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A Simple Model of

International Capital Flows, Exchange Rate Risk, and Portfolio Choice

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I. Introduction

Banking, by its very nature, is a balancing act. Borrowing short and lending long exposes banks to liquidity risk. More closely matching the maturity of its assets and liabilities exposes a bank to capital risk. Borrowing and/or lending in foreign currencies exposes a bank to exchange rate risk. In this paper we examine a bank's decision to borrow short-term in foreign currency and its consequent exposure to exchange rate and liquidity risk. We examine when this choice maximizes the expected discounted value of the bank, and when institutional constraints lead banks or foreign depositors to prefer short-term to long-term deposits when, absent these constraints, the two forms of lending/borrowing would be perfect substitutes ex ante. The structure of the model, while simple, can explain some features of international capital flows and their effects on the domestic financial system.

The model developed shares features of the Diamond-Dybvig (1983) model modified to an open economy setting. However, this is not a model of bank runs, and the setting is chosen to generate bank profits in the closed economy. Specifically, we assume that there is a monopoly bank. The bank provides liquidity services to domestic depositors at a profit. Domestic depositors know the composition of the bank's portfolio and there is no extraneous uncertainty. Domestic depositors will be repaid, in the closed economy setting, with certainty. However, there are more long-term positive net present value projects available domestically than can be internally funded. Foreign investment is intermediated through the domestic banks, as in Chinn and Kletzer (1999) and Chang and Velasco (2000). Intermediated foreign investment is possible if the expected return on deposits is sufficiently high given current expectations of future exchange rates. Since the bank borrows short and lends long, exchange rate expectations can vary over the life of the loans. We examine the effects of such changes in expectations on bank and depositor behavior, and analyze how institutional features can strengthen or weaken a bank's position vis à vis its foreign depositors.

The paper proceeds as follows. We develop the model in section II. In section III we examine why profit maximizing, risk neutral banks choose to borrow abroad, whether they choose to recontract with risk neutral foreign lenders when exchange rate expectations change (to impede currency outflows), and how the correlation of loan returns with the rate of depreciation of the domestic currency affects the foreign currency in which they borrow. In section IV we examine the effects of deposit insurance on depositors' choices to withdraw early, and on banks' ability to recontract. In section V be examine our assumption on exchange rate formation more fully, and in section VI we examine how well our model fits the Asian financial crisis. Section VII concludes.

II. The Model

Consider an economy that exists at three points in time, t = 0, 1 and 2, and in which there are four types of agents: domestic entrepreneurs, domestic investors, foreign investors, and a domestic bank.

Assume there exist $N=N_1+N_2$ domestic entrepreneurs and M domestic investors, where $N_1>M$. Each entrepreneur is risk neutral and has no initial wealth. N_1 of the entrepreneurs have access to a technology that requires a unit investment and pays $R_1\leq 1$ units if liquidated in period 1, and $R_2>1$ units if liquidated in period 2. Assume that the risk free rate of return is 0, so that these projects have positive net present value if funded domestically. N_2 of the entrepreneurs have access to a technology that requires a unit investment, and pays r_1<1 in period 1 and r_2>1 with probability p and 0 with probability 1-p in period 2. These projects have negative net present value if funded domestically, that is pr_2<1. Assume initially that R_i and r_i, i=1,2, are constants such that the average investment has a negative expected return: $[(N_1/N)\, R_2 + (N_2/N)\, pr_2] < 1$.

Each domestic investor is risk averse, has an initial endowment of wealth of 1 unit, and has access to a risk free storage technology that allows wealth to be held across time without loss. Domestic investors can differentiate between safe and risky entrepreneurs (projects) at zero cost. There are two types of domestic investors: early consumers who get utility from consumption in period 1 but not in period 2, and late consumers who get utility from consumption in period 2 but not in period 1. Assume that a fraction ϕ are early consumers and the remainder are late consumers. In period 0 investors do not know their type, which is revealed at the onset of period 1. Domestic investors' preferences can be represented by the utility function $u(c_i)$, i=1,2, depending on their type, where $u(\ )$ is strictly concave, increasing.

There are many risk neutral foreign investors.[1] Each of these investors has an initial endowment of e_0 foreign currency units of wealth equivalent to one domestic currency unit. Thus, e_0 is the time 0 foreign currency price of domestic currency.[2] Foreign investors can fund domestic projects, but can only distinguish between safe and risky entrepreneurs at a cost K per entrepreneur examined. If the domestic projects are

[1] The assumption that foreign investors are risk neutral can be justified on a number of levels. First, Bohn and Tesar (1996) present evidence that foreign investors are return chasers. This suggests that these investors are concerned only with expected returns, as are risk neutral agents. Second, the proportion of an international investor's portfolio likely to be held as bank deposits in any single country is small. Thus, an examination of the investor's portfolio choice with respect to that portfolio component will appear to be governed by risk neutrality.

funded in the domestic currency, the foreign investors face exchange rate risk, otherwise the entrepreneurs face exchange rate risk.

Economy with no Bank

Consider the economy first in the absence of a domestic bank. Domestic investors in period 0 must choose how to allocate their wealth. As Freixas and Rochet (1997) show for the generalization of the Diamond and Dybvig (1983) model outlined above, agents will allocate their endowment between the long-term illiquid investment and storage. Their expected utility from their own investment is $\phi u(c_1)+(1-\phi)u(c_2)$, where c_1 and c_2 are the levels of consumption for patient and impatient investors, respectively, when they allocate their portfolios on own account. This allocation is, generally, not optimal.

