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Banking Sector Fragility and Systemic Sources of Fragility

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Abstract

A theoretical framework to assess the degree of fragility or, inversely, the soundness of the banking system is proposed. It is argued that, while a bank may be either solvent or insolvent at any given time, its degree of fragility must be a forward-looking measure based on the probability that it can withstand a destabilizing shock. Externalities are particularly important because they can constitute a serious source of systemic risk. The factors that determine banks' soundness can be separated into bank-specific and those common to all banks (subject to microprudential and macroprudential considerations, respectively). The interconnection between banking crises and currency crises (in both directions) is also discussed.

JEL Classification: D81, D82, F31, G21

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Contents

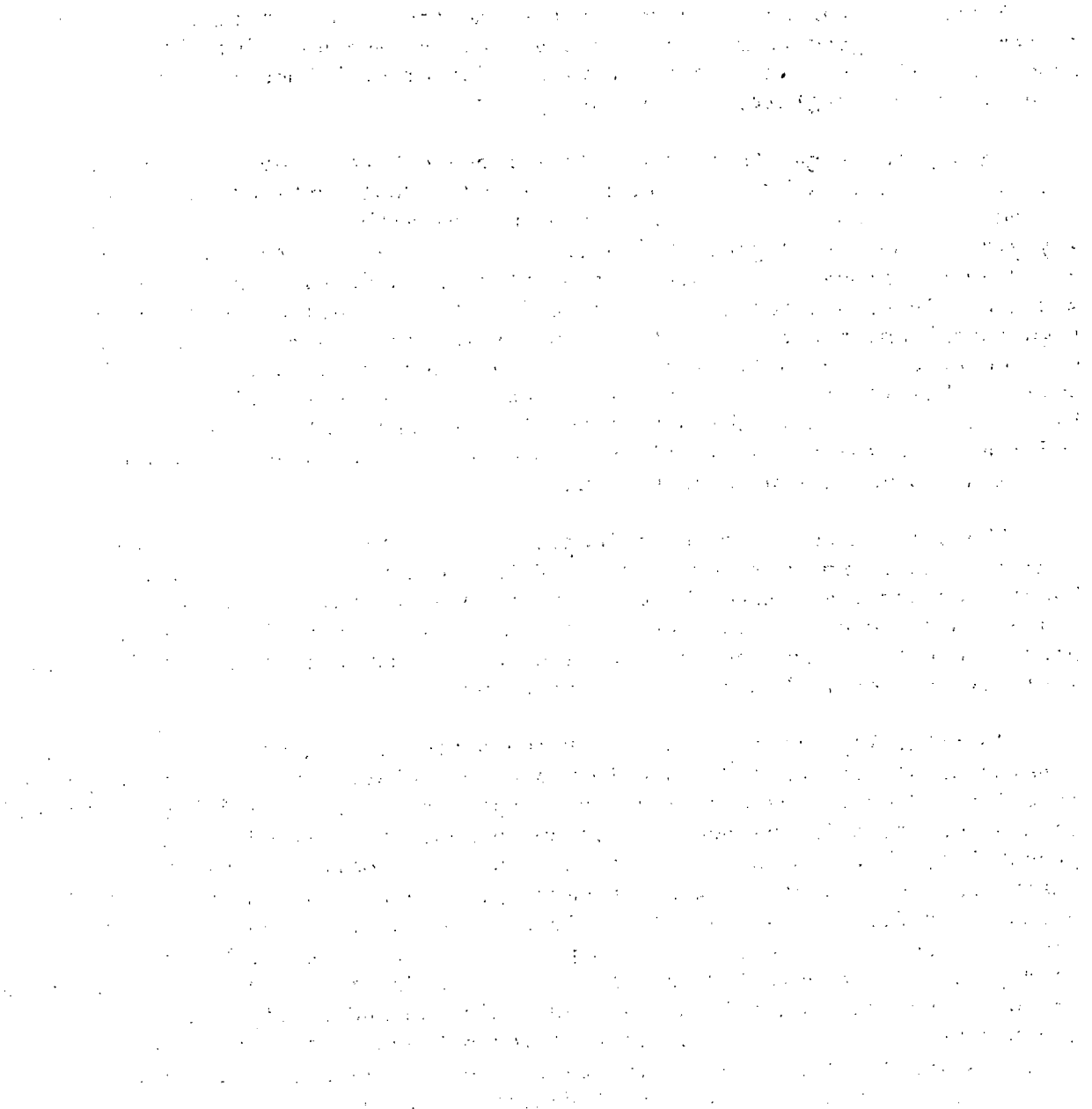
Summary

Recently interest has grown in the implications of fragile banking systems with regard to monetary policy, capital account liberalization, and Fund surveillance. In this connection a fundamental question is what determines the fragility of banking systems.

This paper suggests a theoretical framework to assess the degree of fragility or inversely the soundness of individual banks and banking systems. It argues that, while a bank may be either solvent or insolvent at any given time, its degree of fragility must be a forward-looking measure based on the probability that it can withstand a destabilizing shock. The model distinguishes between bank-specific shocks (subject to microprudential regulation) and those common to all banks (subject to macroprudential considerations), as well as between market risk and credit risk, and analyzes how (implicit or explicit) deposit guarantees influence depositors' behavior. The case in which individual banks face externalities (e.g., information asymmetries) is given special attention because these can constitute a major source of systemic risk.

The paper also attempts to identify a possible connection between banking crises and currency crises. While currency crises leading to banking crises are a more obvious direction of causality (an unexpected change in the exchange rate can constitute a macroeconomic shock affecting banks), banking crises could also lead to currency crises and, indeed, the whole process could become self-reinforcing.

Specifically, it is argued that the perceived higher probability that a banking crisis may unfold would increase the relative risk of holding bank deposits. Even in the case where all deposits are de jure fully guaranteed, if the resources in the deposit guarantee fund are limited and the probability that many banks may fail is high, depositors would withdraw their (insured) deposits from the banks perceived to be unsound. To the extent that depositors have little information about which banks may be in trouble, they may withdraw their deposits from the overall banking system. If depositors can hold foreign assets, the funds withdrawn from banks would be converted into domestic currency-denominated and foreign currency-denominated cash. The cross-elasticities between these assets could be such that a significant portion of the deposit withdrawals can be directed into foreign currency at the expense of domestic currency.



"Much as the study of disease is one of the most effective ways to learn about human biology, the study of financial crises provides one of the most revealing perspectives on the functioning of monetary economies. Indeed, epidemiological metaphors like fever and contagion feature prominently in the literature of financial crises. Financial crises, like contagious disease, threaten not only the host organism, namely the financial market, but the entire economic environment in which that host resides."

(Eichengreen and Portes (1992), p. 193)

I. Introduction

The topic of financial crises has been the focus of significant attention in economics for quite some time. There exists, accordingly, a voluminous literature concerned with episodes labelled financial and/or banking crises. 1/ Although most of the literature focusses on analyzing events that occurred prior to the 1930s and largely in the United States, recent work has also examined financial crises which have occurred more recently in several other countries. 2/

The increased attention which has been recently devoted to analyzing financial crises has partly surfaced as a result of growing interest to examine the implications for monetary policy of financial systems whose institutions may be unsound. 3/ As well, against a background of increased globalization of capital markets and greater mobility of capital flows across countries, there have been growing concerns over whether liberalization of the capital account should be undertaken only gradually in economies whose banking sectors are fragile. 4/ In this connection, a

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1/ See, for example, Kindleberger (1978) for a comprehensive survey.

2/ For example, Sundararajan and Baliño (1991), and Rojas-Suárez and Weisbrod (1995) examine financial crises in a number of developing countries since the 1980s. As well, the financial crises in Finland, Norway and Sweden, during the late 1980s and early 1990s, are examined in Goldstein, Folkerts-Landau et al. (1993), and in Drees and Pazarbasioglu (1995).

3/ See, for example, Mathieson and Haas (1994) and Garcia and Dziobek (1994).

4/ Indeed, the Interim Committee of the Board of Governors of the Fund, in its 1995 Biennial Surveillance Review, stressed, inter alia, the importance of paying "... more attention to members' financial policies, and *the soundness of their financial sectors*, in [the Fund's] surveillance activities" (see International Monetary Fund (1995a)). This objective was further reiterated by the Interim Committee in its 1995 Annual Meetings: "[t]he Committee encouraged the Fund, in promoting liberalization in a global market setting, to pay increased attention to capital account issues and *the soundness of financial systems*" (see International Monetary Fund (1995b)).

fundamental question is how to gauge the degree of soundness, or fragility, of the banking sector. 1/

While the literature on early-warning systems of bank failure has mainly relied on bank-specific variables (usually banks' financial ratios or equity market data) for clues about the soundness of individual banks, 2/ analyses on the role that macroeconomic factors--affecting all banks--can play in determining the soundness of individual banks have been generally lacking. 3/ If anything, the analysis of macroeconomic factors has been essentially the domain of the literature on banking (and financial) crises. 4/ Moreover, the linkage between early-warning systems of individual bank failure and banking crises is virtually nonexistent.

