - r^* D + R_t - \bar{R} < \pi_t \delta D] = Pr_t[b_{t+1} < \alpha \pi_t] \tag{3}$$

The possibility for multiple equilibria, as in that paper, depends on the values for α and ϕ_t. We assume that the innovation in variable b_t:

$$\epsilon_t = b_t - \phi_{t-1}$$

is normally distributed with mean zero and variance σ^2. Expressing π_t in terms of the cumulative distribution function of the innovation in b_t, we can write

$$\pi_t = F_\sigma[\alpha \pi_t - \phi_t] \tag{4}$$

where F_σ (.) is the c.d.f. of a normal distribution with variance σ^2.

Equation (4) defines the formation of expectations by investors. As in Jeanne (1997), since both right and left sides of equation (4) depend positively on π_t, there may be multiple solutions. A necessary condition for the latter is that

$$z \equiv \frac{\alpha}{\sqrt{2\Pi}\sigma} > 1 \tag{5}$$

which requires that the slope of the cumulative distribution function (the right hand side of equation (4)) be steeper at some point than the left hand side. This condition can be interpreted as a condition on the size of foreign debt and on the extent of default or devaluation in case of a crisis, since $\alpha \equiv \delta$ D, relative to the standard deviation of shocks to the trade balance, σ. To give a numerical illustration, suppose that the time period is one year, so that π_t refers to the probability of devaluation or default in the coming year. If the standard deviation of trade balance shocks is 2 percent of GDP, and the expected devaluation size is 25 percent, then multiple equilibria are possible if the stock of external debt exceeds about 20 percent of GDP.

There is also a complicated condition on ϕ_t, which requires it to be within a certain range. Solutions of equation (4) for π_t involve intersections of a 45° line from the origin (the LHS) with the c.d.f. on the RHS (see Figure 1). If the fundamentals are very good (ϕ_t large), then the c.d.f. is shifted to the right and there is only one intersection, giving a low value for π_t. Alternatively, poor fundamentals shift the c.d.f. to the left, giving one (high π_t) intersection. The range of multiple equilibria is defined by two tangency conditions of the c.d.f. and the 45° line. In particular, if we let $w \equiv \sqrt{2 \log z}$, then the tangency conditions can be written as defining the following range for ϕ_t where multiple equilibria are possible:

$$\alpha F_1(-w) + \sigma w < \phi_t < \alpha F_1(w) - \sigma w \tag{6}$$

Figures 2 and 3 plot the dependence of this multiple equilibria region on D and σ respectively. Equation (6) is in essence a condition on reserves. If they are higher than a certain value, then there is very little possibility of crisis, while if they are below a minimum, a crisis is virtually certain. In between, multiple equilibria can occur. To continue the numerical example cited above, the following table gives the values for the right and left hand sides of the inequality (6), labeled ϕ^{min} and ϕ^{max}, respectively, for various values of D which exceed the level of 20 percent of GDP, necessary for multiple equilibria. It is further assumed that the threshold level of reserves is zero, and that the expected value of the trade balance is equal to 1.25 percent of GDP (chosen so that it equals the product of the foreign interest rate, assumed to be 5 percent, and a debt level of 25 percent of GDP). The values ϕ^{min} and ϕ^{max} are translated into corresponding values for initial reserves, labeled R^{min} and R^{max}, calculated as

$$R^{\min,\max} = \phi^{\min,\max} - E_t(T_{t+1}) + r^* D + \bar{R}:$$

D	ϕ^{min}	ϕ^{max}	R^{min}	R^{max}
25	2.91	3.34	2.91	3.34
50	3.81	8.69	5.06	9.94
75	4.23	14.52	6.73	17.02
100	4.50	20.50	8.25	24.25

Figure 1: Solutions for Pi

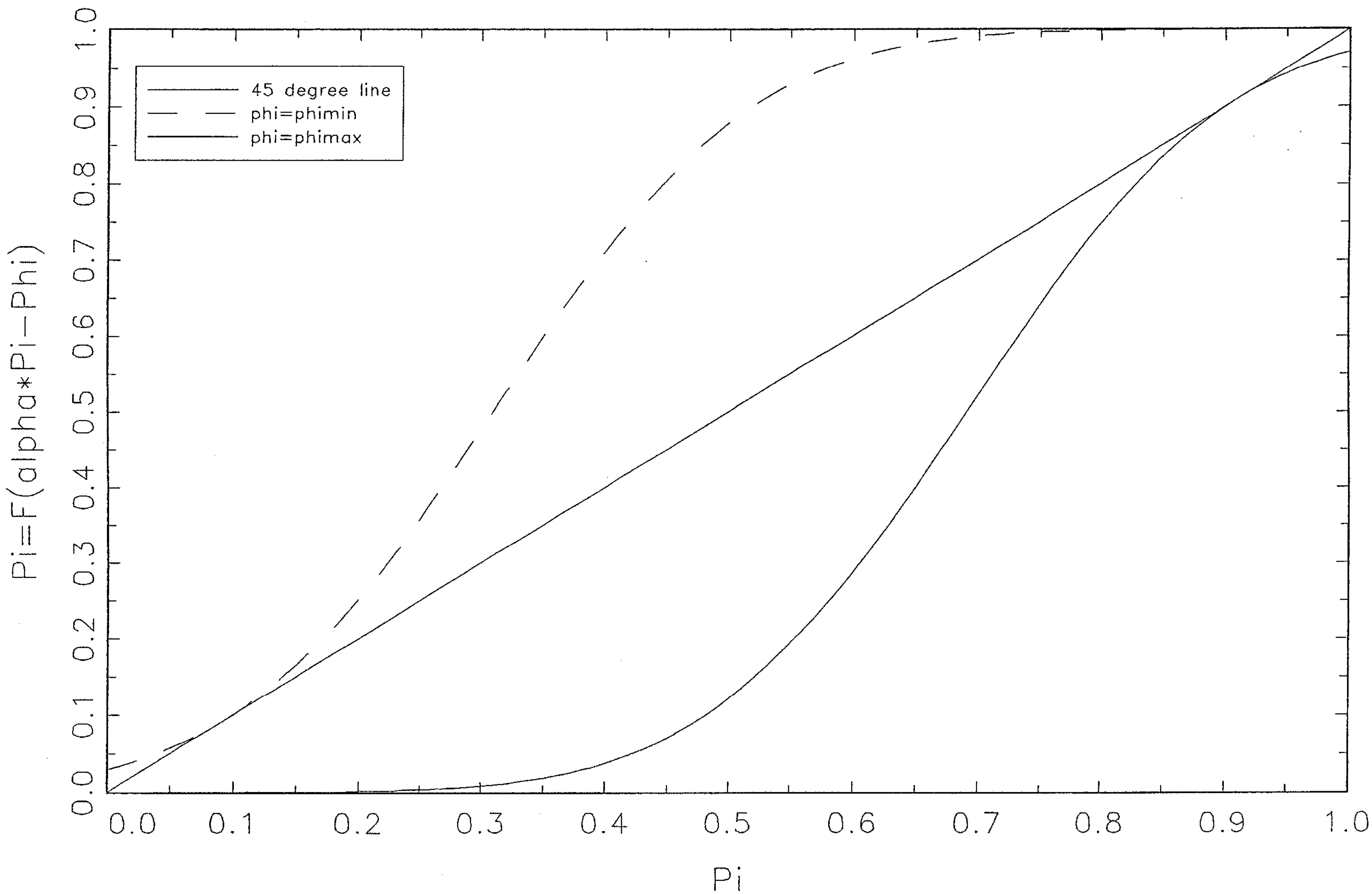


Figure 2: Multiple equilibria region for phi (sigma=.02)

