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SHORT-TERM DEBT IN INTERNATIONAL BANKING CRISES*

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This paper explores how a bank run can occur when a bank takes into account short-term capital inflow from abroad. My model is an extension of the Diamond-Dybvig model to include the possibility that short-term liquidity needs can be met by borrowing from abroad. In the model, it is more efficient to meet short-term liquidity needs this way than by holding liquid domestic assets. I show conditions under which a "bad" equilibrium exists in which pessimistic foreign investors withhold their investments, making a bank run the equilibrium strategy for domestic agents and making those expectations self-fulfilling.

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I. INTRODUCTION

The liberalization of world financial markets in the 1980s attracted increased levels of foreign assets to the developing economies of Asia and Latin America. However, soon afterward, severe financial market crises struck these countries; first in Latin America and then in Asia. In the case of the Asian countries, many economists believe that a large amount of short-term foreign debt had exacerbated the crises. It seems reasonable, therefore, that any examination of the financial market crises in Asia should take into account theoretical questions about the role that foreign assets, and in particular, short-term assets, played in those crises.

Several economists seeking to explain how banks adjust their liquidity position in relation to short-term debt have made use of, and have also extended upon, Bryant (1980) and Diamond and Dybvig (1983)'s banking models. For example, Chang and Velasco (2000) developed a useful model that demonstrated how a bank can optimally arrange the maturity of its foreign liabilities. The authors described how the maturity of the external debt of banks, their level of international reserves, and the term structure of interest rates are jointly determined. They found that banks will deliberately choose an illiquid-asset-liability position, thereby exposing themselves to the consequences of a bank run.

This paper starts by briefly considering the relationship between short-term debt and the Asian financial crises; however, it then raises too questions about this relationship. Was the amount of short-term debt the main cause of the financial market crises? If so, why?

In fact, short-term debt is not the only cause of the problem. If domestic banks in open economies are able to borrow unlimited short-term assets from abroad, then why do they experience bank runs nevertheless? After all, borrowing from foreign countries could be used to guarantee sufficient liquid funds for banks to service their depositors. In other words, it seems that if domestic banks had more liquidity, they would be able to prevent Diamond-Dybvig-type bank runs. Cooper and Ross (1998) expanded the Diamond-Dybvig framework into a model in which banks respond to the possibility of a run by adjusting their investment portfolios. These authors argued that, when banks adjust their investment portfolio in this way, they desire more liquidity and will therefore hold sufficient amounts of liquid investments. Compared with their model, the bank in my model holds a sufficient amount of liquidity from abroad, and therefore may be able to prevent a run. If the cooper and Ross model is correct, what happened in the Asian countries during the 1990s? Why did many Asian countries experience severe financial crises despite having opened their financial markets to foreign investors? To answer this question, the model that domestic banks have an additional strategy, foreign short-term debt, in addition to domestic liquid and illiquid assets will be considered. The role of this short-term debt in the bank's optimal contract will be explained. The answer to this question may also be connected to the behavior of foreign investors.

This paper focuses particularly on the behavior of foreign investors. Those investors take two factors into account when they decide the amount they are willing to lend to financial intermediaries in the domestic country. One factor is foreign investors' expectations on the behavior of *domestic depositors*. Foreign investors will take into account whether the domestic depositors reveal their type truthfully or whether they are in panic. The second factor is *other foreign investors*' decision on whether they lend to extend sufficient credit to the domestic financial system or not. Based on these two factors, foreign investors will derive their "optimal behavior" for the country in which they plan to invest. In the end, changes in this optimal behavior act the same as any other constraint on domestic banks' ability to borrow. As a result the "pessimistic perspective" of foreign investors can be an important cause of domestic bank runs.