This paper attempts to provide a link between individual banks' fragility and that of the banking system. It is argued that, while a bank may be either solvent or insolvent at any given time, its degree of soundness/fragility must be a forward-looking measure based on the probability that it can withstand an unforeseen destabilizing shock (i.e., the probability that the bank(s) will remain solvent following a shock). Specifically, the probability of bank failure is modeled as a function of certain stochastic variables--some of which affect particular individual bank(s) and some which impact all banks. The variables affecting individual

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1/ Policymakers are, of course, particularly interested in assessing the soundness of the whole financial system, and not only that of banks. If the banks' presence is small relative to the non-bank financial intermediaries, focussing solely on the banking sector could clearly represent a serious shortcoming for the purpose of assessing the vulnerability of the entire financial sector. However, banks still play a prominent role in the financial systems of most countries. Even in cases where financial systems are based on universal banking or holding company structures, the financial health of the banking sector would be generally representative of that of the financial system at large as long as banks are the central institutions within the financial conglomerates. This paper focuses on the banking sector only and no attempt is made to extend this analysis to the case of a full-fledged financial crisis, except to the extent that a banking crisis may be representative of a more generalized financial crisis.

2/ For example, see Sinkey (1975, 1977, 1979), Martin (1977), and Lane, Looney and Wansley (1986), among others.

3/ Although some of the empirical early-warning models of bank failure (e.g., Whalen (1991)) have included, in addition to banks' financial ratios, certain macroeconomic variables in the analysis (e.g., the unemployment rate, personal income data, activity in real estate construction, etc.), the rationale for introducing such variables is usually not specified in a formal framework.

4/ Analyses of banking/financial crises based on macroeconomic variables include Gorton (1988), Minsky (1977), Mishkin (1994), and Canova (1994), among others.

banks are associated with certain decision parameters characteristic of specific banks--conditioned by the management's decisionmaking process and regulatory guidelines (e.g., the composition and diversification of the bank's portfolio, the optimal level of capitalization, the bank's risk control management system, etc.)--that make certain banks particularly vulnerable to specific types of shocks. Thus, a distinction is made between the factors that may be bank-specific (and subject to microprudential regulation) and those that may affect all banks (subject to macroprudential considerations).

These concepts are extended to the aggregate banking sector. In particular, the probability that a banking crisis may unfold is examined under various scenarios. Of especial interest is the case where individual banks can face externalities. Thus, shocks directly affecting specific banks can have indirect spill-over effects on other banks initially unaffected by the shock. This "contagion" process could have a material impact on banks which would be otherwise fundamentally sound, possibly resulting in this group of banks also failing due to contagion effects--hence, potentially leading to systemic bank failures.

The paper also attempts to identify the connection that may exist between banking crises and currency crises (in both directions). While currency crises leading to banking crises is a more obvious direction of causality, the opposite direction has been long suspected but seldom explored. 1/ The theoretical model presented here is intended to be followed by future empirical analysis.

The paper is structured as follows. Section II discusses the concepts of bank fragility or soundness, bank "failure," and systemic banking sector fragility. Section III presents a formal model to address the factors that may determine the degree of fragility of individual banks. The model makes a distinction between bank-specific shocks and those common to all banks, between market risk and credit risk, and analyzes the role that (implicit or explicit) deposit guarantees play in influencing depositors' behavior. Section IV extends these concepts to the banking sector, focussing on the

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1/ The connection between banking crises and currency crises has been perceived to have materialized in a number of episodes of banking crises (see, for example, Sundararajan and Baliño (1991), and Baer and Klingebiel (1994)). However, a formal theoretical link between the large body of literature dealing with banking crises and that dealing with currency crises has been rarely addressed. Among the seemingly few studies that have linked banking crises to currency crises are Gruben and Welch (1993) and Rogers (1995) where the focus is on a currency-substitution type of demand for money and the level of nonperforming loans of the overall banking system constitutes one of the explanatory variables in the demand for money function. As well, Kaminsky and Reinhart (1995) look at some macroeconomic stylized facts for clues about links between banking crises and currency crises in several countries.

factors that may determine the degree of fragility of the banking system. In particular, the role that information asymmetries can play as a source of systemic risk is examined; indeed, panic deposit runs could result from depositors having less than complete information about the relative health of different banks. Section V introduces foreign currency assets in the analysis. It is argued that currency crises could lead to banking crises, but that the reverse direction of effects could also occur and that, indeed, this may become a self-reinforcing process. Finally, Section VI provides some concluding remarks and directions for empirical research.

II. Taxonomy of Bank Fragility/Soundness

1. Defining banks' fragility/soundness

Banks fail primarily because they take risks and subsequent events (or shocks) sometimes turn out to be worse than expected. 1/ Risk-taking is, however, intrinsic to banking. The degree of a bank's financial soundness (or, inversely, its degree of financial fragility) requires evaluating its ability to withstand shocks. Banks with a fragile financial position (e.g., as a result of poor asset quality, excessive vulnerability to a particular class of risks, or a significant duration/yield mismatch of assets and liabilities) risk failing if subject to a destabilizing shock, even though they were seemingly solvent prior to the shock. 2/ *Ex post*, after a shock has occurred, a bank can only be solvent or insolvent (i.e., its net worth is either ≥ 0 or < 0). However, even this conceptually clear separation of alternative states can be difficult to determine in practice because of the difficulty in valuing banks' nonmarketable assets. Before the occurrence of a shock, however, a bank's degree of soundness can only be assessed in a probabilistic form: the more fragile the bank, the higher its probability of falling into insolvency if subject to a destabilizing shock. Indeed, adverse shocks often reveal (*ex post*) the actual degree of fragility of a bank.

Adverse shocks affecting banks can take a number of forms, either at the institution-specific level or at the macroeconomic level. These

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1/ Banks also fail, of course, as a result of misconduct and other improper business practices (e.g., fraud and self-dealing). These causes of bank failure are not dealt with in this paper because they largely result from weak banking supervision and regulatory practices.

2/ Sparve (forthcoming), for example, notes that banking supervision has traditionally consisted "mainly of review mirror control"--based on reviewing the banks' activities during the last financial year, quarter or month, and comparing them to applicable laws and regulations. He argues that banking supervision should emphasize the economic and operational risks in the financial system and be less focused on the formal legal aspects. Understanding the functioning of the markets, the balances of the institutions, and the macroeconomic prospects should be given priority.

include, for example: unanticipated changes in the level of interest rates, in the yield curve, the exchange rate (in the face of uncovered positions), or the inflation rate; an unexpected change in the country's terms-of-trade; structural changes in the financial system (for example, resulting from financial reform); structural changes affecting public sector enterprises, particularly in former centrally-planned economies (since they are typically the principal creditors of banks in those countries); 1/ the burst of a speculative asset "bubble;" an unexpected change in the price of an asset or class of loans; a sharp contraction in the level of liquidity of the financial system; and certain type of externalities that could impact on otherwise sound banks (including, for example, the "contagious" loss of confidence in the overall financial system, and spill-over effects through the payments system or open derivatives positions). 2/

Because of some of the characteristics intrinsic to banking, widespread failures constitute an especially threatening risk to the overall financial system and the economy at large. In particular, banks are highly leveraged (total liabilities are considerably larger than the value of the institution's own capital) and depend critically on maintaining the confidence of depositors. While a bank's assets are usually relatively illiquid and have a longer-term maturity, and at any given time are redeemable at the (usually unknown *ex ante*) prevailing market value, a significant part of a bank's liabilities are in the form of deposits payable *at par* at the option of the depositors (who essentially hold American put options payable at par). Thus, a loss of public confidence could lead to sudden large withdrawals of deposits from banks, possibly resulting in extensive liquidity problems. Acute liquidity problems, in turn, could potentially lead to widespread solvency problems if banks are forced to liquidate their assets at a significant loss. These effects, of course, would have grave consequences to borrowers, lenders and the economy at large.

1/ Baer and Klingebiel (1994), for example, argue that Estonia's banking crisis during 1992/1993 was partly caused by the severe adverse shocks experienced by the public enterprises.

2/ The role of depositors' expectations as a mechanism for contagion has been addressed by a large body of the literature, including the so-called asymmetric information literature (on which this paper relies substantially). An excellent survey of the expectations literature is provided in Calomiris and Gorton (1991). Concerns over systemic risk derived from derivatives open positions have been expressed by a number of observers (e.g., Bank for International Settlements (1992), and Farrant (1992)), especially because of the high degree of leverage in this type of transactions--however, no formal work appears to have been delivered on this issue.