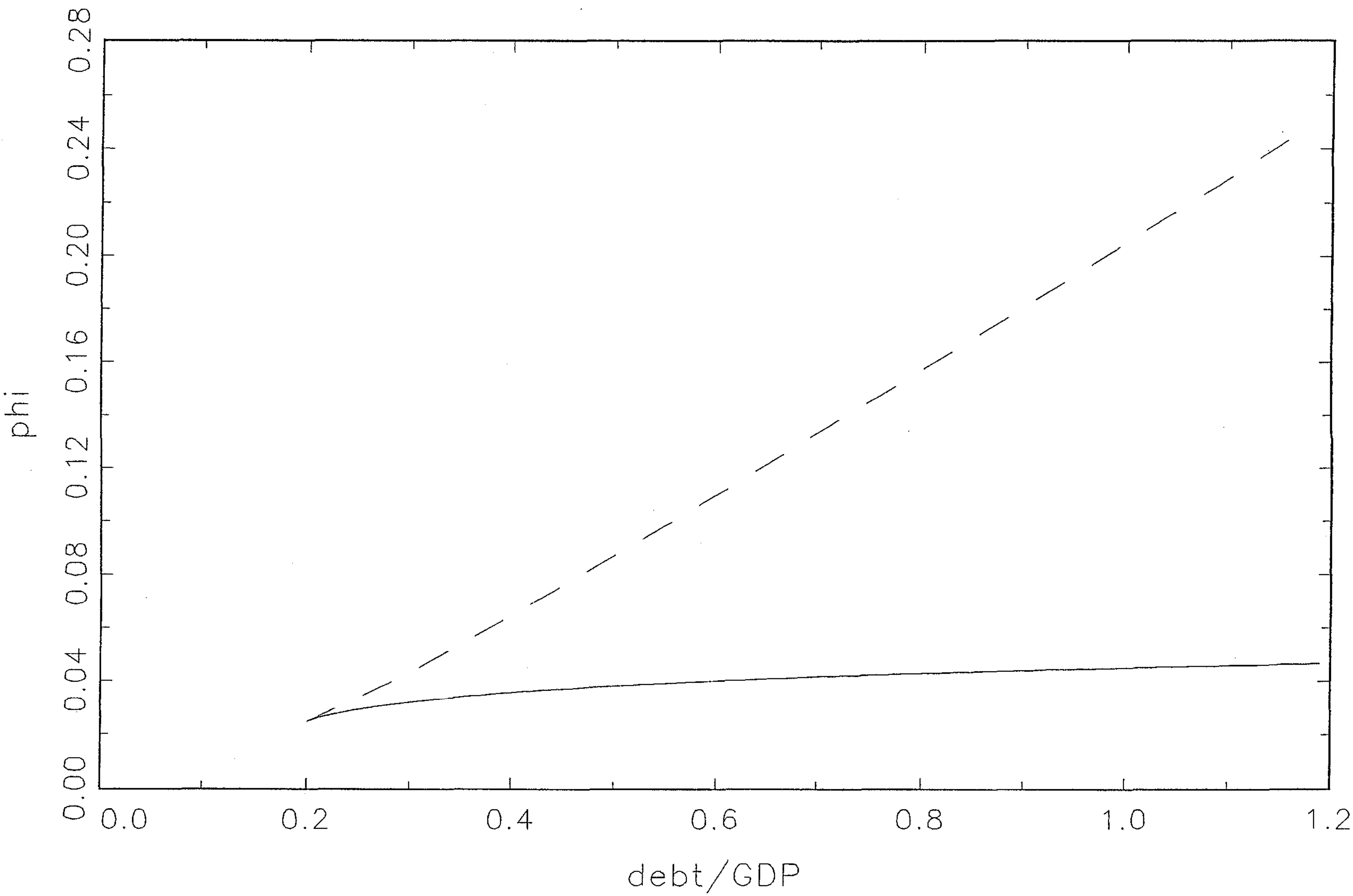
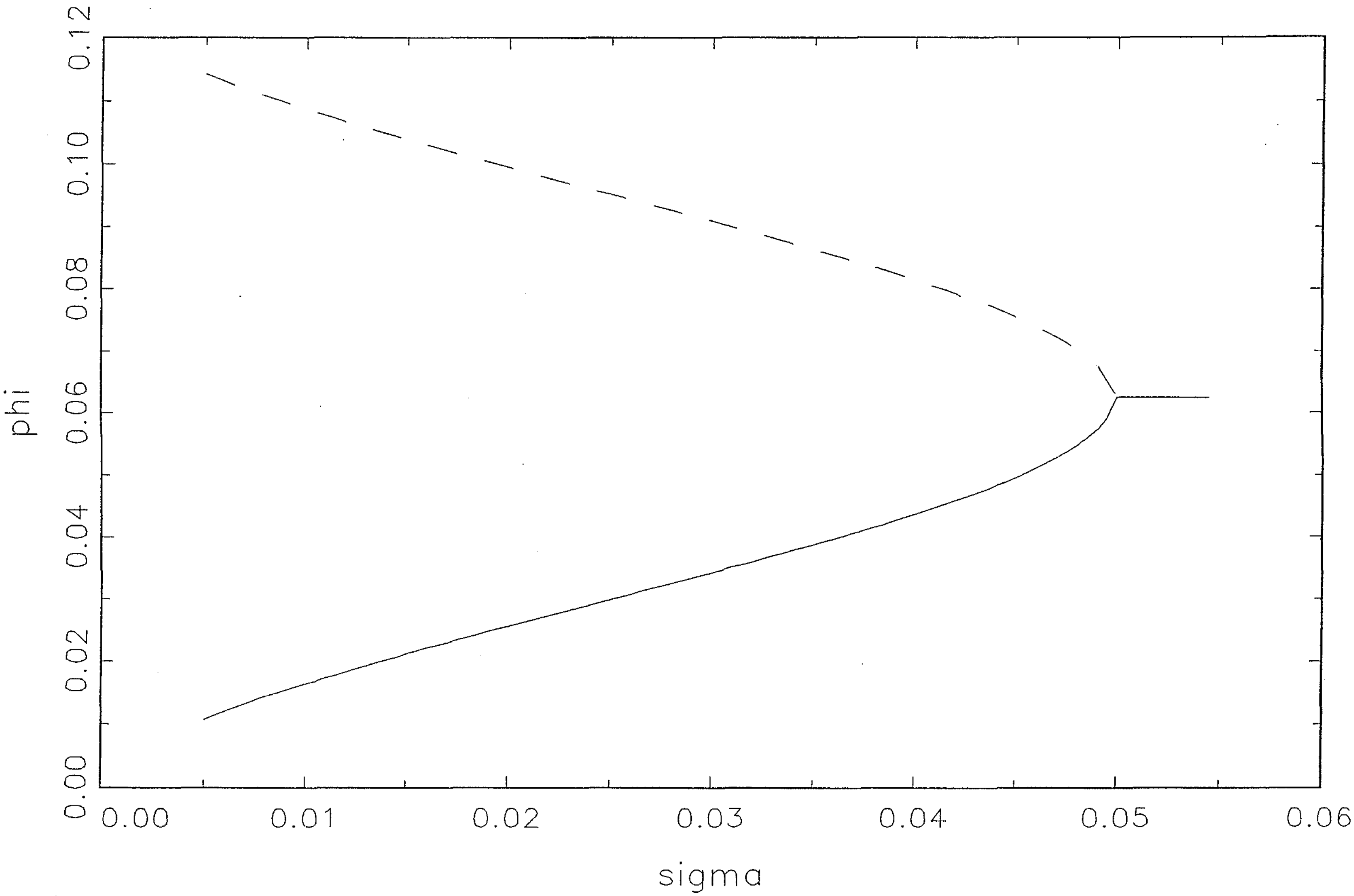


Figure 3: Multiple equilibria region for phi (D=.50)



Thus (assuming as before that σ=2 percent), for D=25 percent of GDP, values for the initial level of reserves between 2.91 and 3.34 percent of GDP permit multiple equilibria to occur. Below 2.91, only a single (high) value of π_t would prevail, while above 3.34, a devaluation would be viewed as unlikely and self-fulfilling crises could not occur. The range of values widens considerably as D rises, as indicated in the table (though an increase in D also increases the lower bound below which a single high probability equilibrium would prevail). For D=100 percent of GDP a range of reserves between 8.25 and 24.25 percent of GDP would permit multiple equilibria.

B. Contagion: A Jump Between Equilibria Triggered by a Crisis Elsewhere

So far the model has not explained which equilibrium is chosen. It is usual to consider jumps between equilibria as being stochastic, and having a simple Markov probability structure describing the likelihood of staying in a particular equilibrium or moving to another one (as in Jeanne and Masson (1996)). For instance, once a "bad" equilibrium occurs (i.e., devaluation or default), it may be reasonable to suppose that a jump back to the "good" equilibrium is not straightforward—the bad equilibrium could be an absorbing state. The experience of Mexico and Thailand suggests that an attack followed by a substantial depreciation seems to have enduring effects on confidence and also on the health of financial and nonfinancial corporations that have substantial foreign-currency debt. Contagion would occur when the home country jumps to a "bad" equilibrium when there is a crisis in another emerging market country.

