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BANK RUNS IN OPEN ECONOMIES AND THE INTERNATIONAL TRANSMISSION OF PANICS

Peter M. Garber

Vittorio U. Grilli

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ABSTRACT

In this paper, we extend the bank run literature to an open economy model. We show that a foreign banking system, by raising deposit rates in the presence of a domestic banking panic, may generate sufficient liquid resources to acquire assets sold by the domestic banking system at bargain prices. In this case, foreign depositors will benefit from the domestic panic. We also show that our simple model is able to generate the spreading of panics. Perhaps not surprisingly, the crucial element in determining the propagation of financial crises is the effect of interest rates on savings decisions.

Peter M. Garber
Economics Department
Brown University
Providence, RI 02912

Vittorio U. Grilli
Economics Department
Yale University
New Haven, CT 06520

1. Introduction

Recent models of systematic bank runs [Diamond and Dybvig (1982), Waldo (1985)] have been set in the context of a closed economy. The important banking collapses of the previous century and of the first third of this century, however, occurred in an environment marked by financial openness and by the operation of a gold standard. Foreign holders of liquid gold reserves could therefore ship them to a country experiencing a banking panic and benefit from an opportunity to acquire assets cheaply, provided that they were themselves confident that the panic would not spread to their own banking system.

In this paper, we extend the bank run literature to an open economy model. We show that a foreign banking system, by raising deposit rates in the presence of a domestic banking panic, may generate sufficient liquid resources to acquire assets sold by the domestic banking system at bargain prices. In this case, foreign depositors will benefit from the domestic panic. Another important reason for studying bank runs in an open economy framework, is that financial crises and panics are frequently international phenomena: "... financial crises tend to be international, either running parallel from country to country or spreading by one means or another from the centers where they originate to other countries" (Kindleberger (1978) p. 118). We will show that our simple model is able to generate the spreading of panics. Perhaps not surprisingly, the crucial element in determining the propagation of financial crises is the effect of interest rates on savings decisions.

We divide the paper into three sections. In section 1, we present a two-country banking model and examine its equilibrium in the absence of bank runs. In section 2 we study the international equilibrium that would arise with a bank run in the domestic country. Section 3 contains conclusions.

1. The Model and its No-Run Equilibrium

In this section, we describe a simple three-period economy with financial intermediaries in many ways similar to previous models, especially that of Waldo (1985). Whereas previous analyses of bank runs were confined to closed economies, we examine a two-country setting.

The domestic economy is comprised of an infinite number of identical individuals who live for three periods and have preferences given by:

$$U(c_1) + \beta U(c_2), \ 0<\beta<1.$$

People consume only in periods one and two. In period zero, they receive an endowment E_o, identical for all individuals.

In the economy, three different ways exist to transfer wealth over time: storage with no depreciation, short term (one-period) investment with a payoff r_1, and long term (two-period) investment with payoff r_2. The payoffs are parametric. We will assume that $r_2 > r_1^2$. Individuals do not have direct access to investment technology. Because of indivisibilities (not modelled) in the size of investment projects, they must pool their resources to invest in a short or long term project. Such a pooling institution could be either a bank or a mutual fund.

Previous papers, i.e. Diamond-Dybvig (1983) and Waldo (1985), assume the presence of unobservable, idiosynchratic shocks which generate liquidity needs in the first period to justify the existence of banks which provide demand deposit arrangements. The addition of this assumption would not change our conclusions in any important way. Since the focus of the paper lies in another direction, we simplify the analysis by ignoring this kind of shock. We assume directly that banks providing demand deposits prevail in the society. We allow the presence of a securities market, but only for large players as in Waldo.[1]

We assume that the foreign country is a mirror image of the domestic country: it has identical preferences, technology, endowments, and financial institutions. Any equilibrium with no bank runs will be characterized by the absence of trade between the two countries.

