The International Lender of Last Resort:

How Large Is Large Enough?

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1. Introduction

The Asian crises have triggered a debate on how new rules and institutions could increase the resilience of the international monetary system. Among many proposals, it has been suggested that an international lender of last resort would be a useful addition. One idea, a distant reminder of Keynes' proposal in Bertton Woods, is to set up an international central bank which would issue a global currency (Garten, 1998). Other ideas start from the observation that crisis lending by the international community has already evolved toward *de facto* lending in last resort since the Mexican bailout—a trend which, some argue, should be developed and institutionalized (Fischer, 1999). A report to the U.S. congress recently advocated the transformation of the IMF into a "quasi-lender of last resort" lending at penalty rates and against good marketable collateral (IFIAC, 2000).

The idea that an international lender of last resort (LOLR) could and should become the linchpin of the global financial architecture has been criticized on different grounds. It has been noted, first, that an international lender of last resort might worsen the moral hazard problem which, some argue, is one of the main causes of fragility of the international financial system. Another argument is that while a true international lender of last resort might be desirable in theory, it has no chance of being instituted in practice because the institutional changes involved go well beyond what the international community is ready to accept (Eichengreen, 1999). Some further claim that an international lender of last resort cannot function effectively unless it can issue an indefinite amount of its own currency (Capie, 1998), while others argue that the lender of last resort would need an amount of hard currencies which, though finite, is unrealistically large (Eichengreen, 1999; Rogoff, 1999).

The debate suggests that the notion of an international lender of last resort is not well understood, or at least subject to different interpretations. Questions range from the nature of crises to the arrangements required for the lender of last resort to operate.[1] This paper proposes a formal framework which may help shed light on several of these issues.

The question with which this paper is primarily concerned is that of the *size* of the international LOLR. Does the international LOLR have to be a global central bank, or could it function effectively as a "fund" with limited and predetermined resources? And in the

[1] This lack of consensus reflects, to some extent, the state of the literature on the lending-in-last-resort doctrine. Indeed, the dominant genre in this literature seems to be the exegesis—the spirit and letter of Bagehot's *Lombard Street* being invoked to promote various interpretations of the "classical" doctrine. The more formal (model-based) literature, which is generally based on variants of the Diamond-Dybvig model, fails to capture many insights of its its less formal counterpart. Naturally, the transposition of these debates to the international context makes things more difficult.

second case, how large should the fund be? To answer these questions, we build a model of an emerging economy that is vulnerable to international liquidity crises. An international lender of last resort can in principle cope with these crises by providing hard currency to cash-strapped countries. We scrutinize the size of LOLR interventions that are required to that effect.

The need for an international LOLR stems, in our model, from a currency mismatch in the aggregate balance sheet of the banking sector. The domestic banking sector does not hold enough foreign currency assets to cover its short-term foreign currency liabilities. It is vulnerable, as a result, to panics in which short-term creditors withdraw their credit lines and depositors run on domestic banks. Like in some recent models of "twin" crises, these panics can be self-fulfilling because of the two-way feedbacks between the depreciation of the currency and the deterioration of banks' balance sheet (see, e.g., Burnside *et al*, 1999).

The question, then, is how large the *international* LOLR should be to remove the bad equilibrium. We find that the required size of the international LOLR crucially depends on how its resources are used by the domestic authorities. We compare two approaches, which correspond to the distinction—originally made by Goodfriend and King (1988) in a domestic contex—between "lending-in-last-resort as an input in monetary policy" and "lending-in-last-resort as an input in banking policy". In the former approach, the domestic authorities inject the lending-in-last-resort resources into the market by foreign exchange interventions. In the second one, the resources of the international LOLR are used to back domestic banking safety nets, such as a deposit insurance or a government guarantee of banks' foreign currency liabilities. The two approaches have the following implications for the size of the international LOLR:

- If the international LOLR resources are used to finance foreign exchange intervention by the domestic central bank, the bad equilibrium is not removed, even by an arbitrarily large LOLR. We find that if lending-in-last-resort is an input in monetary policy, it must be carried out by the issuer of the international currency (the U.S. Fed).

- If the LOLR backs a guarantee of the foreign currency liabilities of domestic banks, its resources do not need to be larger than the *liquidity gap* in the domestic banking sector, i.e., the difference between the domestic banking sector's short-term foreign currency liabilities and its foreign currency liquid assets.

Clearly, the second approach seems more practical than the first one. We argue, however, that it differs significantly from Bagehot's "classical" doctrine, and raises knotty moral hazard issues that seem difficult to address under the current international financial architecture. In particular, it implies that the international LOLR would probably have to assume some responsibility in supervising domestic banking sectors. Such an evolution is possible in principle, but it would imply an involvement of the international LOLR in domestic banking sectors that is probably deeper than what can realistically be supported by existing institutions and arrangements.

Interestingly, the logic of our argument does not rely on the existence of a fixed currency peg. The country's vulnerability to twin crises is the same under a flexible exchange rate regime than under a fixed peg. The reason is that the scope offered by exchange rate flexibility is largely illusory in a twin crisis. A floating exchange rate regime allows the domestic monetary authorities to set lower interest rates, but the associated exchange rate depreciation is no less destabilizing for the domestic financial sector—when there is a currency mismatch—than high interest rates.[2] Indeed, if our analysis has any implications for exchange rate regimes, it is to suggest the optimality of very hard pegs, or dollarization. A credible commitment not to devalue the currency removes the bad equilibrium at no cost to the international community.

The paper is structured as follows. Section 2 presents some evidence on the Asian crises to motivate the model. Section 3 presents the model. Section 4 examines the role of domestic monetary policy, and section 5 that of an international lender of last resort. Section 6 concludes.

2. The Asian twin crises: some stylized facts

Although the concomitance of banking and currency crises is not an original feature of the Asian 1997 crisis,[3] it appeared as a very salient one for market participants at the time. Market analysts generally viewed the banking crises as the primary determinant of the currency instability, and conditioned their exchange rate forecasts on the prospects of a recovery in the banking sector.[4] This section presents a few stylized facts on the banking and currency crises in the four countries most affected by banking instability: Indonesia, Korea, Malaysia, and Thailand. Our main purpose is to motivate the assumptions of our model, which will be presented in the following section.

2.1 Maturity and currency mismatches

The four crisis-hit countries received an exceptionally high level of capital inflows in the period leading up to the crisis. A significant fraction of these inflows took the form of short-term credit in foreign currency. Meanwhile current account deficits were draining the foreign exchange reserves, leading to the buildup of a large and increasing gap between short-term external debt and the foreign exchange reserves at the central bank (figure 1). At the eve of the crisis, only Malaysia had enough reserves to cover its short-term debt to BIS-reporting banks. The international liquidity gap was especially large in Indonesia, where it exceeded 7

[2] A similar point is made by Bacchetta (2000) and Aghion *et al* (2000).

[3] Kaminsky and Reinhart's (1999) count 19 twin crises prior to 1995.