Such a definition of contagion, and the balance of payments model given above, are not inconsistent with various micro theories that involve the revision of expectations or detailed models of the portfolio behavior of financial institutions. For instance, jumps between equilibria could occur because of small triggers which lead to herding behavior or "informational avalanches" (Lee (1997)). Or, as discussed above, a crisis in one country might lead to a reassessment of the fundamentals in others. Or the theory of bank runs (Diamond and Dybvig (1983)) could explain a race for the exits when it comes to the rollover of outstanding debt. However, the micro theories need to be placed in a macroeconomic context, otherwise it is difficult to understand the severity of crises affecting the real economies of Latin America and East Asia in recent years.

Moreover, the model presented above, though not providing a theory of jumps between equilibria, has something to say something about vulnerability to contagion. Vulnerability is greater when there is a large (floating rate) debt, when reserves are low, and when the trade balance is in deficit.

C. Links with Other Emerging Markets

We now make more explicit monsoonal and spillover effects, and in particular introduce interactions between the home country (a) and emerging market economy b, through competitiveness effects on trade. For simplicity we will assume that all structural parameters are the same in the two countries, and omit superscripts for those parameters.

The home country trade balance is assumed to depend on the logarithm of the real exchange rate (RER), which gives a weight w on country b, x on the United States, and $u\equiv(1\text{-}w\text{-}x)$ on the rest of the world. Nominal exchange rates $S_t^a, S_t^b, \bar{S}_t$ (the rest of the world's exchange rate, assumed fixed) are expressed as the dollar price of local currency, so that an increase in S (and in RER) is an appreciation. It is assumed that the currencies of a and b are, at least initially, pegged to the dollar. Prices are assumed fixed so that nominal devaluation produces an improvement in competitiveness. The equations for the trade balance and the real exchange rate are as follows:

$$T_t^a = \bar{T} - \beta RER_t^a + \epsilon_t^a$$

$$RER_t^a = S_t^a - wS_t^b - u\bar{S}_t$$

Similar equations exist for country b.

Now the assessment of the probability of devaluation is more complicated, since it depends on the possibility of devaluation for country b, captured through π^b_t. In particular, in place of equation (3) above, the probability of $R^a_{t+1} < R$ will be different depending on whether b is expected to devalue (by δ) next period:

$$\begin{aligned}\pi_t^a = (1-\pi_t^b)Pr_t[\bar{T}-\beta(S_t^a-wS_t^b-u\bar{S}_t)+\epsilon_t^a-(r^*+\pi_t^a\delta)D^a+R_t^a-\bar{R}<0]\\ +\pi_t^b Pr_t[\bar{T}-\beta(S_t^a-wS_t^b+w\delta-u\bar{S}_t)+\epsilon_t^a-(r^*+\pi_t^a\delta)D^a+R_t^a-\bar{R}<0]\end{aligned} \tag{7}$$

The model illustrates the three channels by which crises can coincide in time. Monsoonal effects can take the form of a change in r^* (e.g., U.S. interest rates), or $\bar{S}_t$ (e.g., the dollar-yen rate). Spillovers can take the form of changes in the initial level of the exchange rate of country b. The potential for contagion will be affected by the expectation of devaluation in b (π_t^b), which will have a direct effect on π_t^a.

As discussed above, the range (ϕ^{min}, ϕ^{max}) within which multiple equilibria are possible is determined by points of tangency with the 45 degree line from the origin. However, instead of equation (4) above, we now have a linear combination of it and a curve that is shifted to the right, by the amount of potential loss in competitiveness due to the possible devaluation of the currency of country b, $\beta w\delta$:

$$\pi_t^a = (1-\pi_t^b)F_\sigma[\alpha^a\pi_t^a - \phi_t^a] + \pi_t^b F_\sigma[\alpha^a\pi_t^a - \phi_t^a + \beta w\delta] \tag{8}$$

where now $\phi_t^a = \bar{T} - \beta(S_t^a - wS_t^b - u\bar{S}_t) - r^*D^a + R_t^a - \bar{R}$ *and* $\alpha^a = \delta D^a$.

Figure 4 plots solutions to equation (8), for D=25 percent of GDP, βw=0.1, δ = 25 percent, and either π_t^b =0.2 or 0.5. Relative to the original curve, equation (8) is shifted up further on the left side of the figure than at the right. As a result, both the lower and upper equilibria will involve a higher value for π^a than when $\pi^b = 0$, but the lower equilibrium (if there are multiple equilibria) will be more affected.[8] Though points of tangency (determining ϕ^{min} and ϕ^{max}) are not shown, this suggests that the value of ϕ^{min} (this is the lower tangency point) will be more affected than ϕ^{max} (corresponding to the upper tangency point), because the curve needs to be shifted more in the horizontal direction to compensate for contagion from country *b*. Numerical solutions confirm this intuition.

However, there is another possibility, shown for π_t^b=0.5, namely that the fear of a devaluation in *b* will eliminate the multiple equilibria region entirely in *a*, and produce a single, high value of π_t^a indicating that a devaluation is very likely. We would still characterize this as contagion, since it is the fear of a crisis in *b* that triggers a crisis in *a*, not spillover effects per se.

Figure 5 pursues the relationship between devaluation expectations in *a* and *b*, by calculating π_t^a as a function of π_t^b and vice-versa. If there is only a single equilibrium, then that is plotted, but for values where multiple equilibria exist, both the upper and lower intersections (as in Figure 4) are plotted (the middle equilibrium, which is unstable, is ignored). In this example (unlike in Figure 4), the fundamentals ϕ_t^a are good enough in the absence of contagion effects that there is only a single equilibrium (as long as π_t^b<0.58). It can be seen that in this case, in which the countries are assumed identical, an equilibrium where the probability of devaluation in both *a* and *b* is roughly zero is possible: in the absence of fears of devaluation in the other country, each would not be vulnerable to self-fulfilling attacks. However, above π_t=0.58 for the other, each country is in the range of multiple equilibria. Therefore, attacking *both* countries' currencies would also be rational, and two other equilibria are possible: one with $\pi_t^a = \pi_t^b = 0.58$, and a second where $\pi_t^a = \pi_t^b$= 0.99 (see Figure 5). Thus, contagion effects amplify the possibility of self-fulfilling attacks in this model. Even if each country separately is not subject to multiple equilibria, together they may be, since the fear of crisis in one will increase the devaluation probability in the other, making a crisis more likely in both.

III. Empirical Evidence

The phenomenon of the coincidence of speculative crises in a number of emerging markets is striking, and has been extensively discussed elsewhere so that no chronology or

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[8]It is also possible that $\pi^b > 0$ would give two points of inflection to the RHS of equation (8), increasing the number of equilibria for π^a. This possibility was not relevant here, given the range of numerical values assumed.

