Financial Institutions, Financial Contagion, and Financial Crises*

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1. INTRODUCTION

It has been documented that financial crises often accompany problems in financial institutions, particularly at some specific stages of development. The recent financial crises in Japan and Korea, and the major financial crises in Europe and America in the late 1920s and in earlier times are some examples (e.g., Kindleberger, 1996 and Delhasise, 1999).

This paper develops a theory which endogenizes financial crises through institutions related to the corporate sector and the interbank lending market. The basic idea is that different ways of financing corporate projects may affect the nature of bankruptcy which in turn determines information in the interbank market. This is because the liquidation of a bad project by a bank is observable by outsiders, but the full balance-

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sheets of the banks are often less observable. This information problem creates the conditions for a market failure (a la Akerloff, 1970) and can lead to a financial crisis.

In our model, an economy has many banks which receive deposits (a la Diamond and Dybvig, 1983) and invest in long-term projects with a stochastic technology. A technological shock can make a bank insolvent and a liquidity shock can make a bank illiquid. If in the interbank market there is a separating equilibrium such that solvent and insolvent banks are distinguishable by the public, when a solvent bank faces an excess of early withdrawals, there should be no difficulties for the bank to borrow. But the symmetric information for illiquid and insolvent banks makes it impossible for them to borrow. Therefore, bank runs are isolated to illiquid and insolvent banks, and a bank run contagion will never occur in such an economy.

However, if there is a pooling equilibrium in an interbank market such that the information on the insolvency of the banks is not available, then all illiquid banks will be treated in the same manner. That is, all banks with a realized positive value of assets will have to repay. With private information about one's own solvency, a manager for a better bank will face a higher cost of borrowing since there is a higher probability that the bank will generate profits. When the expected costs of borrowing for the best illiquid banks are higher than liquidating their prematural assets, the banks will not borrow but rather they will liquidate some of their prematural assets. The withdrawals of the best banks from the interbank market will generate negative externalities. That is, as a result the quality of the interbank market will be driven down -which will make the cost of borrowing for other good banks higher than the costs of liquidating some of their prematural assets as well. Thus, more banks will withdraw from the market. A repetition of this process will lead to a collapse of the interbank market.

More interestingly, a pooling equilibrium in the interbank market does not always drive the economy to a financial crisis. This is because the expected borrowing cost for the best banks monotonically increases with the heterogeneity of the projects financed by the banks. When the projects in the pool are homogeneous, the interbank market will always work well and there will be no financial crisis. But when the projects are heterogeneous, a pooling equilibrium in the interbank market becomes an incubator for financial crises.

This result sheds some light on the timing of a financial crisis in a pooling equilibrium economy. The economy should have no trouble when most of its sectors are at similar imitation stages, or with only a small variation; but the situation will change after the imitation stage of the economy has ended.

In our model, the pooling and separating equilibria in the interbank lending market are endogenized through two types of financial institutions. A financial system that requires 'collective decisions' by multi-financiers is more likely to liquidate bad projects ex-post. The reason for this is that the costs of re-negotiation are higher when there are 'collective decisions'; hence the negotiations required to restructure the projects are less likely to be successful, and liquidations are more likely. That is, multi-bank financing can be used as a commitment device to create a separating equilibrium. In contrast, financial systems where key decisions are made by single agents do not face such high re-negotiation costs and thus are more likely to restructure rather than to liquidate. That is, the system is not able to commit to stopping bad projects, thus good and bad projects are pooled together.[1] Examples of such 'single-financier' systems include the main-bank system in Japan, the principle-transaction-bank system in Korea.

To focus on our major points, we analyze two types of 'pure' economies: 1) an economy where all projects are financed by one bank only – a pure pooling equilibrium economy; and 2) an economy where all projects are co-financed by two banks – a pure separating equilibrium economy. We also suppose that the choice of the financial system in an economy is due to some exogenous reasons, such as the legal system, etc.