Foreign investors in period 0 will choose to invest in domestic projects only if the expected exchange rate adjusted rate of return on funded projects less any quality determination costs equals or exceeds the risk free rate of return of zero (the return on storage). By assumption, the expected gross return on the average domestic investment held for two periods is less than unity. Assume further that R_2-K<1: the cost of a single quality determination investigation makes the net present value on a good project negative. These assumptions imply that foreign investors will not directly invest and that not all positive expected net present value projects will be funded.

[2] In our model e is a real exchange rate.

Economy with a Bank

Now introduce a single risk neutral domestic bank that is endowed with B units of wealth. Assume, initially, that the bank borrows and lends domestically only, and that $M+B<N_1$, so that the bank's own funds do not overcome the fund shortage problem. The bank, like the domestic investors, can costlessly distinguish the good from the bad entrepreneurs. Freixas and Rochet (1997) establish that the bank can offer domestic depositors an optimal risk-sharing contract. Since the domestic investors are risk averse and identical ex ante, a bank with some market power could also offer them another contract that they would still prefer over own investment. The bank offers each depositor a fixed return of $(1+\varepsilon)$ per unit deposited regardless of when the deposit is withdrawn, where the choice of ε is constrained by individual rationality of the investors:

$$\phi u(c_1)+(1-\phi)u(c_2) \leq u(1+\varepsilon)$$

and feasibility

$$[1-\phi(1+\varepsilon)]R_2 \geq (1+\varepsilon)(1-\phi).$$

where $\phi(1+\varepsilon)$ represents the proportion of deposits invested in the storage technology to repay early consumers, and $(1-\phi(1+\varepsilon))$ are the funds invested in the long-term investment which pays R_2 in period 2. By the concavity of the utility function, for R_2 high enough, there exist feasible εs satisfying the individual rationality constraint. Assume that this is the case. The bank, to maximize its profits, chooses the smallest ε consistent with individual rationality, call this ε^*. At ε^* domestic depositors are indifferent between investing on their own account and depositing with the bank. Assume whenever they are indifferent they deposit their wealth in the bank and withdraw in the period in which they consume. This generates a profit of πM on the local deposit accounts. Since domestic depositors have full information on the bank's portfolio, if we rule out exogenous uncertainty, late consumers have no incentive to withdraw their funds early in the closed economy.

Now assume that the bank can also borrow from international investors, but is required, by charter, to continue to serve the domestic market.[3] Under the assumptions on the inability of international investors to determine the quality of local projects, the bank, a price taker in the international market, can profitably offer, at most, N_I-M-B of the risk neutral foreign investors deposit accounts that pay the expected exchange rate adjusted return, $E_0(1+d_{02})$, if

$$\begin{aligned} (1) \qquad & FR_2 \geq E_0(1+d_{02})F \\ & \Rightarrow R_2 \geq E_0(1+d_{02}) \end{aligned}$$

where $F \leq N_I$-M-B is the number of foreign deposit accounts, $d_{ij} \equiv 1+(e_i / e_j)$ is the rate of depreciation of the local currency relative to the foreign currency between dates i and j. E_t is the expectation operator given information available at date t. Assume if foreign depositors, instead, lend for only a single period at a time, the bank can, in expectation, profitably fund positive net present value local projects if

$$\begin{aligned} (2) \qquad & FR_2 \geq E_0[(1+d_{01})(1+d_{12})]F \\ & \Rightarrow R_2 \geq E_0[(1+d_{01})(1+d_{12})] = E_0(1+d_{02}) \end{aligned}$$

where the bank anticipates rolling over its deposit accounts in period 1. Assume, initially, that the bank quotes depositors one period deposit rates and two period deposit rates, and that there is no penalty for early withdrawal.

[3] Thus, should the cost of domestic deposits exceed the expected cost of foreign deposits, the bank must still accept domestic deposits.

III. Exchange Rate Expectations and International Capital Flows

Assume local investors, foreign investors, and the bank all have the same information upon which to form their exchange rate expectations at each point in time, that exchange rate expectations are time independent, and that all form their exchange rate expectations in the same manner.

Certain Returns on Domestic Investments

Let R_2, the return on positive net present value domestic investments, be a constant. The bank borrows on the international market if inequality (1) holds. When this condition is met, at date 0 the bank borrows $F = N_1\text{-}M\text{-}B$ on the international market, M on the local market, and invests B of its own funds. At date 1 the actual exchange rate, e_1 is revealed, and expectations concerning the rate of depreciation of the currency during period 1 are updated. Foreign depositors, facing no penalty for early withdrawal, must decide whether to withdraw their funds, or to leave their funds in until period 2. We analyze two cases. In the first foreign depositors absorb the exchange rate risk, in the second the bank does. From the perspective of date zero, these two contracts are identical.

Foreign depositors bear exchange rate risk

Assume that the foreign depositors absorb all the exchange rate risk. Then at date zero the bank quotes the following one and two period (domestic currency) deposit rates:

Return on deposits held from period 0 to period 1: $E_0(1+d_{01})$

Return on deposits held from period 1 to period 2: $E_0(1+d_{12})$

Return on deposits held from period 0 to period 2: $E_0(1+d_{02})$

That is, the bank agrees to compensate the foreign investors for the *expected* not realized depreciation of the exchange rate.

