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Exogenous Shocks, Deposit Runs and Bank Soundness: A Macroeconomic Framework

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Abstract

In a model where all banks are initially solvent, an exogenous shock affects confidence, causing a flight from deposits into domestic and foreign currency. Real interest rates increase unexpectedly, affecting firms and raising the share of the banks' nonperforming assets. This increase causes genuine solvency problems and accelerates the bank run. Policy simulations show that compensatory monetary policy (increasing currency supply when deposits fall) mitigates the bank run but causes inflation and external imbalances. Combining compensatory monetary policy with tight fiscal policies also slows the bank run and mitigates insolvency, but at a lower macroeconomic cost. A devaluation is shown to have little positive impact.

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[1]A first version of the paper was completed in the summer of 1996. Ernesto Feldman died on December 12, 1996. He contributed extensively to the preparation of the paper, which reflects many of his views and ideas. Blejer and Feltenstein wish to dedicate this paper to his memory. Andrew Feltenstein is a Professor at Virginia Polytechnic Institute, and worked on this paper while visiting the Monetary and Exchange Affairs Department.

Contents **Page**

SUMMARY

This paper develops a framework to analyze how an exogenous shock that provokes a run on bank deposits in an initially solvent banking system could create a genuine solvency crisis that threatens the overall soundness of the system. The transmission mechanism presented here works through a spillover of the bank run to the real economy, which leads to a contraction in economic activity.

In a fully solvent banking system, an unanticipated exogenous shock raises inflationary expectations. As money demand falls, the public withdraws bank deposits. If the attempt to liquidate deposits is abrupt, it could be perceived as evidence of bank insolvency and generate a deposit run. If the banks' loss of liquidity is significant, banks would be forced to decrease their lending and to call in loans as they attempt to replenish reserves. In response, real interest rates rise, and the resulting credit contraction affects real economic activity as working capital and consumer credit decline.

The unanticipated credit crunch affects the enterprises' liquidity position and leads to inter-firm and financial arrears. As the financial position of the business sector deteriorates, the bank-induced liquidity contraction could result in a breakdown of the chain of payments, which may, in turn, worsen the banks' portfolio quality. As this is learned by the public, the deposit run intensifies, with further negative impact on the banking system's soundness.

In this paper, a general equilibrium macroeconomic model is simulated to analyze the credit collapse dynamics following the initial deposit run and to examine alternative policy responses. The simulations show that compensatory monetary policy (increasing currency supply when deposits fall) mitigates the bank run but causes inflation and external imbalances. Combining compensatory monetary policy with tight fiscal policies also slows the bank run, but at a lower macroeconomic cost. A devaluation is shown to have little positive impact.

I. Introduction

This paper develops a formal macroeconomic framework to analyze the mechanisms under which an exogenous shock that provokes a run on bank deposits in an initially solvent banking system could create a genuine solvency crisis. The transmission mechanism presented here operates through a spillover of the bank run to the real economy that leads to a contraction in economic activity. We use this framework in order to analyze various policy responses to the initial banking run. In particular, we examine the implications for stabilizing the banking system of compensatory monetary policy, of tightening fiscal policy, and of devaluating the exchange rate.

Consider the following scenario: suppose that, in the context of a fully solvent banking system, an unexpected exogenous shock causes financial markets to anticipate a surge in inflation and/or a devaluation. Such a shock might be related to external factors, such as an abrupt deterioration in the country's terms of trade, a revelation about the real magnitude of a country's balance of trade deficit, or a systemic macroeconomic deterioration, due to developments taking place in other parts of the world. Alternatively, an exogenous shock could be internally generated; for instance, it could arise from an unexpected election result, from the worsening in a leading indicator of recession, or from a decline in the net worth of a particular class or sector of bank borrowers affected by a change in relative prices. Such a shock would provide a negative signal to the domestic financial market but is exogenous in the sense that it is not caused by any factor inherent to the functioning of the banking system.

In these situations, it is likely that a contraction in the demand for domestic money will follow. In practice, the public will typically respond to the negative signal by "flying to quality," i.e., by withdrawing its deposits in the banking system in order to convert them into foreign exchange and/or to acquire other inflation hedges.[2] However, if the attempt to liquidate deposits is abrupt and temporally concentrated, it could be interpreted as a sign of possible bank insolvency and generate the beginning of a generalized deposit run. This could occur even though, prior to the exogenous shock, bank solvency was not in doubt. If the banks' loss of liquid assets is significant, it would force banks to decrease their new lending, as well as to call in existing loans as they attempt to replenish reserves. Accordingly, interest rates will start rising rapidly in real terms, and the resulting credit contraction will affect the level of real economic activity, as both working capital and consumer credit decline sharply.

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[2]This is the most usual kind of flight to quality. There is another, not less important flight to quality that happens when depositors, faced with increasing uncertainty, shift deposits from one bank category to another that is perceived as enjoying an implicit (or explicit) guarantee. "Flight to quality" in this sense took place in Brazil, from private to federal banks after the Real Plan was adopted, and in Paraguay, from domestic to foreign-owned banks.

A common consequence of such unanticipated credit crunch is a sharp reduction in the liquidity position of enterprises, with the consequent development of inter-firm, wage, and financial arrears. In these circumstances, as the short-term financial position of the business sector deteriorates, the bank-induced liquidity contraction could rapidly result in a breakdown of the chain of payments, which may, in turn, cause a worsening in the **portfolio quality** of the banking system. Depending upon how these developments are perceived by the public, the run on deposits could intensify, with a further negative impact on the soundness of the banking system. Notice that, since the initial liquidity and solvency position of the banking sector was deemed to be solid, these negative consequences of an exogenous confidence shock could not have been prevented simply by strengthening bank supervision and/or improving prudential regulations.

The effect of the liquidity crunch could, in principle, be ameliorated by the central bank, in its role as lender of last resort. However, any attempt to assist commercial banks by increasing the provision of liquidity through the discount window could prove to be destabilizing, as it may result in stronger inflationary pressures and inflationary expectations that might lead to further increases in interest rates, and to an intensification of the depressing forces on the real economy. The financial difficulties of bank clients and the quality of commercial bank assets will, in this event, deteriorate further.