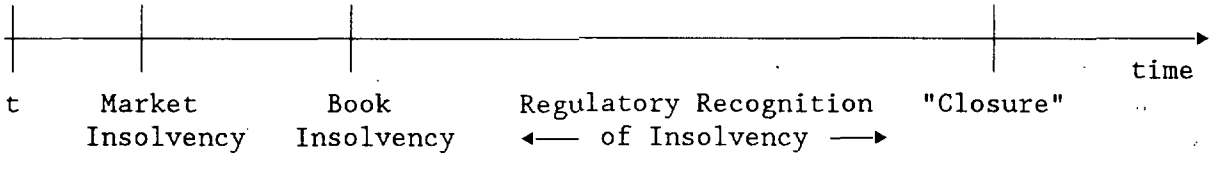
2. What constitutes bank "failure"?

A discussion on banks' soundness or, inversely, their degree of fragility (and, specifically, their probability of "failure"), should be explicit about what is understood to constitute bank "failure." In particular, economic failure and the regulators' recognition of bank failure do not typically occur at the same time. Economic failure, or market insolvency, occurs when a bank's net worth becomes negative, or if it is unable to continue its operations without incurring losses that would immediately result in a negative net worth.

On the other hand, official failure (typically the observable event) occurs when bank regulators recognize that an institution is no longer viable and it is either closed or receives assistance in order to remain open. In a broad sense, bank "closure" can be said to occur when the regulators recognize that a bank is insolvent and either decide to liquidate it, or assist it in a variety of forms so that it can remain in business. These forms of assistance include: merger or acquisition of the ailing bank; direct injections of additional capital or other recapitalization schemes; and different restructuring schemes engineered in order to keep a bank open (e.g., change in management, assisted generalized rescheduling of loan maturities, removal of banks' bad loans, etc.).

In practice, it is difficult to know precisely when a bank becomes economically insolvent--especially in the absence of accurate estimates on the market value of banks' assets. In particular, there can be important discrepancies between the market-value and book-value of a bank's assets. Book values are recorded in terms of acquisition costs but, as market prices change, these costs tend to depart from market values.

Chart 1. Bank "Failure"



Furthermore, the lags between (market and book) insolvency and closure may vary over time and across different types of institutions. For example, "too large to fail" considerations may influence regulators to postpone the closing of larger institutions, making the period between insolvency and closure longer than it would be the case for smaller banks. Similarly, faced with a large number of insolvencies occurring within a relatively

short period of time, regulators may be less willing or able to close additional banks. 1/

Economic failure of a firm occurs when it becomes insolvent--that is, when the firm's net worth becomes negative or, equivalently, when the net present value of its assets falls short of the net present value of its liabilities. However, it is often difficult to judge in practice whether a bank is facing a problem of liquidity or one of insolvency. A bank may be liquid but insolvent; illiquid and insolvent; or illiquid but solvent--while a severe liquidity problem could result in insolvency. Thus, for example, if many of the debt holders of a given bank decided all at once to exercise the option to redeem their deposit contracts (payable at par), the bank may face a liquidity problem if it has insufficient cash of its own, if it is unable to borrow additional funds (from capital markets, other banks or the central bank) to meet the cash outflow, or if its assets cannot be readily cashed-in (e.g., if it is unable to recall some of its loans or if it cannot readily sell some of its assets). Such bank would be facing a temporary problem of illiquidity, provided that the net present value of its assets remains at least equivalent to that of its liabilities. A severe liquidity problem, however, could lead to a problem of insolvency if the bank is forced to hold a "fire sale" of its assets and market conditions are such that this results in significant downward pressure on the overall price of its assets. This could result from the market for those assets not being sufficiently deep, or if other banks in an analogous situation are also in the process of selling large volumes of similar assets.

3. Defining systemic banking sector fragility/soundness

The term "systemic" has been used in the literature to denote at least two different concepts. On the one hand, the term "systemic" often refers to an event having effects on the functioning of the entire banking, financial, or economic system--rather than just a few institutions. 2/ On the other hand, others have conveyed the term "systemic" to denote an event which entails costs to otherwise unrelated third parties. Thus, under the latter definition, a systemic event would create a type of externality whereby one firm's failure can induce failures elsewhere. As noted by Bartholomew, Mote and Whalen (1995), however fuzzy the definition of systemic risk, there seems to be broad agreement that it involves potential

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1/ Regulators may face significant constraints (e.g., imperfect information, and legal or political considerations) limiting their ability or readiness to close insolvent banks promptly. An important strand of the literature has centered on modelling the regulators' decision function of closing a bank (see, for example, Thomson (1992)).

2/ Increasing linkages between financial institutions (e.g., bank and nonbanks), among markets (e.g., spot and derivatives securities), and across countries (i.e., financial integration), and the remarkable development of new and more efficient means of communication and technology, can also serve to magnify the repercussions of a particular disturbance.

adverse effects on the financial system or the economy that go well beyond the failure of one or a few banks.

In this paper, systemic risk is reserved to denote a situation whereby certain types of externalities can entail costs to otherwise unrelated parties. Hence, systemic risk is assumed to embody some sort of contagion or spill-over effect.

To further clarify the concepts used in this paper, banking crises are not necessarily synonymous to systemic banking failures. A banking crisis is said to occur when a sufficient number of banks (weighed by their share in total deposits/assets) fail within a given period, and that proportion of banks is equal to or greater than a particular threshold that serves as a boundary of what may constitute a "crisis proportion." Systemic risk in the banking sector refers to the spill-over effects that an original shock can have in the system, hence magnifying the initial impact. Thus, there can be a banking crisis, even if there are no spill-over effects from one bank to another (systemic risk, in this definition). At the same time, an externality causing important spill-over effects from one bank to another would serve to increase, per se, the probability of a banking crisis developing. Thus, it may be the case that, in the absence of externalities, the probability of a banking crisis unfolding may be quite low, but in the presence of externalities it could be high. These concepts are addressed formally in the model discussed below.

III. Individual Banks' Fragility/Soundness

The theoretical framework proposed below builds on Baltensperger's (1980) survey piece on the behavior of the banking firm, and the banking crises models suggested in Batchelor (1992) and Ho and Saunders (1980). In particular, this framework relies importantly on the view that informational asymmetries play a fundamental role in the contagion effects that may render banks that are otherwise fundamentally sound to fail--a source of systemic risk in the banking system.

The model presented here builds on those studies in various respects. First, it introduces the role of the effective, or credible, level of (implicit or explicit) deposit guarantees in influencing depositors' behavior. Second, the model makes a distinction between the shocks that may be specific to certain banks (i.e., banks' management determine certain parameters which make some banks vulnerable to a particular type of shock) and those affecting all banks (i.e., factor risks common across the portfolios of various depository institutions that are beyond the direct

control of the bank) which condition the probability of bank failure. 1/ Finally, the model proposed here introduces foreign currency assets in the analysis.

Consider first a simple economy where (home currency) deposits and cash are the only two assets held by individuals. At any given time, risk-neutral deposit-taking institutions ("banks") face the decision of investing the deposits received (from individuals and other banks) 2/ and their capital liabilities (D and K, respectively) in a portfolio consisting of reserves (R) and risky earning assets (A). For simplicity, it is assumed that banks' reserves are all in the form of currency and that no interest is being paid on them. 3/ Risky earning assets include loans and other type of investments, and the risk embodied in those assets include default (or credit) risk and market risk. 4/ As depicted in Chart 2, these variables are components of a bank's balance sheet and represent stocks.

Chart 2: Bank's Balance Sheet

Assets	Liabilities
Reserves (R)	Deposits (D)
Risky earning assets (A)	Capital (K)

1/ The former type of risk is sometimes referred to as "idiosyncratic risk", while the latter as "systematic risk" (see, for example, Bartholomew, Mote and Whalen (1995), Nagarajan and Sealey (1993), and Grenadier and Hall (1995)).

2/ For simplicity, no explicit distinction is made at this stage between deposits from the public and those from other banks. Later in the analysis this differentiation can become particularly relevant if these two types of depositors have access to different types of information sets.

3/ In practice, however, banks typically also include holdings of interest-bearing securities in their reserves.

4/ Credit risk is the risk that the borrower may not be able (or willing) to honor its loan commitments to the bank. Market risk refers to the risk that the value of a portfolio may change as a result of price (or yield) changes in the market. In general, market risk includes interest rate risk, exchange rate risk, shifts in the term structure of interest rates, and other factors affecting cyclical movements in the economy. For example, in the case of a portfolio that includes derivatives securities (though off-balance sheet items), market risk is a function of certain specific risks, including: volatility risk (exposure to a change in the volatility of the price of the underlying instrument); absolute price or rate risk (exposure to a change in the price or return of the underlying instrument); and market liquidity risk (risk that a large transaction in a particular instrument could result in a sharp move in the price of the instrument). (See González-Hermosillo (1994), for example, for a discussion of the market risks for derivatives securities.)

Let the bank's net deposit inflows during a given period of time be denoted by X (i.e., $X < 0$ if net deposit outflows), and the bank's net asset income (net of expenses) during the same period be Y. At each decision period, management is assumed to have knowledge about the stock values of the bank's balance sheet items at the beginning of that period, but it has uncertainty about the values that the flows X and Y may take during the interval of time until the next decision period arrives.

