BANKS, MATURITY MISMATCHES AND LIQUIDITY CRISES: A SIMPLE MODEL

by

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Abstract

In determining the maturity structure of bank loans in the presence of pre-determined short-term international liabilities, we show that maturity mismatches in banks' balance sheets are fully consistent with the assumption of banks acting as self-interested, optimising agents. Although often attributed to the moral hazard associated with safety nets, the analysis shows that financial crises can occur in their absence.

Key words: *banks, currency crisis, East Asia, maturity mismatches, moral hazard*

JEL Classification: *F34, F39, G21*

1. Introduction

For many years it has been recognised that maturity mismatches between liabilities and assets in balance sheets can lead to liquidity crises. Such mismatching has been presented as explaining a significant part of the crisis dynamic in East Asia in 1997-98. But it has often been contended that in this case it was the prospect of bailouts in one form or another that encouraged domestic banks to pay insufficient attention to the maturity and currency composition of their balance sheets, and international banks to underestimate the *ex-ante* risk premium. An increase in the liquidity preference of international lenders then exposed the vulnerabilities of domestic banks that resulted from the mismatching of their balance sheets. Consider, for instance, the following statement by an authoritative study on the East Asian crisis by the Bank for International Settlements (1998):

> A main cause of the crisis was the lack of prudence shown by banks in several countries…(B)anks that had developed under tight regulation failed to appreciate the extra precautions needed in the new liberalised environment where higher profits can normally be earned only by assuming greater risks and by pricing them accordingly….(G)overnment guarantees and encouragement doubtless played a part in this expansion. Some foreign banks may have believed that Asian banks enjoyed implicit guarantees for foreign borrowing from their governments (pp.118, 123-4).

The purpose of this note is modest and highly focused. It is to reconfirm that liquidity crises can occur in the absence of bail out provisions and can result simply from maturity mismatches that themselves reflect the outcome of self-interested optimising behaviour by commercial banks[1]. Although guarantees and deposit insurance may lead to moral hazard problems, their absence certainly does not ensure that mismatching will be avoided altogether. It is thus possible to attribute excessive strategic importance to moral hazard.

Furthermore, where the currency composition of assets and liabilities is different, exchange rate changes can create liquidity crises that did not seem likely at the initial set of

[1] This is in contrast to Diamond and Dybvig (1983) who model banks as maturity-transformers that pool the resources of the economy and, taking advantage of the law of large numbers, maximise the welfare of the representative member by providing them insurance against idiosyncratic shocks and channeling funds to illiquid but profitable domestic investment. Extending this framework to an open economy, Chang and Velasco (1998), Goldfajn and Valdes (1999) and others have argued that foreign asset-liability mismatches in the East Asian economies was an "inevitable" consequence of international financial intermediation.

exchange rates. The maturity mismatches accepted by the banks make them vulnerable to acute (international) liquidity risk, as available liquid foreign assets prove insufficient to meet short-term foreign liabilities. Failure to allow for a positive probability of devaluation may then retrospectively explain why *ex-ante* risk premia are too low. Moreover, the probability of exchange rate changes may increase over time. In the case of currency pegs, these are rarely abandoned in order to revalue the domestic currency, so that the actual probability is inevitably biased towards devaluation. Given government guarantees regarding maintenance of the peg, on the one hand, and the costs of hedging, on the other, there is little reason for domestic banks to hedge their foreign obligations[2]. This leads to large foreign exchange (forex) mismatches and consequent exchange rate risks, with a devaluation leading to an outright currency and financial collapse (Corbett and Vines, 1999)[3].

2. The Model

Before proceeding, we stress that no attempt is made here to develop a "full theory of the banking firm" (see Baltensperger, 1980 and Bhattacharya and Thakor, 1993); the aim is to design the model in a minimalist fashion.