The model put forth in this paper has two distinguishing characteristics. First, this work does not put any artificial constraints on the borrowing of domestic banks. This is the principal difference with the Chang and Velasco (2000) model. In their model, without these borrowing constraints, they could not find an equilibrium, since domestic banks could earn infinite profits. In fact, there is no need to set such borrowing constraints. Historical data show that, before the Asian crisis, many Asian countries had either opened their financial markets completely or had significantly lowered the limits on foreign lending to domestic banks.

Second, this work implements a coordination game between the domestic depositors and foreign investors to show the existence of two pure-strategy Nash equilibria[1]. Using this approach, I build a model that explains the interactions among foreign investors, domestic agents, and domestic banks. The paper is organized as follows: Section 2 explains the basic model for domestic depositors, foreign investors, and domestic banks and characterizes the optimal allocations for each; Section 3 examines the equilibrium allocation derived in Section 2, and shows that it is vulnerable to a run when foreign investors have a pessimistic perspective. If coordination among the actors fails, there will be a bank run equilibrium; Section 4 presents conclusions and examines the extensions of this model.

II. MODEL SETUP

II.1. Environment

The model extends the Diamond and Dybvig setup to an open economy. This economy has three periods, $t = 0,1,2$. A continuum of agents is born during $t = 0$. There are two types of agents of equal measure (normalized to one).

Each domestic depositor is endowed with y units of a single good at $t = 0$. There are no endowments during $t = 1$ and $t = 2$. All domestic depositors are ex ante identical. At $t = 0$, they all face uncertainty regarding their preferences. Ex post, domestic agents are one of two types. With probability $\lambda \in [0,1]$, a domestic depositor is "impatient" (type 1) and will derive utility from consuming only during $t = 1$; with probability 1 - λ, the domestic depositor is "patient" (type 2) and wants to consume only during $t = 2$. Denote c_i as the consumption of a type i agents, $i = 1,2$. The domestic depositor's expected utility will then be given by

$$U(c_1, c_2) = \lambda u(c_1) + (1 - \lambda)u(c_2), \tag{1}$$

where the utility function u is twice continuously differentiable, strictly

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[1] These are also symmetric equlibria.

increasing, and strictly concave. I assume that $u'(\infty)=0$ and $u'(0)=\infty$.

Domestic agents learn their own type in the beginning of period 1. A domestic agent's preference type is private information, and cannot be directly observed by any other agents. Type realizations are i.i.d. across domestic depositors. There is no aggregate uncertainty in this economy, and so λ is also the number of impatient agents as a fraction of the population.

There are two physical assets in the domestic economy. On the one hand, a single good can be stored from one period to the next. Storage yields the gross rate of return x. On the other hand, one unit of the single good can be transformed into one unit of capital. Capital yields the gross real rate of return X after two periods. Capital can also be liquidated after one period; however, liquidation is costly and yields only a low return of γ unit of consumption good per unit of capital. Assume that:

$$X > x^2 \geq 1, \quad \text{and} \quad x > \gamma . \qquad (A.1)$$

This implies that storage constitutes a short-term liquid asset, while capital constitutes a long-term illiquid asset.

Domestic agents seek to insure themselves against the preference shocks they face. As Diamond and Dybvig (1983) show, insurance is efficiently provided by coalitions of agents, otherwise known as banks. Banks pool the resources of domestic agents, the "depositor", and invest them on their behalf. Banks improve on the autarkic allocation by helping depositors avoid costly liquidation of capital and by effectively transferring resources between patient and impatient agents as part of the insurance provision. In this model, domestic banks play an additional role. They may borrow a nonnegative amount of short-term assets from foreign investors at $t=1$. Unlike banks, domestic agents cannot directly borrow this short-term asset from foreign investors. This may be justified, for example, by noting that agents can hide in period 2 and therefore can avoid repaying the loans they take out in period 1. Banks, on the other hand, can always be located by foreign lenders. The role of short-term debt is the following: in order for banks to pay impatient depositors in period 1, they need to have some resources at that time. In the closed economy model, these resources can come either from storage initiated in period 0 or from liquidation of capital. In the open economy, there is a third potential source: borrowing from abroad. There is no borrowing constraint, so domestic banks can borrow as much as foreign investors are willing to lend.