In this paper, we develop a simple general equilibrium macroeconomic model that incorporates such endogenous bank behavior. After defining the concepts in Section II, the model is developed in Section III, and is applied, through a number of simulations, to analyze the dynamics of the credit collapse following the initial run on deposits. The extent to which behavioral parameters determine the severity of the erosion of the system's soundness is also considered. We then examine alternative budgetary and central bank policies intended to reduce the severity of the shock on the real economy and, therefore, on the ultimate solvency of the banking sector. We conclude by discussing a number of policy implications.

II. Deposit Runs and Bank Soundness: Some Conceptual Issues

This section summarizes some conceptual issues related to the particular nature of the banking system that could give rise to a deposit run. In particular, we discuss how, within existing theoretical frameworks, an exogenous shock could trigger a bank "panic" setting in motion changes in economic agents' behavior that shift the economy away from its initial equilibrium position. In this framework, the concept of "initial equilibrium" involves an initially sound financial system. Banks are on a solid footing in the sense that their degree of solvency and liquidity, as perceived by the supervisory agency and by the market participants, is satisfactory, and that banks have a reasonable level of capitalization (capital to risk-weighted asset ratio). In sum, there is nothing inherent to the functioning of the banking system that would result in deposit runs.

The analytical work on "deposit runs" (better known in the literature as "banking panics") is very extensive and touches upon different related issues. For our purposes, we need to narrow down the concept of "deposit runs" and define more accurately the circumstances leading to the particular kind of run we are seeking to analyze. Calomiris and Gorton's definition of a banking panic [3] is very general, but it fits well the problem at hand: "A banking panic occurs when bank debt holders *at all or many banks* in the banking system *suddenly* demand that banks convert their debt claims into cash, at par, ..." The event involves, consequently, a large number of institutions. It is important, however, to make clear that deposit runs may not necessarily involve all banks of a given financial system and that the concept rules out a process of protracted withdrawals, as depositors *suddenly* attempt to redeem deposits for cash.[4] Also, a deposit run would require that the volume of desired redemptions of deposits into currency be large enough to threaten the normal functioning of banks or of the payments system,[5] either because available liquidity is depleted or because depositors perceive that the danger of a systemic collapse is highly probable.

In recent years three major lines of thought have developed to explain the origins of deposit runs and each of these approaches have different policy implications. The first approach argues that while it is feasible to design optimal bank contracts, it is still possible that these contracts could lead to costly panics arising from random behavior.[6] Within this view, a number of ingredients are needed for a deposit run to occur but the most relevant is the so-called "sequential-service constraint", i.e., the fact that deposits can only be withdrawn sequentially. This could lead to the self-fulfilling behavior by which depositor think that other depositors think that there will be a significant amount of withdrawals in the very near future. Then, since fractional reserves are always present, and as the first-come-first-served rule prevails, depositors at the end of the sequential service line may suffer losses. To avoid these losses all depositors try to place themselves at the head of the line, causing a panic in the process. A problem with this type of models is that they do not look at the important question of what kind of shocks would cause agents to decide that indeed multiple withdrawals are likely. However, it is commonly agreed that if this type of random behavior is the major cause

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[3]Calomiris and Gorton (1991, p. 112). In what follows, "banking panics" and "deposit runs" will be used as interchangeable concepts.

[4]Despite the fact that a run may proceed for several weeks with varying intensity.

[5]The magnitude of the run can consequently be assessed by comparing deposit withdrawals to total deposits or to base money.

[6] The first random withdrawal risk model was developed by Diamond and Dybvig (1983). Alonso (1996) has shown that banks can make sure that runs do not occur by designing deposit contracts appropriately. However, he shows that while in some circumstances it is profit-maximizing for the bank to avoid runs, in other conditions occasional runs could be part of optimal bank behavior.

of deposit runs, then deposit runs are indeed undesirable events that should be, as much as possible, prevented.

The second view on deposit runs is based on the idea that bank depositors could change **rationally** their beliefs regarding the riskiness of banks. This view focus on the identification of the conditions under which such shift in perceptions could take place and concludes that deposit runs arise, generally, from genuine solvency concerns and therefore serve a positive function in monitoring bank performance. However, while such concerns could, in principle, cause only the downfall of affected banks, generalized, and therefore damaging, deposit runs could arise from contagious effects, and also from the fact that depositors may be able to obtain only aggregate information about banks' financial situation. This would not allow depositors to sort out which individual banks are the most likely to get in trouble and the public may decide, in response to a negative signal, to withdraw a large volume of deposits from many, if not all, banks. This view of deposit runs, essentially associated to rational revisions of the perceived risk of banks, is broadly consistent with the arguments of Friedman and Schwartz (1963), who stress that **real disturbances** are the cause of the erosion in the credibility in the banking system and are the precursors to deposit runs.

The third approach to deposit runs postulate that, because of its intrinsic nature, the banking sector is bound to suffer this type of crises given that asymmetric information is, in fact, part and parcel of the business. Banks are seen as creating nonmarketable assets that are difficult to value while, in turn, bank managements are difficult to monitor. For this reason, there is asymmetric information between banks and depositors concerning portfolio behavior and bank management. This characteristic leads to excessive risk taking and results in periodic loss of credibility and bank crises. In this view deposit insurance and other mechanisms to reduce depositors' risks, tend to augment in fact, the problem by reducing the monitoring incentives of the holders of bank liabilities.

In the model presented below, deposit runs are broadly consistent with the first two views. The initial deposit run could emerge, as predicted by the first view, either because of certain random, negative signals, or because an exogenous unexpected shock causes depositors to lose confidence in the banking system. At the same time, however, the credit crunch conditions that are created by the initial run generate a contraction of the real sector of the economy that cause genuine solvency problems that are similar to those postulated by this second view, i.e., the "real disturbance" approach to bank crises.

A way to illustrate these two views regarding the causes of deposit runs is to look at two recent Latin American banking crises, those of Venezuela and Argentina. These cases unfolded during 1994 and early 1995.[7] The Venezuelan banking crisis can be broadly

[7]During this period a serious banking crisis also affected Mexico; however, Mexico did not suffer significant deposit runs. The absence of deposit runs in Mexico, particularly after the (continued...)

characterized as being triggered by endogenous factors that eroded bank solvency and is, therefore, more akin to the type of episodes characterized by the second view. Inconsistent macroeconomic policies, combined with poor bank management, significant corruption and fraud, and lack of appropriate banking supervision, led to a strong deterioration in the depositors' perception of the viability of banks and resulted in significant deposit runs.