For simplicity, assume there are two "types" of loans, viz. short-term loans with interest rate i^s and long-term loans with interest rate i^l. Assume further that $i^s < i^l$. This reflects the usual liquidity-return tradeoff, i.e. the greater the liquidity of an asset, the lower the risks. Under a pegged exchange rate regime, the expected currency depreciation in the short-term may generally be assumed to be less than that in the longer-term[4]. Assume, in addition, that

[2] This is due partly to the relatively under-developed foreign exchange (forex) markets in the East Asian region (Min and McDonald, 1999).

[3] Indeed, an important characteristic of financial crises in emerging economies is that it consisted of two distinct stages: an initial crisis-induced devaluation followed by a post devaluation financial and economic collapse. The post devaluation economic collapse in emerging economies appears incompatible with the conventional textbook view that devaluation would have expansionary effects because it increases the demand for tradables. For detailed discussions of some of these issues, see Bird and Rajan (2001b), Rajan (2001) and Rajan and Shen (2001).

[4] For concreteness, one may think of the Krugman (1979) model, in which the currency peg is sustained for some period of time (i.e. zero expected depreciation), but macroeconomic imbalances

the bulk of the lending is to domestic firms and is denominated in the local currency. Domestic banks therefore bear the forex risks. In the context of unhedged foreign borrowing, even if banks limit their foreign currency exposures by making foreign currency loans to domestic firms, this merely replaces forex risks with credit risks. Alternatively, some sort of country/currency risk premium may be assumed which increases over time.

Specifically,

$$i^s = i^{*s} + \varepsilon_s + rp_s < i^l = i^{*l} + \varepsilon_l + rp_l, \qquad (1)$$

where: i^{*s} and i^{*l} are the international interest rates on short-term and long-term loans; ε_s and ε_l are the expected long-term and short-term exchange rate depreciation rates respectively; rp_s and rp_l are the (domestic country/currency) risk premia on short-term and long-term loans respectively; and the risk-adjusted uncovered interest parity (UIP) is assumed to hold.

Assume that the liabilities of the banks (domestic deposits and foreign loans and deposits) are pre-determined and are all short-term in maturity[5]. Also assume that banks do not hold any excess reserves, capital or liquid assets (such as bonds or CDs). Given these assumptions, the sole focus of the banking firm in our model is on a rather restrictive form of asset management. This allows us to abstract from the other forms of bank management, including liability management, which is particularly popular among money center banks[6]. This abstraction has been fairly commonplace in the literature. As Baltensperger (1980) has noted:

> relatively little attention has been paid to the structure of the other side of the firm's balance sheet and the question of liability management. Total volume

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(viz. monetisation of the fiscal deficit) lead to positive expected depreciation and eventual breakdown of the currency peg.

[5] Under a fixed exchange rate system, demand deposits in domestic currencies ought also to be included as an international liability of the domestic banking system.

[6] For a textbook discussion of the principles of bank management, see Mishkin (2001). For a recent review of contemporary banking theory, see Bhattacharya and Thakor (1993). For a detailed recent discussion of the role of banks as liquidity providers, see Kashyap et al. (1999).

> as well as structure of liabilities usually is assumed to be exogenous and not subject to optimising behaviour. An argument often advanced in support of this assumption is that a bank does have no choice other than accepting all the deposits offered to it by the public at ruling deposit rates. Thus volume and structure of deposits are viewed as being totally demand-determined, and from the point of view of the bank, exogenous (p.96)[7].

In other words, in our model, while the quantity of loans is also pre-determined (by the usual banks' adding up constraint), the bank must decide on the maturity structure of their loans. With a short-term maturity structure of liabilities, the cost of providing long-term loans may be seen as the possibility of an international liquidity crisis. Banks may be unable to liquidate their assets rapidly enough to meet claims that are made against them. In the midst of a crisis, assume that the interest rate on long-term loans that are prematurely liquidated (i.e. "fire sale") falls to zero. Let the probability of such a crisis occurring be $\propto$[8].