[4] See, for example, the *Financial Time Currency Forecaster*, 1997- 98.

percent of GDP at the end of 1996 (table 1). A significant fraction of this build-up in short-term external debt reflected borrowing by domestic banks. The foreign liabilities of domestic banks increased markedly in all countries, most dramatically in Thailand, where they were approaching one third of GDP at the eve of the crisis (table 1).

Most of the external borrowing by banks and corporates was denominated in foreign currency, and the resulting currency risk was largely unhedged. Data limitations make it very difficult to assess the extent to which the currency risk was assumed directly by banks, or passed along to their borrowers. While bank regulation typically disallows currency mismatches, one of the lessons from the recent crises is that they do occur and can be sizeable. Even when the banks themselves avoid currency mismatches, firms which are their customers may carry such a risk on their own books. If many large firms fail simultaneously, so will their banks, especially as maturity transformation is a key function of the banking system.

2.2 The bust

The crisis was accompanied by sharp depreciations of the exchange rate in all countries, a phenomenon that was more pronounced and persistent in Indonesia than elsewhere (figure 2). Indonesia was also exceptional in the level at which it raised its interest rate, a difference that reflected more the burst of inflation than followed the depreciation than an aggressive defense of the currency (figure 3). By contrast, the interest rates in Malaysia seem to have been somewhat insulated from exchange rate developments by capital controls.

Simultaneously, the banking problems which had started to surface before the crisis took a sudden turn to the worse under the joint pressure of high interest rates, a depreciated currency, and a general loss of confidence. The currency depreciation had an adverse effect on the solvency of banks and firms because of the currency mismatches in their balance sheets. A large-scale run by domestic depositors was observed in Indonesia, where, by mid-December 1997, 154 banks representing half of the total assets of the system had faced a significant erosion of their deposit base (Lindgren et al, 1999). The other countries had to cope with a similar pressure coming from short-term creditors, especially foreign banks in Korea.

While the withdrawal of foreign credit lines certainly exercised a drain on the foreign exchange reserves, it does not seem to have been in general the primary cause of capital outflows. Table 1 reports peak-to-trough changes in foreign exchange reserves, as well as the change in the foreign liabilities of domestic banks at the time of the crisis. With the exception of Korea, the drop in reserves was much more driven by speculative capital outflows than by the repayment of banks' foreign debt. On average (excluding Korea), the fall in reserves was six times as large as the decline in banks' foreign liabilities. In other words, out of each dollar flowing out of these economies less than fourteen cents were used to repay the foreign liabilities of domestic banks. The rest was capital flight caused by domestic and foreign residents shifting their portfolio towards foreign assets and by speculation against the domestic currency.

The four countries suffered large falls in output—see figure 4—and there is evidence that the banking problems contributed to the slumps. The importance of banks in financial intermediation had increased markedly in the period leading up to the crisis.[5] As the crisis developed, the most insolvent banks were closed, and the others saw their ability to lend curtailed by the withdrawal of short-term credit lines. Banking problems were associated with a severe decline in real credit (Lindgren *et al*, 1999). Although it is delicate, as always, to disentangle the respective contributions of demand and supply in the credit crunch, some studies have found evidence that it was in part supply-driven (Ghosh and Ghosh, 1999; Ding, Domaç and Ferri, 1998).

2.3 Policy responses

Countries responded to the crisis on several fronts. We briefly review the emergency measures in macro and banking policies—leaving aside the more structural policies that were also initiated at the time of the crisis.

The first and most immediate decision in a currency crisis is the choice between increasing the interest rate in order to defend the currency, or let the exchange rate go. Our four countries did both to various extents, in part as the reflection of a dilemma in which the monetary authorities were caught. On the one hand, there were limits to which the interest rate could be raised, given the fragile state of the banking and corporate sectors. On the other hand, letting the currency depreciate had also adverse effects because of the currency mismatch in the balance sheets of banks and firms.

The limited scope offered by monetary policy led the authorities to rely on policies that were more directly targeted at banks. In all four countries central banks provided liquidity to financial institutions under various emergency lending and lender-of-last-resort facilities. The amounts were especially large in Indonesia and Thailand, where they excedeed 20 percent of GDP (table 1). This liquidity support was provided in domestic currency except in Korea, where it was primarily in U.S. dollars. To the extent that its impact on the monetary base was sterilized, however, the liquidity support provoked the same reserves losses irrespective of the currency in which it was provided.[6]

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[5] Total commercial bank and near-bank assets grew from between 50 percent and 100 percent of GDP in 1992 to between 150 and 200 percent of GDP at the end of 1996 (see table 1). As a comparison, deposit money banks held assets equal to 80 percent of GDP in the United States.

[6] Sterilization was largely effective in Korea and Thailand, but not in Indonesia and Malaysia.

The provision of emergency liquidity was enhanced by various forms of government guarantees of banks' liabilities. None of the four countries had a formal insurance scheme on bank deposits at the beginning of the crisis, so that the guarantees had to be introduced under the pressure of events. As the severity of the crisis became apparent, and the introduction of more limited guarantees failed to restore confidence, the four countries ended up providing blanket guarantees for all depositors and most creditors (Lindgren *et al*, 1999). The guarantees did not always succeed in stemming capital outflows, however, possibly because of uncertainty about the government's ability to honor them. In Korea, for example, the guarantee on foreign debt were not sufficient to convince short-term foreign creditors to roll over their credit lines. This was followed by an effort to coordinate creditors, and resolved by voluntary debt restructuring. In all four countries, the guarantees were announced to be temporary and meant to maintain public confidence during the period of restructuring.

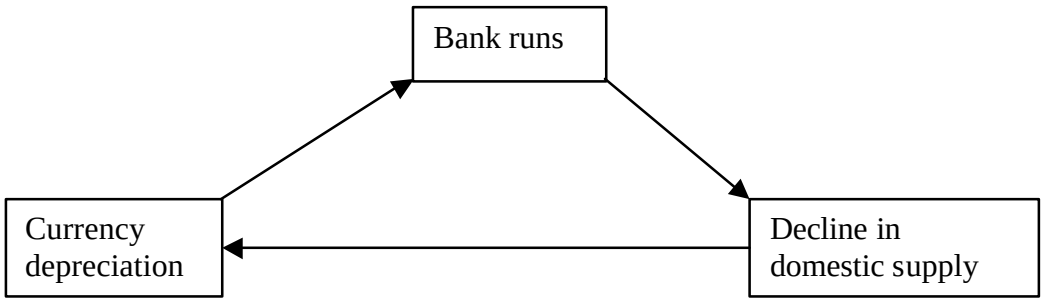
These policies were backed by large rescue packages arranged under the auspices of the IMF, with the notable exception of Malaysia. Interestingly, the size of these packages were of the same order of magnitude as—and in fact slightly larger than—the liquidity gap before the crisis (table 1). Malaysia instead chose to introduce drastic capital controls.