An institution is solvent as long as it is able to meet all of its debt obligations out of its own income over the long run. Hence, it becomes economically insolvent when the present value of its net stream of cash flows is negative or, equivalently, when its net worth is negative. Because measuring economic solvency requires information about the stream of cash flows under every possible circumstance, estimating economic solvency based on net present values is an extremely complex exercise. An alternative approach is to use the market value of the institution (or its underlying assets) as a proxy for its net present value. Insolvency would occur, therefore, whenever the market value of the institution's non-ownership liabilities exceeds the market value of its assets, or when the market value of its enterprise-contributed equity becomes negative (Demirgüc-Kunt (1991)).

Thus, it is assumed that the market values of the various stock components of a bank's balance sheet are known at the beginning of the period, but the market values of the flows X and Y during the time interval through the end of the period are only known in a probabilistic form at the beginning of the period. Assuming that market values reflect discounted net present values, a bank would fall into (economic) insolvency at the end of the period if the beginning-of-period market value of its total assets plus their accrued net income through that period is less than the payments due to the outstanding depositors at the end of the period; that is

$$R + A + Y < D + X$$

or

$$(X - Y) - (A + R - D) > 0$$

$$(X - Y) - K > 0$$

Normalizing for size, by dividing through by the level of deposits D, (such that x = X/D, y = Y/D, k = K/D), a bank becomes insolvent if

$$(x - y) - k > 0$$

or if

$$z < 0$$

where

$$z \equiv k + y - x$$

The probability (at the beginning of the period) that bank i would fall into insolvency (at the end of the period) can be therefore denoted as

$$F_{z_i} = Prob\ (z_i < 0) = Prob\ (k + y - x < 0)$$

or, more generally,

$$F_{z_i} = F\ (x, y, k)$$

The decision variable from the bank's perspective is k since deposit withdrawals and net asset income (at the beginning-of-period) are known *a priori* in a probabilistic form only.

A priori, whether a bank will remain solvent after being subject to a shock (which, as discussed below, is assumed to affect x and/or y) is only known in probabilistic form. Before examining what may determine the stochastic variables in the model, we turn now to the factors influencing the bank's optimal level of capital.

1. Choice of capital level

In general, insolvency can be viewed as a costly affair for the bank and thus an event which the institution would try to avoid. In particular, insolvency may force the bank into costly portfolio rearrangements and could severely disrupt its regular activities as a result of a loss of confidence by the public or because it may be suspended by the supervising authorities.

As suggested in Baltensperger (1980), the costs of insolvency can be assumed to be proportional to the size of the capital deficiency, with the cost per dollar of deficiency being equal to a parameter q. 1/ The expected cost of insolvency S, such that $[x - (k + y)] > 0$, can be expressed as

$$S = \int_{-\infty}^{\infty} \int_{-\infty}^{-(y+k)} q\,[x - (y + k)]\, f(x)\, g(y)\, dx\, dy$$

The bank's decision regarding its optimal level of capitalization, thus, involves the balancing of the overall expected costs of insolvency S, against the opportunity cost of raising equity capital vis-à-vis deposits. Let ρ be the cost of raising additional equity and i_d the interest rate paid by the bank on deposits, and assume that $\rho > i_d$. 2/3/ The marginal opportunity cost of increasing capital is $(\rho - i_d)$ and optimality would require that

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1/ Insolvency costs would include those derived from legal charges, the reorganization of the bank's portfolio if its capital position fell below some critical level, penalties for noncompliance with regulatory guidelines, etc.

2/ The interest rate offered by the bank on deposits is assumed to be determined by management. However, to a certain extent at least, i_d must be a function of the "market" rate of return i_m which, as discussed later, is assumed to be stochastic and exogenous. In practice, nevertheless, banks usually have some room of manoeuvre to offer a slightly lower interest rate on loans or a higher rate on deposits than those in the market--reflecting, for example, the relative efficiency of the bank or the desire to gain market share. The difference between i_d and i_m would generally reflect the degree of competition in the financial system; the more competitive financial markets are, the closer i_d would approximate the "market" rate of return i_m. Thus, in general, $i_d = f(i_m, \eta)$ where η is assumed to capture the factors that may allow i_d to differ from i_m.

3/ While ρ is assumed to be exogenous in this set-up, if capital markets are efficient then ρ will be a function of the estimated market value of the net worth of the bank--or, equivalently, its perceived degree of soundness.

$$\rho - i_d = q \int_{-\infty}^{\infty} \int_{-\infty}^{-(y+k)} f(x)\, g(y)\, dx\, dy$$

Therefore, the optimal demand for equity capital k^* would be determined by a vector α encompassing certain cost parameters (ρ, i_d, q), and by the stochastic variables x and y. 1/ In general,

$$k = k(\alpha, x, y)$$

2. Net deposit flows

Depositors' behavior regarding their desired flows of deposits into, or out of, the bank(s) where their deposits are held can be viewed as a function

$$x = x\,(\,u\,,\,(\,\hat{F}_{z_i}\,|\,\hat{\gamma}^*, \Omega\,)\,)$$

$$\text{such that } \frac{\partial x}{\partial \hat{F}_{z_i}}\,|\,\Omega \rightarrow 0 \quad \text{if} \quad \hat{\gamma}^* \rightarrow 1$$

$$\forall \quad 0 \leq \gamma^* \leq 1$$

where u refers to the depositors' exogenous and stochastic needs for bank deposit transactions (e.g., reflecting liquidity needs, payments

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1/ Here, k is modelled as a parameter chosen by bank management (versus one determined by regulators). In fact, many banks choose, in practice, to hold capital levels beyond the regulatory minimum capital level. And, indeed, this would be the general process under the new approach agreed to by the Basle Committee on April 12, 1995, whereby banks are to be allowed to participate in the design of the framework for establishing capital requirements by using their own internal risk-management models to estimate value-at-risk. (Value-at-risk, the Basle Committee's new standard measure for risk exposure, is an estimate of the maximum loss in the value of a portfolio or financial position over a given period of time, with a built-in probability that the actual loss will not exceed a prespecified maximum.)

requirements, savings decisions, etc.), 1/ $\hat{F}_{z_i}$ is the expected probability that the bank in question (bank i in this case) will fail given the expected effective level of (implicit or explicit) deposit guarantees $\hat{\gamma}^*$, and given the information set available at time t, Ω, used to estimate the probability of failure.

The expected effective level of deposit guarantees, $\hat{\gamma}^*$, is assumed to be endogenously determined by the amount of resources perceived to be effectively available to depositors should bank i, where their deposits are assumed to be held, failed. In the case of an explicit deposit insurance program, the amount of resources available to the depositors of bank i would be determined by the statutory maximum level of deposits per account covered by the deposit insurance program, γ_{max}, and the endowment available for that purpose in the deposit insurance fund. However, because the deposit insurance fund (as a contingent fund) would be unlikely to have enough resources to cover all of the insured deposits should all (or a large number of) banks in the system failed, $\hat{\gamma}^*$ is also assumed to be a function of the expected probability that there may be a significant number of other banks in the system also failing--such that the effective endowment may not be sufficient to cover all the deposits of all the ailing banks. Thus, for example, if only bank i failed, the odds would be that enough resources would be available in the insurance fund to cover all the insured deposits in bank i (and perhaps even the deposits of some other ailing banks). However, if many banks failed at the same time, the resources available in the insurance fund may not be sufficient to cover all the insured deposits in the system--without, of course, providing additional resources.

Though perhaps less straightforward, a similar argument can also be made about implicit deposit guarantee schemes. In the case of implicit deposit guarantees, the resources deemed to be effectively available would be those that do not imply a monetary expansion. Thus, while in an implicit deposit guarantee scheme the government would be expected to assume the deposit liabilities of the ailing banks, to the extent that those liabilities are monetized (i.e., the banks' liabilities exceed a certain level of non-inflationary resources available for the purpose of covering depositors' losses) the resulting inflationary impact would tax the real value of deposits (and, of course, other assets), hence reducing the real, effective level of protection that is provided to depositors--as measured by

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1/ For simplicity, u can be assumed to be stochastic and exogenous. Thus, for example, the evolution of u over time can be assumed to follow a geometric Brownian motion diffusion process, such that

$$du = \mu_u \cdot dt + \sigma_u \cdot dw$$

where μ_u is the instantaneous expected drift of u per unit of time t, σ_u its instantaneous standard deviation per unit of time, w is a standard Wiener process with $E(dw) = 0$ and $E(dw^2) = dt$, and E is the expectations operator. Both the drift and the volatility of u are assumed to be exogenous.