At date 1 foreign investors compare the foreign currency return to early withdrawal, $E_0(1+d_{01})e_1$, to the foreign currency return to waiting, $E_0(1+d_{02})E_1e_2$. If

$$(3)\qquad \begin{aligned} &E_0(1+d_{01})\, e_1 \le E_0(1+d_{02})E_1e_2 \\ &\Rightarrow\ E_1(1+d_{12}) \le E_0(1+d_{12}) \end{aligned}$$

then foreign depositors will not withdraw early. [4]

Suppose the inequality in (3) is reversed so that the expected rate of depreciation of the domestic currency has increased. The bank may be able to prevent the foreign depositors from withdrawing their funds by offering to recontract. The bank must offer each foreign depositor enough to make the depositor indifferent between withdrawing early and waiting. That is, the bank must supplement the expected return to waiting, $E_0(1+d_{02})E_1e_2$, by a constant, s, such that it is expectationally equivalent to the return from withdrawing early: $E_0(1+d_{01})e_1= [E_0(1+d_{02})+ s]E_1e_2$. Solving for s yields

$$(4)\qquad s= E_0(1+d_{01})[E_1(1+d_{12}) - E_0(1+d_{12})].$$

The new return for deposits held from period 0 to period 2 is $E_0(1+d_{01})E_1(1+d_{12})$.

Recontracting is both feasible and optimal for the bank whenever the value of its assets meets or exceeds the expected value of its liabilities:

$$(F+B)R_2 + \pi M \ge [E_0(1+d_{02}) + s]F.$$

Substituting for s from equation (4) gives

$$(5)\qquad (F+B)R_2 + \pi M \ge [E_0(1+d_{01})E_1(1+d_{12})]F.$$

[4] This calculation requires that exchange rate expectations are time independent.

Recontracting is analogous to paying off all foreign depositors with new foreign deposits borrowed at the current market rate.

The incentive for foreign depositors to withdraw early and the ability of the bank to recontract depends solely on the extent to which expectations concerning the period 1 depreciation of the domestic currency have changed. If the depreciation of the currency during period 1 is expected to be less than previously expected or if expectations are unchanged then foreign depositors will not withdraw early. If, however, the domestic currency is expected to depreciate by more than previously expected, foreign depositors may have an incentive to withdraw their funds early. The deviation of the actual from the expected depreciation of the domestic currency during period 0 influences the decision to withdraw early only to the extent that it affects expectations of a future depreciation.[5]

Domestic bank bears exchange rate risk

Risk averse foreign investors together with a risk neutral domestic bank could push the exchange rate risk onto the bank. Foreign investors would lend and receive their returns in the foreign currency. If the bank absorbs the exchange rate risk it quotes the following one and two period local currency deposit rates at period zero:

Return on deposits held from period 0 to period 1: $(1+d_{01})$

Return on deposits held from period 1 to period 2: $(1+d_{12})$

Return on deposits held from period 0 to period 2: $(1+d_{02})$

That is, the bank agrees to compensate foreign depositors for the *realized* not expected depreciation of the exchange rate. At time 0 the expected values of these obligations are identical to those in the previous case.

At the start of period 1 foreign depositors must determine whether the bank has the wherewithal to meet its contractual liabilities given e_1 and $E_1(e_2)$. The updated expected return to waiting for each foreign depositor is $(1+d_{01})E_1(1+d_{12})$ in local currency terms.[6] Thus, if

(6) $$(F+B)R_2 + \pi M \geq [(1+d_{01})E_1(1+d_{12})]F \geq [E_1(1+d_{02})]F$$

then the value of the bank's assets are adequate to meet its expected liabilities given the realized period 1 exchange rate and revised expectations so that no net outflow of foreign deposits will occur.

When the bank bears the exchange rate risk, an unexpected depreciation of the domestic currency during period 0 reduces the solvency of the bank making early withdrawal more likely.[7] If foreign depositors bear this risk the unexpected depreciation has no direct effect on withdrawal decisions as shown in inequalities (3) and (5).

Nevertheless, regardless of which party assumes the exchange rate risk, the ability of the domestic bank to prevent capital outflows in the face of an expected change in the exchange rate in period 1, not foreseen at time 0, depends on several common factors. The better capitalized is the bank (the higher B), the higher is the return to lending (R_2), the larger is the ratio of domestic to foreign deposits (M/F), and the more profitable is local lending (π), the bigger the now expected depreciation of the domestic currency can be without causing capital flight.

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[5] This point is discussed in detail in Section IV.

[6] Assuming the bank is expected to be solvent at the start of period 2, the foreign currency return to early withdraw, $(1+d_{01})e_1$, is identical to the expected return to waiting , $(1+d_{01})E_1(1+d_{12})E_1(e_2)$.

[7] In period 0 the bank solvency condition is $[(F+B)R_2+\pi M] \geq [E_0(1+d_{02})]F$. Comparing this to the new solvency condition given by inequality (6) shows that if $E_0(1+d_{02}) < E_1(1+d_{02})$ the solvency of the bank is reduced. This may occur either because of an unexpected depreciation in period 0 or the expectation of depreciation in period 1 that was not expected at time 0.

Random Returns on Domestic Investments

Now suppose that the returns on the N_1 positive net present value projects are random variables that are correlated with changes in the exchange rate. First assume that

(7) $\widetilde{R}_2 = \overline{R}_2 + f[(1+\widetilde{d}_{02})]$

where $\widetilde{R}_2$ and $\widetilde{d}_{02}$ are random variables, $f(1)=0$, $f(x)>0\,\forall\, x>1$, and $f(x)<0\,\forall\, x<1$. Under these assumptions the returns on the projects are positively correlated with the rate of depreciation of the domestic currency. Also assume that $f()\in[\underline{f},\overline{f}]$ where $\overline{R}_2 + \underline{f} \geq R_{2,\min}$ the minimum return such that local depositors are made better off by depositing their endowments in the bank. Finally assume that the bank can write variable rate loan contracts (or, in this case, equivalently lends in the foreign currency): the bank receives $\widetilde{R}_2$.