3. Model

One feature of twin crises that the Asian experience illustrates very well is the mutually self-reinforcing nature of banking and currency fragilities. As Kaminsky and Reinhart (1999) put it: "Financial-sector problems undermine the currency. Devaluations, in turn, aggravate the existing banking-sector problems and create new ones. These adverse feedback mechanisms…can be amplified , as we have seen in several of the recent Asian crises, by banks' inadequate hedging of foreign-exchange risk."

We present a model in which these negative feedback effects are linked together in the following vicious spiral:

Figure 5. The vicious spiral



The currency depreciation triggers bank runs because of a currency mismatch in the balance sheets of domestic banks. Banking problems in turn depress domestic supply by inducing a

credit crunch. Finally, the decline in domestic supply weakens the currency, as the domestic authorities attempt to boost output by a depreciation. This closes the circle.

In our model this vicious circle goes beyond making twin crises simply persistent or difficult to manage: it makes them self-fulfilling. We would like to emphasize, however, that we do not view this paper as a contribution to the debate on whether twin crises are self-fulfilling in the real world. The purpose of this paper is not to convince the reader that they were, in Asia or elsewhere. It is to study the *feasibility* of an international LOLR. It makes sense to look at this question in the context of a model with self-fulfilling bank runs, which is the problem that a LOLR is supposed to solve in theory.

3.1 The linkage from the currency depreciation to bank runs

We consider a two-periods model of an open emerging economy (*t=1, 2*). The agents are: the domestic private banks, their depositors, and the domestic central bank. For the sake of brevity and *couleur locale* we call the domestic and foreign currencies "peso" and "dollar" respectively. We denote by S_t the price of one peso in terms of dollars at time *t*. An increase in S_t thus corresponds to an appreciation of the peso.

The peso/dollar exchange rate satisfies uncovered interest parity (UIP):

$$S_1 = \frac{1+i}{1+i^*} S_2^e, \qquad (1)$$

where S_2^e is the expected exchange rate, and i and i^* are respectively the peso and dollar riskless interest rates in period 1.

Domestic banks have deposits and income streams denominated in dollar and peso. The currency composition of banks' assets and liabilities is inherited from an earlier time, in which some banks found it optimal to borrow or lend in dollar, or for some reason could not borrow in peso.[7] It does not seriously weaken our analysis to take the structure of banks' balance sheets as given, since we focus here on the policy measures in crisis, after the currency and maturity mismatches have built up.[8] We denote by $D(j)$ and $D^*(j)$ the

[7] Chang and Velasco (2000) and Goldfajn and Valdes (1999) endogenize the maturity mismatch in open economy versions of the Diamond-Dybvig model of bank runs. Burnside *et al* (1999) and Schneider and Tornell (2000) endogenize the currency mismatch as the result of a government guarantee on foreign currency liabilities, while Caballero and Krishnamurty (2000) attribute it to domestic financial underdevelopment.

[8] Of course it would be essential to endogenize the currency mismatch if we wanted to understand how policy measures can prevent its emergence ex ante (Jeanne, 2000b).

quantities of peso and dollar deposits at bank *j*, and by $R_t(j)$ and $R_t^*(j)$ its peso-denominated and dollar-denominated income streams in period *t*.

Deposits are repayable on demand, and demand is served sequentially, like in the Diamond-Dybvig model of bank runs. Each bank has a continuum of atomistic depositors who decide at $t=1$ whether or not to withdraw their deposits. The withdrawing depositors are randomly allocated in a queue which determines the order in which they are served. The bank repays depositors by selling its assets for peso or dollars in the market. If the bank does not have enough assets to repay all the withdrawing depositors in period 1, the depositors at the end of the queue, and those who have not joined the queue, receive nothing. In the opposite case, the assets that remain in the possession of the bank at the end of period 1 are sold in period 2 to repay the remaining depositors—those who have not withdrawn in period 1. Deposits are interest-bearing, and yield the riskless interest rate corresponding to their currency of denomination. The holder of one dollar of deposit at time 1, for example, is entitled to withdraw $1+i^*$ dollars at time 2.

We assume that bank assets are liquid in the sense that they can be sold costlessly on a perfectly competitive market at their present discounted value.[9] Thus bank *j* is solvent if and only if the present value of its income streams exceeds the value of its deposits, that is:

$$D^*(j) + S_1 D(j) \leq R_1^*(j) + \frac{R_2^*(j)}{1+i^*} + S_1\left(R_1(j) + \frac{R_2(j)}{1+i}\right) \qquad (2)$$

If this solvency condition is satisfied the bank can repay all its depositors irrespective of the date at which they withdraw, and depositors have no (strict) incentives to withdraw early. If this condition is not satisfied, then all depositors run on the bank at period 1. Some depositors will have to take a loss, and each depositor minimizes the likelihood of being one of them by withdrawing his deposits early. Note that by contrast with the Diamond-Dybvig model the equilibrium is unique at the level of an individual bank. The occurrence of a run is determined by the bank's solvency, which is exogenous to the actions of its own depositors.

In order to simplify the exposition we shall consider the following extreme case: all the deposits are denominated in dollar and banks receive only one income stream, which is denominated in peso and arrives in period 2. In terms of the variables of our model this

[9] In theory, the benefit of banking intermediation should be linked to the illiquidity of bank assets. Assuming that bank assets are sold at a discount relative to their present value would not change the thrust of our results, and it is interesting to see that in fact we do not need this assumption. The role played by the illiquidity assumption in the bank run literature is played here by a state-conditional depreciation of the domestic currency.

corresponds to the case where R_1^*, R_2^*, R_1 and D are equal to zero. The assumption that R_1^* and R_2^* are equal to zero does not restrict the generality of the analysis, and is made simply to save on notations. The case where R_1 and D are different from zero is analyzed in the appendix. It has interesting implications for domestic monetary policy, which we choose not to discuss here because they are not essential to the core of our argument.

Using the interest parity condition, (1), to substitute S_1 and i out of the solvency condition (2), we find that bank j is solvent if and only if:

$$D^*(j) \leq \frac{S_2^e}{1+i^*} R_2(j) \qquad (3)$$

In order to avoid the discontinuity associated with the use of integers we assume that the set of banks is isomorphic to a continuum of mass 1, and that the banks' characteristics are continuously distributed. As condition (3) makes clear, the set of solvent banks shrinks if the expected peso exchange rate depreciates (S_2^e goes down). Consequently the number of bank runs in period 1, n, is a continuous and decreasing function of the expected exchange rate:

$$n = N(S_2^e), \qquad N' < 0. \qquad (4)$$

An expected depreciation of the peso reduces the value of bank assets relative to their liabilities, drawing a larger number of banks into insolvency.

3.2 The reverse linkage

The linkage from bank runs to exchange rate expectations in the spirit of the escape clause or "second-generation" approach to currency crises (Jeanne, 2000). It involves the endogenous policy response of the domestic authorities to the real disruption provoked by the bank runs.