Figure 4: Solutions for Pi, with and without Contagion

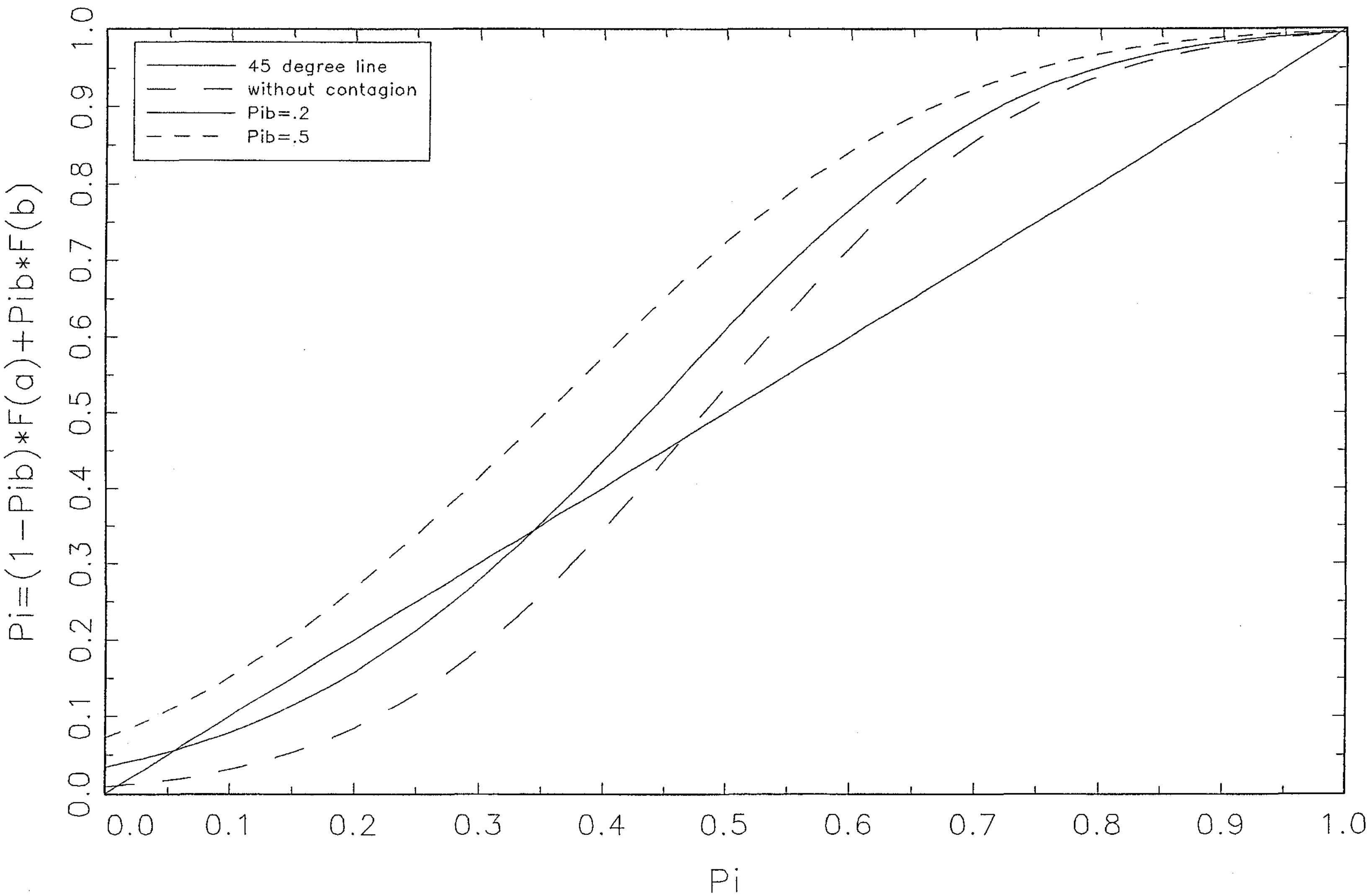
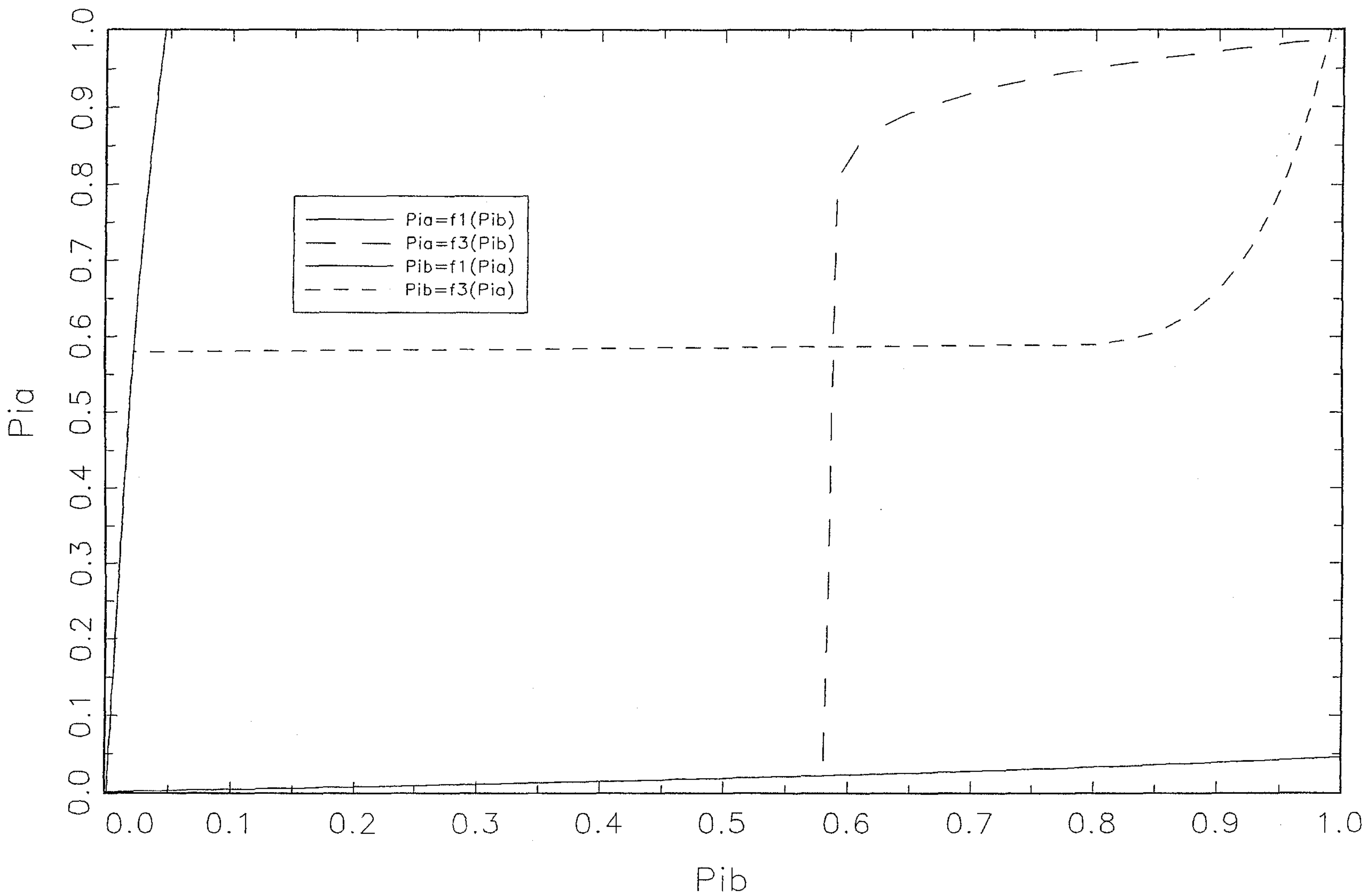


Figure 5: Pia as function of Pib and Pib as function of Pia



detailed analysis of the various crises will be presented here.[9] Suffice it to say that the exchange rate devaluation in Mexico in December 1994 and in the pressures on and eventual depreciation of the Thai baht in 1997 quickly led to speculative pressures on other currencies. For instance, there is high correlation between the spike upward in December 1994 of Mexican Brady bond spreads with those of Argentina, Brazil, and the Philippines (Chart 1). As for Southeast Asian currency crises, it is harder to discern the coincidence of pressures in interest rates, since few have issued Brady bonds and domestic rates are subject to institutional differences and are hard to compare. However, the effect of the crises shows up in a striking co-movement of the U.S. dollar exchange rates of Indonesia, Malaysia, the Philippines, and Thailand after a long period of relative stability (Chart 2). In this crisis, unlike the Mexican one where the effects of contagion (e.g., on Argentina and Brazil) were successfully resisted, all the currencies affected experienced large devaluations. As a result, the spillover effects were compounded.

This coincidence of speculative crises may have been caused by developments in industrial economies through monsoonal effects that involve interest rates (and capital flows) and trade flows. For instance, the Mexican crisis was preceded by an increase in U.S. short-term rates beginning in March 1994 (Chart 3). Though this was a contributory factor to the crisis in Mexico, it does not seem likely that it can explain its timing, nor the coincidence of crises elsewhere.

Similarly, trade linkages with industrial countries could contribute to the existence of monsoonal effects on emerging markets. It is interesting in that regard to examine the trade patterns of these economies. The recent crises affecting Southeast Asian countries do seem consistent with some impact of the fluctuations of the yen/dollar rate, given the large extent of their trade with both the United States and Japan (Table 1). Hence, pegging to a basket giving a dominant weight to the dollar led to a strong nominal (and real) effective appreciation when the dollar appreciated against the yen, which occurred over the period April 1995 to July 1997 (Chart 4). However, the timing of the major appreciation of the dollar against the yen predates the Southeast Asian exchange rate crisis by at least a year, and it also needs to be recognized that trade patterns differ substantially across countries in the region.