When returns on domestic investments are random the condition under which the bank will borrow in international markets (1) becomes:

(1′) $E_0\widetilde{R}_2 \geq E_0(1+d_{02})$

where $\widetilde{R}_2$ is given by equation (7). If (1′) holds then at date 0 the bank borrows F on the international market, M on the local market and B on its own account. As with non-random returns, at date 1 the actual exchange rate, e_1, is revealed, and expectations concerning the rate of depreciation of the currency between dates 1 and 2 are updated. When foreign depositors bear the exchange rate risk they compare the return to withdrawing early with the expected return from waiting, as shown in inequality (3). If this holds then investors will not withdraw early. If the inequality is reversed then a supplement s [equation (4)] is required to induce foreign depositors not to withdraw. The feasibility condition for recontracting becomes

$$(5') \qquad [(F+B)\widetilde{R}_2 + \pi M] \geq [E_0(1+d_{01})E_1(1+d_{12})]F.$$

When the bank assumes the exchange rate risk the solvency condition becomes

$$(6') \qquad [(F+B)\widetilde{R}_2 + \pi M] \geq [E_1(1+d_{02})]F.$$

Comparing these feasibility/solvency conditions to those when returns are non-random, [(5′) to (5) and (6′) to (6)] it is clear that early withdrawal is now less likely to occur. The expected value of the bank's liabilities is unchanged by introducing random returns. The expected value of the bank's assets, however, is greater when returns are random, $\widetilde{R}_2 > R_2$, because these returns are positively correlated with the rate of depreciation of the domestic currency.[8] This relationship between the expected return on domestic projects and the depreciation of the domestic currency suggests that the bank is lending to businesses that benefit from a (real) depreciation of the local currency against the currency "lent" by foreign investors, e.g. to export oriented or import competing businesses, as in South Korea.

The above analysis assumes that the returns on the projects the bank finances are positively correlated with the rate of depreciation of the domestic currency relative to the foreign currency it borrows. If the returns on the projects are negatively correlated with the rate of depreciation of the local currency relative to the foreign currency it borrows then should the domestic currency depreciate more than initially expected the return to lending falls increasing the likelihood of withdrawal.

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[8] If the domestic currency is expected to appreciate then $\widetilde{R}_2 < R_2$.

Suppose now that the domestic currency is pegged to one foreign currency, the dollar for example, yet returns are positively correlated with the depreciation of the domestic currency against another foreign currency, the yen for example. If the bank borrows dollars and lends dollars net deposits will flow in as long as the dollar/yen exchange rate is constant or the dollar is depreciating against the yen. When the dollar appreciates against the yen, the return on projects falls in dollar terms although banks' cost of deposits remains the same in dollar terms. Clearly, this weakens bank balance sheets, and in many cases makes recontracting/meeting foreign currency liabilities impossible. Once again, one could blame the weakness of bank balance sheets on unanticipated exchange rate movements, but in this case borrowing practices are also suspect since borrowing yen rather than dollars would have lessened bank exposure to adverse exchange rate movements. In this case it is sensible to "borrow" and "lend" in the same currency (that is, have loan returns and deposit costs pegged to the same foreign currency).

IV. Deposit Insurance

Our modeling strategy to this point has been to assume that the only participants in the deposit market were the bank and its depositors. We now assume that there is a deposit insurer, either the domestic government or an international agency. The existence of insurance creates the possibility of four regimes depending on in which currency the insurance is denominated and who, the bank or the depositor, bears the exchange rate risk.

Guarantee in Domestic Currency

First assume that the domestic central bank provides a guarantee in domestic currency terms. That is, should a domestic bank fail, for whatever reason, the foreign depositors get their initial domestic currency investment back in full. Consider the case of the bank investing only in positive net present value projects, with certain returns. Then, as before, the bank will only borrow on the international market if condition (1) holds. Assume this is the case. At date 1, given e_1 and $E_1(e_2)$ foreign depositors must decide whether to withdraw their funds early, or to leave their funds in until period 2.

If foreign depositors bear the exchange rate risk then the foreign currency return to early withdrawal is $\max\{E_0(1+d_{01})e_1,\ e_1\}$ which equals

$$\begin{array}{lll} E_0(1+d_{01})e_1 & \text{if} & E_0(1+d_{01}) \geq 1 \\ e_1 & \text{if} & E_0(1+d_{01}) < 1 \end{array}$$

When $E_0(1+d_{01})\geq 1$ the guarantee is nonbinding. The condition under which waiting is preferable to early withdraw remains inequality (3) and the feasibility condition for recontracting remains inequality (5).

If, however, $E_0(1+d_{01})<1$ the guarantee is binding. Now the condition under which waiting is preferable to early withdrawal becomes

$$\begin{aligned} &e_1 \leq E_0(1+d_{02})E_1 e_2 \\ &\Rightarrow E_1(1+d_{12}) \leq E_0(1+d_{02}) \end{aligned} \tag{3′}$$

A necessary condition for inequality (3′) to hold is $E_1(1+d_{12}) < E_0(1+d_{12})$. If (3′) does not hold the bank must supplement the return to each foreign depositor by a constant, $\hat{s}$, such that $[E_0(1+d_{02})+\hat{s}]E_1 e_2=e_1$. Solving for $\hat{s}$ yields

(4′) $\hat{s}=E_1(1+d_{12})-E_0(1+d_{02})$.

A comparison of equations (4) and (4′) shows that $\hat{s} > s$, the deposit guarantee increases the cost to the bank of recontracting. The supplement $\hat{s}$ is feasible and optimal if

(5″) $$(F+B)R_2 + \pi M \geq [E_1(1+d_{12})]F.$$

Comparing (5″) with (5) shows that given a period 0 expected appreciation of the domestic currency, $E_0(1+d_{01})<1$, a guarantee on the initial domestic value of deposits makes it more difficult for a bank to recontract whenever $E_1(1+d_{12}) \geq E_0(1+d_{12})$.