We assume that period 2 output is given by a standard open-economy Phillips Curve augmented by a term reflecting the real disruption induced by runs on domestic banks in period 1:

$$Y_2 = \bar{Y} - a(S_2 - S_2^e) - f(n), \qquad f(0) = 0, \quad f' > 0, \qquad (5)$$

$\bar{Y}$ is the natural level of output and n is the number of banks that are subject to runs in period 1. Bank runs reduce output by inducing a credit crunch: the banks that are subject to runs are no longer able to provide loans to borrowers with no easy access to other forms of finance.[10]

[10] Disyatat (2000) presents a model of an open economy in which a depreciation tends to stimulate output because of a short-run Phillips curve, but reduces the domestic banks' ability (continued)

Function $f(\cdot)$ characterizes how the output loss in period 2 depends on the number of bank runs in period 1. The output loss is increasing with the number of runs, presumably in a non-linear way: for example, one could assume that a small number of bank runs has no effect on output but that widespread runs (the truly systemic banking crises) entail large output losses.

The domestic government minimizes the quadratic loss $L_2 = (Y_2 - \bar{Y})^2 + a(S_2 - \bar{S})^2$. The exchange rate term captures the idea that the domestic authorities care about changes in the exchange rate because of their impact on the price level. Using (5) to substitute out Y_2 and minimizing L_2 over S_2, one finds that the period 2 exchange rate is a function of the number of bank runs and of the expected exchange rate:

$$S_2 = \frac{1}{a^2 + a}\left(a\bar{S} + a^2 S_2^e - af(n)\right) \qquad (6)$$

The expected exchange rate in period 2 is decreasing with the number of bank runs in period 1, as the authorities attempt to mitigate the effect of the credit crunch on domestic output by a depreciation of the domestic currency.

3.3 Multiple equilibria

We look at rational expectations Nash equilibria, in which each depositor decides whether or not to withdraw in period 1, taking the actions of the other depositors as given. Under rational expectations, the expected exchange rate and its realized level must coincide, since there is no uncertainty in the model. Replacing S_2^e by S_2 in equations (4) and (6), we find that the number of bank runs and the second period exchange rate are linked by two relationships:

$$\begin{cases} n = N(S_2), & (CM) \\ S_2 = \dfrac{a}{a^2 + a}(a\bar{S} - af(n)), & (CC) \end{cases}$$

The Currency-Mismatch (CM) relationship characterizes the linkage from the exchange rate to the number of bank runs. Its shape is determined by the currency mismatch in banks' balances sheets—in the absence of mismatch the number of bank runs would not depend on the exchange rate. The Credit-Crunch (CC) relationship characterizes the linkage from bank runs to the exchange rate. This link arises because the domestic authorities depreciate the currency in response to a credit crunch.

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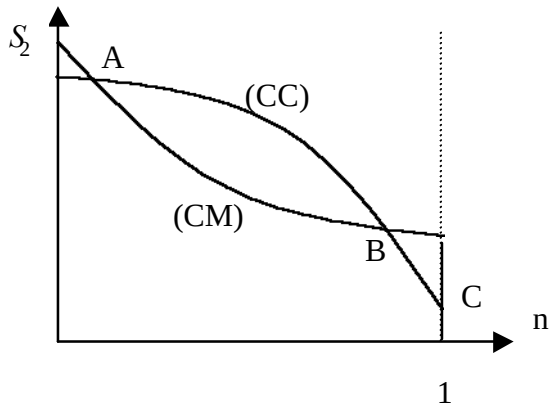
to lend. The credit crunch in his model comes from a reduction in banks' net worth, not from runs.

Figure 6 shows the (CC) and (CM) curves with the number of bank runs on the *x*-axis and the exchange rate on the *y*-axis. Both curves are downward-sloping, so that the model generically gives rise to multiple equilibria. In the case represented in figure 6 there are two stable equilibria, corresponding to points A and C. In the good equilibrium (point A) the currency is strong and only the "truly insolvent" banks are subject to runs. In the bad equilibrium (point C) the currency is expected to depreciate markedly and all the banks are subject to runs. The equilibrium corresponding to point B is unstable.[11]

Figure 6. Twin crisis equilibria



Note that although bank runs may be self-fulfilling in this model, they never hit an "illiquid but solvent" bank. There is a perfect coincidence, in equilibrium, between runs and insolvency. The insolvent banks are subject to runs and the banks subject to runs are insolvent. They are made insolvent by the expected depreciation of the domestic currency. If there is a form of "illiquidity" in this model, it is an aggregate one, at the level of the country rather than individual banks.

3.4 How panics depend on the fundamentals

The model makes several predictions about the conditions under which twin crises occur. First, there must be a significant currency mismatch in the balance sheets of domestic banks—the equilibrium is uniquely determined if banks' assets and liabilities are denominated in the same currency and, by continuity, if the two are sufficiently close. Second, the authorities' commitment to the exchange rate (or price) objective must be

[11] At point B, the bank runs caused by a slight fall in the expected exchange rate tend to depreciate the exchange rate even further, pushing the economy to point C.

sufficiently weak. To consider an extreme case, if the weight of the exchange rate objective in the authorities' loss function, *a*, is infinite, the bad equilibrium disappears because bank runs are no longer expected to depreciate the currency. Finally, self-fulfilling twin crises are more likely when the foreign interest rate, i^*, is high, because this increases the number of insolvent banks, other things equal.

It is not difficult to complicate slightly the model so as to make the multiplicity of equilibria contingent on other economic variables. For example, we could introduce a persistence effect in the Phillips curve, replacing (5) by:

$$Y_2 = \overline{Y} + r(Y_1 - \overline{Y}) - a(S_2 - S_2^e) - f(n) \qquad (7)$$

The second period exchange rate will then depend on the first-period output Y_1, and twin crises can occur only if Y_1 is not too high. These results are broadly consistent with Kaminsky and Reinhart's (1999) observation that twin crises are preceded by recessions or below normal economic growth, and tend to occur when U.S. interest rates are high. The contingency of the multiplicity on output is not essential for our discussion, however, and we use the simpler model.

Whether the economy lands on one or the other of the equilibrium may depend on a sunspot variable, which may or not be correlated with the underlying fundamentals. As one of us has argued elsewhere, the sunspot should not be interpreted literally, but rather as a "black box" for the little understood phenomena involved in the selection of the equilibrium in the real world (Jeanne, 2000).[12] We do not loose much from using this black box in this paper, since we look at policy measures that aim at removing the multiplicity of equilibria—not measures aimed at favoring the selection of the good equilibrium.

4. The limits of monetary policy

This section presents the implications of the model for domestic monetary policy. These implications are of independent interest, and also help to understand the case—analyzed in the following section—where international lending-in-last-resort is used as an input into domestic monetary policy. We discuss the scope for the domestic authorities to respond to twin crises by manipulating the interest rate, and then move on to make some points on exchange rate regimes.