Spillover effects are another possible explanation for the coincidence of speculative attacks. However, Table 1 shows that exports to Thailand constitute a very small proportion of exports from the other countries in the region, suggesting only a modest scope for spillover effects. Table 2 shows that the importance of Mexico for the other two largest Latin American economies is even smaller. Of course, as the Asian crisis spread the regional competitiveness effects became amplified. Nevertheless, an estimate of the loss of competitiveness, in each of the five Asian countries principally affected by the crisis is given in Table 3, and this shows that until November, when the won started to depreciate significantly (relative to its modest

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[9]See, for instance, IMF (1997a, 1997b), and Corsetti, Pesenti and Roubini (1998).

rate of crawl), regional competitiveness spillovers were small. Furthermore, there was no reason to expect a crisis in Korea to be triggered through this channel.

This rough quantification therefore suggests that there may have been a role for pure contagion effects, that is, the simultaneous occurrence of crises which is not linked to changes in observed macroeconomic fundamentals. We therefore turn to some simple calculations to see whether the fundamentals of the countries concerned were such that the balance of payments model implies that multiple equilibria were possible. In assessing the possible relevance of the model we need to face whether the debt stock should be limited to domestic currency debt held by foreigners, or whether it should include all external debt (which would be legitimate if default risk and devaluation risk can be confounded into one). We choose the latter approach at this early stage, which is just intended to gauge broad orders of magnitude in order to assess the potential explanatory power of various effects.[10]

Table 4 summarizes some of the relevant data for end 1994 and end 1996, the latest full years preceding the crises in Mexico and East Asia. We use the simplest version of the model to see whether it implies that multiple equilibria were possible (using equation (2) above). The model suggests that a composite fundamental, called ϕ_t, needs to be in a certain range for multiple equilibria to occur. The fundamental depends positively on the level of reserves and the expected trade balance, and negatively on the stock of debt and the foreign interest rate. The calculation assumes that the threshold level of reserves, $\bar{R}$, is zero; that is, a devaluation does not occur until reserves are completely exhausted. This is unrealistic, and a positive value for this threshold level would tend to reduce the values of ϕ_t calculated below. The possibility for multiple equilibria also depends on the value for z_t, which in turn depends on the debt, the size of a potential devaluation, and the variance of innovations to the trade balance—as does the range for ϕ_t within which multiple equilibria are possible. In implementing these calculations, for each country a first order autoregressive process was estimated for the trade balance as a percent of GDP, with innovations assumed to be normally distributed, and the standard error of estimate of this regression (over 1980-96) was the estimate of σ. The U.S. one-year rate on Treasury securities was used as the foreign interest rate. Data for reserves, debt, and the trade balance, all as ratios to GDP, are given in Table 4. It is hard to gauge ex ante devaluation expectations, but it was assumed that the expected devaluation size δ was 25 percent. This is much smaller than ultimately occurred in Mexico and several Asian countries, but roughly the extent of initial currency adjustments. A larger value for δ would increase the value of z and the range (ϕ^{min}, ϕ^{max}).

It is interesting that in most, but not all, cases, there is a range of values for ϕ_t for which multiple equilibria can occur: that is, z_t is greater than unity as a result of substantial

[10]Another approach, adopted in their theoretical modeling by Sachs, Tornell, and Velasco (1996), is to consider domestic currency debt, regardless of whether it is held domestically or abroad. However, it seems clear that the Asian crisis, at least, had an important external dimension, and most external debt was in foreign currency.

foreign debt. The exceptions are Korea and South Africa, neither of which was significantly affected by the Mexican crisis, which have relatively low external indebtedness, giving values for z_t that do not allow multiple equilibria.[11]

Nevertheless, the value of the fundamental ϕ_t, which reflects among other things the level of reserves, was not in all cases in the multiple equilibria region. Brazil, Chile, Colombia, and Malaysia, though admitting of multiple equilibria, had fundamentals above the admissible range in which they are predicted to occur, mainly because their reserve levels were high. Of these latter countries, only Malaysia was significantly affected by the 1997 crisis, while though Brazil was subjected to the 1994–95 "Tequila effect," it did not suffer the loss of confidence experienced by Mexico. Thailand also belongs in this latter group on the basis of the end-1996 data, but subsequent intervention no doubt changes the picture markedly, especially when forward commitments are taken into account. Mexico, interestingly enough, has a value at end-1994 for ϕ_t that is so low that it implies a very high probability of a crisis (essentially because reserves were so low and the trade deficit large), but by 1996 its fundamentals had put it in a much more favorable position (though still in the multiple equilibria region). The Philippines and Turkey are estimated to have fundamentals that imply in both years a high probability of crisis, which would be consistent with high interest rates on their borrowing.

The results are suggestive that contagion effects were possible at the time of the 1994–95 and 1997 crises, though it does not in any way test for contagion. To some extent, also, the countries spared the worst effects of crisis come out well in terms of the fundamentals identified by the balance of payments model as being important. This is true of such countries as Brazil, Chile, and Colombia. Korea and Malaysia, in contrast, should have been immune to multiple equilibria when considered in isolation, suggesting that other factors came into play.

IV. Extensions

Other factors that seem likely to have been important in the Latin American and East Asian crises, and should be included in the simple balance of payments model to make it more realistic, include rollover risk, banking sector problems and the existence of risk-averse investors.

In particular, the fear of nonrollover next period could trigger higher interest rates today, and even the refusal to roll over debt today. With heterogeneous agents, the probability that other agents will not roll over debt will influence any given agent's decision. As in bank runs, the expectation of what others will do is crucial to the possibility of self-fulfilling balance of payments crises, and shifts in investors' assessments of "market" sentiment could trigger

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[11]Korea was strongly affected by the Southeast Asian crisis, though relatively late, while South Africa was not.

movements between equilibria. These factors may expand the region in which multiple equilibria were possible, and also amplify the potential effect of crises on other countries.

A weak banking system may also contribute to vulnerability to balance of payments crises (Kaminsky and Reinhart, 1996). Banks are typically exposed to interest rate risk and currency risk: if the central bank resists a depreciation by raising interest rates, banks suffer because their liabilities are of shorter maturity than their assets, while devaluation hurts them if they have net foreign currency exposure. The first factor may make crises more likely because speculators will know that central banks will be less likely to defend the currency, while the second may make the severity of the crisis greater.

The simple model described above assumed risk-neutral investors. However, this is unrealistic, and a more satisfactory approach would allow for the fact that they need to be compensated for greater riskiness in emerging markets than in advanced economies. Moreover, the degree of perceived riskiness may also vary over time, as well as the degree of aversion to risk. Flood and Marion (1996) show that changes in views on riskiness can be self-fulfilling, that is, an increase in expected risk can raise the actual variability of asset prices, the exchange rate in particular. In the framework of this paper such riskiness effects could be the result of contagion if they were triggered by crises in other countries.