Each foreign investor is endowed with y^f units of a single good at $t=1$. The investor derives utility from consumption during $t=2$, which is denoted by c_2^f. For most of the analysis in this paper, foreign investors are risk neutral.

Just like domestic depositors, a foreign investor has access to two means of saving: storing the consumption good at the rate of return x, or lending to domestic banks at the gross real interest rate of r_{12}. Let $\widetilde{d}_{12}(r_{12})$ denote the amount of lending by the foreign investor in period 1. Clearly,

$$\widetilde{d}_{12}(r_{12}) = \left\{ \begin{array}{ll} 0, & if \;\; r_{12} < x \\ \in \left[0, y^f\right], & if \;\; r_{12} = x \\ y^f, & if \;\; r_{12} > x \end{array} \right\}. \tag{2}$$

I assume that y^f is large relative to y. In particular,

$$y^f > \frac{X}{x} y . \tag{A.2}$$

This assumption will guarantee that the availability of foreign funds is not a problem and that the only determinant is the foreign investor's willingness to lend the funds to domestic banks.

It is useful to discuss the differences between this model and that of Chang and Velasco (2000). Chang and Velasco assume that domestic banks can borrow in world financial markets at $t=0$. They then examine the composition of the debt (short-term versus long-term) incurred at $t=0$. For technical reasons, they impose an artificial borrowing constraint on the domestic bank (otherwise the bank could earn infinite profits and an equilibrium would not exist). One consequence of the borrowing constraint is that short-term debt cannot be incurred in period 1 unless an equal amount of storage was initiated in period 0. This eliminates the role of short-term borrowing as a source of liquidity in period 1. In contrast, the model presented in this paper focuses exactly on this type of short-term borrowing.

II.2. The Domestic Bank's Problem

The optimal banking arrangement in this environment can be described as follows. Domestic agents deposit their entire endowment y with a domestic bank[2]. Part of this endowment is held as storage to provide for what the bank expects to pay out at $t=1$, and the remainder is held as capital for what it expects to pay out at $t=2$. Let b_i denote the amount stored by a bank in period i, where $i=0,1$, and let K denote the amount invested in capital. Then,

$$y = b_0 + K . \tag{3}$$

At $t=1$, a bank can borrow an amount d_{12} from foreign investors. Using this borrowed amount and the return from storage initiated at $t=0$, the bank provides c_1 to any domestic depositor that wishes to withdraw, and stores the remainder as a safe asset again. Thus the bank's balance sheet constraint at $t=1$ is:

$$\lambda c_1 + b_1 = x b_0 + d_{12} . \tag{4}$$

At $t=2$, the bank will pay a return c_2 to those domestic depositors that waited two periods for their returns. It will also clear its short-term debt, d_{12}, and accrued interest at rate r_{12} using the return from the capital initiated at $t=0$ and from storage initiated at $t=1$. Thus,

$$(1-\lambda)c_2 + r_{12} d_{12} = X\,K + x b_1 . \tag{5}$$

The above balance sheet constraints reflect two assumptions. First,

[2] No bank run in an open economy model is better than that in the closed Diamond-Dybvig. I will explain this property in Proposition 4. Thus, agents do not want to have participation constraints.

capital investments will not be liquidated. It is easy to show that, in this setting in which there is no aggregate uncertainty, premature liquidation of capital is not optimal. Second, the fraction of depositors withdrawing in periods 1 and 2, respectively, equals the true fraction of impatient and patient depositors. Since preference type is private information, this second assumption is not guaranteed automatically. Instead, the bank must offer contracts that induce self-selection. Next, I describe this self-selection constraint.