Deposit runs started in Venezuela once the interbank market *and* the Central Bank took the decision to halt their financial support to the country's second largest private bank. Shortly thereafter, a group of banks perceived by depositors as financially weak and risky started suffering deposit runs. The Venezuelan crisis is, thus, characterized by the fact that deposit runs were generated by genuine solvency concerns, and they were initially "targeted" at a group of banks, those that the market believed to be in poor financial condition.[8]

In contrast, the initial cause of the Argentine banking crisis is more similar to the one postulated by the first view about bank runs, since it was clearly triggered by an external shock, the 1994 Mexican debacle, and affected all banks (albeit with different intensity). Despite some financial problems that had started to unfold before the emergence of the Mexican crisis of December 1994, the Argentine banking sector was basically sound (showing a reasonable level of solvency and liquidity). It was the sudden change in expectations about the underlying fundamentals of the Argentine banking system, arising from the Mexican crisis, that led to a generalized deposit run that affected all banks and bank categories.[9]

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[7](...continued)
emergence of the serious December 1994 crisis, can be linked to the large and unexpected peso devaluation. Depositors caught by the devaluation had already incurred an enormous capital loss. Consequently, it was useless for them to withdraw funds from the system and, in fact, it paid to remain within the banking system if the expectation (later validated by facts) was that the peso devaluation had overshot and a subsequent appreciation could follow.

[8]Interestingly enough, the experience showed a few months later that many of the banks perceived as healthy were actually in deep trouble; consequently, a second wave of runs took place.

[9]The loss of confidence that generated the run was related to past episodes in Argentine financial history. In particular, there was the perceived threat of a deposit freeze. This sentiment led the public to move away from all banks (even from state-owned banks that were normally perceived as enjoying an implicit deposit guarantee) and to seek refuge in currency holdings, both domestic and foreign-denominated. Deposit withdrawals only subsided after Argentina reached an agreement with the IMF in March 1995, which reestablished most of the lost credibility. However, deposit runs stopped completely only after the presidential elections held in May 1995. A comprehensive analysis of Argentina's financial crisis can be found in Machinea (1996).

Therefore, while in Venezuela the crisis was endogenously generated when the market decided that the long-standing problems of some banks (compounded by significant macroeconomic imbalances) were no longer sustainable, the Argentine banking system was affected by depositors' fears about the impact of the Mexican crisis on the fate of the entire banking system, a system that was basically sound as the shock hit. However, once the financial situation of Argentine banks deteriorated following the initial shock, the Argentine crisis could be seen, to some extent, as more comparable to the type of episodes that we are characterizing in this paper.[10]

III. Model Structure

The concepts discussed above are analyzed in this section with the help of a dynamic model designed with the objective of permitting, in Section IV, to present some simulation results. The model presented is based on n discrete time periods. In each period all agents optimize over a two-period time horizon. That is, in period t agents optimize given prices for periods t and price expectations for period t+1. When period t+1 arrives, agents re-optimize for periods t+1 and t+2, based on new information about period t+1. In particular, after events that take place during the first period, certain sectors in the economy may have become insolvent, leading to bank defaults. Since these defaults were not anticipated in period t, they cause agents to recalculate the value of their assets as they optimize over the next two periods.

The specific details of the model are as follows:[11]

A. Production

We assume that the process of production indirectly requires, in addition to conventional factors, the use of liquidity, i.e., monetary assets, in order to finance investment. These assets are, therefore, implicitly incorporated as factors in the production function. We assume that domestic production takes place in agriculture (which utilizes land and rural labor) and in five non-agricultural sectors (which utilize sector-specific capital and urban labor). Therefore, the productive structure of the model includes eight factors of production (five types of capital, two types of labor, and land) and three categories of financial assets:

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[10]Argentina was the only country in the region to be severely affected by the Mexican crisis. Perhaps this unique impact could be associated with the currency board scheme operating in Argentina. This is, however, an issue that goes beyond the scope of this paper. The relevance for our discussion here is that the Argentine crisis provides a clear factual case for the type of shock in which we are interested.

[11]The basic structure of production and demand, in a perfect foresight context, is given in Feltenstein and Morris (1990) and Feltenstein (1992).

domestic currency, bank deposits, and foreign currency. Each of these factors of production, as well as the financial assets, are replicated in each period and, accordingly, have a price in each period. Domestic currency in period 1 is taken as the numeraire.

The simulations also consider imports and, therefore, we use a seven sector input-output matrix, A_t, to determine intermediate and final production in period t. Corresponding to each *domestic* sector in the input-output matrix, value added is produced using capital and urban labor for the non-agricultural sectors, and land and rural labor in agriculture.[12]

We may now specify the following problem for the firm. Let y^j_{Ki}, y^j_{Li} be the inputs of capital and urban labor to the jth non-agricultural sector in period i. Let Y_{Gi} be the outstanding stock of government infrastructure in period i. The production of value added in sector j in period i is then given by:

$$va_{ji} = va_{ji}\left(y^j_{Ki}, y^j_{Li}, Y_{Gi}\right) \qquad \textbf{(1)}$$

Sector j pays value-added taxes on inputs of capital and labor, given by t_{Kij}, t_{Lij}, respectively, in period i. Agriculture is taxed on its use of labor.[13] Hence, the effective price for labor and capital paid by sector j is:

$$\tilde{P}_{Lij} = \left(1 + t_{Lij}\right)P_{Li}, \ \tilde{P}_{Kij} = \left(1 + t_{Kij}\right)P_{Kij} \qquad \textbf{(2)}$$

Thus, if $\tilde{P}_{Kij}$, $\tilde{P}Lij$ are the prices of capital and labor in period i, then the goods' prices charged by enterprises, P_i, are given by

$$\left(P_i\right) = va\left(P, Y_{Gi}\right)(1 + t)(I - A)^{-1} \qquad \textbf{(3)}$$

[12]The use of neoclassical value-added functions "sitting above" an input-output matrix is common. The reader may wish to see Shoven and Whalley (1984) for articles that use this approach. An application and detailed description of functional forms are given in Feltenstein (1986).

[13]The interpretation of these taxes is, thus, as a profit tax and a personal income tax that is withheld at the source.

where $va(P,Y_{Gi})$ is the vector of cost-minimizing value-added per unit of output.

We suppose now that each type of sectoral capital is intra-sectoral, produced via a sector-specific investment technology that uses inputs of capital and labor to produce new capital. Investment is carried out by the private sector and is entirely financed by domestic borrowing.[14] The producer/investor may receive an investment tax credit as well as a depreciation allowance, and pays a profit tax on the returns to his investment.