The representative bank's choice variable is the share of short-term loans relative to total loans (ω). Assume that the bank's objective is to maximise the single period expected utility (U) of the owner/manager. To simplify the analysis, as well as to emphasise that the results are not generated by or attributable to risk aversion, we assume that banks are risk neutral. The objective function of a representative bank may be written as follows:

$$\text{Max } EU = (1 - \propto)EU(A) + \propto EU(Y), \qquad (2)$$

where: $Y = \omega i^s$ and $A = Y + (1 - \omega)i^l$ and $EU'(.) > 0$.

One would expect the probability of an adverse shock to a bank's portfolio ($\propto$) to be directly related to the extent of vulnerability ($1 - \omega$). In other words, it is not a shock per se

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[7] More generally, the assumption of highly limited risk management is not untenable in the case of the East Asian crisis. As the BIS (1998) has noted:

> (T)he foreign transactions of domestic banks – long regulated – were often liberalised before bank managers had acquired the proper skills for managing foreign exchange risks or before the supervisory framework had been strengthened to monitor risks effectively" (pp.123-4).

For international banks, the shortcomings of risk management relate to the absence of adequate *ex-ante* risk premia. In the event of a maxi-devaluation and even in the absence of a maturity mismatch, banks would become unable to pay back foreign depositors and creditors since the forex value of domestic liquid assets would be less than deposits.

[8] While this model assumes that banking crises could arise due to random events ("bad news or "sunspots"), there is a class of "fundamentals-based" models of bank runs (see Agenor and Aizenman, 2000).

that matters, but the extent to which that shock affects the bank's balance sheet. In order to be more precise, assume that:

$$\propto = g(\omega), \tag{3}$$

where: $g'(.) < 0$, $g(0) = 1$, $g(1) = 0$. Substituting eq. (3) into eq. (2) and differentiating with respect to (w.r.t.) ω, yields:

$$-g'(.)EU(A) + (1 - g(.))EU'(A)(i^s - i^l) + g'(.)EU(Y) + g(.)EU'(Y)i^s. \tag{4}$$

Solving the first order condition (f.o.c.) obtains:

$$g(.) = \{EU'(A)(i^l - i^s) + g'(.)[EU(A) - EU(Y)]\}/[EU'(A)(i^l - i^s) + EU'(Y)i^s]. \tag{5}$$

Assume that $EU''(.) < 0$ and, for simplicity, that $g(.)$ is linear, i.e., $g''(.) = 0$. Totally differentiating eq. (4) w.r.t. ω implies:

$$-2g'(.)EU'(A)(i^s - i^l) + 2g'(.)EU'(Y)i^s + (1 - g(.))EU''(A)(i^s - i^l))^2] < 0. \tag{6},$$

i.e., the second order condition (s.o.c.) for utility maximisation is automatically satisfied. Note that while the denominator of eq. (5) is unambiguously positive, the numerator cannot be signed a priori.

More insight might be obtained by assuming a specific functional form. The simplest case, for illustrative purposes, would be to assume a linear relationship between $g(.)$ and ω as follows:

$$g(.) = 1 - \omega. \tag{7}$$

Substituting eq. (7) into eq. (5) then derives:

$$\omega = \{EU'(Y)i^s + EU(A) - EU(Y)\}/\{EU'(A)(i^l - i^s) + EU'(Y)i^s \quad (8)$$

$$\text{If } \omega < 1, \quad (i^l - i^s) > [EU(A) - EU(Y)]/EU'(A). \quad (9)$$

$$\text{If } \omega > 0, \quad i^s > [EU(Y) - EU(A)]/EU'(Y) \quad (10)$$

Thus, as long as eq. (9) is satisfied the share of long-term loans to total loans (1- ω), is non-zero. If eq. (10) is simultaneously satisfied then there is an optimal (non-zero) mix of short and long-term loans that an optimising bank would choose to hold[9].