In this environment, impatient depositors cannot benefit from pretending to be patient, since they cannot consume in period 1 if they are planning to withdraw only in period 2. On the other hand, patient depositors can claim to be impatient, withdraw in period 1, and then secretly store the proceeds at the rate of return x until period 2. A contract can make this strategy suboptimal only if it satisfies the "truth-telling constraint" given by

$$c_2 \geq xc_1 . \tag{6}$$

Also, at period 1, domestic banks will offer the interest rate r_{12} to foreign investors and foreign investors decide how much to lend to the domestic bank based on this interest rate. Domestic banks take account of foreigners' lending profiles when they write contracts. Therefore, their foreign borrowing is subject to the constraint:

$$d_{12} \leq \widetilde{d}_{12}(r_{12}) . \tag{7}$$

where $\widetilde{d}_{12}(r_{12})$ is given by (2).

In summary, domestic banks will offer contracts to domestic depositors such that (1) is maximized subject to (3), (4), (5), (6), and (7). A domestic bank chooses an optimal contract $\hat{\delta} = \{\hat{c}_1, \hat{c}_2, \hat{d}_{12}, \hat{b}_0, \hat{b}_1, \hat{K}, \hat{r}_{12}\}$ taking x and X as given.

For the remainder of this paper I assume that the utility function of domestic depositors is given by

$$u(c_i) = \frac{c_i^{1-\sigma}}{1-\sigma}. \tag{8}$$

III. THE OPTIMAL BANKING CONTRACT

Now, I find the optimal banking contract.

Proposition 1 *The optimal solution to the bank's problem is*

$$\begin{aligned}
\hat{c}_1 &= \frac{X\,y}{\lambda x + (1-\lambda)x^{\frac{1}{\sigma}}} \\
\hat{c}_2 &= \frac{X\,y}{\lambda x^{1-\frac{1}{\sigma}} + (1-\lambda)} \\
\hat{d}_{12} &\in [\lambda \hat{c}_1, \infty) \\
\hat{K} &= y \\
\hat{b}_0 &= 0 \\
\hat{b}_1 &= d_{12} - \lambda \hat{c}_1 \in [0, \infty) \\
r_{12} &= x.
\end{aligned} \tag{9}$$

The proof of this proposition is provided in Appendix A. Here, I discuss some of the properties of the optimal solution. Notice that at period 0 the domestic bank will invest the entire domestic endowment in long-term illiquid capital instead of holding a combination of short-term storage and long-term capital. In order to pay the impatient agents, the domestic bank borrows from abroad at period 1. This is because this strategy is more efficient to meet short-term liquidity needs than holding liquid domestic assets in the economy that borrowing from abroad in possible. In fact, the strategy of borrowing from abroad at $t=1$ and repaying it from the proceeds of capital investments effectively raises the short-term rate of return that the bank faces between $t=0$ and $t=1$

from x to $\frac{X}{x}(>x)$ [3]. This is shown more precisely in the following Proposition.

Proposition 2 *The values of* c_1 *and* c_2 *in the optimal solution to the bank's problem with foreign borrowing are the same as they would be in the two-asset version of the closed economy Diamond-Dybvig model with short-term return* $\frac{X}{x}$ *and long-term return* X.

Proof. Denote $c_i^{DD}(R_1, R_2)$ consumption in period i of the Diamond-Dybvig model in a closed economy when the rate of return on storage is R_1 and the (two-period) rate of return on capital is R_2. Then,

$$\{c_1^{DD}(R_1,R_2),\, c_2^{DD}(R_1,R_2)\} = \{\frac{R_2 y}{\lambda(\frac{R_2}{R_1}) + (1-\lambda)\,(\frac{R_2}{R_1})^{\frac{1}{\sigma}}}, \frac{R_2 y}{\lambda(\frac{R_2}{R_1})^{1-\frac{1}{\sigma}} + (1-\lambda)}\}. \quad (10)$$