Let us adopt the following notation:

k_i = investment tax credit in period i (percent)

d_i = depreciation allowance in period i (percent)

t_{ki} = profit tax rate (percent)

C = the cost of producing the quantity H_i of capital in period i

r_i = the interest rate in period i

p_{Ki} = the return to capital in period i

P_{Mi} = the price of money in period i

Suppose, then, that the rental price of capital in period i+1 is $P_{K(i+1)}$. If C_{Hi} is the cost of producing the quantity of capital, H_i, then future debt obligations must equal the return on new capital. Hence: where r_i is the interest rate in period i, given by:

$$C_{Hi}(1 - k_i - d_i) = \frac{(1 - t_{K2})P_{K2}}{1 + r_1} \tag{4}$$

$$r_i = 1/P_{Bi} \tag{5}$$

[14]We assume that all foreign borrowing for investment is carried out by the government, so that, implicitly, the government is borrowing for the private investor but the debt thereby incurred is publicly guaranteed.

where P_{Bi} is the price of a bond in period i. Accordingly, the investor takes out a loan from the banking system to cover his costs. The operational assumption is now made that, when feasible new investment, *as a percentage of the existing sectoral capital stock*, falls below a certain minimum threshold, the firm is unable to pay the debt obligations which were incurred to finance its capital formation.[15] Accordingly, the bank holding these assets now holds corresponding bad debts. This situation might occur if, unexpectedly during the period, interest rates in the economy rose sufficiently so as to reduce the firm's profitable investment below the predetermined threshold. This assumption implies that each firm has a lower feasibility bound for its operations, reflected by its level of investment, below which it cannot operate. This threshold, expressed as a percentage of the existing capital stock, is taken here as exogenously determined (by pre-existing technology, for example). We also assume, for simplicity, that the threshold is uniform across sectors.

B. Banking

The model includes a simple banking sector. There is one bank for each non-agricultural sector of the economy, i.e., there are five relatively specialized banks. Each bank lends primarily, but not exclusively, to a certain sector; therefore, banks are not fully specialized. In order to simplify the simulations, it is assumed that each bank holds 50 percent of the outstanding debt of its particular sector. It then holds 12.5 percent of the debt of each of the remaining four sectors.[16] This assumption about the diversification of assets avoids the ease in which the insolvency of a particular sector leads to the automatic insolvency of its related bank. A solvency requirement is then imposed on individual banks: if 8 percent of a bank's assets are in default, caused by a corresponding insolvency of its borrowers, then the bank is declared insolvent and it is seized by the government. Depositors in the seized bank find their assets frozen. Of course, a bank declared insolvent cannot continue to lend.[17]

Thus, the bank's supply of loans and, hence, its assets, are determined by the demand for loans from the productive sectors of the economy. Of course, given the existence of a maximum lending-to-capital ratio, its supply of loans is restricted by the bank's capital. The bank's liabilities (deposits) are determined by the consumers' savings behavior, which, in turn, is derived from the intertemporal optimization of consumption.

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[15]It is thus claimed that, as a proxy, a firm whose investments fall below some predetermined rate is, in practice, bankrupt.

[16]Clearly, these percentages are arbitrary and should serve only for simplification and illustrative purposes. We could have any initial pattern of distribution of bank assets across the different sectors.

[17]An 8 percent loss of assets would be tantamount to a total liquidation of capital. Of course, other values could be equally used for the purpose of the simulation, although 8 percent corresponds to international standard practices.

C. Consumption

There are two types of consumers, representing rural and urban labor. We suppose that both consumer classes have the same demand patterns for goods, and that their demands for the seven different types of goods are given by constant fractions of their incomes. The consumers differ, however, in their initial allocations of scarce resources and financial assets.

The consumers maximize utility functions—subject to intertemporal budget constraints—which have as arguments the levels of consumption and leisure in each of the two periods. The consumer saves by holding money, bank deposits, government bonds, and foreign currency. He requires money for transactions purposes, but his demand for money is sensitive to changes in the interest rate. In addition, *the consumer's demand for bank deposits is sensitive to his perception of the solvency of the banking system*. In particular, as banks increasingly incur bad loans, the consumer's interest elasticity of money declines, leading him to reduce his bank deposits.[18]

A detailed description of the consumer's intertemporal optimization problem is given in the Appendix. The model is similar to that of a standard cash-in-advance model. The consumer maximizes intertemporal utility while being constrained to hold money in order to finance consumption. However, an important special feature of the model is that the consumer's demand for money depends not only upon desired consumption and the interest rate, but also upon the perceived solvency of the banking system. This solvency is reflected in the level of nonperforming assets of the banking system.

D. The Government

The government collects income, profit, and value-added taxes, as well as import duties. It pays for the production of infrastructure and public goods, as well as for subsidies. In addition, the government must cover both domestic and foreign interest obligations on public debt. The deficit of the central government in period 1, D_1, is then given by:[19]

$$D_1 = G_1 + S_1 + r_1 B_0 + r_{F1} e_1 B_{F0} - T_1 \tag{6}$$

where S_1 represents subsidies given in period 1, G_1 is spending on goods, infrastructure, and services, while the next two terms reflect domestic and foreign interest obligations of the government, based on its initial stocks of debt. T_1 represents tax revenues.

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[18]This reflects the notion that the consumer worries about the safety of his own deposits as he perceives the banks becoming progressively more insolvent.

[19]As before, 1 denotes period i and 2 denotes period i+1.

The resulting deficit is financed by a combination of monetary expansion, as well as domestic and foreign borrowing. If Δy_{BG1} represents the face value of domestic bonds sold by the government in period 1, and C_{F1} represents the dollar value of its foreign borrowing, then its budget deficit in period 2 is given by:

$$D_2 = G_2 + S_2 + r_2(\Delta y_{BG1} + B_0) + e_2 r_{F2}(C_{F1} + B_{F0}) - T_2 \tag{7}$$

where $r_2(\Delta y_{BG1}+B_0)$ represents the interest obligations on its initial domestic debt plus borrowing from period 1, and $e_2 r_{F2}(C_{F1}+B_0)$ is the interest payment on the initial stock of foreign debt plus period 1 foreign borrowing.