If the bank assumes the exchange rate risk then given a domestic currency guarantee the foreign currency return to early withdrawal is $\max\{(1+d_{01})e_1,\ e_1\}$ which equals

$$\begin{array}{lll} (1+d_{01})e_1 & if & (1+d_{01}) \geq 1 \\ e_1 & if & (1+d_{01}) < 1 \end{array}$$

When $(1+d_{01}) \geq 1$ the guarantee is nonbinding. The condition under which withdrawal will not take place remains inequality (6).

If, however, the domestic currency appreciates in period 0 the guarantee is binding. In this case the expected foreign currency return to waiting, $(1+d_{01})E_1(1+d_{12})E_1(e_2)$ is less than the foreign currency return to early withdrawal, e_1. The bank must offer a supplement $\tilde{s}$, such that the return to waiting is expectationally equivalent to the return from withdrawing early: $[(1+d_{01})E_1(1+d_{12})+\tilde{s}]E_1e_2 = e_1$. Solving for $\tilde{s}$ yields

(4″) $$\tilde{s} = E_1(1+d_{12})[1-(1+d_{01})]$$

This supplement is feasible and optimal if

(6″) $$\begin{aligned}(F+B)R_2 + \pi M &\geq [(1+d_{01})E_1(1+d_{12})+\tilde{s}]F \\ &\geq [E_1(1+d_{12})]F\end{aligned}$$

A comparison of (6) and (6″) shows that the liabilities of the bank have decreased as a result of the guarantee, making it more likely that the bank will be able to recontract.

A domestic currency guarantee may have the perverse result of increasing the likelihood of capital outflows given an initial appreciation or expected appreciation of the currency. The outflows occur not because of unexpected changes in the exchange rate, but rather because the existence of the guarantee changes the incentives of the depositors.

Guarantee in Foreign Currency

Suppose, instead, the deposit guarantee is in foreign rather than domestic currency. The deposit guarantor provides each foreign depositor with the initial investment, e_0, should the bank fail. When foreign depositors bear the exchange rate risk,[9] if they withdraw their funds at t=1 the foreign currency return is $\max\{E_0(1+d_{01})e_1,\ e_0\}$ which equals

$$\begin{array}{lll} E_0(1+d_{01})e_1 & if & E_0(1+d_{01}) \geq (1+d_{01}) \\ \quad e_0 & if & E_0(1+d_{01}) < (1+d_{01}) \end{array}.$$

If the domestic currency depreciated by less than expected, the condition under which waiting is preferable to early withdraw remains inequality (3) and the feasibility condition for recontracting remains inequality (5).

If, however, $E_0(1+d_{01})<1+d_{01}$, then the condition under which waiting is preferable to early withdrawal becomes

$$(3'') \qquad \begin{array}{l} e_0 \leq E_0(1+d_{02})E_1 e_2 \\ \Rightarrow E_1(1+d_{02}) \leq E_0(1+d_{02}) \end{array}$$

[9] If the bank bears the exchange rate risk the guarantee provides the same return for early withdrawal as the deposit contract.

If the inequality in (3″) is reversed the bank must supplement the return to each foreign depositor by a constant, $\breve{s}$, such that $[E_0(1+d_{02})+\breve{s}]E_1e_2 = e_0$. Solving for $\breve{s}$ yields

(4‴) $\breve{s} = E_1(1+d_{02}) - E_0(1+d_{02})$.

Comparing equations (4) and (4‴), it can be seen that the deposit guarantee increases the required supplement, $\breve{s} > s$.

The supplement $\breve{s}$ is feasible and optimal if

(5‴) $(F+B)R_2 + \pi M \geq [E_1(1+d_{02})]F$.

Comparing (5‴) with (5) shows that in the event of a greater than expected depreciation a guarantee of deposits in foreign currency reduces the ability of the bank to recontract, increasing the chance of early withdrawals.[10] This is because deposit insurance here provides foreign depositors an alternative contract with different return characteristics than their deposits.[11] When initial exchange rate expectations are not realized the foreign depositors choose the contract that offers them the highest expected return, and if the bank cannot match that return, capital flows out. This is precisely the condition that prevailed at the beginning of the Asian crisis.

Notice, in the case of a greater than expected depreciation of the currency, the supplement generates a recontracting condition (5‴) which is identical to the early withdrawal condition (6) when the domestic bank promises the foreign currency deposits on demand. Clearly, then, if domestic banks did offer foreign currency demand deposits, they also exposed themselves to the risk of early withdrawals whenever the domestic currency depreciated more than expected. This is because, as suggested above, the bank

[10] This holds for all possible correlations of returns on local investments.

[11] In this model both the domestic bank and the foreign investors are risk neutral. This being the case, they have no incentive to hedge exchange rate risk. However, even if the foreign investors were risk averse, the existence of the guarantee on their deposits would make hedging exchange rate risk unnecessary.

rather than the foreign depositor absorbs the loss on the foreign currency transaction. In this case an explicit deposit guarantee matches the return structure promised by the deposit contract and there is no reason for early withdrawal. If the guarantee is implicit, the foreign depositors must evaluate which contract promises them the highest expected return. If it is the insurance contract then early withdrawals occur whenever the bank cannot recontract.