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[12] Morris and Shin (1998) present a possible theory for the selection of the equilibrium. Their approach requires the number of equilibria to depend on the value of some exogenous hidden fundamental about which market participants receive private signals. It could be applied to our model by assuming, for example, that market participants do not know the true value of the domestic government's aversion to inflation, *a*.

4.1 The irrelevance of interest rates

The most immediate question that policymakers have to solve in the heat of crises is macroeconomic: what to do with the interest rate? The debates spurred by the IMF's policy recommendations in the Asian crisis have seen the opposition between two views: the view that the interest rate should be raised, at least for a while, in order to defend the currency, and the view that it should be kept at a low level to spare the domestic economy. The advocates of the latter view have pointed out that a policy of high interest rate may be self-destructive to the extent that it aggravates the real problems in the economy, in particular in the banking sector (Furman and Stiglitz, 1998). The opposite side has emphasized that letting the currency depreciate is not a viable alternative when there is a currency mismatch in the balance sheet of banks or firms. Our model is consistent with at least one part of each view: monetary policy simply does not offer the right tools to deal with twin crises.

In our model, low or high interest rates are equally ineffective against twin crises. In order to establish this point it is sufficient to recall that the domestic interest rate, i, was not in the list of variables that determine the set of equilibria. Hence if the economy is vulnerable to a self-fulfilling twin crisis, there is nothing that the domestic authorities can do about it by manipulating the domestic interest rate.

One may dig out the economic intuition behind this result by going back to the condition for bank solvency, equation (3). The solvency of banks is determined by one variable: the time 1 dollar price of time 2 pesos, $S_2^e/(1+i^*)$. This price can be decomposed as the product of two terms, the time 1 peso price of a time 2 peso, and the time 1 exchange rate:

$$P^* = \frac{1}{1+i} \quad \frac{(1+i)S_2^e}{1+i^*}$$

The first term is decreasing with the domestic interest rate. The second term is increasing with the interest rate. Increasing the interest rate, thus, has two opposite effects, which capture the two sides of the debate mentioned above. On the one hand, raising the interest undermines banks' solvency by depressing the peso price of long-term peso assets. On the other hand, this enhances banks' solvency by appreciating the domestic currency. The first effect arises because of the maturity mismatch in the balance sheet of banks, and the second effect because of the currency mismatch. On balance the two effects cancel out, so that the level of the interest rate is irrelevant.

The two effects *exactly* cancel out because of the particular assumptions we have made on the currency and maturity structure of banks' balance sheets—that bank deposits are denominated in dollars, and that their receipts are given in period 2 pesos. The robustness of our results to more general assumptions is explored in the appendix. We show that the solvency of banks is no longer independent of the level of the interest rate, so that a policy of high interest rates may or not dominate a policy of low interest rates. A policy of high

interest rates tends to become more desirable when the maturity mismatch between the peso-denominated assets and liabilities of banks is less pronounced.

This extension, however, does not invalidate our main conclusion. Even under the more general assumptions, self-fulfilling twin crises remain possible, and monetary policy remains powerless in preventing them. This is because the scope of monetary policy in preserving banks' solvency, although no longer completely empty, remains limited, and contingent on exchange rate expectations.

4.2 Implications for the exchange rate regime

The recent major twin crises were all associated with fixed but adjustable currency pegs, hence the natural conclusion that in order to be viable, exchange rate regimes have to be either more flexible or more fixed. The exchange rate alternative, for emerging economies, is increasingly defined as a choice between exchange rate flexibility and very hard pegs, or dollarization (Eichengreen, 1999; Rubin, 1999).

In the debate between these two extremes, a classical argument in favor of flexibility is that it gives monetary policy more scope to respond to shocks, especially in times of crisis. However, the apparent margin of maneuver offered by a flexible exchange rate is largely illusory in our model.[13] The reason is that the threat is not a currency crisis (a run on the central bank's foreign exchange reserves) but a bank crisis (a run on dollar deposits in banks). The occurrence of a banking collapse is determined by the dollar price of future pesos. Whether a given change in this price is achieved by changing the interest rate or the exchange rate is irrelevant for financial stability. While it is true that a floating regime allows the monetary authorities to set a lower interest rate in the face of speculative pressure, the resulting depreciation hurts domestic banks no less than high interest rates.

In fact, if the model has an implication for exchange rate regimes, it is rather to suggest the optimality of very hard pegs, or dollarization. As we argued earlier, if the defense of the fixed peg is delegated to a conservative central banker putting a very high weight a on exchange rate stability, the bad equilibrium disappears. If, more generally, the domestic authorities find a way to make a credible commitment to exchange rate stability, the vicious spiral that underpins twin crises is broken. It is broken because bank runs no longer feed devaluation expectations.

This might lead us to conclude in favor of very hard pegs over exchange rate flexibility. But this conclusion should be qualified by an important caveat: the currency mismatch that is taken as exogenous in the model could in fact be endogenous to the exchange rate regime. It is often argued that fixed exchange rate regimes are conducive to currency mismatches

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[13] It is completely illusory under the assumption that D and R_1 are equal to zero. It is not completely illusory, but remains limited, in the more general case (see appendix).

because domestic borrowers tend to underestimate the risk of a devaluation (Lindgren et al, 1999), or feel protected by an implicit promise of a bail-out if they are made insolvent by a devaluation (Burnside, Eichenbaum and Rebelo, 1999). The model does not capture one possible benefit of exchange rate flexibility—in fact, the only possible benefit, under our assumptions—which is that it prevents the emergence of currency mismatches.

5. The international LOLR

Our model seems to provide an ideal setting for the intervention of international LOLR. Domestic banks are vulnerable to self-fulfilling runs because the country as a whole lacks international liquidity. Perhaps the bad equilibrium could be removed by an international LOLR standing ready to provide the missing international liquidity to the country in the event of a twin crisis.[14]

Let us start to study this question by introducing some new notations. Let $D^* = \int D^*(j)dj$ be the aggregate level of dollar deposits in domestic banks, X^* the level of foreign exchange reserves at the domestic central bank, and L^* the dollar endowment of the international LOLR. The international LOLR promises to augment the central bank reserves by lending up to L^* in the event of a crisis, and the central bank's access to international liquidity is limited to $X^* + L^*$ in a crisis. The question is how large L^* should be to remove the bad equilibrium. As we show in this section, the answer crucially depends on how the domestic authorities use the liquidity provided by the international LOLR.

5.1 Lending-in-last-resort as an input in domestic monetary policy

Goodfriend and King (1988) argue, in a domestic context, that the lender of last resort should inject liquidity into the market, by open market operations. Lending-in-last-resort, in other words, should involve the same operations as monetary policy in normal times—although possibly to a much larger scale. According to this view, lending-in-last-resort policies in which the authorities attempt to by-pass the market and target liquidity directly at selected institutions—for example by lending to them at the discount window—is a vestige of a time when financial markets did not have the depth and efficiency that they have achieved today.