Similar to Aghion, Bolton and Dewatripont (1999), we also reach the view that

[1] Similar ideas about multi-financiers being used as a commitment device can be found in Dewatripont and Maskin (1995); Hart and Moore (1995); and Bolton and Scharfstein (1996).

the failure of interbank market is a mechanism which generates contagious bank run. Unlike them, who focus on pure liquidity shortage, we deal with both liquidity shortage and technological shock, and their effects in triggering a contagious bank run. We also compare two financial institutions and their roles in generating and containing financial crises. We are in agreement with Allen and Gale (1998) in that fundamentals affect financial crises, and we argue that financial institutions are just such a fundamental factor. Moreover, the interbank market in our model can be viewed as a form of interconnectedness among all the investors that causes the financial contagion in Allen and Gale (1999).

The remainder of the paper is organized as follows. Section 2 establishes the basic structure of the model and analyzes the relationship between financial institutions and the two types of equilibria. Section 3 investigates how bank run contagion is created under a pooling equilibrium and when it may lead to a financial crisis; and it explores what will happen under a separating equilibrium. Section 4 examines government policy, in particular the central bank's lender of last resort policy, and endogenizes a soft-budget constraint trap. Section 5 discusses policy implications for the transparency of financial institutions and liberalization of the financial sector. Section 6 discusses possible extensions to the model to include corruption. The final section, Section 7, concludes with some qualifications and elaborations of our theory, a short literature survey, and a brief discussion of the financial institution arrangement in Korea and Taiwan to show the relevance of financial institutions to financial crises.

2. THE MODEL

In our economy, there are many entrepreneurs, M banks and bank managers, and $N \times M$ depositors.

Entrepreneurs have ideas about new investment projects but no wealth to finance them. In this model any uncertain investment can be a project, such as technological innovation. An entrepreneur can be an inventor or a financier (such as a venture capitalist). Among all the projects proposed by entrepreneurs, λ percentage of the projects are a good type, and the rest are a bad type. Ex ante, neither the entrepreneurs or the banks know which projects are good and which projects are bad, but they both are fully aware of the distribution.

A project takes three periods to finish, requires a total investment of $I_1 + I_2 + I_3$, where I_t is the required investment in period t, and $I_t \gg 1$. The technology of the project has a constant return to scale. A good project generates an ex-ante profitable return, $Y > I_1 + I_2 + I_3$; while a bad project generates no return as it stands. A bad project, however, can be reorganized at date 2 and the best return a reorganized bad project can generate is X, and $I_3 < X < I_2 + I_3$, that is, it is ex-ante unprofitable but can be ex-post profitable. The expected return from a project in the pool is positive, that is, $(1-\lambda)X + \lambda Y - I_1 - I_2 - I_3 > 0$.

We assume that if a project is financed, at date 1 an entrepreneur will learn the type of the project, but the bank(s) still will not know its type. At date 2, the bank(s) will know the type of the project, and if it is a bad one, a decision will be made either to liquidate or to reorganize.

We assume that an entrepreneur gets a private benefit b_t from working on a project, where t denotes the date when the project is either completed or terminated at $t = 1, 2, 3$. Specifically, if the entrepreneur quits the project at date 1, he gets a low private benefit, $b_1 > 0$. At date 2, if a bad project is liquidated, the entrepreneur gets an even lower private benefit b_{2b}, where $0 \leq b_{2b} < b_1$. At date 3, if a bad project is reorganized and completed, it will generate a private benefit $b_{3b} > b_1$ to the entrepreneur; in the case of a good project, it will generate a private benefit, $b_{3g} > b_{3b}$, to the entrepreneur. To summarize, we have $b_{3g} > b_{3b} > b_1 > b_{2b} \geq 0$.

With respect to the financing, the bank can either finance the project alone, or it can co-finance the project with other banks. We refer to the former as a case of single-bank financing, and to the latter as a case of multi-bank co-financing. Here, one bank financing reflects real cases where financing decisions are made by a single agent, such as the case of government-coordinated financing where the government makes the decisions, or the case of the principal-bank system where the principal bank makes the decisions (e.g., in South Korea) and, of course, also true single-bank financing or internal financing. Multi-bank co-financing reflects cases where there are diversified and decentralized financial institutions and a large number of agents are involved in investment decisions.

The timing of the game related to project financing is as follows:

- Date 0: All parties know the distribution of the projects and the depositors, but no one knows the type of each project and the type of each depositor. The bank(s) offer a take-it-or-leave-it contract to the entrepreneur. If the contract is signed, the bank(s) will invest I_1 units of money into the project during period 1.