The budget constraints for the representative agent in the domestic economy are given by:[2]

Period 1: $E_o = S_o + DD_o + FD_o$

Period 2: $S_o + i_1 DW + i_1^* FW = S_1 + DD_1 + FD_1 + C_1$

Period 3: $S_1 + i_2(DD_o - DW) + i_2^*(FD_o - FW) + i_1 DD_1 + i_1^* FD_1 = C_2$

where:

E_o = period zero endowment.

S_o = storage from period zero to period one

S_1 = storage from period one to period two

DD_j = deposits in domestic banks at period j

FD_j = deposits in foreign banks at period j

DW = withdrawals from domestic deposits in period one

FW = withdrawals from foreign deposits in period 1

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[1] Diamond and Dybvig implicitly assume the absence of securities markets in the presence of the sorts of contracts offered by their banks.

[2] Budget constraints for foreign individuals are identical. Simply add an asterisk (*) to represent foreign variables and parameters.

C_j - consumption in period j

i_1 - payoff on one unit of demand deposits held for one period

i_2 - payoff on demand deposits held for two periods.

Competition among banks assures that $i_1 = r_1$ and $i_2 = r_2$.[3] Moreover, since foreign banks have access to the same linear technology, $i_1 = i_1^*$ and $i_2 = i_2^*$. This model will have a multiplicity of equilibria due to the indeterminacy of the division between domestic and foreign investment arising from the identical, constant return technology. We resolve this indeterminacy by assuming that, given identical returns, individuals will choose deposits in banks in their own countries.

The maximization problem therefore simplifies to

$$\max\ U(C_1) + \beta U(C_2)$$

$$\text{s.t. } E_o \geq S_o + DD_o \qquad (\lambda_o)$$

$$S_o + r_1 DW \geq S_1 + DD_1 + C_1 \qquad (\lambda_1)$$

$$S_1 + r_2(DD_o - DW) + r_1 DD_1 \geq C_2 \qquad (\lambda_2)$$

λ_j is the Lagrange multiplier corresponding to period j budget constraint. The first order conditions for this problem are:

$$C_1 : u'(C_1) = \lambda_1$$

$$C_2 : \beta U'(C_2) = \lambda_2$$

[3] Alternatively, we could assume that there is a single bank aiming to maximize consumer welfare.

$S_o : S_o[\lambda_1 - \lambda_o] = 0$

$DD_o : \lambda_o = r_2\lambda_2$

$DW : r_1\lambda_1 = r_2\lambda_2$

$S_1 : S_1 [\lambda_2 - \lambda_1] = 0$

$DD_2 : DD_1[\lambda_1 - r_1\lambda_2] = 0.$

In equilibrium, S_o, S_1, and DD_1 will be zero, since these investments are dominated by DD_o and $(DD_o - DW)$. Formally, in addition, we must consider the bank solvency constraints:

$r_1 SI_o = i_1 DW$

$r_1SI_1 + r_2LI_o = i_2(DD_o - DW) + i_1 DD_1$

where SI_j are the short term assets purchased by the bank at time j and LI_o are the long term assets purchased at time zero.

The equilibrium is such that the bank will invest DW in short term securities and $(E_o - DW)$ in long term securities. (Recall that $DD_o = E_o$ in equilibrium.)

Example: Constant Relative Risk Aversion Utility Function

Suppose that $U(C_j) = C_j^{1-\alpha}/[1 - \alpha]$. The first order conditions are then:

$C_1 : C_1^{-\alpha} = \lambda_1$

$C_2 : \beta C_2^{-\alpha} = \lambda_2$

$DD_o : r_2 = \lambda_o/\lambda_1$

$DW : r_2/r_1 = \lambda_1/\lambda_2$

$\lambda_o : E_o = DD_o$

$\lambda_1 : r_1 DW = C_1$

$\lambda_2 : r_2(DD_o - DW) = C_2$

Using these conditions, we find that

$$C_1 = r_1 DW = [r_1^{1/\alpha} E_o] / [r_1^{(1-\alpha)/\alpha} + \beta^{1/\alpha} r_2^{(1-\alpha)/\alpha}]$$

$$C_2 = [\beta^{1/\alpha} r_2^{1\alpha} E_o] / [r_1^{(1-\alpha)/\alpha} + \beta^{1/\alpha} r_2^{(1-\alpha)/\alpha}]$$

$$LI_o = [\beta^{1/\alpha} r_2^{(1-\alpha)/\alpha} E_o] / [r_1^{(1-\alpha)/\alpha} + \beta^{1/\alpha} r_2^{(1-\alpha)/\alpha}]$$

As expected $dDW/dr_1 > 0$, and $dDW/dr_2 < 0$.

Specifically, if $\beta = 1$, $\alpha = .5$, $r_1 = 1.05$, and $r_2 = 1.15$, equilibrium allocations are:

$DW = 0.48\ E_o$

$C_1 = 0.50\ E_o$

$C_2 = 0.60\ E_o$

2. Equilibrium with Bank Runs

This type of model can support equilibria with self-fulfilling panics, i.e. bank runs that are triggered by events exogenous to the model's fundamentals. Also, fundamental insolvencies may generate bank runs.

After allocations have been decided in period 0 on the basis of predicting no runs, depositors can self-generate a run in period one by suddenly believing that other depositors will withdraw the entire amount in their accounts from the bank.

This kind of scenario is similar to one described by Waldo (1985) for a closed economy. Waldo completes his model by assuming that agents in period 0 believe that the probability is ϕ that such a panic will occur in period one. This probability, however, is exogenous in Waldo's model, and we choose to assume here that it equals zero. The operational difference is that, if $\phi>0$, depositors will invest part of their endowments in storage to protect against the possibility of not beating the run. Equilibrium deposits in period 0 will change accordingly. Whether or not individuals use storage technology will not affect the thrust of our argument. For simplicity, therefore, we assume that the exogenous event that could trigger a bank run in period one is completely unexpected as of period zero.

The experiment that we will consider is that of a panic occuring only in the home country; foreign banks are not subject to panic runs. When the panic occurs in period one, agents will demand the immediate redemption of all their deposits (DD_o). We will assume that domestic agents, after withdrawing their deposits, will use storage technology (hoarding) to transfer goods to the second period. Solvency of the domestic banks requires that the bank pay out $r_1DD_o - r_1E_o$. Since the liquid assets of the banks only amount to r_1SI_o, banks must liquidate their long term securities LI_o. The only potential buyers are banks in the foreign country.

Foreign banks can acquire resources to purchase the securities by inducing their depositors to consume and withdraw less in period one. The foreign bank will offer its depositors a new contractual arrangement.

Individuals can still withdraw in period one and collect the payoff i_1. The payoff on deposits not withdrawn in period one, however, is changed to i_2'. [The (') represents foreign bank payoffs in the presence of a panic in the domestic banking system.] The maximization problem of the foreign individual as of period one will be:

$$\max U(C_1*) + \beta U(C_2*)$$
$$\text{s.t. } C_1* = r_1 DW* \qquad (\lambda_1)$$
$$C_2* = i_2'(E_o* - DW*) \qquad (\lambda_2)$$

The first order conditions are:

$$C_1* : U'(C_1*) = \lambda_1$$
$$C_2* : \beta U'(C_2*) = \lambda_2$$
$$DW* : i_2'/r_1 = \lambda_1/\lambda_2$$

i_2' will be determined by the equilibrium condition:

$$C_2* = 2r_2 (E_o - DW)$$

Consumption in the second period must equal the world output of the long-term investment.

<u>Self-Justification of Panics</u>

As is common in the bank panic literature, we can demonstrate that a bank panic in the domestic country is self-justifying. Domestic banks are assumed to pay out funds to their depositors on a first come - first served basis until they exhaust their assets.