The above analysis was conducted under the assumption that the guarantee would not affect the bank's portfolio choice. This may not be the case since, as is well-known, deposit insurance creates a moral hazard. Suppose that the negative net present value projects are such that $r_1 < R_1$, and $r_2 > R_2$ but $pr_2 < 1 < R_2$. With the guarantee of foreign deposits, if the bank invests in negative net present value projects alone, the bank must offer foreign depositors at time zero at least $\hat{r}_2$, where $\hat{r}_2$ solves

$(1-p)E_0(1+d_{02})+ p\hat{r}_2 = E_0(1+d_{02})$, since if the investment does not pay off and the bank fails, the guarantor pays depositors their initial foreign currency investment, which, as of date 0, has expected value of $E_0(1+d_{02})$ in domestic currency terms. The bank's expected profit is then $E_0\pi^{NNPV} = p(r_2-\hat{r}_2)$. Its expected profit from investing foreign deposits in positive net present value projects is $E_0\pi^{PNPV} =[R_2 - E_0(1+d_{02})]$. If $E_0\pi^{NNPV} > E_0\pi^{PNPV}$ then foreign deposits are more profitably invested in negative net present value projects. The local economy will be harmed (less output will be produced) by this allocation of funds if $[(N_1-M)/(N-N_1)]R_2>pr_2$, assuming domestic depositors are still well served. Further, the global economy is harmed since the guarantee leads to negative net present value projects being funded and the international community bearing the loss.

V Formation of Exchange Rate Expectations

In this paper we do not endogenize exchange rate expectations. Our reasoning is motivated by studies showing that models of exchange rate determination perform poorly empirically (Frankel and Rose (1995), Meese and Rogoff (1983), Chinn and Meese (1995), Mark (1995)). In addition, work by Goldfajn and Valdés (1998) indicates that exchange rate expectations do not anticipate currency crises.[12]

As the model in sections II through IV shows, exchange rate expectations serve two functions in this paper. First, expectations determine if foreign investment occurs (inequality 1). Second, changes in expectations determine if foreign investors have an incentive to withdraw early and given such an incentive if the bank can recontract. While explicitly modeling expectations formation is possible, it does not fundamentally change the message of the paper.[13]

VI. Confronting the Model with the Data

Although the model presented in this paper is very simple, most of the assumptions as well as many of the implications are consistent with the data on the five East Asian countries most directly associated with the Asian crisis – Indonesia, Korea, Malaysia, Philippines and Thailand in the years prior to the crisis. First, this model assumes that banks have some market power in their domestic markets, and that domestic banks are the only source of external finance for firms. Table 2 examines the structure of the banking industry in these Asian countries. Prior to the crisis, the banking industry

[12] Berg and Pattillo (1999), however, find that the probability of a currency crisis rises when the real exchange rate is overvalued relative to trend.
[13] In an earlier version of this paper we model expectation formation explicitly. This version is available from the authors on request.

was highly concentrated and domestic banks were the primary players in the industry.[14] Foreign banks accounted for 10 percent or less of the assets of the banking industry in each country, with the exception of Malaysia. Banks generally had the predominant role in the financial services industry. As Table 2 shows, in Indonesia, Malaysia and Thailand, 75 percent or more of total financial sector assets were held by banks.

The dominant role of the domestic banking industry is further supported by the data in Table 3. In the three countries for which data are available, financing for the private non-financial sector was overwhelmingly provided by the domestic sector and banks were an important if not the most important source of these funds. These data support the assumptions that those seeking finance borrow from banks rather than raising funds in the capital market and that foreign funding, to the extent it exists, is channeled through domestic banks.

Foreign banks, however, were an important source of deposits for East Asian banks. Figure 1 shows the rapid expansion of foreign bank lending to East Asian banks. Foreign bank lending to Korean, Malaysian and Philippine banks tripled while lending to Thai banks increased five-fold from the end of 1992 to just prior to the onset of the crisis in 1997. These foreign bank deposits were an important source of domestic credit expansion. Although Asian banks borrowed abroad they lent locally rather than channeling the funds back into the international market. In mid-1997 the foreign liabilities of the banks were 2-3 times greater than their foreign assets in all the East Asian countries, with the exception of Thailand were foreign liabilities of the banks were

[14] This situation has changed somewhat as a result of post-crisis financial liberalization.

13 times greater than their foreign assets.[15] Moreover, this ratio had more than doubled, since the early 1990's, in every country except Korea.

The expansion in foreign bank lending to East Asian banks was accompanied by an expansion in domestic credit markets. In all countries, except Indonesia, the role of borrowing from foreign banks to finance domestic credit increased in the mid-1990s[16]. The model suggests that this increase would make the banks more vulnerable to any given change in the expected rate of depreciation of the local currency, since domestically generated profits would have to stretch further to cover recontracting costs. Thailand, again displays a dependence on foreign deposits that is noticeably greater than that of the other East Asian countries.

The model's assumption that domestic bank borrowing from foreign banks is effectively short-term in nature is also supported by the data. In all countries, at least half of the borrowing from foreign banks was short-term in nature.[17] Short-term borrowing, particularly to the extent that it is in foreign currencies and not covered by foreign exchange reserves can increase the vulnerability of domestic banks to changes in expectations about the path of the exchange rate. Banks in Indonesia, Korea and Thailand all had short-term foreign debt to foreign banks in excess of the country's foreign exchange reserves.[18] In all countries, over 90 percent of this debt was in foreign currencies, indicating that the banks, rather than the large foreign lenders, absorbed the

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[15] Bank for International Settlements, *Quarterly Review: International Banking and Financial Market Developments*, various issues.
[16] Bank for International Settlements, *Quarterly Review: International Banking and Financial Market Developments*, various issues and International Monetary Fund, *International Financial Statistics*, various issues.
[17] Bank for International Settlements, *Semi-annual International Banking Statistics*, various issues.
[18] Bank for International Settlements, *Semi-annual International Banking Statistics*, various issues and International Monetary Fund, *International Financial Statistics*, various issues.
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exchange rate risk.[19] These data indicate that if exchange rate expectations changed such that the local currency was expected to depreciate more than previously expected a deposit outflow would be likely. [20]

Table 4 indicates that foreign depositors may reasonably have expected little change in the real value of the local currency relative to the dollar in the years prior to the crisis. The variability of the real local currency/U.S. dollar exchange rate was generally much smaller than the variability of either the real DM/$ or the real ¥/$ exchange rate in the years prior to the crisis. Thus, $E_0(1+d_{02})$ may have been close to one prior to the onset of the crisis as real exchange rates remained relatively constant.