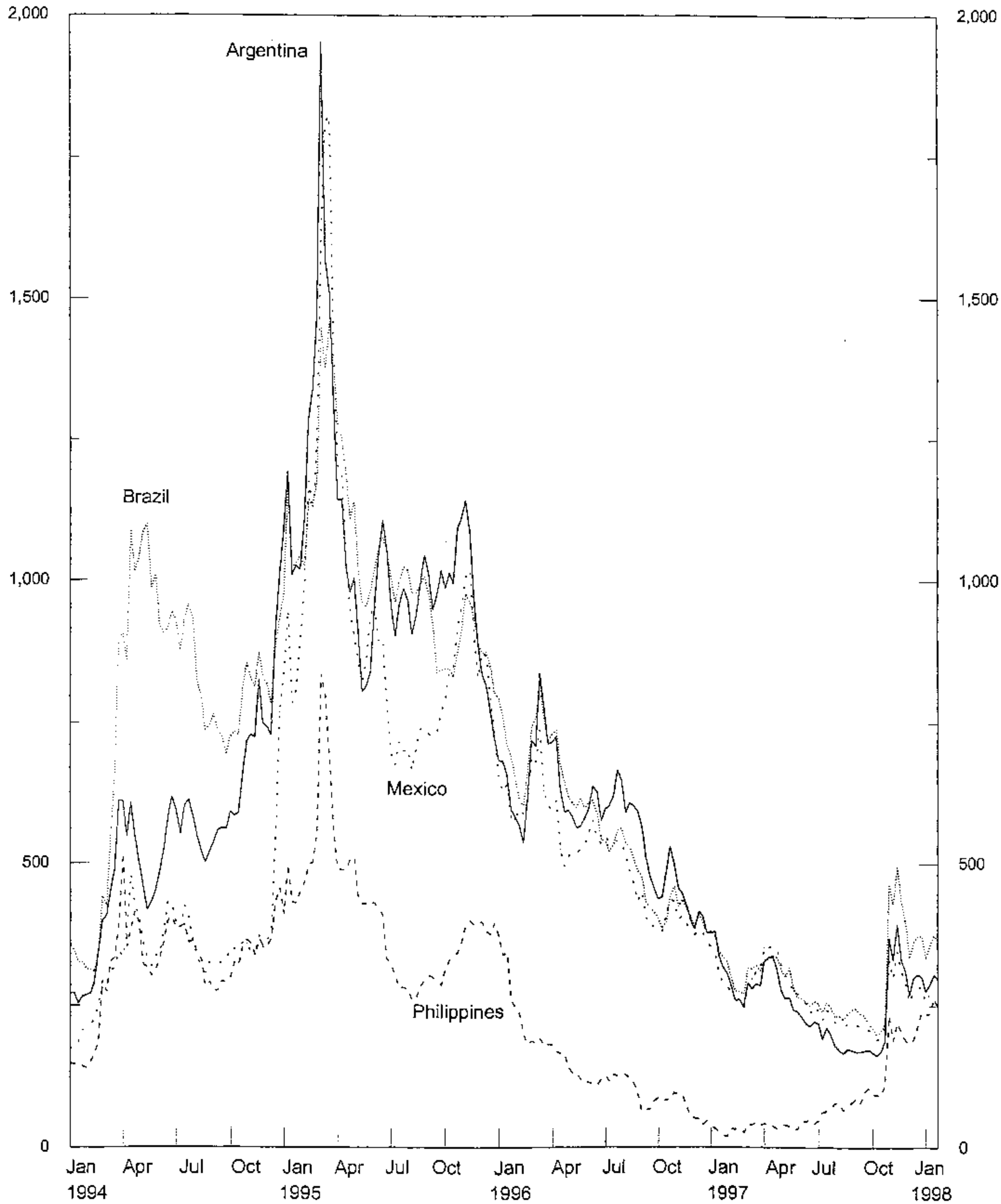
V. Conclusions

The paper has attempted first to sort through various explanations for what has been called contagion, while retaining that term for only a narrow set of effects. In particular, pure contagion is associated here with multiple equilibria, and a balance of payments model was presented in which multiple equilibria are possible. Some back-of-the-envelope calculations suggest that there might be some insights to be drawn from that model when considering whether contagion effects are possible, though no actual tests for contagion itself are presented here. Moreover, any empirical application of the model needs refining as regards the currency composition and the maturity structure of the debt.

With refinements, such a model may have some use in constructing early-warning indicators of balance of payments crises (see, for instance, Kaminsky, Lizondo, and Reinhart (1997)). The value for the composite fundamental can be used to identify countries that may be vulnerable to multiple equilibria. It needs to be recognized, however, that the existence of contagion as defined here implies that early warning of crises may be difficult, since they are triggered by stochastic events that are inherently unpredictable.

Actually estimating the model would also need to consider the probability structure of jumps between equilibria (as in Jeanne and Masson (1996)), and whether there was evidence that the probability of jumps was related to crises, or at least speculative pressures, in other countries. This would constitute a test for the existence of contagion, and may be the subject of another paper.

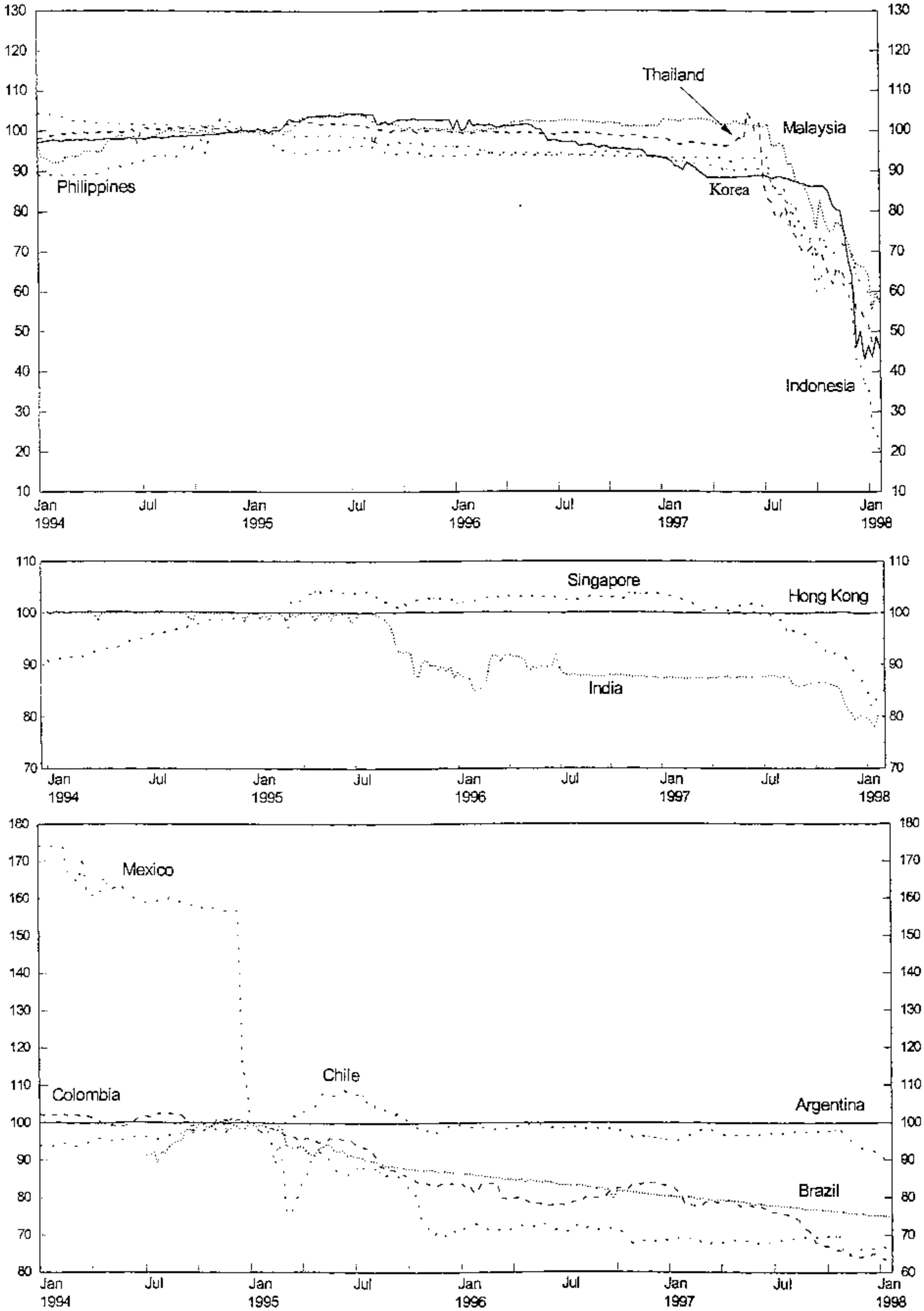
Chart 1. Stripped Yield Spreads, Selected Brady Bonds
(In basis points)



Sources: Reuters; Salomon Brothers; and IMF Staff estimates.