In the closed economy model, if $R_1 = \frac{X}{x}$ and $R_2 = X$, then the optimal consumption profile would be

$$\{c_1^{DD}(\frac{X}{x}, X), c_2^{DD}(\frac{X}{x}, X)\} = \{\frac{X\,y}{\lambda x + (1-\lambda) x^{\frac{1}{\sigma}}}, \frac{X\,y}{\lambda x^{1-\frac{1}{\sigma}} + (1-\lambda)}\}. \quad (11)$$

This is the same as the optimal consumption of an open economy model that was derived from Proposition 1. ■

The inefficiency of storage relative to foreign borrowing implies that a bank's portfolio at the beginning of period 1 will be completely illiquid. In the closed economy version of this model, banks hold both short-term storage and long-term illiquid capital. This illiquidity in the open economy version is efficient, because it allows for higher consumption by both types of domestic agents. However, we might expect that it also

[3] This condition comes from (A.1).

makes the domestic banks extremely vulnerable to runs. In Section 4, I will confirm this conjecture.

Finally, note that at period 1, both short-term borrowing $\hat{d}_{12}$ and storage $\hat{b}_1$ are indeterminate. If the bank borrows more than $\lambda \hat{c}_1$ from foreign investors in period 1, then it simply stores the extra amount. Since $r_{12} = x$, there is zero profit in this activity and the bank is indifferent to undertaking this activity at any scale.

IV. THE GAME AMONG FOREIGN INVESTORS AND DOMESTIC DEPOSITORS

Now I consider the strategic behavior of domestic agents and foreign investors. As in Diamond and Dybvig (1983), patient agents must decide whether to wait until period 2 to withdraw or to run on the bank. If they expect the bank to be insolvent in period 2, they will have an incentive to run. In addition, in this model, foreign investors also have strategic decisions to make: they must decide whether or not to supply funds in the range given by (2). Similarly, to patient depositors, foreign investors may also expect the bank to be insolvent at $t = 2$. In that case, they will withhold their loans. The question in this section is when these expectations can arise in equilibrium.

I assume that domestic and foreign depositors make their choices simultaneously[4]. This means that the action of a patient depositor must be the best response to beliefs about the actions of other patient agents as well as the actions of foreign investors. Similarly, the action of a foreign investor must be a best response to beliefs about the actions of the other foreign investors as well as the patient depositors.

I assume there is no suspension of convertibility. In the Diamond and Dybvig (1983) model, when withdrawals are too numerous at $t = 1$, then if banks can suspend convertibility, they can prevent a bank run. The assumption of "no suspension of convertibility" means that banks in this model will respond to large withdrawals instead by liquidating capital[5].

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[4] In my model, bank is a mechanism. Players in the game are domestic depositors and foreign investors.

[5] Freeman (1988), Cooper and Ross (1998), and Chang and Velasco (2000) assume "no suspension of convertibility".

More precisely, if the bank cannot pay c_1 from its foreign borrowing to depositors who want to withdraw at $t=1$, then the following policy will be adopted. First, the bank starts liquidating capital to try to meet withdrawal demand. If $d_{12}+\gamma K$ is still insufficient to pay c_1 to everyone, then the bank will ration its resources ($d_{12}+\gamma K$) equally between depositors who are trying to withdraw early. At $t=2$, domestic depositors have priority over foreign lenders.

IV.1. An Equilibrium Without Bank Run

My analysis follows Diamond and Dybvig (1983) in that it first shows that there is a "good" pure-strategy Nash equilibrium in which patient agents reveal their type truthfully and foreign lenders lend at least λc_1^*. Section 4.2 considers other pure-strategy Nash equilibria.

Proposition 3 *Under the contract $\hat{\delta}$ proposed by domestic banks, there is an equilibrium of the game at $t=1$ between patient depositors and foreign investors in which the optimal strategy for patient depositors is not to run and the optimal strategy for foreign investors is to choose $\tilde{d}_{12} \geq \lambda c_1^*$.*

Proof. A) If all foreign depositors supply at least λc_1^* and all other domestic patient agents do not run, then it is optimal for a domestic patient agent not to run. By claiming to be impatient, a patient depositor would receive c_1 and could consume xc_1. By writing a contract, they can receive the full promised value, c_2, which satisfies $c_2 \geq xc_1$.