Proposition 1: If a run occurs, the banking system is insolvent.

Proof: Note first that for the domestic banking system to be solvent, it must be able to sell period two securities for at least $r_1 LI_o$ which implies that foreign consumption in period one should drop to $r_1(SI_o - LI_o)$. In this case, the rate of return that the foreign bank can pay on deposits not withdrawn in period one is $i_2' = \frac{2r_2 LI_o}{2LI_o} = r_2$, where we used the symmetry property $LI_o = LI_o^*$. But at r_2 it was optimal for the foreign agent to consume $r_1 SI_o^*$. In order to induce a reduction in period one consumption, it is necessary that $i_2' > r_2$, which implies that domestic banks will be unable to receive $r_1 LI_0$ in exchange for their long term securities. The domestic banks are then bankrupt and the run is self-justifying. (Notice that $i_2' < r_2$ is not a possibility, since in this case the foreign country would be made worse off by purchasing securities from the domestic country).

<u>Example: Panic Equilibrium with a Constant Relative Risk Aversion Utility Function</u>

In this case the first order conditions for the foreign country are:

$$
\begin{aligned}
C_1^* &: C_1^{*-\alpha} = \lambda_1 \\
C_2^* &: \beta C_2^{*-\alpha} = \lambda_2 \\
DW^* &: i_2'/r_1 = \lambda_1/\lambda_2 \\
\lambda_1^* &: r_1 DW^* = C_1^* \\
\lambda_2^* &: i_2'(E_o - DW^*) = C_2^*
\end{aligned}
$$

To derive the explicit solution for this problem we first take i_2' as given.

The solution's form is then analogous to that of the previous case, with i_2' substituted for r_2:

$$DW^* = [r_1^{(1-\alpha)/\alpha}E_o] \;/\; [\, r_1^{(1-\alpha)/\alpha} + b^{1/\alpha}i_2'^{(1-\alpha)/\alpha}]$$
$$C_1^* = [r_1^{1/\alpha}E_o] \;/\; [r_1^{(1-\alpha)/\alpha}+ \beta^{1/\alpha}i_2'^{(1-\alpha)/\alpha}]$$
$$C_2^* = [\beta^{1/\alpha}i_2'^{1/\alpha}\, E_o] \;/\; [r_1^{(1-\alpha)/\alpha} + \beta^{1/\alpha}i_2'^{(1-\alpha)/\alpha}]. \qquad (1)$$

The next step is to find the equilibrium i_2'. To do this, we use the equilibrium condition:

$$C_2^* = 2r_2\,(E_o - \underline{DW}) \qquad (2)$$

where $\underline{DW}$ is given by period zero decisions when no bank runs were expected, i.e.

$$\underline{DW} = [r_1^{(1-\alpha)/\alpha}\, E_o] \;/\; [r_1^{(1-\alpha)/\alpha}+\beta^{1/\alpha}r_2'^{(1-\alpha)/\alpha}]. \qquad (3)$$

Substituting (3) into (2) and equating the result to (1) yields an expression in i_2' as a function of r_1, r_2, α, and β:

$$2r_2^{1/\alpha}[r_1^{(1-\alpha)/\alpha} + \beta^{1/\alpha}i_2'^{(1-\alpha)/\alpha}] = i_2'^{1/\alpha}[r_1^{(1-\alpha)/\alpha} + \beta^{1/\alpha}r_2^{(1-\alpha)/\alpha}].$$

Solving this non-linear expression provides the equilibrium i_2' which we can use to derive DW^*, C_1^*, and C_2^*.