- Date 1: The entrepreneur learns the type of the project. If the entrepreneur stops the project (liquidation), he gets a private benefit $b_1 > 0$ and all the banks observe the liquidation of the project. However, unless a project is stopped by the entrepreneur the bank(s) still does (do) not know the type of the project and further I_2 units of money are invested into the project. Moreover, the bank(s) will know the distribution of their own project better as their private information, i.e., each bank m will have λ_m which is more accurate than the prior λ.

- Date 2: The type of a project becomes public knowledge:

  - If a project is a good type, a further I_3 will be invested.
  - If a project is a bad project, a decision whether to liquidate or to reorganize has to be made.
    - If a project is liquidated the bank(s) gets zero and the entrepreneur gets $b_{2b} < b_1$; otherwise,
    - if a project is reorganized, I_3 will be invested.

- Date 3: All projects are completed,
  - for a good project, return Y goes to the bank(s), the entrepreneur gets $b_{3b} > b_1$;
  - for a bad project, return X goes to the bank(s), the entrepreneur gets $b_{3g} > b_{3b}$.

If a project is a good one, it generates a high return Y no matter whether it is financed by one bank alone or it is co-financed by two banks. For a bad project, we suppose that there are several strategies to reorganize it during the third period, but only one of them can generate X, which is ex post profitable. But this strategy can only be selected and implemented when all the involved bank(s) in agreement.

Under single-bank financing, given that the earlier investments are sunk, the bank will choose an ex-post efficient strategy to reorganize the project such that the payoff is greater than the ex-post cost of refinancing, I_3. That is, the bank is unable to commit to terminating a bad project ex post.

Moreover, the fact that the bank is not being able to commit to terminating a bad project affects the entrepreneur's ex-ante incentives to reveal information. When the entrepreneur at date 1 discovers that his project is a bad one, he expects that the project will still be continued and refinanced by the bank at date 2. Consequently, if he decides to quit the project, he gets private benefit b_1; if he decides to continue the project, the bad project will always be refinanced by the bank and will generate a private benefit $b_3 > b_1$ for the entrepreneur. Therefore, the entrepreneur will always choose to continue a bad project after he privately discovers its type.

However, in the case of multi-bank financing, we suppose that there are conflicts interest among the involved banks about how to reorganize the project. Such conflicts incur a negotiation cost, C. When this cost, C is high, the gain from reorganization becomes less than the total costs, i.e., $X < I_3 + C$. Therefore reorganization will not be worthwhile and liquidation will be follow.[2]

[2] For similar arguments and models, see Bolton and Scharfstein (1996), Dewatripont and Maskin

The commitment to liquidate a bad project that has multi-bank financing has a deterrent effect on entrepreneurs who have bad projects. Afraid of further losses later, an entrepreneur with a bad project will choose to quit once he discovers it is a bad project because the losses incurred by quitting at date 1 are smaller than those incurred at date 2, i.e., $b_{2b} < b_1$. To summarize, we have the following result:

Lemma 1 *The equilibrium achieved under single bank financing is pooling that both good and bad projects will be completed. The equilibrium achieved under multi-bank financing is separating that all bad projects will be liquidated at date 1 and only good projects will be completed.*[3]

With this result, for simplicity we will term an economy under multi-bank financing as an economy of hard-budget constraints (HBC), while an economy under single bank financing as an economy of soft-budget constraints (SBC) in the rest of paper.

In this economy, banks are risk-neutral and they maximize expected profits.

All the M banks in the economy are ex-ante identical, and N depositors each deposit \$1 in a bank. Thus, each bank's assets are N. For the M banks, there is an interbank lending market to solve potential liquidity shortage problems. We assume that a liquidation of a bad project is observable by all the banks.

In our economy there are two types of depositors, as described by Diamond and Dybvig (Diamond and Dybvig, 1983): early and late risk-averse consumers, with early consumers only consuming at $t = 1$, and late consumers only consuming at $t = 3$. Ex ante, all depositors are identical and do not become aware of the types of the projects until $t = 1$. They make their investment decisions on their endowment of \$1 based on an ex-ante belief about the riskiness of the banking system and about the market equilibrium return on deposits. They supposedly do not monitor the banks because of high surveillance costs and lack of expertise.

(1995), Hart and Moore (1995).

[3] To highlight the major points of our paper and to present the model in the simplest possible way, we treat this part in a less formal way. Rigorous proof of this lemma based on a formal model with precise conditions is available upon request.