B) If all patient depositors do not run and all other foreign investors deposit at least λc_1^*, impatient depositors can be paid as planned without liquidating capital, and the bank will have sufficient resources in period 2. Therefore, a foreign investor will receive $r_{12}=x$, and it will be optimal to invest any amount, including $d_{12} > \lambda c_1^*$. ■

Proposition 4 *If there is no bank run, then utility in an open economy is greater than that in a closed economy.*

Proof. Combining (4) and (5) to eliminate d_{12} and noting that $r_{12}=x$ yields the lifetime resource constraint of bank in the open economy as

$$\lambda x c_1 + (1-\lambda)c_2 = X\,y\,. \tag{12}$$

The bank's lifetime resource constraint in the closed economy Diamond-Dybvig model is

$$\lambda \frac{X}{x} c_1 + (1-\lambda)c_2 = X\,y\,. \tag{13}$$

Comparing (12) with (13), we note that the feasible set in the open economy case is strictly larger than in the closed economy case. The other constraint on the bank's problem are the same. Therefore, the bank's optimal choice in the open economy must provide strictly higher utility than in the closed economy. ■

IV.2. A Bank Run Equilibrium

Now let us suppose that the domestic depositors are pessimistic about foreign investors' willingness to lend. In this situation, the rational behavior of patient Type 2 agents causes them to misrepresent their type as "impatient". A domestic bank will face a bank run if it does not have enough resources to guarantee the withdrawals of all depositors. Is it possible that foreign investors will lend even though there exists the possibility of a bank run? In this section, I show that there is a "bad" pure-strategy Nash equilibrium, in which patient agents misrepresent their type and foreign lenders do not lend.

Proposition 5 *Let bank offer contract $\hat{\delta}$ and follow the policy of no suspension of convertibility, and suppose that*

$$\gamma < \frac{\hat{c}_1}{y} = \frac{X}{\lambda x + (1-\lambda)x^{\frac{1}{\sigma}}}\,. \tag{14}$$

Then, there is an equilibrium of the game at $t=1$ between patient domestic depositors and foreign investors in which an optimal strategy of foreign investors is to choose $d_{12}^R = 0$, and an optimal strategy of patient *domestic depositors is to run.*

Proof. A) When all foreign depositors supply nothing, all other domestic patient agents run, and the bank must liquidate all its capital, then a patient depositor receives a repayment of $\gamma y < \hat{c}_1$ on their deposits if they withdraw early, and nothing if they wait. Therefore, it is optimal for this agent to run.

B) When all domestic depositors run and all the other foreign investors invest nothing, then all the bank's resources will be liquidated at $t = 1$, and a foreign investor will not be able to receive resources in period 2. Therefore, it is optimal for the investor to also supply nothing. ■

This proposition implies that there exists a bank run equilibrium, in which pessimistic foreign investors withhold their funds, making early withdrawal of their deposits an equilibrium strategy for all domestic depositors, and justifying the pessimism of the foreigners.

An interesting feature of this equilibrium is that foreigners do not have to be pessimistic about the domestic economy, or even the behavior of domestic depositors. Instead, their pessimism concerns other foreigners' willingness to lend.

Condition (14) describes when a bank run can occur. This condition is always true if $\sigma \geq 1$, as in Diamond and Dybvig's closed economy model. However, it can also be true when $\sigma < 1$, if γ is sufficiently small, or X is sufficiently large. This result is similar to the closed-economy findings of Cooper and Ross (1998). In fact, it is interesting to compare the condition under which a bank is subject to runs in an open versus. a closed economy.