3. Concluding Observations

In seeking to explain the East Asian financial crisis, much has been made in the literature of implicit safety nets and the excessive credibility of exchange rate pegging. These served to reduce, to an inappropriate degree, the risks of lending, as perceived by international creditors. It is often suggested that domestic banks were in turn enticed to engage in maturity transformation to an imprudent degree because they believed that in the event of a liquidity crisis, associated with the withdrawal of short-term funds, they would be bailed out.

The model presented in this note carries a simple message. While it may be true that underestimation of risks contributed to the East Asia crisis, maturity transformation by banks *does not* rely on implicit safety nets. It may simply be explained as the outcome of decisions made by domestic banks acting as self-interested optimising agents. The implication is that while the potential moral hazard problems associated with government guarantees, weak bankruptcy laws, and deposit insurance may be important, their eradication does not entirely eliminate the chances of liquidity crises. With any degree of maturity mismatch, banks will be vulnerable to changes in liquidity preference; any resulting scramble for liquidity exposes this vulnerability. In this event, the underlying strength of balance sheets may matter less than the

[9] While this model focuses on the difference between short and long-term interest rates in an environment of credible pegged exchange rates, differences between domestic and international short-term interest rates may also be important. For a discussion of this and a broader discussion of the East Asian crisis and the role of banks, see Bird and Rajan (2001a).

liquidity of assets. In the absence of reliable *ex-ante* ways of predicting shifts in liquidity preference, the task of determining the optimal degree of maturity transformation becomes daunting indeed.

References

Agenor, P. and J. Aizenman (2000). "Costly Intermediation and Fundamentals-Based Bank Runs", mimeo (June).

Baltensperger, E. (1980). "Alternative Approaches to the Theory of the Banking Firm", *Journal of Monetary Economics*, 6, pp.1-37.

Bank for International Settlements (BIS) (1998). *68th Annual Report*, Basle: BIS.

Bhattacharya, S. and A. Thakor (1993). "Contemporary Banking Theory", *Journal of Financial Intermediation*, 3, pp.2-50.

Bird, G. and R. Rajan (2001a). "Banks. Financial Liberalisation and Financial Crises in Emerging Economies", *The World Economy*, 24, pp.889-910.

Bird, G. and R. Rajan (2001b). "Recovery or Recession? Post-Devaluation Output Collapse: The Thai Experience", *CIES Discussion Paper No.00/42*, Centre for International Economic Studies, University of Adelaide (November).

Chang, R. and A. Velasco (1998). "The Asian Liquidity Crisis", *Working Paper 6796*, NBER (November).

Corbett, J. and D. Vines (1999). "The Asian Currency and Financial Crises: Lessons from Vulnerability, Crisis, and Collapse", *The World Economy*, 22, pp.155-77.

Diamond, P. and P. Dybvig (1983). "Bank Runs, Deposit Insurance, and Liquidity", *Journal of Political Economy*, 91, pp.401-19.

Goldfajn, I. and R. Valdes (1999). "Liquidity Crises and the International Financial Architecture", mimeo (February).

Khasyap, A., R. Rajan and J. Stein (1999). "Banks as Liquidity Providers: An Explanation for the Co-existence of Lending and Deposit-Taking", *Working Paper No.6962*, NBER (February).

Krugman, P. (1979). "A Model of Balance of Payments Crises", *Journal of Money, Credit and Banking*, 11, pp.311-28.

Min, H. and J. McDonald (1999). "Does a Thin Foreign-Exchange Market Lead to Destabilizing Capital-Market Speculations in the Asian Crisis Countries?", *Policy Research Working Paper No.2056*, World Bank (February).

Mishkin, F. (2001). *The Economics of Money, Banking, and Financial Markets*, Addison Wesley (sixth edition).

Rajan, R. (2001). "(Ir)relevance of Currency Crisis Theory to the Devaluation and Collapse of the Thai Baht", *Princeton Study in International Economics*, International Economics Section, Princeton University (February).

Rajan, R. and C.H. Shen (2001). "Are Crisis-Induced Devaluations Contractionary?", *Working Paper No.5*, Visiting Researchers Series, Institute of Southeast Asian Studies, Singapore (November).