Combining the outcome of the banks' project investments and the consumers' deposit decisions, the evolved timing of the game can be summarized as follows:

- Date 0: Depositors make a savings decision; the banks make an investment decision regarding how much and in which project to invest.
- Date 1: Early consumers withdraw money from the banks; late consumers make decisions about wether to withdraw or to keep their deposits in the banks. A bank facing too many early withdrawals has to borrow from other banks. All bad projects financed by multi-banks will be liquidated.
- Date 2: All single-bank financed bad projects will be reorganized by the banks.
- Date 3: All projects are completed; banks pay back the loans if they borrowed at date 1; and late consumers collect their rewards.

3. SOFT-BUDGET CONSTRAINTS AND FINANCIAL CRISES

To highlight our points, we first abstract government away from the model. The role of government will be incorporated into the model in a later section. Moreover, we will make some assumptions to simplify the model. Most of our simplification assumptions can be relaxed without qualitatively compromising the results.

3.1 Deposit Contract

We consider a one-good economy. Each depositor's \$1 endowment can be stored from one period to the next, without any cost, or it can be invested in a bank which then invests in a project with stochastic technology, yielding a positive expected return in the future as described in the above section.

Each depositor's preference is defined as

$$U = \pi_1 u(C_1) + \rho \pi_2 u(C_2),$$

where C_j is the consumption of type j depositor; $j = 1$ being early consumers who consume at $t = 1$ and $j = 2$ being late consumers who consume at $t = 3$; π_j is the probability that a depositor is a type 1 or a type 2 consumer, and $\pi_1 + \pi_2 = 1$; $\rho < 1$ is the discount factor and $\rho\,(R+1) > 1$, where R is the return from investment, which is to be determined in the later sections; and $u^{'} > 0$, $u^{''} < 0$, and $(Cu^{'})^{'} = u^{'} + Cu^{''} < 0$.

At date 0, consumers make a deposit decision by solving[4]

$$
\begin{aligned}
\max_{C_1} U &= \pi_1 u(C_1) + \rho \pi_2 u(C_2) \\
\text{s.t. } 1 &= \pi_1 C_1 + \pi_2 C_2/(1+R)
\end{aligned}
$$

In general, the first order condition of this problem is

$$u^{'}(C_1^*) = \rho(1+R)u^{'}(C_2^*).$$

Given that $u^{'} + Cu^{''} < 0$, $\rho < 1$ and $\rho(1+R) > 1$, we have

$$u^{'}(1) > \rho u^{'}(1) > \rho(1+R)u^{'}(R).$$

Consequently, an ex-ante optimal market equilibrium can only be achieved by increasing C_1 and decreasing C_2, that is,

$$
\begin{aligned}
C_1^* &> 1, \\
C_2^* &< 1+R.
\end{aligned}
$$

Similar to the model of Diamond and Dybvig, in our model a market equilibrium in which a banks implements deposit contracts with consumers can Pareto dominate that of autarchy. That is for \$1 deposit at $t = 0$, a depositor receives either C_1^* at $t = 1$, or C_2^* at the end of the exercise. The bank holds $\pi_1 C_1^*$ (as cash) at no extra cost, and invests the rest in an illiquid project which yields a higher return. At equilibrium, an early consumer always wants to consume at $t = 1$, but a late consumer has no incentive to withdraw early. This is because when $\rho(1+R) > 1$,

[4] Here, $u(C_2)$ is the expected utility, because unlike the Diamond and Dybvig model, there is technological uncertainly in our model.

the first order condition $u^{'}(C_1^*) = \rho(1+R)u^{'}(C_2^*)$ implies $C_1^* < C_2^*$. Thus for a late consumer a deviation does not pay as long as other late consumers do not deviate.

However, there is no perfect insurance against liquidity shocks and there may be a bank run equilibrium, that is, a simultaneous deviation of all late consumers. When there is an interbank lending market, the key for the existence of a bank run equilibrium is the possibility that banks cannot solve their liquidity shortage problems by borrowing from the market. In that case, the bank will fail to meet all late consumers. Anticipating this, all late consumers will withdraw at $t = 1$.