the purchasing power of the cash received by depositors as compensation. 1/

Thus, in the case of an explicit deposit insurance program, the expected effective level of deposit guarantees can be viewed as a function

$$\hat{\gamma}^* = \gamma(\gamma_{max}, e, \hat{F}_T \mid \Omega)$$

where $0 \leq \hat{\gamma}^* \leq 1$, such that deposits are fully and credibly guaranteed if $\hat{\gamma}^* = 1$; not guaranteed and/or not credible if $\hat{\gamma}^* = 0$; or partially guaranteed and/or not fully credible if $0 < \hat{\gamma}^* < 1$. The level of $\hat{\gamma}^*$ is, therefore, a function of the statutory maximum level of deposits per account covered by the deposit insurance program γ_{max}, the endowment available in the deposit insurance fund e, and the expected probability $\hat{F}_T$ --given the information available Ω--that there may be a significant number of other banks also failing; such that the effective endowment may not be sufficient to cover all ailing banks ($\hat{F}_T$ is discussed below when addressing the overall banking sector). 2/ Thus, for example, if all deposits were *de jure* fully guaranteed, the extent to which depositors would expect their

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1/ The deposit liabilities of ailing banks that are assumed by the government (in excess of a certain endowment readily available to finance those liabilities) could also be financed by other means different from monetization--for example, by issuing domestic or external debt. While these sources of financing need not be inflationary, if the volume of resources is sufficiently large, markets may come to expect future monetization and act upon such expectations. Moreover, the larger the relative amount of the deposits of the ailing banks (e.g., relative to GDP), the more difficult it would be for the authorities to resist monetizing those liabilities because, inter alia, the markets may demand a high risk premium (making borrowing from the market extremely expensive) or because it may be politically difficult to shift the costs of the bail-out intertemporarily into future taxes.

2/ For simplicity, the value of e is assumed to be known, but this assumption could be relaxed by letting depositors form an expectation of e based on the information set Ω.

deposits to be effectively guaranteed would depend on the size of the endowment available in the fund and the expected probability that many banks may fail at around the same time. 1/

Similarly, in the case of full implicit deposit guarantees, the expected effective level of deposit guarantees γ^* would also be a function of a certain (noninflationary) level of e--which determines the real effective level of protection available to repay the depositors of the ailing banks--and $\hat{F}_T$, given Ω.

If the effective (implicit or explicit) deposit guarantees covered all deposits and if they were fully credible ($\hat{\gamma}^* = 1$), then deposit flows into and out of a bank(s) would not be driven by concerns over the soundness of banks, and would be only a function of u,

$$x = x(u)$$

Not surprisingly, neither $\hat{F}_{z_i}$ nor $\hat{F}_T$ would play a role in determining x in such case. 2/ 3/

In practice, however, the effective level of deposit guarantees can be generally expected to be less than 1. Most deposit guarantee schemes offer less-than-full insurance coverage--either because the insurance program only

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1/ However, if the deposit fund priced risk perfectly and the premia covered exactly the banks' risk of failure (and assuming no externalities that could result in the probability of a banking crisis being larger than the summation of the individual probabilities of bank failures), then the endowment would exactly cover the expected probability of banks failing. Nevertheless, as discussed in Section IV, the presence of externalities could result in a higher probability of a banking crisis than otherwise, possibly resulting in a shortfall of e even in the case where the endowment is funded based on $\hat{F}_T$ (but not priced to take into account potential externalities).

2/ Assuming, of course, that transaction costs resulting from bank failures are negligible for depositors.

3/ However, even if not affecting x, the existence of deposit insurance where the premia is not priced according to risk-taking would encourage banks to increase the riskiness of their portfolios, hence increasing their probability of failure F_{z_i}. For simplicity, it is assumed that banks' deposit insurance premia are priced according to the riskiness of their portfolios (thus, eliminating the possibility of moral hazard for banks).

guarantees deposits up to a certain limit (and individuals with larger deposits are hence not fully covered) 1/ and/or because the available (noninflationary) endowment is typically limited. 2/

If the effective level of deposit guarantees is less than full and/or if is not totally credible, depositors can be expected to react to the estimated probability of failure of the bank where their deposits are held and to the effective level of deposit guarantees perceived to be available if several banks failed at about the same time (which, as noted, is conditioned by e and $\hat{F}_T$). Thus, notwithstanding the existence of an explicit *de jure* full deposit insurance scheme, if it is not regarded to be fully credible, for the reasons discussed, this would result in depositors being uncertain about the effective level of protection that they may be able to obtain in case of bank failures. 3/

1/ For example, deposit accounts are insured up to Can$40,000 in Canada, and US$100,000 in the United States. Kyei (1995) surveys key characteristics of various deposit guarantee schemes worldwide.

2/ Most, if not all, deposit insurance agencies have limited own resources to fully meet all deposit liabilities in a situation where there are widespread bank failures. For example, Japan's deposit insurance system was apparently viewed as being underfunded to deal with potential widespread banking problems in 1995. The *Wall Street Journal* (September 26, 1995, page A8) notes that "[i]n closing down three defunct banks over the summer [of 1995], Japanese regulators exhausted Japan's US$8.7 billion deposit-insurance fund."

3/ For simplicity, the model presented combines all depositors into one group denoted by x. However, this framework could be extended to separate small depositors, x_i, whose deposits fall below the statutory maximum amount of deposits per account that are formally insured γ_{max}; and depositors x_n with larger deposits γ, such that $\gamma > \gamma_{max}$. If e is large enough to cover the deposit liabilities of all banks--such that the expected effective amount of resources available is not constrained by whether in fact many banks fail at once--then only the group of individuals x_n would be sensitive to changes in $\hat{F}_{z_i}$ and $\hat{F}_T$, simply because part of their deposits would not be covered by the deposit insurance scheme. However, should e be insufficient to cover all depositors in case of widespread bank failures, then even the group of individuals x_i would be also sensitive to changes in $\hat{F}_{z_i}$ and $\hat{F}_T$. Indeed, whether or not, and by how much, they can expect to be effectively reimbursed (despite the fact that the full face value of their deposits is de jure guaranteed) will depend on the level of resources available to the deposit fund and the probability that many banks may fail at once--assuming that depositors do not believe that the government can provide additional noninflationary funds to the insurance agency in order to meet the shortfall.

In general, therefore, the probability that bank i would fall into insolvency F_{z_i} can be expressed as a function of y (which is discussed below), k^*, and the depositors' behavior which is assumed to be determined by u and expectations about potential deposit losses, or

$$F_{z_i} = F\,(y\ ,\ k^*(\alpha, x(\cdot), y)\ ,\ x\ (\ u\ ,\ (\hat{F}_{z_i}\ |\ \gamma^*(\gamma_{max}, e, \hat{F}_T)\ ,\ \Omega\ )))$$

3. Net asset income

The realized net asset income of a bank at the end of the period will depend on the following factors: (i) the realized market return i_m adjusted by the β of the bank's asset portfolio ($\beta \geq 0$) chosen by bank management; 1/ the occurrence of default by the borrower; and the recovery rate of defaulted loans (e.g., the lender may receive a portion ξ of the loan's book value).

Ex-ante, and assuming for simplicity that $E(\xi) = 0$, 2/ a bank's expected net asset income at the beginning of the period could be expressed as a function

$$y = y(\beta^* i_m\ ,\ \tau)$$

where the market return i_m is assumed to be exogenous and stochastic, 3/ the default risk of the borrower τ is assumed to be unknown a priori except in a probabilistic form, and β^* is the optimal β chosen by the bank's management.

1/ Such that highly cyclical investments would be characterized by a high β, while investments that hedge the market risk will have a β that approximates 0. Thus, for example, a $\beta = 0.5$ would denote that the return on the bank's portfolio is expected to be about half of the market's return.

2/ Thus, management does not expect to recover any portion of the outstanding balances should the loans default.

3/ The evolution of i_m over time can be assumed to follow a geometric Brownian motion diffusion process, such that

$$di_m = \mu_{i_m} \cdot dt + \sigma_{i_m} \cdot dw$$

where μ_{im} is the instantaneous expected drift of i_m per unit of time t, σ_{im} its instantaneous standard deviation per unit of time, w is a standard Wiener process with $E(dw) = 0$ and $E(dw^2) = dt$, and E is the expectations operator. Both the drift and the volatility of u are assumed to be exogenous.

The expected net income derived from a bank's portfolio could be therefore decomposed into two risk factors: market risk (determined by $\beta^* i_m$) and default or credit risk τ. While i_m is assumed to be stochastic and exogenous to the system, a bank will choose the optimal β^* of its portfolio depending on the expectations formed about certain variables conditioning the performance of the economy. 1/ In particular, the vector Γ is assumed to encompass variables related to the state of the business cycle (e.g., output growth, industrial production, housing market activity, etc.). 2/ Thus,

$$\beta^* = \beta(\hat{\Gamma})$$

The credit risk of the bank's portfolio, τ, is not directly controlled by the bank. 3/ However, two cases can be considered: (i) borrowers are able, but possibly unwilling, to service their debt obligations; and (ii) borrowers are willing, but possibly unable, to service their debt obligations. In the first case, credit risk could be treated as stochastic and exogenous. However, in the second case, credit risk would be itself a function of certain parameters affecting the state of the economy. Of course, in practice, it is often difficult to distinguish between borrowers' willingness and ability to pay. However, assuming that borrowers are always willing (but sometimes unable) to pay, 4/ credit risk can be described as a function

$$\tau = \tau(\Gamma, i_m)$$

1/ The choice of β^* will also determine other types of portfolio-related market risks, such as concentration risk and liquidity risk.