Proposition 6 *Domestic banks in an open economy are more vulnerable to runs than those in a closed economy, in the sense that runs can occur under a larger set of parameter values.*

Proof. Whether or not a bank run can occur depends on the comparison between the promised payments to impatient agents and the resources available at period 1. That is, if $c_1^{DD} > xb_0^{DD} + \gamma K^{DD}$, then there is a bank run in the closed economy. Here b_0^{DD} and K^{DD} denote the optimal portfolio of a closed economy bank that faces short-term return x and long-term return X. In the open economy, if foreign investors are pessimistic, the bank's resources at period 1 are γy. Therefore, a bank run occurs if $\hat{c}_1 > \gamma y$. We know from Propositions 1 and 5 that the promised payments in the closed economy (c_1^{DD}) and in the open economy (c_1^*) satisfy $c_1^* > c_1^{DD}$. In the closed economy, the resources available at period 1 can be written as $xb_0^{DD} + \gamma K^{DD} = x(y - K^{DD}) + \gamma K^{DD} = \gamma y + (x - \gamma)(y - K^{DD})$. Since $x > \gamma$ from (A.1), we know that $xb_0^{DD} + \gamma K^{DD} > \gamma y$. Therefore, bank runs can occur in the open economy for a larger set of parameter values. ■

The intuition behind Proposition 6 is that the bank's portfolio at the beginning of the period will be more illiquid in an open economy than in the baseline closed economy case. This illiquidity makes the domestic banks more vulnerable to runs than in a closed economy.

V. CONCLUSION

This model suggests a useful framework for analyzing how a bank run occurs when a domestic bank takes into account short-term borrowing from abroad. This model includes the possibility that short-term liquidity needs can be met by borrowing from abroad. As such, it is more efficient to meet short-term liquidity needs this way than by holding liquid domestic assets. As a result, a bank's portfolio at the beginning of the period will be more illiquid than in the baseline closed economy case. This illiquidity, in turn, makes the domestic banks extremely vulnerable to runs.

This model gives us an answer to the question of why domestic banks in open economies experience bank runs even though they have access to short-term foreign debt.

According to my model, the answer to this question lies in the strategic behavior of domestic agents and foreign investors. As in the model of Diamond and Dybvig (1983), patient agents must decide whether to wait until period 2 to withdraw or to run on the bank in period 1. In addition, foreign investors also have a strategic decision to make, "lend", or "not lend". The cause of a domestic bank run in my open economy model is the self-fulfilling pessimistic expectations of foreign investors.

This paper demonstrated that, under some condition, there are two pure-strategy Nash equilibria. The first is a no-bank-run equilibrium. In this case, if foreign investors lend a sufficient amount, and anticipating that the bank's short-term liquidity needs will be met by foreign investors' lending, domestic agents will not run. In the second scenario, run equilibrium, pessimistic foreign investors withhold their funds, which makes running on the bank an equilibrium strategy for domestic agents. This "bad" equilibrium is the result of a coordination failure between foreign investors.

For my next work, this model may be extended into a general equilibrium model with a sunspot-triggered bank run. A domestic bank can devise an optimal contract by taking into account foreign investors' pessimistic expectations in the presence of the possibility of a sunspot-triggered bank run.

My results suggest that it may be possible to avoid a bank run equilibrium by imposing a stricter international reserve requirement on banks. In the case that foreign investors' pessimistic perspectives are the main cause of bank runs, this policy that domestic banks hold an international reserve requirement might lower foreign investors' pessimism. This, as well as other, policy implications of the model are left for future research.