In our multi-bank economy the total number of depositors is finite, with N depositors in each bank and the realized numbers of type 1 and type 2 depositors for each bank are random draws from binomial distributions of π_1 and $\pi_2 = 1 - \pi_1$ respectively. In the next two subsections, we will analyze the possibility of a financial crisis in economies with an HBC institution or with an SBC institution. We start with an SBC economy.

3.2 Financial Crisis in an SBC Economy

In an SBC economy, all projects will last for three periods, requiring a total investment of $(I_1 + I_2 + I_3)$. Moreover, each project's expected rate of return is $R^S(\lambda) = \frac{\lambda Y + (1-\lambda)X}{I_1+I_2+I_3} - 1 > 0$. Thus, with an endowment of N and anticipating the expected withdrawal at date 1, a bank's optimal investment decision is to hold $N\pi_1 C_1^*$ in cash and invest $N(1 - \pi_1 C_1^*)$ in one project at $t = 0$.[5]

[5] With an endowment of N and anticipating the expected withdrawal at date 1, a bank's optimal investment decision is to hold $N\pi_1 C_1^* + l^S$ in cash and invest $N(1 - \pi_1 C_1^*) - l^S$ in k^S projects at $t = 0$, where $l^S \geq 0$ is the amount of excessive liquidity a bank puts aside ex ante, and

$$k^S = \frac{N(1 - \pi_1 C_1^*) - l^S}{I_1 + I_2 + I_3}.$$

Ex ante, each bank faces the same problem in planning its liquidity. The total supply of liquidity at date 1 in the economy, for any given l^S, is

$$MN\pi_1 C_1^* + l^S.$$

We suppose that at date 1 bank managers in an SBC economy do not know the type of the project that they are financing. But through their monitoring over one period of time, they have better information than at date 0, and that is their private information. This private information is difficult to convey since all banks have an incentive to falsely report if there is a benefit of doing so. Moreover, we suppose that the only public information in the interbank market is the average quality of all the projects financed by all the banks in the market. Formally, we suppose that at date 1, the manager of bank m ($m = 1, ..., M$), learns privately that the probability of his project being good is λ_m. Suppose the rank of the qualities of all the banks' projects is $\lambda_1 < \lambda_2 < \lambda_3 < ... < \lambda_M$, and the average quality is $\overline{\lambda} = \frac{1}{M}\sum_{m=1}^{M}\lambda_m$.

If the total number of early withdrawals at date 1 is smaller than the expected number $\pi_1 N$, a bank will have excess liquidity reserves to lend; if the total number of early withdrawals is more than $\pi_1 N$, however, the bank will face a liquidity shortage; we call this bank illiquid. An illiquid bank may solve its liquidity problem either by borrowing in the interbank market or by liquidating some of its investment prematurely.

In the case of borrowing, an illiquid bank issues a bond in the interbank lending market. With limited liability, a borrowing bank can only pay back the bond if it has a good project. However, given the market knows only $\overline{\lambda}$ all illiquid banks will be treated in the same way when they borrow. Therefore, all the bonds issued by banks have the same structure: contingent on the realization of the project at date 3, the bond pays,

$$\begin{cases} 1, & \text{if the project is good,} \\ 0, & \text{otherwise.} \end{cases}$$

The total expected demand for liquidity in the economy, is

$$MN\pi_1 C_1^*.$$

Thus, at equilibrium we must have

$$l^S = 0.$$

For simplicity, with $l^S = 0$, we assume $k^S = 1$.

To highlight our points, we assume that there is a Bertrand competition among lenders that these banks break even in lending. Hence, given the probability that a bank will pay back 1 is $\bar{\lambda}$, the equilibrium bond price is $p^S = \bar{\lambda}$.

For an illiquid bank to raise \$1, it needs to issue $\frac{1}{p^S}$ shares of a bond in the interbank market. Thus, in order to deal with n excessive early withdrawal consumers for an amount of nC_1^*, a total of $\frac{nC_1^*}{p^S}$ shares of a bond should be issued. While the bond structure is the same for all illiquid banks, with the private information about the quality of each bank's project, the borrowing cost for each bank is different. With the private information of bank m that its probability of being able to pay back the bond is λ_m, the cost of raising nC_1^* dollars is $\frac{\lambda_m}{\bar{\lambda}} \frac{nC_1^*}{p^S}$. That is, the marginal borrowing cost is $C_B(\lambda_m) = \frac{\lambda_m}{\bar{\lambda} p^S} = \frac{\lambda_m}{\bar{\lambda}^2}$. Therefore, the higher the quality of a bank the higher the borrowing cost. Not surprisingly, $\bar{\lambda}$ has to be relatively high to λ_m to make the expected profit of bank m non negative.