This view is based on the premise that market forces will allocate the liquidity better than the authorities. Market participants have more information than the authorities on the situations

[14] The lending-in-last-resort arrangement could involve a pool of private banks. However, there are reasons (outside of the model) why the provision of liquidity by public institutions may be more effective. In particular, it may be difficult for private banks to commit not to hedge their risk by market operations that drain international liquidity from the country in the event of a crisis. A comparison between the various possible types of lending-in-last-resort arrangement is outside the scope of this paper, however.

of individual banks, and are not subject to the temptation of bailing out insolvent banks under political pressure. Market forces, thus, will ensure that the liquidity is allocated to the "illiquid but solvent" banks, in accordance with Bagehot's rules. The moral hazard resulting from the bail-out of insolvent banks is avoided. Goodfriend and King call this policy "lending-in-last resort as an input into monetary policy", as opposed to "lending-in-last resort as an input into banking policy".

What the international LOLR's should do, if one follows Goodfriend and King's logic, is finance sterilized foreign exchange interventions by the domestic central bank. The domestic central bank injects international liquidity in the market by selling foreign exchange reserves against peso-denominated assets, that is, by a sterilized foreign exchange intervention.

In our model, this approach is completely ineffective in removing the bad equilibrium. Sterilized foreign exchange interventions have no impact on the exchange rate or the depositors' actions. Every billion dollars that is injected in the market simply goes out of the country in capital outflows. The foreign exchange intervention, in other words, is immediately sucked out of the country in capital outflows, instead of going to the agents that need foreign liquidity the most, the domestic banks that are subject to runs.

Our model suggests that if lending-in-last resort is an input into monetary policy, then it should be carried out by the center's monetary authorities (in the present case where foreign assets are dollar-denominated, the U.S. Fed). There are at least two ways in which this statement can be understood. First, as we already saw, lowering the foreign interest rate, r^*, may remove the bad equilibrium. Second, the Fed could successfully peg the dollar price of future pesos, P^*. It could do so by injecting dollar liquidity in the market until the point where market participants can no longer increase their short positions in peso (because of credit constraints or other reasons) so that uncovered interest parity ceases to apply. In order to be successful, this policy would require an immense liquidity injection at the global scale, which can be implemented, in practice, only by the issuer of the center currency. Making international lending-in-last-resort an input in monetary policy thus vindicates Capie's (1998) claim that the international lender of last resort must be the issuer of the international currency.

These results stem in part from our assumption that financial markets are perfectly integrated internationally. If financial markets were segmented, international liquidity might have a better chance to reach domestic banks if it were injected in the domestic financial market. Uncovered interest parity also plays a role. In the presence of portfolio effects, the domestic currency could in principle be strengthened by sterilized foreign exchange interventions.

The segmentation of financial markets is influenced by the domestic authorities if they introduce capital controls. It would be interesting to study whether, and how, capital controls can remove self-fulfilling twin crises in this model. While capital controls may prevent depositors from taking their dollar deposits out of the country, they will not prevent them from running on the domestic banks that they view as insolvent. The solvency of banks in

turn results from the expected exchange rate. Hence capital controls can remove twin crises only to the extent it gives the authorities more scope in influencing exchange rate expectations. This could be the case, for example, if the controls introduce a wedge in the interest parity condition.

5.3 Lending-in-last-resort as an input into domestic banking policy

We consider now the case where the liquidity provided by the international LOLR is used by the domestic authorities as an input in their banking policies and safety nets—that is, the case of an "International Banking Fund". We consider two policies. In the first one, the LOLR provides a blanket guarantee on dollar deposits at domestic banks. In the second one, the international LOLR backs a discount-window lending policy, that is, a commitment by the domestic central bank to lend to domestic banks all the liquidity they need to repay withdrawing depositors.[15] In both cases, the international LOLR does not have to provide more than the liquidity gap, $D^* - X^*$, in order to make the domestic promises credible.[16]

It is easy to see that both policies remove the bad equilibrium, although they succeed in doing so for slightly different reasons. The blanket guarantee breaks the vicious circle depicted in figure 5 by suppressing the linkage from the currency depreciation to bank runs. The depositors, once insured, no longer have (strict) incentives to run against insolvent banks. Discount window lending breaks the vicious circle by suppressing another linkage, that running from bank runs to the decline in domestic supply.[17] The intervention of the lender of last resort ensures that banks remain in operation and that their balance sheets do not shrink in response to runs. By alleviating the credit crunch, the lender-of-last-resort prevents runs from resulting into a depreciation of the domestic currency.[18]

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[15] This is the way lending-in-last-resort is modeled in Chang and Velasco (2000) and Goldfajn and Valdes (1999).

[16] This supposes that in the discount window lending policy, the central bank can ensure that its loans are used to repay running depositors and not for other purposes.

[17] If depositors do not enjoy some form of seniority over the central bank, lending at the discount window will not prevent them from running against insolvent banks, since not running in period 1 would put them in the situation of having to share the losses with the central bank in period 2.

[18] Central bank lending at the discount window would not remove the bad equilibrium if the linkage from bank runs to the expected exchange rate relied on the monetization of the fiscal cost of the bail-out, like in Burnside *et al*'s (1998) "fiscal theory" of the Asian crisis. This is because market participants expect the losses resulting from the central bank's lending-in-last-resort activity to be monetized.

Rescuing all the banks that are subject to runs may be very costly in terms of moral hazard ex ante, however. It may be desirable, thus, to reserve the guarantee, or the access to the discount window, to the "truly solvent" banks (those that are not subject to runs in the good equilibrium). Selecting the "truly solvent" banks in the bad equilibrium is a delicate and information-intensive task, however. It requires making a judgment on the value that each bank's assets would take in the hypothetical, good equilibrium—taking into account the various feedbacks between the banking system, the productive sector and the foreign exchange market. In particular, this task cannot be achieved by Bagehot's rules of rescuing only "illiquid but solvent institutions", or lending only "against good collateral". If applied literally, these rules will defeat the LOLR's purpose of removing the bad equilibrium, since in our model the banks subject to runs are insolvent, and their collateral is only as good as the equilibrium. The authorities' benchmark for assessing the solvency of banks should be the good equilibrium, even—in fact, especially—in the bad equilibrium.[19]

This problem is complicated, in the international context, by the fact that the lending-in-last-resort arrangement involves two authorities: the international LOLR and the domestic central bank. There could be an agency problem between the international LOLR and the domestic authorities if the latter thought that the cost of an excessively generous lending-in-last-resort policy could somehow be transferred to the international community.[20]

There are different ways to deal with this agency problem but they all seem to require a significant involvement of the international LOLR in domestic supervision and financial safety nets. The international LOLR should be associated to the lending-in-last-resort decisions at the time of the crisis, and it should be able to form an independent judgment on the quality of these decisions. This supposes that it has access to the information of the domestic supervisors, and that it trusts this information to be reliable. The international LOLR, thus, would probably have to take an active role in monitoring domestic banking systems, or cooperate closely with an international agency in charge of international supervision. However, in spite of efforts at promoting international standards, the operation

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[19] This point is in fact rather general and could have some relevance for the closed economy context. The general statement is the following: If the multiplicity of equilibria comes from the fact that the intrinsic value of bank assets is endogenous to the crisis, then restricting the access to lending-in-last-resort to the banks that are solvent *in equilibrium* does not remove the bad equilibrium. In the present paper, the exchange rate opens up a simple channel by which the value of bank assets goes down in crises. In a closed economy context the same effect could result from a decrease in stock prices or an increase in credit risk.