E. The Foreign Sector and Exchange Rate Determination

The foreign sector is represented by a simple export equation in which aggregate demand for exports is determined by domestic and foreign price indices, as well as world income. The specific form of the export equation is:

$$\Delta X_{no} = \sigma_1\left[\frac{\pi_1}{\Delta e_i \pi_{Fi}}\right] + \sigma_2 \Delta y_{wi} \tag{8}$$

where the left-hand side of the equation represents the change in the dollar value of exports in period i, π_i is inflation in the domestic price index, Δe_i is the percentage change in the exchange rate, and π_{Fi} is the foreign rate of inflation. Also, Δy_{wi} represents the percentage change in world income, denominated in dollars. Finally, σ_1 and σ_2 are corresponding elasticities.

The government also chooses an exchange rate regime. The model permits essentially any regime, from fixed to floating. In the simulations, the nominal exchange rate is indexed to the domestic inflation rate, hence, fixing the real exchange rate, except in the case when a step devaluation is simulated.

F. Money Supply

Changes in the money supply in period i, ΔM_{Si}, are now given by:

$$\Delta M_{Si} = \Delta y_{Mi} + \Delta OMO_i + e_i y_{FGi} - e_{i-1} y_{FG(i-1)} \tag{9}$$

where Δy_{Mi} is determined by the government's financing of its budget deficit, and ΔOMO_i represents money created by the central bank via open market operations. The remainder of the right-hand side represents the domestic currency value of the external sector balance.

IV. Simulation Results

In order to simulate the model, structural parameters are needed. Without losing generality, we have used here parameter estimates reported in Feltenstein and Morris (1990), Feltenstein (1992), and Feltenstein and Shah (1995).[20] These include parameter estimates for behavioral equations for consumption, money demand and portfolio allocation, as well as production coefficients and export elasticities. Estimates of the sectoral production of value-added as a function of inputs of sector-specific capital and three types of public infrastructure are also included.

A. A Base-Case Simulation

After constructing a benchmark case, a simulation for a three-year period is run, utilizing, as mentioned before, predetermined values for most of the exogenous parameters.[21] This benchmark case corresponds to the initial, pre-shock case in that the elasticity of money demand does not change over the various periods and therefore, the stock of bank deposits does not fall.

A number of constraints were imposed in this first simulation. First, the only source of monetary expansion is to finance budget deficits (i.e., ΔOMO = 0 in eq. (9)). Second, the real exchange rate is constant, i.e., the rate of change of nominal rate follows the inflation rate. Third, consistently with the discussion in Section III.2, it is supposed that when a firm's ratio of investment to the existing capital stock falls below a certain threshold, say, 18 percent, the firm is unable to service its debt.[22] Finally, government spending, and, hence, the budget

[20]These parameter estimates are, in turn, derived from Alberro (1989a,b), Jarque (1988), Jung (1988), and Zedillo (1986). It should be emphasized that these parameters are being used only for illustrative purposes.

[21]In particular, we take the interest elasticity of money, c, to be equal to the value estimated in Feltenstein (1992), that is, $c = -0.268$, where c is given in equation (Ab) (see Appendix). It is to be stressed that more important than the initial value of c is its change and direction of this change as the economy is subject to an exogenous shock.

[22]The ratio of 18 percent is, of course, arbitrary. We should note that our quantitative results are fairly sensitive to the choice of this ratio, since falling below the threshold results in a discontinuity. Our qualitative conclusions do not change, however, when alternative ratios are

(continued...)

deficit, have been adjusted, so as to start with a zero inflation rate. The resulting equilibrium outcomes are reported in Table 1.

In period 2, there is a sharp increase in the real interest rate, primarily because of the assumption about tight monetary policy that allows monetary expansion only to finance a budget deficit, which is being restricted at 0.5 percentage points of GDP. Accordingly, the real GDP growth in period 2 is not accommodated and does not lead to a corresponding monetary increase, resulting in a rise in the nominal, and, hence, real interest rate.

In the base case there are no bank defaults, although banks do hold some nonperforming assets. These arise because, given the sectoral parameters in period 3, investment to capital stock ratio of sector 2 is equal to 14.5 percent. This is less than the assumed 18 percent threshold necessary for the firm to be able to service its borrowing. Hence, banks that have lent to sector 2 experience a default on that borrowing. Since bank 2 is the largest lender to sector 2 and holds 50 percent of the sector's borrowing, it experiences the largest loss as a fraction of its total assets. However, since none of the banks have nonperforming assets greater than 8 percent of total assets, no bank is declared insolvent.[23]

B. An Exogenous Shock

Suppose now that the economy suffers an unexpected exogenous shock of the nature analyzed in Section II, that causes increased anxiety among consumers regarding their bank deposits holdings. This anxiety is reflected by a fall in the interest elasticity of money from 0.268 to 0.150. This reduction in the elasticity means that consumers are, in response to an interest rate increase, less likely to shift their portfolio structure from money into bank deposits.

The numerical value assigned to this change is, of course, arbitrary but it will allow certain qualitative conclusions. All other parameters in the simulation remain as in Table 1. In particular, the government continues to adhere to a tight money policy in which there are no open market operations, and the only monetary expansion stems from budget deficit financing. The resulting outcomes are presented in Table 2.

[22](...continued)
chosen.

[23]In the real world, however, one could expect that supervisory authorities start taking preventive measures *before* bank capital is fully depleted. We do not consider partial defaults in this world.

Table 1. Base Case: c = - 0.268 1/

	Period 1	Period 2	Period 3
Nominal GDP 2/	100.6	100.2	100.1
Real GDP 2/	100.0	101.8	98.6
Price level 2/	100.0	100.3	105.1
Budget Deficit (% of GDP)	0.5	1.3	1.6
Exchange Rate ($/peso)	100.0	100.4	105.3
Interest rate 3/	10.0	25.6	26.5
(real interest rate)	(0.0)	(15.6)	(10.9)
Deposits 4/	100.0	100.0	100.0
Trade balance ($)	7.3	3.1	1.5
Defaults	0	0	0
Aggregate insolvent assets (% of total)	0	0	0

Net capital stock at end of period 5/		**Percent of bank assets in default at end of period 3**	
Sector 1 1	00.0	Bank	1.9
Sector 2	00.0	Bank	27.3
Sector 3	100.0	Bank	31.6
Sector 4	100.0	Bank	41.9
Sector 5	100.0	Bank	51.1

1/ This corresponds to the case in which there is no shock to bank deposits. Recall that c, the interest elasticity of the money demand, as in equation (Ab) in the Appendix, is not constant, but varies over time as a function of the share of nonperforming assets in total bank assets.
2/ These are index numbers based on period 1.
3/ Here and in subsequent simulations the real interest rate is normalized based on the period 0 implied price level. If the period 1 price level is 100, and the assumed rate of inflation for period 1 is 10 percent, an arbitrary figure, then $P_0 = 90.9$. Thus, the real interest rate for period t is calculated as the nominal rate minus $(P_t/P_0 - 1)$, where P_t is the period t price level.
4/ The stock of deposits is normalized in each period to simplify comparisons with counterfactual simulations.
5/ The capital stocks are normalized to their net period 3 values in this simulation.