There is also evidence that implicit guarantees of the liabilities of domestic banks existed. Indonesia, Malaysia and Thailand had all experienced financial crises in the 1980s or 1990s that were resolved at least partially through a public bailout. Alba et al. (1998) note "These bailouts reinforced the perception of an implicit deposit or even wider liability cover to the detriment of market discipline." The existence of implicit guarantees is given support by Mishkin (1999) who claims "depositors and foreign lenders to the banks in East Asia, knew that there were likely to be government bailouts to protect them."

The data presented in this section, highlight the particular vulnerability of Thailand to unanticipated changes in the expected rate of depreciation of the baht as its foreign exposure rose precipitously over the mid-1990s. This reduced its ability to withstand exchange rate fluctuations. While the other Asian countries exposure did not

[19] This may not be the case and depends on the specific deposit contract.
[20] Mishkin (1999) argues that one factor linking the currency crisis and the financial crisis in Asia was the negative effect of the devaluation on banks' balance sheets, resulting from foreign currency liabilities. Moreover, he argues that the effect was compounded by the short-term nature of bank borrowing.

change appreciably over the same period, drastic changes in exchange rate expectations, perhaps a spillover from the Thai market, could have destabilized these banking systems as well.[21] As Table 5 shows movements in the baht/dollar exchange rate were positively correlated with movements in the won/dollar and ringgit/dollar exchange rates in the years prior to the crisis. Once the crisis began there was a strong positive correlation between changes baht/dollar exchange rate and the dollar value of the other Asian currencies.

VI. Conclusion

This paper has presented a very simple model of exchange rate risks faced by banks. Our analysis suggests that if exchange rate expectations change, transparency, as it relates to domestic banks' balance sheets, may not be adequate to avert foreign currency outflows in the presence of substantial, unhedged, exchange rate risk, since in this model banks' balance sheets are perfectly transparent. However, the lack of transparency of the central bank's balance sheet, as noted by Federal Reserve Chairman Greenspan (1998), may be precisely what generates extreme changes in exchange rate expectations that increase the probability of capital outflows and threaten bank solvency.

Banks could, of course, hedge their exchange rate risk by means of a forward or futures contracts, thus guaranteeing their ability to make good on their foreign currency obligations and their ability to meet current demands by foreign depositors with new foreign currency borrowing. Since the bank in this model is risk neutral it has no

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[21] Froot, O'Connell and Seasholes (2001) show, institutional investors exhibit herd like behavior, moving money into and out of a region en masse, suggesting that exchange rate expectations may be driven by regional as well as local factors.

incentive to hedge. If banks are risk averse but choose not to hedge, then it must be the case that the costs exceed the benefits, a likely outcome if the market does not expect exchange rates to change so the forward and futures markets are thin.

There are other means by which banks could reduce their exposure to exchange rate risk. They could do this by borrowing long-term from foreign sources while imposing a significant penalty for early withdrawal. In practice banks have not chosen to borrow long, suggesting that the cost of doing so exceeds the benefit. This would be the case if foreign depositors require a liquidity premium to compensate them for the loss of flexibility of lending long, which offsets the penalty for early withdrawal. It could also be the case as a result of regulations that favor short over long-term inter-bank lending, as was the case under the 1988 Basle regulations (Basle Committee on Banking Supervision, 1998) that place a 20 percent risk weight on short-term inter-bank deposits from OECD banks to non-OECD banks, and an 100 percent risk weight on long-term inter-bank deposits from OECD banks to non-OECD banks. Thus, contrary to Calomiris (1998), Chang and Velasco (2000) show that a run up in short-term foreign debt may not be a symptom of weakness, but rather of rational choices of risk-neutral or even moderately risk averse (not risk loving) domestic banks, while Diamond and Rajan (2001) show that short term debt finance is the optimal method of financing “difficult” borrowers.

While policies cannot affect the liquidity premium foreign depositors demand on long-term lending, they can change the domestic bank’s incentives and ability to borrow long-term. First, international capital requirements on short-term inter-bank deposits could be increased and capital requirements on long-term inter-bank deposits reduced.

This would, all else equal, increase the desirability of long term lending to foreign depositors. Further, the domestic government could impose reserve requirements on foreign short-term deposits, as suggested by Federal Reserve Chairman Greenspan (1998), thereby increasing their cost to domestic banks, and, if high enough, making long-term borrowing from foreign depositors cheaper than short-term borrowing. Clearly, these policies reduce the domestic bank's profits, but do not reduce domestic lending so long as foreign borrowing remains profitable. Now if foreign depositors choose to withdraw early, they will get only the market value of the debt, the value of a one period investment in the illiquid asset. Further, the bank's solvency is unaffected by this withdrawal of foreign funds, although domestic output will be adversely affected. Domestic output and bank solvency could both be insulated from the early withdrawal risk by making the time deposits negotiable.