[20] Jeanne and Zettelmeyer (2001) show how moral hazard could arise even if the cost of an excessively generous bailout policy is borne by the domestic taxpayer. Their explanation involves the rent-seeking activities of the domestic special interests that benefit from the bail-out.

of financial safety nets and financial oversight policies remains—and will remain for the foreseeable future—squarely within the bounds of national sovereignty.

6. Concluding comments

The main result of this paper should be to instil a solid degree of skepticism regarding the feasibility of international LOLR without sweeping institutional reforms. If the international LOLR makes its resources an input into domestic monetary policies, the model presented here vindicates those who claim that it must stand ready to provide virtually unbounded amounts of currency. Central banks satisfy this condition, not any existing international financial institution. The alternative is an international LOLR that is directly involved in the supervision of the domestic banking systems that it might be called upon to rescue.

An interesting by-product of the paper is to interpret the trade-off that central banks often face at the time of currency crises. A vigorous interest rate defense weakens the banking system. If banks are fragile, central banks risk triggering a bank run and may end up with both a currency crash and a bank collapse. On the other hand, letting the currency go is not a solution either, since this also fragilizes the banking system by decreasing the dollar value of its assets. This dilemma explains part of the debate that has arisen after the Asian crisis, between those who favored a vigorous interest rate defense and those who called for a sharp decline in interest rates.

The model presented has a number of microeconomic loose ends. The special role of banks in financial intermediation, which is invoked to justify the credit crunch term in the Phillips curve, it is not explicitly modeled. The balance sheet effects, which are so important in triggering bank runs in period 1, are neglected in period 2. Fixing these loose ends will probably lower the insight-to-algebra ratio, a price which seems to us worth paying now that we have taken a panoramic shot of the range of policy issues on which the model sheds light.

The model also glosses over several important moral hazard issues. This includes the role of a fixed exchange rate as an implicit guarantee on foreign borrowing and the effect of a LOLR on risk taking. Finally, it should be noted that if regulation prohibited open currency position by banks is effective, none of our results obtain. Then, however, we would need to take into account that firms rarely face such a regulation. If the corporate sector becomes insolvent as banks do in our model, and precipitate bank failures, most of our results stand. But there are interesting differences in the effectiveness of financial safety nets, which would be interesting to explore further. It is not so clear that the provision of liquidity to the banking sector, or government guarantees on banks' liabilities would remove the bad equilibrium if the currency mismatch is in the corporate sector.

Appendix A. Data

Sources.

Foreign exchange reserves: International Financial Statistics, line 1d.

Short-term debt to BIS reporting banks: BIS.

Foreign liabilities of deposit money banks: International Financial Statistics, line 26 c.

Liquidity support to financial institutions: author's computations based on Lindgren *et al* (1999), table 3.

IMF-supported packages (disbursements): author's computations based on different sources; this variable includes the loans by the IMF, other multilaterals and governments; it reflects the actual disbursements, which were lower than the initial commitments.

Bank closures: Lindgren *et al* (1999), table 7.

Total assets owned by banks: Lindgren *et al* (1999), box 3.

GDP (bn U.S. dollars): International Financial Statistics, line 99b (Gross Domestic Product, national currency) divided by line rf (exchange rate).

Appendix B

This appendix solves for the equilibria in the general case where banks have peso- and dollar-denominated deposits and income streams. The quantities of peso and dollar deposits at bank j are denoted by $D(j)$ and $D^*(j)$. Bank j's peso-denominated and dollar-denominated income streams in period t are denoted by $R_t(j)$ and $R_t^*(j)$.

Using uncovered interest parity (1) to substitute S_1 out of equation (2), the condition for bank j's solvency becomes:

$$D^*(j) - \left(R_1^*(j) + \frac{R_2^*(j)}{1+i^*} \right) < \frac{S_2^e}{1+i^*} \left((R_1(j) - D(j))(1+i) + R_2(j) \right) \qquad (A1)$$

The impact of the interest level on bank j's solvency depends on the sign of $R_1(j) - D(j)$, which reflects the maturity mismatch between assets and liabilities denominated in domestic currency. If $R_1(j) - D(j) < 0$, that is if the bank has more short-term debt than liquid assets in domestic currency, then raising the interest rate undermines the bank's solvency. On the other hand if $R_1(j) - D(j) > 0$ raising the interest rate enhances the bank's solvency.

In aggregate, raising the interest rate increases (reduces) the number of insolvent banks if $R_1(j) - D(j) < 0$ ($R_1(j) - D(j) > 0$) for all banks. If the sign of $R_1(j) - D(j)$ differs across banks, then the impact of the interest rate on the number of insolvent banks is ambiguous. We denote by $I(S_2^e)$ the interest level that minimizes the number of insolvent banks when the expected exchange rate is S_2^e, and by $N(S_2^e)$ the corresponding number of insolvent banks.

How does the minimum number of insolvent banks, $N(S_2^e)$, vary with the expected exchange rate? This question is easy to answer if we assume that all the banks are short in dollars, that is, if the left-hand-side of equation (A1) is positive. Then the set of solvent banks shrinks for *any* level of the interest rate when S_2^e decreases, implying that the minimum number of insolvent banks, $N(S_2^e)$, is a decreasing function of S_2^e.

We define the rules of the game between the domestic central bank and the depositors as follows. First, the central bank announces how it will adjust the interest rate to the economic conditions, i.e. its policy reaction function $i(S_2^e)$. Then, depositors play the same Nash game as before, taking the central bank policy reaction function as given. Depositors still maximize their expected consumption, and the central bank minimizes its expected loss L_2^e.

Because the central bank's expected loss is increasing in the number of bank runs, it optimally announces the policy rule that minimizes the number of runs, $I(S_2^e)$. Given this policy rule, the equilibrium number of runs is a decreasing function of the expected exchange rate, like before:

$$n = N(S_2^e), \qquad N' < 0.$$

This equation is the same as equation (4) in the text, and the characterization of the equilibria remains the same.

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Table 1

The variables are expressed in percentage points of 1996 GDP, except when specified otherwise.