Assuming $\alpha = .5$, this expression reduces to a second order equation, whose positive root is:

$$i_2' = (\beta^2r_2^{\,2}+(r_2^{\,2}[(\beta^2r_2+r_1)^2+r_1)^2+r_1^{\,2}])^{1/2}) \;/\; [r_1+\beta^2r_2]$$

If we substitute the same values used in the previous example, i.e. $\beta = 1$, $r_1 = 1.05$, $r_2 = 1.15$, we obtain:

$i_2' \approx 1.875$

$DW^* \approx 0.36E_o$

$C_1^* \approx 1.05\ DW^* - 0.38\ E_o$

$C_2^* \approx 1.875\ (E_o - DW^*) - 1.2\ E_o.$

The amount paid by foreign banks for the domestic securities is given by the difference between the levels of foreign, first period consumption with and without bank runs:

$C_1^{NR} - C_1^{R} - 0.5E_o - 0.38E_o - 0.12E_o.$

The liquidity needs of the domestic bank were $r_1E_o - 1.05E_o$. The liquidity derived from short term investment is $.5E_o$. The goods acquired as a result of long term security liquidation amount to $.12E_o$. Therefore, the total liquidated assets of $.62E_o$ fall short of the claims against the banks. The bank run produces the bankruptcy of the domestic banking system.

The result of a bank run in the domestic country is a redistribution of wealth from the domestic to the foreign country. As a result of the domestic panic, the total utility of the representative foreign agent has increased to $U^{R*} - 2[0.38E_o]^{.5} + 2[1.2E_o]^{.5}$ while it was only $U^{NR*} - 2[.5E_o]^{.5} + 2[.6E_o]^{.5}$ with no run in the domestic banking system.

Finally, this simple model predicts that, at the time of the bank run, the domestic country will experience a deficit in the trade balance, financed by exports of long-term assets. In the next period, it will have a surplus in its trade balance and a fall in national product below the no-run level. While domestic production will not change, the share owned by foreigners will increase and that of the residents will decrease. Therefore, while GDP will remain constant, GNP will fall. Also, the foreign country will experience an increase in the interest rate.

The International Transmission of Panics

In the event of a domestic bank run, we have assumed above that a positive flow of goods will be forthcoming from the foreign country in exchange for long term securities. The acquisition of long term securities, however, will favorably change the intertemporal budget constraint facing the typical resident of the foreign country. Under the circumstances of increased wealth, foreign depositors may in fact choose to increase their period one consumption beyond their previous plans. Since foreign banks lack sufficient liquidity to meet the implied withdrawals, the apparently favorable opportunity available to the foreign country can lead to a run on the foreign banking system. In this section we consider the conditions under which this case may arise.

Since all domestic long-term securities are sold to the foreign banking system, the amount of period two goods available to the typical foreign resident will double. To encourage foreign residents to give up claims on some of the consumption that they had planned for period one, the foreign banking system raises the yield on deposits between period one and period two to $i_2'/r_1 > r_2/r_1$. In Figure 1, this change is diagrammed as a shift from budget line 1 to budget line 2, as perceived by the typical household.

Since the foreign banking system's holdings of long term bonds will double, we know that in equilibrium, the typical household must choose a consumption bundle along the horizontal line $2\bar{c}_2^*B$ (recall that $c_2^* = r_2LI_o$). Thus, i_2' will be determined as the slope of the line through $(r_1E_o^*, 0)$ and tangent to an indifference curve along the line $2\bar{c}_2^{*}{}'B$. If the substitution effect of the budget shift dominates the income effect, that tangency will occur to the left of the point E, and foreign residents will give up some of their previously planned consumption ($\bar{c}_1^* - c_1^{*\prime}$). They will withdraw less than C_1^* from the banking system, leaving foreign banks free to trade their excess liquidity abroad for domestic securities. This was the case described in the previous example.

If the income effect outweighs the substitution effect, however, a tangency will occur along a budget line like line 3 at a point to the right of E. In this case, foreign households will try to consume more than is available in period one. This implies that a budget line like line 3 cannot be an equilibrium. Rather, perceiving that the banks are illiquid, the typical foreign household would then run the foreign banks, forcing them also to dump their securities and precluding any purchases of domestic bonds. Thus, a run on the domestic banking system would be transmitted to the foreign system.