Table 2. Uncompensated Exogenous Shock: c = - 0.150

	Period 1	Period 2	Period 3
Nominal GDP 1/	41.0	34.1	27.7
Real GDP 1/	99.5	97.7	97.2
Price level 1/	41.2	34.9	28.5
Budget deficit (% of GDP)	0.7	1.8	2.5
Exchange Rate ($/peso)	63.0	56.7	43.9
Interest rate	5.9	21.4	23.3
(real interest rate)	(60.6)	(83.0)	(92.0)
Deposits 2/	56.8	45.8	39.3
Trade balance ($)	5.3	2.7	2.8
Defaults	0	Bank 2	Banks 2,4
Aggregate insolvent assets (% of total)	0	13.5	27.9

Net capital stock at end of period 3 3/		Percent of bank assets in default at end of period 3	
Sector 1	97.7	Bank 1	3.2
Sector 2	87.5	Bank 2	15.5
Sector 3	97.8	Bank 3	5.8
Sector 4	98.5	Bank 4	20.3
Sector 5	97.7	Bank 5	4.2

1/ Index numbers based on period 1 in Table 1.
2/ These are index numbers based on corresponding deposits in each period in Table 1.
3/ These are index numbers based on the corresponding end-of-period stocks in Table 1.

A number of significant changes can be observed, as compared with the base case. The shift out of deposits into currency, caused by the shock-induced decline in the interest elasticity, has led to a drastic initial deflation. This deflation, in turn, has brought about a corresponding large increase in the real interest rate, reflecting an increased demand for currency with no counterpart on the supply side. The high real interest rate has caused a decline in the net formation of capital in all sectors over the three years, and a corresponding decline in real GDP.[24]

The rising real interest rate also causes a decline in the ratio of investment to the stock of capital in all sectors, and in some sectors the ratio falls below 18 percent. Again, since the affected sectors are unable to service their debts, banks are now holding significantly higher amounts of nonperforming assets compared with the base case. As a result, two banks have failed, leaving more than a quarter of bank assets and liabilities in the hands of regulators. It is to be recalled that, as the share of nonperforming assets in total bank assets rises, the run from deposits accelerates.[25] Accordingly, by period 3, the interest elasticity of demand for money will be smaller than the 0.15 assumed for period 1. Thus, the shock becomes more severe as time passes.

C. Policy Responses

Certain policy responses designed to alleviate the severe contractionary effects of the exogenous shock could now be considered. One possibility would be to implement an expansionary monetary policy in order to compensate for the decline in bank deposits caused by the shift in the public's perception about solvency. Assume then, that the central bank issues currency in direct proportion to the decline in deposits. This takes place with a one-period lag so that, for example, if deposits fall by 10 percent in period 1, then the stock of currency will be increased by 10 percent at the start of period 2.[26] The currency expansion is carried out as an open market operation and, hence, is in addition to the monetization of the budget deficit. Table 3 reports the outcome.

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[24]The magnitude of the changes in nominal and real variables are indeed exaggerated. This is intentional in order to highlight the consequences of the shock and policy responses. It is possible, of course, to obtain more realistic numerical outcomes by calibrating the impact of the shock on the changes in c, the interest elasticity.

[25]Appendix equation (Ab).

[26]This policy takes place with a one-period lag in order to reflect the unexpected nature of the deposit loss. If the central bank responded at the same time as the shock, then, by definition, it would not be a shock.

Table 3. Exogenous Shock: Compensatory Monetary Policy

	Period 1	Period 2	Period 3
Nominal GDP 1/	41.0	43.9	52.7
Real GDP 1/	99.5	97.8	97.6
Price level 1/	41.2	44.9	54.0
Budget deficit (% of GDP)	0.7	1.4	1.6
Exchange Rate ($/peso)	63.0	68.7	82.9
Interest rate	5.9	6.2	6.6
(real interest rate)	(60.6)	(57.2)	(46.8)
Deposits[2]	56.8	51.2	57.0
Trade balance ($)	5.3	2.1	0.7
Defaults	0	0	Bank 2
Aggregate insolvent assets (% of total)	0	0	13.3

Net capital stock at end of period 3 3/		Percent of bank assets in default at end of period 3	
Sector 1	98.5	Bank 1	0.9
Sector 2	98.6	Bank 2	8.4
Sector 3	99.1	Bank 3	1.6
Sector 4	100.0	Bank 4	1.9
Sector 5	98.7	Bank 5	1.2

1/ Index numbers based on period 1 in Table 1.
2/ These are index numbers based on corresponding deposits in each period in Table 1.
3/ These are index numbers based on the corresponding end-of-period stocks in Table 1.

Expansionary monetary policy has led to considerably different outcomes, as compared to Table 2. After the shock-induced initial drop in deposits (from 100 to 56.8 and 51.2), the level of deposits rebounded. As a result, real interest rates decline, leading to a rise in the level of economic activity and in the rate of capital formation, as compared to the case when monetary policy does not compensate for the loss of deposits. At the same time, however, the trade balance deteriorates and there is a marked acceleration of inflation. The reduction in the real interest rate improves the solvency of firms, and hence bank defaults also decline. Only one bank is seized by regulators, while all the other banks are significantly more solvent than in the case of the uncompensated shock, as shown in Table 2. The policy of compensating the loss of deposits by increasing the money supply offers, therefore, a tradeoff between more stable financial developments at the expense of a deteriorating macroeconomic situation, reflected in stronger inflationary pressures and a less favorable external position.

Can the above tradeoff be improved by offsetting the monetary expansion through a tighter fiscal stance? The next simulation involves a combination of the expansionary monetary policy with a 10 percent reduction in government spending. Thus, the initial shock has the same effect as before in period 1, since it was unanticipated and, therefore, uncompensated, but the picture in subsequent periods differs, as shown in Table 4.