Appendix : Proof of Proposition 1

Consider the equations for a domestic bank problem with no run, (1), (3), (4), (5), (6), and nonnegativity conditions, $c_1, c_2 \geq 0, b_0, b_1, K$. If we arrange equations (3) and (4), it yields,

$$d_{12} = \lambda c_1 + b_1 - x(y - K) . \tag{15}$$

Combining (5) and (15), result in

$$\lambda c_1 r_{12} + (1-\lambda)c_2 = K(X - xr_{12}) + b_1(x - r_{12}) + r_{12}xy . \tag{16}$$

A.1. Case 1: $r_{12} < x$

From (16), $X - r_{12} > x - r_{12} > 0$. To maximize budget set, I choose the maximum possible value of K and b_1 . Thus, $K = y$ and $b_1 = \infty$. From (15), I get $d_{12} = \infty$. And $c_1 = c_2 = \infty$.

However, when the domestic bank offers $r_{12} < x$, foreign investors choose not to lend.

A.2. Case 2: $r_{12} = x$

When $r_{12} = x$, from (16) since $X - r_{12} > x - r_{12} = 0$, we choose $K = y, b_1 \in [0, \infty)$ to maximize budget set. Thus, (16) becomes:

$$(1-\lambda)c_2 + \lambda x c_1 = X\, y . \tag{17}$$

Now, if I maximize (1) subject to (16), (6), and the nonnegativity condition, $c_1, c_2, b_0, b_1, K \geq 0$. Thus,

$$\begin{aligned} L = {} & \lambda u(c_1) + (1-\lambda)u(c_2) + \mu_1(X\, y - (1-\lambda)c_2 - \lambda x c_1) \\ & + \mu_2(c_2 - xc_1) . \end{aligned} \tag{18}$$

where μ_1 and μ_2 are Lagrangian multipliers and nonnegative.

If $c_2 = xc_1$, then $\mu_2 > 0$. In this case, if the Lagrangian function is maximized,

$$\lambda u'(c_1) - \lambda x \mu_1 - x\mu_2 = 0. \tag{19}$$

$$(1-\lambda)u'(c_2) - (1-\lambda)\mu_1 + \mu_2 = 0. \tag{20}$$

From (19) and (20), I get

$$\mu_1 = \frac{\lambda u'(c_1) + (1-\lambda) x u'(c_2)}{x}. \tag{21}$$

If I substitute (21) into (19) and use $c_2 = xc_1$,

$$\mu_2 = \frac{1}{x} \lambda c_1^{-\sigma} (1-\lambda)[1 - x^{1-\sigma}]. \tag{22}$$

If $\sigma < 1$, then $\mu_2 \le 0$ because $x \ge 1$. This contradicts $\mu_2 > 0$. Therefore, the truth-telling constraint is not binding.

Now, I consider $c_2 > xc_1$.

When we use the specific utility function, $u(c_i) = \dfrac{c_i^{1-\sigma}}{1-\sigma}$, we find the optimal consumption,

$$c_1 = \frac{X\ y}{\lambda x + (1-\lambda) x^{\frac{1}{\sigma}}}. \tag{23}$$

Also,

$$c_2 = \frac{X\ y}{\lambda x^{1-\frac{1}{\sigma}} + (1-\lambda)}. \tag{24}$$

Combining (23) and (15), yields:

$$d_{12} = b_1 + \lambda \frac{X\, y}{\lambda\, x + (1-\lambda) x^{\frac{1}{\sigma}}}. \tag{25}$$

Since $b_1 \geq 0$, I find the following interval for d_{12}:

$$\frac{\lambda\, X\, y}{\lambda\, x + (1-\lambda) x^{\frac{1}{\sigma}}} \leq d_{12} < \infty. \tag{26}$$

Under the assumption (A.2), if a domestic bank offers $r_{12} = x$, the optimal value of d_{12} is indeterminate between this interval.

A.3. Case 3: $r_{12} > x$

If a domestic bank offers the higher interest rate $r_{12} > x$ and does not consider the assumption (A.2), the optimal value of d_{12} for the domestic bank is set as y^f and is unique. However, under the assumption (A.2), foreign investors lend as much as y^f, and this higher interest rate is costly for the domestic bank. This is not the optimal solution for the domestic bank.

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