To avoid this problem and yet benefit from the run on the domestic banks, the foreign system could impose a withdrawal ceiling on its average depositor. For example, a ceiling of $\underline{DW}^* - C_1^* - \epsilon$, where ϵ is a small positive number, would allow the foreign economy to consume at a point close to E, an improvement in well-being for the typical depositor.[4]

If restrictions on payments are not feasible, an alternative that will prevent the run on foreign banks is to impose controls on capital exports. Under an effective set of controls, foreign banks would not attempt to raise liquid resources by raising the yield on deposits. Depositors would then not attempt to withdraw funds to increase their period one consumption plans.

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[4] Interest rate ceilings on deposits may also prevent the run on foreign banks. This measure, however, will also require some form of rationing mechanism to allocate the profits from the operation.

The Limitations of Deposit Insurance

In this model, measures like deposit insurance may be ineffective in preventing the geographical spreading of financial crises. To implement a deposit insurance scheme, a government would have in the background a program to tax all withdrawals and asset holdings after a run to make good depositor claims. Since it cannot tax foreign holders of the dumped securities, however, its promise to repay depositors may not be credible. Since they cannot tax the securities, they must be able to tax the real activities on which the securities are based. If the companies which issued the securities are located domestically, then the tax authorites may credibly promise to generate the necessary revenues. However, if enough companies are located abroad, as would happen in a well diversified banking system, this scheme may not be feasible.

3. Conclusions

In this paper we study banking crises in a world economy. We show that a country's welfare may be increased by the occurence of a financial crisis in the rest of the world. Thus, it may be rewarded for playing the role of lender of last resort.

On the other hand, we also describe conditions under which bank runs "spread" internationally, thus propagating the disruptive effect of financial collapses.

In a recent paper, Smith (1987) analyzes a different environment, which also produces a geographical contagion of panics. His model is based on the existence of "reserve banks" which, by holding interbank deposits, provide the link through which withdrawals of deposits are transmitted in the system.

In this paper, instead, we describe how the liquidation of long term securities by the bank initially under stress, can be the triggering factor of international panics.

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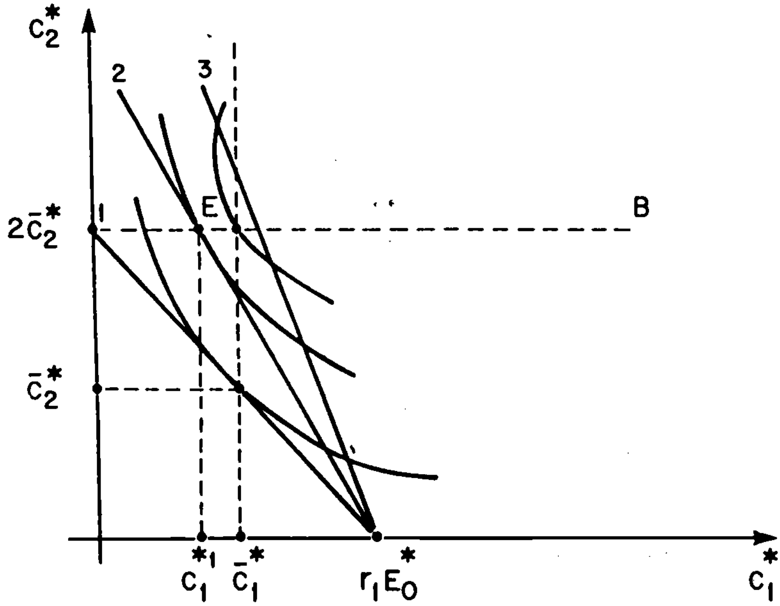

c_2^*
2
3
1
E
B
$2\bar{c}_2^*$
$\bar{c}_2^*$
c_1^{*1}
$\bar{c}_1^*$
$r_1 E_0^*$
c_1^*