Lemma 2 *An illiquid bank's expected profit will not be negative after borrowing if* $\bar{\lambda}^2 \geq \frac{\lambda_m (I_1 + I_2 + I_3)}{\lambda Y + (1-\lambda) X}$.

Proof. A bank's non-negative expected return condition is

$$E(\mathfrak{R}) = (1-\lambda_m)X + \lambda_m Y - I_1 - I_2 - I_3 - [(1-\pi_1)N - n]\, C_2^* - \frac{\lambda_m}{\bar{\lambda}} \frac{nC_1^*}{p^S} \geq 0.$$

From that we have the lower bound of the bond price,

$$\underline{p} = \lambda_m n C_1^* / \left\{ \bar{\lambda} \left[(1-\lambda_m) X + \lambda_m Y - I_1 - I_2 - I_3 - ((1-\pi_1)N - n)\, C_2^* \right] \right\}.$$

Given that all the returns of a bank will be distributed to the late consumers, that is,

$$(1-\lambda)X + \lambda Y - I_1 - I_2 - I_3 = (1-\pi_1) N C_2^*,$$

we have,

$$\begin{aligned} \underline{p} &= \lambda_m n C_1^* / \left\{ \bar{\lambda} \left[(1-\lambda_m) X + \lambda_m Y - I_1 - I_2 - I_3 - ((1-\pi_1)N - n)\, C_2^* \right] \right\} \\ &= \lambda_m n C_1^* / \left\{ \bar{\lambda} \left[(\lambda_m - \lambda)(Y - X) + n C_2^* \right] \right\}. \end{aligned}$$

Using the following relationships,

$$C_1^* > 1, C_2^* < 1 + R^S(\lambda), \text{ and } R^S(\lambda) = \frac{\lambda Y + (1-\lambda)X}{I_1 + I_2 + I_3} - 1,$$

we have

$$\begin{aligned} \underline{p} &= \frac{\lambda_m C_1^*}{\bar{\lambda}} \frac{n}{nC_2^* + (\lambda_m - \lambda)(Y - X)} \\ &\geq \frac{\lambda_m}{\bar{\lambda}} \frac{n(I_1 + I_2 + I_3)}{n(\lambda Y + (1-\lambda)X) + (\lambda_m - \lambda)(Y - X)} \\ &\approx \frac{\lambda_m (I_1 + I_2 + I_3)}{\bar{\lambda}(\lambda Y + (1-\lambda)X)}. \end{aligned}$$

Only when $\underline{p} \leq \bar{\lambda} = p^S$ the illiquid bank will have a non-negative expected profit after borrowing. This will be satisfied if

$$\begin{aligned} \bar{\lambda}^2 &\geq \frac{n\lambda_m (I_1 + I_2 + I_3)}{n(\lambda Y + (1-\lambda)X) + (\lambda_m - \lambda)(Y - X)} \\ &\approx \frac{\lambda_m (I_1 + I_2 + I_3)}{\lambda Y + (1-\lambda)X}. \end{aligned}$$

■

In addition to borrowing, an illiquid bank can also liquidate part of its assets prematurely to solve its liquidity problem. However, liquidating assets prematurely is costly. We denote the exogenously marginal cost of raising cash through liquidating prematural assets as C_L. Given the cost C_L, only the banks that have a non-negative net return after liquidating some of the assets, i.e.,

$$E(\check{R}) = [(1-\lambda_m)X + \lambda_m Y - C_L n C_1^*] - I_1 - I_2 - I_3 - [(1-\pi_1)N - n] C_2^* \geq 0,$$

view the option of liquidating some of their assets desirable.

In general, at date 1 a solvent illiquid bank will compare C_B with C_L to decide how to raise cash. When $C_B \leq C_L$ then it will borrow; otherwise, it will liquidate some of the prematural assets.