Following the monetary/fiscal mix, the rate of inflation is somewhat lower, falling by about 5 percentage points over the three periods, as compared to the case when monetary expansion was solely employed. The level of real income also increases after period 1, in contrast to the previous case. There is, in addition, an improvement in the trade balance, corresponding to the reduction in the rate of monetary expansion. Also, there have been small improvements in the rate of capital formation in three out of the five sectors, while the solvency of the banking system has remained approximately unchanged, although the level of bank deposits rebounds more slowly. It is clear, therefore, that fiscal tightening, combined with accommodating monetary policy, is preferable to a policy based only on monetary accommodation. The policy mix is a superior alternative at a macro level, that is, in terms of inflation and balance of payments results. For the banking system, there appears to be little difference between the effects of a compensatory monetary policy and the policy mix that includes a reduction in the fiscal deficit, simply because the real interest rate remains essentially unchanged under the two policies.

As a final policy alternative, an exchange rate devaluation combined with monetary expansion is considered. The aim of such a policy would be to increase the cost of foreign currency, with the purpose of slowing the substitution away from domestic interest-bearing assets into other assets, including foreign currency. Table 5 reports the result of implementing a policy seeking an initial 25 percent devaluation of the exchange rate, followed by continued real indexation of the exchange rate. No reduction in the fiscal deficit is predicated.

Table 4. Exogenous Shock: Compensatory Monetary Policy—
Reduction in Government Spending

	Period 1	Period 2	Period 3
Nominal GDP 1/	41.0	42.1	50.6
Real GDP 1/	99.5	97.7	98.3
Price level 1/	41.2	43.1	51.5
Budget deficit (% of GDP)	0.7	1.5	1.3
Exchange Rate ($/peso)	63.0	65.9	78.8
Interest rate	5.9	7.0	6.8
(real interest rate)	(60.6)	(59.6)	(50.2)
Deposits 2/	56.8	42.5	50.9
Trade balance ($)	5.3	3.9	3.1
Defaults	0	0	Bank 2
Aggregate insolvent assets (% of total)	0	0	14.5

Net capital stock at end of period 3 3/		Percent of bank assets in default at end of period 3	
Sector 1	94.7	Bank 1	1.1
Sector 2	88.0	Bank 2	9.5
Sector 3	99.3	Bank 3	1.8
Sector 4	100.1	Bank 4	2.2
Sector 5	98.8	Bank 5	1.3

1/ Index numbers based on period 1 in Table 1.
2/ These are index numbers based on corresponding deposits in each period in Table 1.
3/ These are index numbers based on the corresponding end-of-period stocks in Table 1.

Table 5. Exogenous Shock: Compensating Monetary Policy—Devaluation

	Period 1	Period 2	Period 3
Nominal GDP 1/	41.0	47.2	51.7
Real GDP 1/	99.5	97.9	96.1
Price level 1/	41.2	48.2	53.8
Budget deficit (% of GDP)	0.7	2.2	2.4
Exchange Rate ($/peso)	63.0	78.8	87.9
Interest rate	5.9	15.9	14.8
(real interest rate)	(60.6)	(62.9)	(55.6)
Deposits 2/	56.8	51.1	57.4
Trade balance ($)	5.3	2.8	2.1
Defaults	0	Bank 2	Banks 2,4
Aggregate insolvent assets (% of total)	0	13.8	28.1

Net capital stock at end of period 3 3/		**Percent of bank assets in default at end of period 3**	
Sector 1	97.2	Bank 1	3.6
Sector 2	87.2	Bank 2	18.3
Sector 3	97.4	Bank 3	6.1
Sector 4	98.3	Bank 4	20.8
Sector 5	97.9	Bank 5	4.7

1/ Index numbers based on period 1 in Table 1.
2/ These are index numbers based on corresponding deposits in each period in Table 1.
3/ These are index numbers based on the corresponding end-of-period stocks in Table 1.

Comparing the outcome of this policy response with that generated by monetary and fiscal tightness, it is possible to perceive a relatively small change in real GDP, although there is a slight decline in period 3. The budget deficit rises, in response to the higher cost of servicing foreign debt. There is a significant increase in the real interest rate, which, in turn, causes more insolvencies among enterprises. In addition, there is a decline in the rate of capital formation. As a result, the level of insolvent assets is twice as big as that observed in the case of a reduction in budgetary spending. It is possible to conclude, therefore, that compensatory monetary policy, combined with a devaluation, is an inferior policy alternative vis-à-vis compensatory monetary policy alone, as well as compensatory monetary policy combined with fiscal tightening.

V. Summary and Conclusions

A dynamic model of a multi-sector economy, including multiple banks, has been presented. The economy starts from an initial equilibrium in which all banks are solvent, but then experiences an exogenous shock. The analysis stresses how, and through which channels, an external shock which initially impacts nonfinancial sectors can alter the functioning of a sound bank system. The result of this shock is to cause holders of bank deposits to withdraw their deposits and to move into both domestic and foreign currencies. The real interest rate rises, forcing some borrowers--those investing in real capital--into bankruptcy. The resulting rise in nonperforming assets held by the banking system causes increased anxiety among depositors concerned about the solvency of the banking system, and exacerbates the initial disequilibrium. An accelerating run on the banking system thus results. It is important to note that this run occurs even though the model is nonstochastic, and the banking system is initially in good condition. Accordingly, having in place a reasonable system of supervision and prudential bank regulations would not be enough to neutralize the panic that an exogenous shock sets into motion.[27]

Using a quantitative model, various policy simulations were carried out. Compensatory monetary policy, in which the central bank supplies currency in response to the initial loss in deposits, is found to significantly reduce the bank run. The injection of liquidity causes deposits to stabilize, after the initial withdrawals. As a result, the initial rise in real interest rates is moderated and rates start to decline, lowering the rate of bankruptcies and, hence, reducing nonperforming assets. On the other hand, the expansion in the monetary base has brought about inflation and a deterioration in the trade balance.

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[27]Indeed, only restrictions on deposit withdrawals (like deposit freezes, forced rescheduling, or exchange of deposits for long-term bonds) would be able to prevent the bank run from occurring. Such restrictions would, however, create their own problems and essentially would adversely impact credibility and the demand for financial assets.