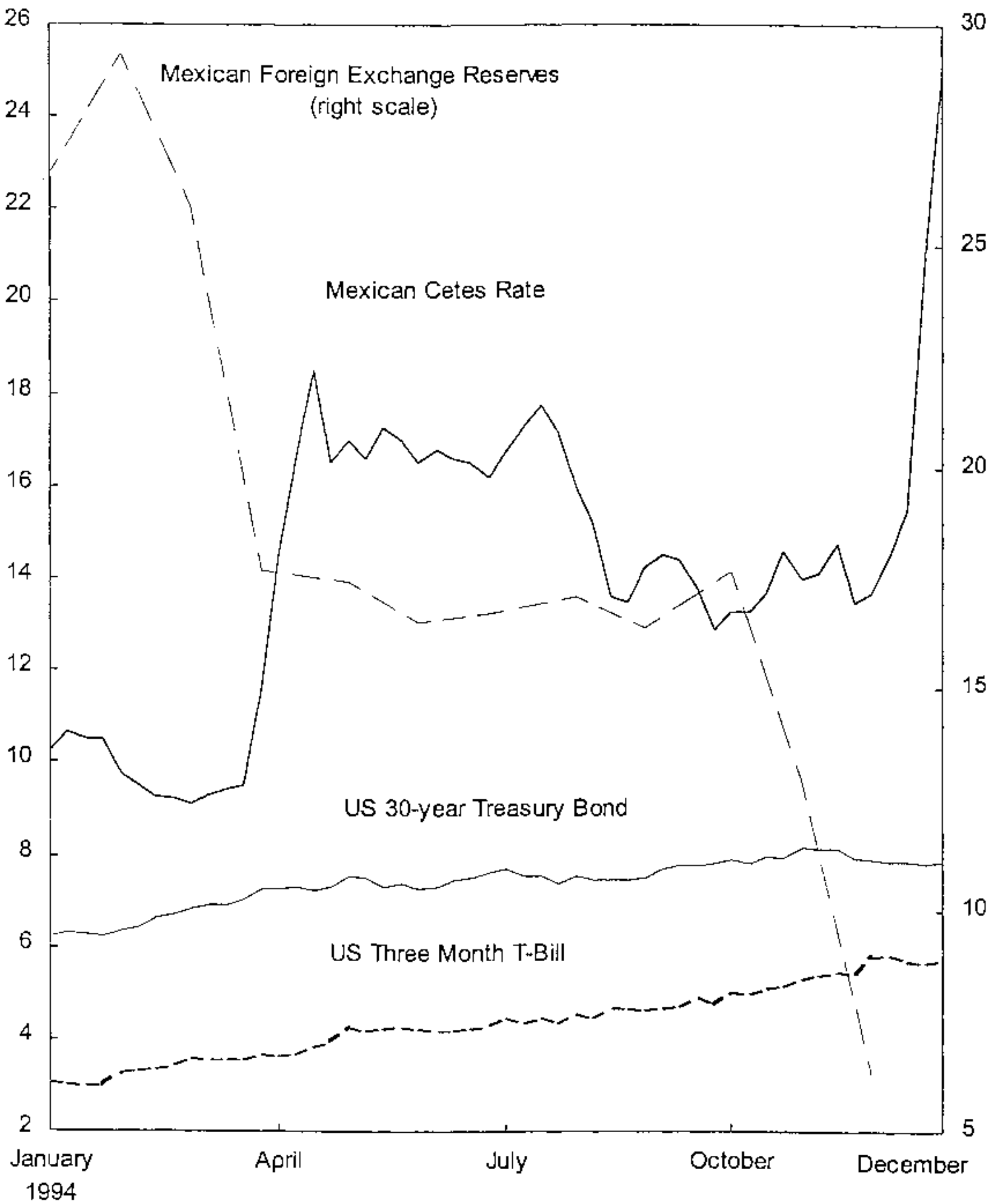
Chart 2. US Dollar per Domestic Currency Unit 1/

(Indices, 1995 end of week 1 = 100)



1/ An increase indicates appreciation of the domestic currency.

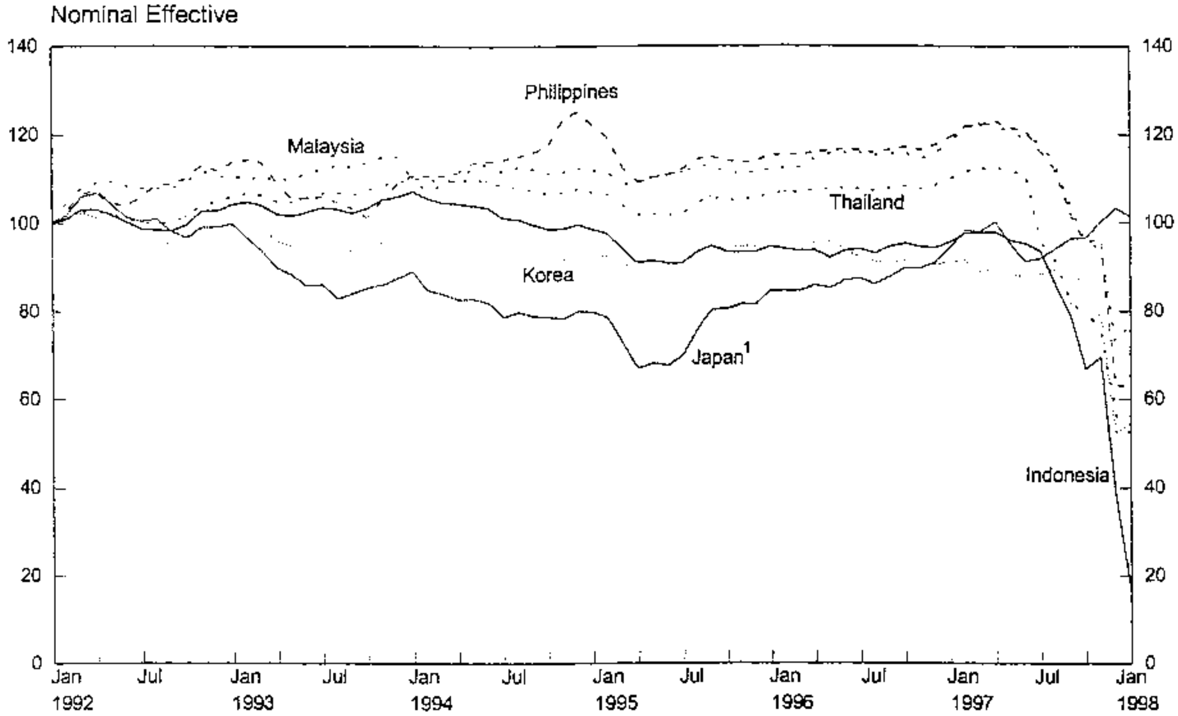
Chart 3. Mexican Interest Rates and Foreign Reserves and U.S. Interest Rates

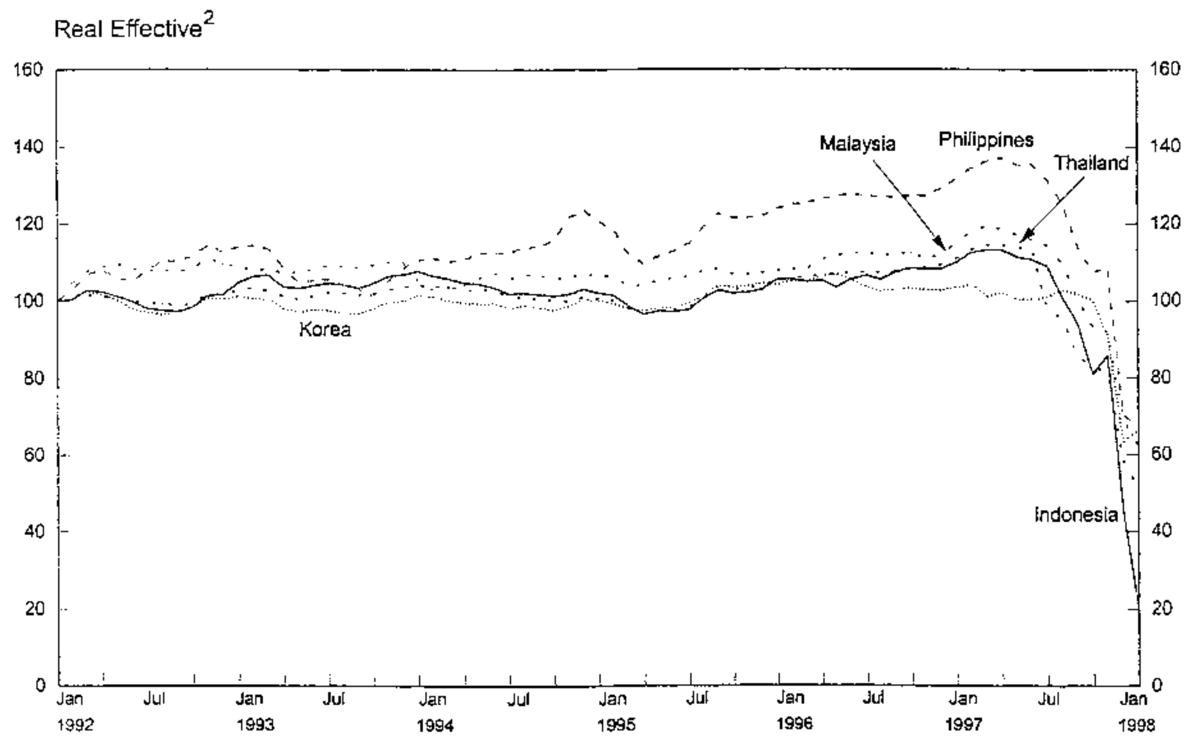


Source: Bloomberg, International Monetary Fund, *IFS*.