2/ If banks were assumed to follow a "herding" type of behavior vis-à-vis other banks, the choice of β^* could also be a function of $\hat{F}_T$, especially if $\hat{\gamma}^* = 1$. In other words, in an effort to maintain market share, banks may increase their degree of risk-taking if they perceive that other banks are doing the same thing. Furthermore, to the extent that deposits are effectively guaranteed, they would face lesser potential costs of assuming such added risk. The author is grateful to Ceyla Pazarbasioglu for noting this point.

3/ Unless, of course, bank management engages in fraudulent activities--which, as noted earlier, is not an event that is explicitly considered in this analysis because it largely reflects poor banking supervision practices.

4/ That is, bank management only engages in authorizing credits to individuals with good credit records, but certain subsequent events may affect borrowers' ability to pay.

so that the likelihood of default by borrowers may change with the business cycle and with changes in the market interest rate. Thus, for example, borrowers are more likely to default during business cycle downturns or when interest rates escalate.

Therefore, y will depend on several factors, some being bank-specific (e.g., β^*) and others being common to the economy at large (e.g., $\hat{\Gamma}$, i_m), or

$$y = y(\beta^*(\hat{\Gamma})\, i_m\, ,\, \tau(\Gamma, i_m))$$

In general, therefore, the probability that bank i would fall into insolvency can be expressed as

$$F_{z_i} = F\,(y\,(\beta^*(\hat{\Gamma})\, i_m\, ,\, \tau\,(\Gamma, i_m))\, ,\, k^*(\alpha,\, x(\cdot), y(\cdot))\, ,\, x(u,\, \hat{F}_{z_i}\,|\gamma^*(\gamma_{\max}, e, \hat{F}_T), \Omega))$$

Thus, F_{z_i} depends on several variables; some which are bank-specific (i.e., β^*, k^*, α) and others that affect all banks (i.e., Γ, i_m, γ^*). 1/ For simplicity, the bank-specific vector of variables can be denoted as Λ_b, while the vector of variables affecting all banks can be denoted as Λ. Indeed, this specification can also distinguish between banks' choice variables (i.e., β^*, k^*), 2/ regulators' control variables affecting

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1/ Clearly, some of these variables are not directly observable. Therefore, one would have to rely on certain proxies in order to estimate empirically this sort of specification. For example, the information set that depositors would use to assess the expected probability of bank failure would likely include, if publicly available, balance sheet and income statement data reported by banks. A number of market indicators could also be used to signal changes in the financial condition of a bank; including, for example, the market price of a bank's equity, reports issued by credit-rating agencies on the financial condition of the bank, etc. As well, β could be proxied by the bank's equity return relative to that in the stock market. Credit risk, for example, is estimated empirically in Grenadier and Hall (1995) by the actual amount of loans delinquent to the point of not recovery and removed from the bank's loan portfolio.

2/ This assumes that k^* is chosen by banks, either as the optimal level of capital required as a result of internal risk controls (as in the new Basle regulations) or as the optimal level of capital beyond the statutory minimum capital requirement established by regulators.

deposit insurance (i.e., γ_{max}, e), 1/ and macroeconomic stochastic variables (i.e., Γ, i_m). Thus, in general,

$$F_{z_i} = F(\Lambda_b, \Lambda, \Omega)$$

IV. Banking Sector Fragility/Soundness

Moving from a bank-specific situation to the banking industry level could occur through various channels. First, by assuming that banks are homogenous and face the same shock in the presence of no externalities. This would be the case if, for example, all banks faced the same shock while having similar exposures to a particular shock (say, all banks are equally exposed to real estate loans and there is an unexpected burst in the real estate "bubble"). This case, though clearly unlikely in practice, would simply entail aggregating similar individual probabilities of bank failure.

The second possibility is that banks are heterogeneous and therefore exposed differently to various risks. Under this scenario there are two possibilities. First, if no externalities exist, there would be two distinctive groups of banks: those affected directly by the shock (and possibly being insolvent as a result), and those unaffected by it. In the presence of full information about the impact of a given shock, depositors would withdraw their funds from those banks affected by the shock, but deposits from other banks should be essentially unaffected. Alternatively, if externalities can develop, a specific shock affecting one or a few banks can indirectly impact on other banks, magnifying the initial impact for the financial system as a whole.

The analysis below pays particular attention to the more realistic case where banks are not homogenous and can face important externalities. In particular, different degrees of information availability are assumed to affect depositors' behavior (i.e., deposits from individuals as well as from other banks), possibly creating significant externalities for otherwise unaffected banks.

It was argued that the probability of an individual bank falling into insolvency can be denoted as

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1/ However, bank regulators also influence banks' behavior by setting limits on certain types of loans or as a result of other prudential regulations (affecting the β's chosen by the banks). For simplicity, these possible avenues of influence over bank behavior are not explicitly considered in this analysis, except to the extent that banks' behavioral functions already capture the costs of not complying with those regulations.

$$F_{z_i} = F(x, y, k)$$

Consider now a banking system formed of n such banks. The depositors' response to a specific shock (or news item) affecting the soundness of a given bank (or set of banks) will largely depend on whether depositors are able to discern that the effects of the shock are indeed limited to that bank (or set of banks). The asymmetric information literature argues that, in practice, depositors typically have less than complete information on the actual financial condition of banks and the impact that a given shock may have on different banks. This view rests on the fact that banks and depositors can be quite numerous, while bank portfolios are complex and information is typically costly and limited. Moreover, banks' balance sheet data (even when publicly available) are difficult to interpret. Different assumptions about information availability can radically change the impact that a specific shock may have on the overall banking system.

Since it has been assumed, at this stage, that the only two assets held by individuals are (home currency) deposits and cash, depositors will adjust the composition of their portfolio according to the expected relative risk-adjusted returns of those two assets. Thus, the perceived increased risk that a particular bank may become insolvent, every thing else constant, would result in deposits (from individuals and other banks) to flow out of that bank and into other banks regarded as sound. However, increased risk about the soundness of the entire banking system would lead to a generalized switch from bank deposits into domestic currency.

1. Case of no externalities: complete information

Consider first the case where banks are heterogeneous, but there is full information about the class of banks that would be affected by a certain shock. 1/ In this set-up, a specific shock which results in the fall in, say, bank 1 asset values sufficient to render this bank insolvent, would trigger depositors to withdraw their funds from this bank but should have no impact on other banks' deposits because depositors are fully aware that the shock only affected bank 1.

With regard to the impact of this event on the overall banking system, there would be a proportional relation (weighted by the share of deposits or assets of bank 1 relative to total deposits or total assets in the banking sector) between the insolvency of bank 1 (i.e., z_1) and the degree of insolvency of the entire banking system (z_T), where the weights λ_i add up to one and

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1/ As discussed earlier, *ex ante* there would still be uncertainty about whether the bank(s) affected by a given shock will fall into insolvency as a result of the shock.

$$z_T = \sum_{i=1}^{n} \lambda_i z_i \qquad \forall \; i = 1, \ldots, j, \ldots, n$$

Banking crises can occur even if not all banks in the system, but only a certain subset of them, become insolvent. 1/ Assume that the "critical mass" of insolvent banks, as measured by the banks' share of total deposits (or assets) in the system, sufficient to generate a banking "crisis" is given by ψ. Thus, a banking crisis would occur if the degree of insolvency in the banking system exceeds a certain benchmark ψ. Thus, the probability that banking failures of a "crisis" proportion may develop is given by

$$F_T = Prob\ (z_T \geq \psi\ ) = F_T\ (z_1\ ,\ \ldots\ ,\ z_n\ ,\ \lambda_i\ )$$

The obvious implication is that there could be a banking "crisis," even in the absence of externalities among banks, as long as a sufficient number of banks (weighted by their share of total deposits or assets in the banking system) become insolvent. This type of banking "crisis," however, would be completely a result of the direct impact that a given shock may have on individual banks and the weight that those banks have in the entire banking system. Failing banks are those which become insolvent as a result of the direct impact of a specific shock. 2/

2. Case of externalities: less than complete information

A more intricate case--and more worrisome because of its implications for systemic risk--would be one where there can be certain externalities among banks. Hence, the direct impact of a shock affecting a given bank (or group of banks) could spread through a number of other unrelated banks which are otherwise sound--possibly leading to widespread banking failures.