The paper also examines the role of foreign deposit guarantees. That the existence of such guarantees can increase the riskiness of domestic bank portfolios is well known. This is the expected response to deposit insurance. In addition, these guarantees, even in the absence of a change in the bank's portfolio, can increase the chance of bank solvency crises by reducing the domestic bank's ability to recontract with its foreign depositors, making them, at best, a poor policy option.

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Table 1

Conditions Under Which Foreign Depositors Will Not Withdrawal Their Deposits Early

	Waiting is Preferable to Early Withdrawal	**Recontracting is Feasible**
Foreign depositor bears exchange rate risk		
Certain Return on Domestic Investment	$E_1(1+d_{12}) \le E_0(1+d_{12})$	$(F+B)R_2 + \pi M \ge [E_0(1+d_{01})E_1(1+d_{12})]F$
Random Return on Domestic Investment	$E_1(1+d_{12}) \le E_0(1+d_{12})$	$(F+B)\tilde{R}_2 + \pi M \ge [E_0(1+d_{01})E_1(1+d_{12})]F$
Guarantee initial domestic currency deposit	$E_1(1+d_{12}) \le E_0(1+d_{12})$ when $E_0(1+d_{01}) \ge 1$ $E_1(1+d_{12}) \le E_0(1+d_{02})$ when $E_0(1+d_{01}) < 1$	$(F+B)R_2 + \pi M \ge [E_0(1+d_{01})E_1(1+d_{12})]F$ $(F+B)R_2 + \pi M \ge [E_1(1+d_{12})]F$
Guarantee initial foreign currency deposit	$E_1(1+d_{12}) \le E_0(1+d_{12})$ when $E_0(1+d_{01}) \ge (1+d_{01})$ $E_1(1+d_{02}) \le E_0(1+d_{02})$ when $E_0(1+d_{01}) < (1+d_{01})$	$(F+B)R_2 + \pi M \ge [E_0(1+d_{01})E_1(1+d_{12})]F$ $(F+B)R_2 + \pi M \ge [E_1(1+d_{02})]F$
Bank bears exchange rate risk		
Certain Return on Domestic Investment	$(F+B)R_2 + \pi M \ge [E_1(1+d_{02})]F$	
Random Return on Domestic Investment	$(F+B)\tilde{R}_2 + \pi M \ge [E_1(1+d_{02})]F$	
Guarantee initial domestic currency deposit	$E_1(1+d_{12}) \le E_0(1+d_{12})$ when $E_0(1+d_{01}) \ge 1$ $E_1(1+d_{12}) \le E_0(1+d_{02})$ when $E_0(1+d_{01}) < 1$	
Note: $E_1(1+d_{02}) = (1+d_{01})E_1(1+d_{12})$		

Table 2

Structure of the Banking Industry

	Assets as a percentage of total bank assets			Share of bank assets
	Market Concentration	Foreign banks	State-owned banks	in total assets of the financial sector
Indonesia	50	4	48	91
Korea	66	5	19	39
Malaysia	59	21	9	78
Philippines	51	10	19	N.A.
Thailand	69	6	7	75

Notes: Market concentration data for Indonesia are based on the 7 largest banks and are for 1994; data for all other countries are based on the 6 largest banks and are for 1995 for Korea, Malaysia and the Philippines; and 1996 for Thailand. All other data are for 1994. Foreign and state-owned banks are defined as banks in which foreign and the state, respectively have a majority holding

Sources: Claessens and Glaessner (1999) for Market concentration data. Hawkins and Turner (1999) for foreign banks and state-owned banks. Kamin, Turner and Van 't dack (1998) for the share of bank assets in total assets.

Table 3

Sources of Financing for the Private Non-Financial Sector

(percent of total financing)

Country	**Commercial Banks**	**Other Financial Institutions**	**Foreign Sources**	**Other**
Korea	24.1	35.5	5.0	35.4
Malaysia	51.3	48.7	..	..
Thailand	84.1	..	7.5	1.0

Notes: Data are for 1996 for Korea and Malaysia, and 1995 for Thailand.

Source: Kamin, Turner and Van ‘t dack (1998).

Table 4

Coefficient of Variation of the Real Local Currency/ U.S. Dollar Exchange Rate (percent)

Currency	1993	1994	1995	1996	1997	1998
Indonesian rupiah	0.73	1.78	0.58	1.11	15.69	18.29
Korean won	0.60	0.96	1.97	2.86	15.04	9.36
Malaysian ringgit	0.81	3.89	1.89	0.86	15.48	4.67
Phillippine peso	4.49	4.08	2.53	1.13	13.71	6.72
Thai baht	0.69	1.18	0.84	0.59	16.24	10.34
German mark	2.58	4.51	2.93	2.40	2.90	3.77
Japanese yen	5.15	3.07	8.07	3.55	3.99	6.68

Notes: Based on monthly data. Producer prices are used to deflate the exchange rates except the 1997 data for the Malaysian ringgit where consumer prices are used.
Source: Exchange rate and price data are from the Internaitonal Monetary Fund, Internaitonal Financial Statistics.

Table 5

Correlations of changes in the local currency/U.S. dollar exchange rate with the baht/dollar exchange rate

	1993-1996	1997-1998
Indonesian rupiah	-0.141	0.625
	(.3408)	(.0011)
Korean won	0.456	0.562
	(.0011)	(.0043)
Malaysian ringgit	0.378	0.761
	(.0080)	(<.0001)
Phillippine peso	-0.254	0.833
	(.0814)	(.0814)
Thai baht	1.000	1.000

Notes: Based on monthly exchange rate changes. P-values in parentheses.

Figure 1

Foreign Bank Loans to East Asian Banks

(Index 1992=100)