Chart 4. Effective Exchange Rates and the Japanese yen per U.S. dollar Rate

(Indices; January 1992 = 100)





Source : International Monetary Fund; *Information Notice System, International Financial Statistics*; and IMF Staff calculations.

1. Japanese yen per U.S. dollar.
2. Based on relative consumer price indices.

Table 1. Selected Southeast Asia Countries: Exports to Various Country Groups, 1996, in Millions of U.S. Dollars

(As a percent of total exports within parenthesis)

Country	Destination of Exports				
	United States	Japan	Other Southeast Asia 1/	Of which: Thailand	All countries
Indonesia	7,948	13,839	5,539 2/	854	48,059
	(16.5)	(28.8)	(11.5)	(1.8)	(100)
Malaysia	14,245	10,484	21,377	3,207	78,246
	(18.2)	(13.4)	(27.3)	(4.1)	(100)
Philippines	6,966	3,668	2,791 2/	780	20,543
	(33.9)	(17.9)	(13.6)	(3.8)	(100)
Singapore	23,062	10,254	31,908 3/	7,096	125,118 3/
	(18.4)	(8.2)	(25.5)	(5.7)	(100)
Thailand	10,026	9,373	10,240	--	55,789
	(18.0)	(16.8)	(18.4)		(100)

Source: *Direction of Trade Statistics Yearbook: 1990-96* (IMF, 1997).

1/ Indonesia, Malaysia, Philippines, Singapore, Thailand.

2/ Exports to some countries estimated on the basis of previous year figures.

3/ Excluding Indonesia.

Table 2. Selected Latin American Countries: Exports to Various Country Groups, 1996, in Millions of U.S. Dollars

(As a percent of total exports within parenthesis)

Country	Destination of Exports			
	United States	Japan	Mexico	All countries
Argentina	1,974	513	248	23,794
	(8.3)	(2.2)	(1.0)	(100)
Brazil	9,312	3,047	679	47,747
	(19.5)	(6.4)	(1.4)	(100)
Mexico	80,663	1,363	--	95,991
	(84.0)	(1.4)		(100)

Source: *Direction of Trade Statistics Yearbook: 1990-96* (IMF, 1997).

Table 3. Selected Asian Economies: Real Effective Exchange Rates[1]

(January 1997 = 100)

	Korea		Indonesia		Malaysia		Philippines		Thailand	
	Actual	Adjusted[2]	Actual	Adjusted[2]	Actual	Adjusted[2]	Actual	Adjusted[2]	Actual	Adjusted[2]
1997 Jan	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Feb	100.2	100.2	102.5	102.5	102.2	102.2	101.8	101.8	101.6	101.6
Mar	97.1	97.1	102.8	102.8	103.3	103.3	103.0	103.0	102.6	102.6
Apr	98.0	98.0	102.9	102.9	102.6	102.6	103.4	103.4	102.6	102.6
May	96.8	96.8	101.1	101.1	101.2	101.2	102.0	102.0	101.9	101.9
Jun	96.8	96.8	100.1	100.1	99.8	99.8	101.7	101.7	101.3	101.3
Jul	97.9	97.9	98.8	101.3	99.0	101.3	98.6	102.8	87.5	102.5
Aug	99.5	99.5	91.4	103.2	95.0	103.5	93.8	104.6	85.1	105.0
Sep	99.4	99.4	85.7	104.1	87.5	104.6	85.7	105.8	77.1	106.4
Oct	99.2	100.0	74.1	104.5	81.0	105.5	81.4	106.6	75.8	107.6
Nov	90.5	101.0	79.7	106.7	80.2	107.4	83.6	108.9	74.1	109.7
Dec	66.0	104.2	60.7	112.2	75.6	112.4	81.0	113.4	67.4	114.5
1998 Jan	60.6	108.0	33.5	115.4	67.7	116.9	72.6	116.3	59.1	118.7
Feb	63.6	105.6	39.6	112.7	77.1	113.1	75.3	113.8	68.1	115.4
Mar	71.3	106.7	38.1	113.2	77.5	112.8	80.0	114.2	75.7	116.2

1/ Partner country weights based on bilateral trade data for 1994-96.

2/ Assumes constant bilateral U.S. dollar exchange rate in the case of Indonesia, the Philippines and Thailaud, a constant real bilateral exchange rate in the case of Korea, and a constant rate of nominal depreciation against the U.S. dollar (based on the average rate over the preceeding twelve months) in the case of Malaysia.

Table 4. External Debt, Reserves, Trade Balance, and Criteria for Multiple Equilibria, 1994 and 1996

(In percent of GDP)

Country (σ)	Date	D_t	R_t	T_t	z_t	Φ^{min}_t	Φ^{max}_t	Φ_t
Argentina (2.12)	1994	31.9	5.1	-2.5	1.51	3.38	4.62	1.93 †
	1996	34.4	6.1	-0.3	1.60	3.47	5.03	4.71 *
Brazil (1.69)	1994	28.0	6.6	1.1	1.65	2.80	4.20	6.04
	1996	28.0	7.8	-1.8	1.65	2.80	4.20	5.83
Chile (3.05)	1994	46.2	25.1	1.4	1.51	4.87	6.67	23.10
	1996	37.1	20.6	-2.2	1.21	4.37	4.90	18.03
Colombia (2.68)	1994	30.3	11.0	-3.1	1.13	3.68	3.90	6.40
	1996	32.6	11.0	-2.1	1.21	3.84	4.31	7.44
India (0.46)	1994	33.3	6.7	-0.7	7.22	1.11	7.22	3.50 *
	1996	27.2	5.8	-1.6	5.90	1.07	5.73	2.80 *
Indonesia (1.23)	1994	55.5	6.9	2.3	4.54	2.71	11.29	4.72 *
	1996	46.9	8.1	1.3	3.81	2.61	9.14	7.46 *
Korea (2.38)	1994	14.9	6.7	-0.7	0.62	--	--	5.43
	1996	21.2	7.0	-4.0	0.88	--	--	3.20
Malaysia (3.53)	1994	39.5	35.1	-1.6	1.12	4.85	5.15	31.97
	1996	38.6	27.0	0.7	1.46	4.77	4.98	26.30
Mexico (3.29)	1994	37.3	1.5	-4.9	1.13	4.50	4.75	-3.86 †
	1996	48.0	5.8	2.5	1.10	5.17	6.83	5.54 *
Philippines (2.76)	1994	57.9	9.4	-6.3	2.10	4.98	9.52	-0.72 †
	1996	51.1	12.0	-9.8	1.84	4.77	7.98	0.44 †
South Africa (3.05)	1994	15.3	1.4	1.8	0.50	--	--	3.08
	1996	18.0	0.7	0.7	0.59	--	--	2.08
Thailand (2.47)	1994	46.2	20.9	-4.3	1.86	4.28	7.22	13.57
	1996	50.1	20.9	-5.7	2.02	4.40	8.10	13.47
Turkey (1.91)	1994	50.1	5.5	-6.3	2.61	3.68	8.82	-5.15 †
	1996	44.3	9.1	-10.0	2.30	3.55	7.45	-1.73 †

Source: WEO and IFS databases, and author's calculations.

* Inside region of multiple equilibria.
† Fundamental is below multiple equilibria region, i.e., in crisis region.

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