1/ A number of episodes of banking "crises" are said to have occurred through history. However, largely because regulators often intervene to avoid the collapse of the entire banking system, these crises have occurred even though financial failure did not span to all banks, or indeed even to most banks, in a country. In the recent episodes of banking crises examined in Sundararajan and Baliño (1991), for example, failing banks accounted for (in some cases, significantly) less than 50 percent of the total assets of commercial banks.

2/ It is, of course, possible that a given bank may fail as a result of a direct shock, and that this bank is also a borrower of another bank (which is otherwise unaffected by the initial shock). Thus, the failure of bank 1, for example, would impact on bank 2. This situation would be captured in the model through the credit risk function of bank 2 which denotes the probability of default of all borrowers (individuals and banks).

A potential source of systemic risk could result from panic deposit runs fostered by depositors having less than complete information about the relative financial health of different banks. In such scenario, depositors, fearing the safety of their deposits, would rush to make withdrawals from solvent as well as insolvent banks because they cannot readily distinguish between these two classes of banks.

Hence, in a situation where depositors have less than complete information about the relative soundness of banks, individuals would still form an estimate $\hat{F}_{Z_i}$ for each bank (i = 1,....j,....n) on the basis of the information available at time t, Ω. While this information set would most likely include recent data on banks' balance sheet and income statement data, in practice these data are often only available with a considerable lag. 1/ Hence, in order to form an estimate of $\hat{F}_{Z_i}$, depositors may use information that may be available on other banks' solvency or degree of soundness. Thus, for example, news that bank j failed at time t-1 (or other information pointing to a high likelihood that bank j may fail) could be included as relevant information in Ω. Therefore, in the function

$$x = x(u, (\hat{F}_{Z_i} \mid \gamma^*(\cdot), \Omega))$$

Ω would include $\hat{F}_{Z_j}$ (and, in general, any information available on other banks). Batchelor's (1992) approach, based on a specific rule relating the perceived relative riskiness of different banks, essentially constitutes a

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1/ Usually, these data are reported with a monthly or quarterly frequency, but sometimes they are only reported on an annual basis. Moreover, these data are often not publicly available or, if available, they are sometimes unreliable or difficult to interpret.

specific case of this more general framework. 1/ While Batchelor assumes that the amount of information on the relative safety of banks is an exogenous parameter, in practice this parameter is likely to depend on a number of factors. In particular, the degree of information available about banks' relative financial standing and the cost of obtaining that information would depend on: whether there are (credible) risk rating agencies that overview the banking system; whether this information is made available to the public; whether banks' balance sheet and income statement

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1/ Batchelor (1992) suggests a particular rule, based on the assumption of uniform differences in risk, whereby the z-scores of other banks can be used to estimate that of any given bank. His approach assumes that banks can be ranked from 1 to n in decreasing order of riskiness (so that bank 1 is the riskiest with the highest probability of failure, and n the least risky). The safety levels of individual banks are also assumed to increase uniformly, so that if z_1 is the safety level of the riskiest bank, the i-th bank will have a $z_i = iz_1$. Risk can be therefore measured in terms of units of size z_1; such that a fall in all asset values of i units will send banks 1, 2...i into insolvency, but banks i + 1 will remain sound. The differences on the z-scores between risk-neighboring banks is assumed to be normal random variates, with equal variances. The estimate of the safety level of bank i can therefore take the form of a weighted average of the estimates of the safety levels of all other banks in the system, with the weights decreasing exponentially according to how distant the bank is deemed to be from bank i in the safety rank order, or

$$\hat{F}_{z_i} = \lambda_i \sum_{j=1}^{n} (1 - \theta)^{|j-i|} (i/j) \hat{F}_{z_j}$$

where λ_i is a factor scaling the wights to sum to unity, and the estimated value of each bank j must be multiplied by (i/j) to form an estimate of

$\hat{F}_{z_i}$ because of the assumption of uniform differences in risk.

The index of the amount of information on the relative safety of banks, θ, can take values ranging from 0 to 1. If θ is high, weights decrease quickly as we move away from bank i--because so much is known about individual banks, only the information on banks very similar to bank i are used in assessing its safety. If θ is low, on the other hand, the weights do not fall so rapidly--in other words, depositors' ignorance of bank performance is so great that even data on banks which are quite dissimilar from bank i are used to assess the risk of bank i. The limiting cases where $\theta = 0$ or $\theta = 1$ are particularly illustrative. When information on the relative standing of banks is complete, $\theta = 1$ and the weights on all scores go to zero, except that on bank i which tends to 1. When information on the relative standing of banks is fully absent, $\theta = 0$ and the weights on all

$\hat{F}_z$ are the same.

data are reliable, as well as readily and promptly available to the market; whether banks' equity is traded in the market, such that the market itself is continuously striving to update the relevant information about banks' financial positions; whether there is a high level of securitization of bank assets (e.g., a secondary market for mortgage-backed securities), and there is an efficient market for those assets; and whether there are a large number of banks in the financial system for depositors to be able to collect all these data without incurring prohibitive costs. 1/ 2/ The more information that is available, and the less costly that it is to obtain such information, the easier it would be for depositors to discern which banks are likely to be in trouble as a result of a shock, and the lower the probability that "contagious" deposit runs will occur. 3/

Indeed, it could be the case that different types of depositors have access to different degrees and quality of information. In the framework proposed here, the net change in deposits x encompass flows from individuals as well as other banks. It is likely that banks have better access to the true information about the relative riskiness of other banks, in which case one would expect to find a different behavior from deposits from other banks and those from individuals.

In general, therefore, the probability that systemic banking failures would occur, fostered by panic deposit runs, can be denoted as a function

$$F_T \mid_\Omega = Prob\ (z_T \geq \psi) \mid_\Omega = F_T\ (z_i, \ldots, z_n, \lambda_i, \Omega)$$

where Ω includes information about the relative standing of different banks. The conditional probability of a banking crisis occurring, in the presence of limited information about the relative standing of different banks, will be a function individual banks' F_z, their weights in the banking system, and Ω.

1/ The concept of information "cost" used here includes not only the price in dollars to obtain access to such information (e.g., a subscription to a data set or specialized publications), but also the expertise that it is required to interpret that information.

2/ This would argue that information would be less costly to monitor in a financial system where there are, say, five banks that control the large majority of all the assets and deposits in the entire banking system (e.g., Canada), than in one where there are over 10,000 banks (e.g., the United States).

3/ It is interesting to note that New Zealand will adopt in 1996 a system of banking supervision that will shift away from detail rules and monitoring by the Reserve Bank in favor of greatly enhanced public disclosure by the financial institutions themselves (e.g., quarterly disclosure statements covering all significant credit and market risks, disclosure of banks' credit ratings, etc.).

Thus, in the presence of information asymmetries, the fragility of the banking sector is determined by the sum of the vectors of variables specific to individual banks' Λ_b (formed by banks' β^*, k^*, α), the vector of variables affecting all banks Λ (formed by Γ, i_m, γ^*), and the degree of information available (including information about the relative standing of different banks) Ω. Thus,

$$F_T \mid \Omega = F_T \left(\sum \Lambda_b , \Lambda , \Omega \right)$$

In essence, therefore, the probability that there may be systemic banking failures (with some failures resulting from the effects of information deficiencies as externalities in the system) is equivalent to the probability that the overall banking system may be more fragile than the sum of its parts (i.e., the sum of probabilities of individual bank failures).

V. Foreign Currency Assets

Until now it has been assumed that individuals only hold two types of assets: deposits and cash (both domestically-held and denominated in home currency). In practice, however, individuals and banks can usually also hold foreign currency assets (domestically and/or abroad) in their portfolios. 1/ Moreover, a number of recent banking crises have been characterized by a banking crisis cum a currency crisis.

In some cases, currency crises seem to have precipitated banking crises (e.g., the recent banking crisis in Mexico appears to have followed the December 1994 currency crisis). 2/ In such cases, a currency crisis could represent a major shock that reveals the actual (ex-post) degree of

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1/ Unless capital controls are indeed effective--which is not typically the case.

2/ Although two banks were intervened by the authorities prior to the currency devaluation that took place in December 1994, their financial difficulties were apparently largely due to fraud-related activities. Since January 1995, however, more than ten banks have received some sort of official assistance--in the form of purchases of impaired loans and various recapitalization schemes (through Procapte or Fobaproa).

fragility of the banking system. 1/ This would be the case, for example, if banks (or their clients) are heavily exposed to unhedged currency risk, or if the monetary authorities attempted to defend the value of the currency by rising interest rates to such high levels that debtors would be forced to default on their outstanding bank loans. In some other cases, however, banking crises seem to have preceded currency crises (e.g., the Venezuelan banking crisis which unfolded in January 1994 seems to have preceded a sharp depreciation of the currency and the reimposition of exchange controls by the authorities in an effort to limit the extent of the currency crisis). 2/

The model proposed here could be extended to examine the potential linkages between banking crises and currency crises just described by introducing the possibility that banks and individuals can also hold foreign currency in their portfolios. In the case of a currency crisis preceding a banking crisis, the change in the exchange rate would enter in the model discussed as a variable in the vector Γ, or indirectly by affecting i_m in the case where the central bank aggressively attempts to defend the exchange rate through exorbitant hikes in the interest rate.