	Indonesia	Korea	Malaysia	Thailand
Foreign exchange reserves (end of 1996)	7.8	6.4	26.0	20.5
Short-term debt to BIS-reporting banks (end of 1996)	15.0	12.0	11.2	25.1
Foreign liabilities of domestic banks (end of 1996)	5.6	8.7	11.2	27.1
Peak-to-trough decline in reserves	5.3 (06.97-02.98)	3.4 (07.97-12.97)	16.5 (03.97-01.98)	7.3 (01.97-08.97)
Decline in domestic banks' foreign liabilities	-0.8 (06.97-02.98)	3.2 (07.97-12.97)	4.1 (03.97-01.98)	2.4 (01.97-08.97)
Liquidity support to financial institutions (June 1997-June 1999)	31.9	6.9	13.8	22.5
IMF-supported packages (disbursement)	8.8	6.0	—	7.9
Bank closures (percentage points of total banking assets)	18.0	15.0	0.0	13.0
Memorandum Items				
Total bank assets (1996)	90.0	300.0	300.0	190.0
1996 GDP (bn U.S. dollars)	227.4	520.2	100.7	181.9

Figure 1. Reserves and short-term debt.

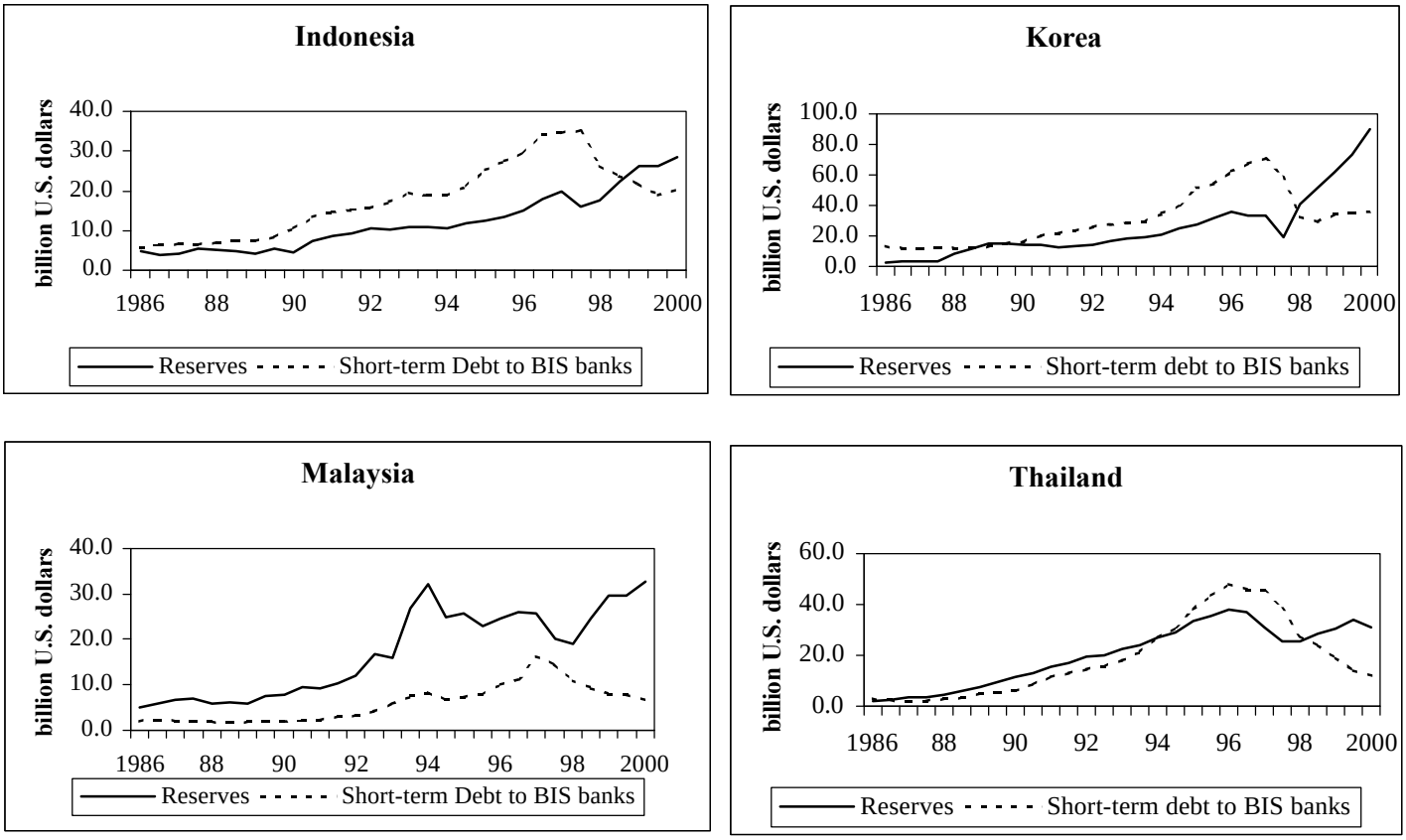

Figure 2. Exchange rates (1990-2000)

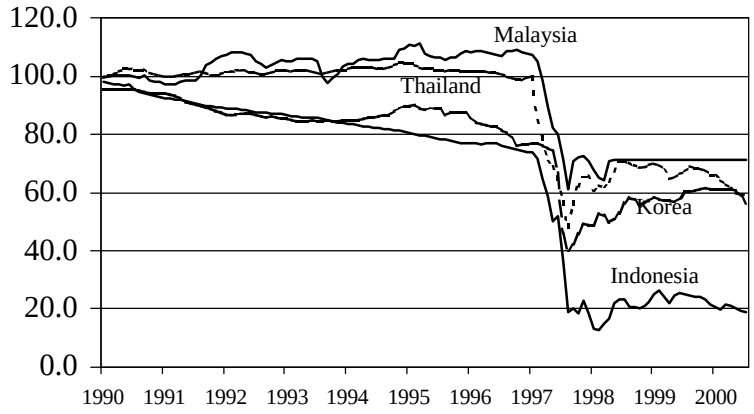

Figure 3. Money market interest rates

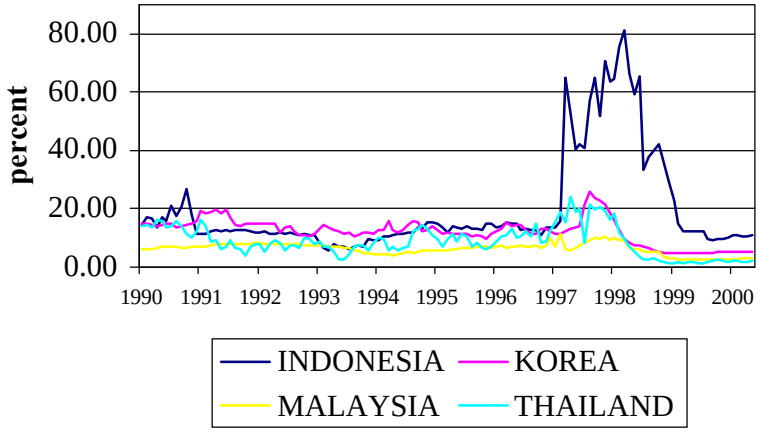

Figure 4. Real GDP (1991=100)