Combining compensatory monetary policy with tighter fiscal policies is found not only to slow the bank run and mitigate bank insolvency, but also to improve the macro economy. The rate of inflation slows, as compared to the case when compensatory monetary policy is used in isolation, the trade balance shows improvement, and capital formation slightly increases. The solvency of the banking system remains approximately the same as when monetary expansion was used alone, primarily because the real interest rate remains essentially unchanged when the two policy responses are compared.[28]

A devaluation, on the other hand, has little positive impact. Here, devaluation is combined with monetary expansion in order to increase the cost of foreign assets and to eliminate expectations, and, hence, to reduce the rush from domestic interest-bearing assets into other assets, including foreign currency. The budget deficit rises, as a result of the higher cost of servicing foreign debt. Consequently, there is a significant increase in the real interest rate, which, in turn, causes more insolvencies among enterprises. Hence, nonperforming bank loans also rise. Devaluation is, therefore, not a beneficial step to reestablish bank soundness, nor to improve the macroeconomic stance.

It is then possible to conclude that an exogenous shock may alter people's perceptions and generate a bank run and genuine insolvency, even when the banking system is initially fully sound. A combination of monetary and fiscal policies can greatly reduce the severity of the run. Moreover, this combination is superior to resorting solely to compensatory monetary policy or to a devaluation of the exchange rate.

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[28]It could be argued, however, that the monetary/fiscal policy mix response leaves the real sector on a sounder footing for the future, which would eventually have healthy repercussions on the banking sector.

THE CONSUMER'S PROBLEM

Here, and in what follows, we will use x to denote a demand variable and y to denote a supply variable. In order to avoid unreadable subscripts, let us let 1 refer to period i and 2 refer to period i+1. The consumer's maximization problem is, thus:

$$\mathbf{max}\ U(x), \quad x = (x_1, x_{Lu1}, x_{Lr1}, x_2, x_{Lu2}, x_{Lr2}) \tag{A}$$

such that:

$$(1+t_i)P_i x_i + P_{Lui}x_{Lui} + P_{Lri}x_{Lri} + P_{Mi}x_{mi} + P_{Bi}x_{Bi} + e_i P_{Bfi}x_{BFi} = C_i \tag{Aa}$$

$$P_{K1}K_0 + P_{A1}A_0 + P_{Lu1}L_{u1} + P_{Lr1}L_{r1} + P_{M1}M_0 + r_0 B_0 + P_{B1}B_0 + e_1 P_{BF1}B_{F0} + TR_1 = N_1$$

$$P_{K2}(1-\delta)K_0 + P_{A2}A_0 + P_{Lu2}L_{u2} + P_{Lr2}L_{r2} + P_{M2}x_{M1} + r_1 x_{B1} + P_{B2}x_{B1} + e_2 P_{BF2}x_{BF1} + TR_2 = N_2$$

$$C_i = N_i$$

$$\log P_{Bi}x_{Bi} - \log e_i P_{BFi}x_{BFi} = \alpha + \beta(\log r_i - \log\frac{e_{i+1}}{e_i} r_{Fi}) \tag{Ac}$$

$$\log(L_{ui}/L_{ri}) = a_1 + a_2 \log\frac{P_{Lui} - P_{Lri}}{P_{Lui} + P_{Lri}} \tag{Ad}$$

$$\log P_{Mi}x_{Mi} = a + b\log(1+t_i)P_i x_i - c\log r_i;\ c_i = c(DEF/ASSETT) \tag{Ab}$$

if $P_{Lui} \geq P_{Lri}$; otherwise $\log (L_{ui}/L_{ri}) = 0$

(if the representative household is rural, otherwise, labor holdings are constant)

$$P_{B2}x_{B2} = s(1+t_2)P_2x_2 \qquad \text{(Ae)}$$

where:

P_i	= price vector of consumption goods in period i
x_i	= vector of consumption in period i
C_i	= value of aggregate consumption in period i (including purchases of financial assets)
N_i	= aggregate income in period i (including potential income from the sale of real and financial assets)
t_i	= vector of sales tax rates in period i
P_{Lui}	= price of urban labor in period i
L_{ui}	= allocation of total labor to urban labor in period i
x_{Lui}	= demand for urban leisure in period i
P_{Lri}	= price of rural labor in period i
L_{ri}	= allocation of total labor to rural labor in period i
x_{Lri}	= demand for rural leisure in period i
a_2	= elasticity of rural/urban migration
P_{Ki}	= price of capital in period i
K_0	= initial holding of capital
P_{Ai}	= price of land in period i
A_0	= initial holding of land
δ	= rate of depreciation of capital

P_{Mi} = price of money in period i. Money in period 1 is the numeraire and, hence, has a price of 1. A decline in the relative price of money from one period to the next represents inflation

x_{Mi} = holdings of money in period i

P_{Bi} = discount price of a certificate of deposit in period i

r_i = domestic interest rate in period i

x_{Bi} = quantity of bank deposits, that is, CD's in period i

e_i = the exchange rate in terms of units of domestic currency per unit of foreign currency in period i

x_{BFi} = quantity of foreign currency held in period i

TR_i = transfer payments from the government in period i

a, b, α, β = estimated constants

DEF = the total value of non-performing assets in the banking system

ASSET = total assets of the banking system

c = a functional form that depends negatively upon the ratio of non-performing assets to total assets in the banking system

The left-hand side of equation (Aa) represents the value of consumption of goods and leisure, as well as of financial assets. The next two equations contain the value of the consumer's holdings of capital and labor, as well as the principal and interest that he receives from the domestic and foreign financial assets that he held at the end of the previous period. The equation $C_i = N_i$ then imposes a budget constraint in each period. Equation (Ab) is a standard money demand equation in which the demand for cash balances depends upon the domestic interest rate and the value of intended consumption. There is, however, one modification. The interest elasticity, c, depends upon the share of nonperforming bank assets in total assets. If there are no bad assets, then c takes its econometrically estimated value. As nonperforming assets rise, c declines.

Equation (Ac) says that the proportion of savings made up of domestic and foreign interest-bearing assets depends upon relative domestic and foreign interest rates, deflated by the change in the exchange rate. Finally, equation (Ad) is a migration equation that says that the change in the consumer's relative holdings of urban and rural labor depends on the relative wage rates.

In period 2 (i+1) we impose an exogenous savings rate on the consumers, as in equation (Ae). Thus, savings rates are endogenously determined by intertemporal maximization in period i, but are fixed in period i+1. Only period i, the current period, is actually realized as the solution of the above optimization problem. When period i+1 begins, the consumer's holdings of financial assets may be different than those incorporated in the above problem, since defaults may have occurred. The consumer then optimizes again for periods i+1, i+2, based on his new, unexpected holdings of financial assets at the beginning of period i+2.

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