1/ This does not preclude, of course, the possibility that a high degree of fragility of the banking system can lead to a currency crisis, even though the actual banking crisis erupted after the currency crisis. The occurrence of a banking crisis, where a significant number of banks are in fact intervened by the authorities, is typically the observed event associated with the regulatory recognition of banking failure and, as discussed in Section II.2, it often occurs at a different time than the occurrence of economic insolvency. Hence, the empirical estimation of the model should be careful in making a distinction between bank's closure and economic insolvency.

2/ Government assistance to the Venezuelan ailing banks during 1994 amounted to more than 13 percent of GDP. Most of this financing derived from central bank credit. Although about one-half of the liquidity injection was absorbed through open market operations, the rest fuelled capital flight, inflation, and led to currency depreciation. Net international reserve losses amounted to nearly US$4 billion during the first half of 1994 and, despite the deepening of the recession, inflation surged during that period. Against these hefty reserve losses, the crawling peg was abandoned in April 1994 and the bolivar depreciated at a faster pace. In June 1994, a new fixed exchange rate was introduced cum a comprehensive system of exchange controls. A maxi-devaluation was effected in December 1995.

A less understood direction of causality is the one where a banking crisis could trigger a currency crisis. 1/ This could be approached in various ways. One route would be to extend the model to account for the possibility that a severe banking crisis, in the face of (implicit or explicit) deposit guarantees, could lead to the monetization of a significant portion of the banks' liabilities (i.e., those not being covered by the available endowment e). In such case, the ensuing inflationary pressures would likely lead to losses in foreign reserves if the exchange rate is pegged (and eventually to a currency depreciation), or to pressures on the exchange rate if it is allowed to move. 2/ Pursuing this line of analysis would entail extending the model of banking sector fragility presented here to incorporate it with a model of exchange rate determination--where the connection is made through the monetization of banks' liabilities in the presence of (implicit or explicit) deposit guarantees and $\gamma^* < 1$. 3/

A second possibility, one which would seem to be significantly more abbreviated, would be to introduce a simple portfolio model, similar to that proposed by Tobin (1969), where investors (depositors) make adjustments to their portfolios based on perceived changes in the risk-adjusted returns of their assets. This approach is outlined below.

Thus, consider the case where individuals can hold three types of competing assets (based on their risk-adjusted returns): domestic bank

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1/ There is, of course, also the possibility that banking crises and currency crises could be caused by common factors or events. Kaminsky and Reinhart (1995), for example, find that it is difficult to separate the direction of causality between these two events--although their empirical analysis does not include bank-specific indicators.

2/ Calvo and Végh (1992), for example, argue that a permanent increase in the rate of monetary expansion induces the public to switch from domestic to foreign money, which results in a nominal exchange rate depreciation if the exchange rate is allowed to move.

3/ Krugman's (1979) approach, for example, could be used to analyze the exchange rate implications of monetizing the banks' liabilities.

deposits, 1/ home currency and foreign currency. Their net wealth W, measured in units of home currency, is exogenous and is allocated among the three financial assets. Thus,

$$W = m(\cdot) + n(\cdot) + x(\cdot)$$

where m, n and x represent individuals' net demands for home money, foreign money, and bank deposits, respectively (all measured in domestic currency). 2/

It may be recalled that the demand for bank deposits x was assumed to be a function

$$x = x(u, (\hat{F}_{z_i} | \gamma^*(\gamma_{max}, e, \hat{F}_T(\cdot)), \Omega))$$

where u encompassed all the elements unrelated to the expected losses derived from bank failure. Since these factors include bank transactions-related motives and savings decisions, u could be further decomposed. In particular, deposits are assumed to pay a nominal interest rate i_d, but there is a chance that there may be a capital loss if the bank fails while the deposit guarantees are unable to cover all the bank's deposit liabilities (especially if many other banks also fail). All other (purely) transactions-related motives can continue to be assumed exogenous.

1/ For simplicity, only one type of bank deposit is considered here (i.e., in domestic currency) since the objective is to analyze the process through which depositors may withdraw their deposits if they suspected that banks are unsound. Presumably, depositors would face a capital loss if their bank failed whether the deposits are in domestic currency or in foreign currency, provided that $\gamma^* < 1$. However, the analysis does not preclude the possibility that domestic banks may also receive foreign-currency deposits. Gruben and Welch (1993) argue that depositors' behavior would be different for domestic-currency and foreign-currency deposits held domestically because the central bank's lender-of-last resort capabilities are only available in the case of domestic currency bank deposits. However, their analysis would seem to presume implicitly that $\gamma^* = 1$ in the case of domestic currency deposits (and $\gamma^* < 1$ for foreign currency deposits).

2/ This could be readily extended to include residents and non-residents, and other assets (e.g., home and foreign securities), but the basic relationships are captured in this simple specification. For a detailed analysis of this class of models, see Branson and Henderson (1985).

Thus, holding deposits in the bank would entail a nominal return i_d, but at the risk of a potential capital loss h. The expected capital loss can be denoted as

$$h = h(\hat{F}_{z_i} \mid \gamma^*(\gamma_{max}, e, \hat{F}_T(\cdot)), \Omega)$$

The returns on the three assets are hence given by

$$R_x = R_x [i_d, h(\hat{F}_{z_i} \mid \gamma^*(\gamma_{max}, e, \hat{F}_T(\cdot)), \Omega)]$$

$$R_n = \dot{\varepsilon}$$

$$R_m = 0$$

Thus, the nominal return derived from holding bank deposits R_x would be given by the interest rate paid by the bank i_d adjusted for the expected capital loss h; the nominal return of holding foreign cash R_n would be the expected rate of depreciation of the home currency $\dot{\varepsilon}$ (which, for simplicity, is assumed to be equal to the actual rate of depreciation); and the nominal return derived from holding domestic cash R_m is zero.

The demand functions for the three assets are hence given by 1/

$$x = x(i_d, h(\hat{F}_{z_i} \mid \gamma^*(\gamma_{max}, e, \hat{F}_T(\cdot)), \Omega), \dot{\varepsilon}, 0, PQ, W))$$

$$n = n(i_d, h(\hat{F}_{z_i} \mid \gamma^*(\gamma_{max}, e, \hat{F}_T(\cdot)), \Omega), \dot{\varepsilon}, 0, PQ, W))$$

$$m = m(i_d, h(\hat{F}_{z_i} \mid \gamma^*(\gamma_{max}, e, \hat{F}_T(\cdot)), \Omega), \dot{\varepsilon}, 0, PQ, W))$$

1/ Of course, once two of the demand functions are determined, the third one is also determined.

The first four arguments in each asset demand function denote the nominal returns derived from holding those assets, PQ is nominal output (Q being real output and P its price level), and W is wealth.

It follows that any change in the relative risk-adjusted returns on the assets held would entail a portfolio adjustment. Thus, for example, a change in the expectations that a banking crisis may occur would affect the expected effective level of deposit guarantees (provided that $\gamma^* < 1$), increasing the risk of holding bank deposits--even in the face of full de jure deposit insurance, as discussed earlier. Everything else the same, this effect would lead to a new equilibrium based on a portfolio where some (or a significant portion, depending on the probability that a full banking crisis will unfold) bank deposits will be converted into home currency and foreign currency. From this specification, it is not readily possible to know exactly what portion of the resources withdrawn from banks would be directed to the other two assets. Depending on the values of the cross-elasticities between the different assets, more or less funds would go into domestic currency or foreign currency--though, this can be tested empirically.

VI. Concluding Remarks

As it was noted earlier, the existing literature on banking failure is indeed quite extensive. In it, some have looked at bank-specific variables (e.g., banks' balance sheet and income statement data, and market-related variables such as banks' equity prices) for clues about the factors that may determine the probability that banks may fail. Others have overlooked those so-called early warning-systems of bank failure--based on the probability of failure of individual banks--and have instead focussed on the aggregate by examining the determinants of banking crises, and even financial crises. Mishkin (1994) and Canova (1994), for example, argue that the factors causing financial crises are largely macroeconomic in nature (e.g., increases in interest rates, changes in stock market prices, increases in uncertainty, changes in the money supply, an unanticipated decline in inflation, changes in interest rate spreads, and other business cycle-related events). However, the linkage between early-warning systems of individual bank failure and banking crises--which address basically the same phenomena, albeit at different degrees of aggregation--is virtually non-existent in the literature. Similarly, there is a vast body of literature addressing phenomena such as currency substitution and dollarization. 1/ However, the linkage between banking crises and currency crises, while often suspected, it has seldom been explored.

1/ See, for example, Calvo and Rodriguez (1977), and Calvo and Végh (1992).

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1/ See, for example, Calvo and Rodriguez (1977), and Calvo and Végh (1992).

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