We suppose that there are $\bar{m}$ banks facing liquidity shocks. In order to highlight our points in a simple way, we assume that $\lambda_m = \lambda_{m-1} + \mu$ for all $m = 1, 2, ..., \bar{m}$; and that C_L is the same for every bank. Denoting $\bar{\lambda}_{\bar{m}} = (\sum_{i=1}^{\bar{m}} \lambda_i)/\bar{m}$, the following Lemma provides a condition for the proof of a bank run contagion.

Lemma 3 *With* $\lambda_m = \lambda_{m-1} + \mu$, *then* $\frac{\lambda_{\bar{m}}}{\bar{\lambda}_{\bar{m}}^2} \leq \frac{\lambda_{\bar{m}-1}}{\bar{\lambda}_{\bar{m}-1}^2}$, *for* $\bar{m} \geq 2$, *and* $\mu > 0$.

Proof. With $\lambda_m = \lambda_{m-1} + \mu$ and $\underline{\lambda} = \lambda_1$, we have

$$\begin{aligned} &\lambda_m = \underline{\lambda} + (m-1)\,\mu; \\ &\textstyle\sum_{m=1}^{\bar{m}} \lambda_m = \underline{\lambda}\bar{m} + \frac{1}{2}\mu\,(\bar{m}-1)\,\bar{m}; \\ &\bar{\lambda}_{\bar{m}} = \frac{1}{\bar{m}} \textstyle\sum_{m=1}^{\bar{m}} \lambda_m = \underline{\lambda} + \frac{1}{2}\mu\,(\bar{m}-1)\,. \end{aligned}$$

Thus,

$$\begin{aligned} \frac{\lambda_{\bar{m}}}{\bar{\lambda}_{\bar{m}}^2} - \frac{\lambda_{\bar{m}-1}}{\bar{\lambda}_{\bar{m}-1}^2} &= \frac{\underline{\lambda} + (\bar{m}-1)\,\mu}{\left[\underline{\lambda} + \frac{1}{2}\mu\,(\bar{m}-1)\right]^2} - \frac{\underline{\lambda} + (\bar{m}-2)\,\mu}{\left[\underline{\lambda} + \frac{1}{2}\mu\,(\bar{m}-2)\right]^2} \\ &= -\frac{(2\bar{m}-3)\underline{\lambda}\mu^2 + (\bar{m}-2)(\bar{m}-1)\mu^3}{(2\lambda + \mu\bar{m} - \mu)^2\,(2\lambda + \mu\bar{m} - 2\mu)^2} \\ &< 0, \end{aligned}$$

for any $\bar{m} \geq 2$, and $\mu > 0$. ■

Proposition 1 *If* $\frac{\lambda_{\bar{m}}}{\bar{\lambda}_{\bar{m}}^2} > C_L$, *then there may be a contagious bank-run equilibrium.*

Proof. Let us look at a situation where $\frac{\lambda_{\bar{m}}}{\bar{\lambda}_{\bar{m}}^2} > C_L > \frac{\lambda_{\bar{m}-1}}{\bar{\lambda}_{\bar{m}}^2} > \frac{\lambda_{\bar{m}-2}}{\bar{\lambda}_{\bar{m}}^2} ... > \frac{\lambda_1}{\bar{\lambda}_{\bar{m}}^2}$. That is, for the best bank (with $\lambda_{\bar{m}}$) its cost of issuing bonds in the interbank lending market is higher than the liquidation cost; but for all other banks their borrowing costs are lower than the liquidation cost. Therefore, only the best illiquid bank will withdraw from the interbank market. But the withdrawal of the best bank from the market will lower the average quality of the borrowers in the interbank market such that $C\left(\lambda_{\bar{m}-1}\right) = \frac{\lambda_{\bar{m}-1}}{\hat{\lambda}^2} > \frac{\lambda_{\bar{m}}}{\bar{\lambda}^2} = C_B\left(\lambda_{\bar{m}}\right)$ according to the above Lemma. Thus, after the withdrawal of the best bank, the second best bank will also find $C_L < C_B$ and will withdraw from the interbank lending market. This will cause the bond price further decrease. Repeating the process, the bond market price will decrease to a level whereby the type-2 depositors will infer that the banks are insolvent. Thus there will be a run on the banks. This will lead to a contagious bank failure. ■

The ratio of $\frac{\lambda_{\bar{m}}}{\bar{\lambda}_{\bar{m}}}$ reflects how a private evaluation and a public evaluation of a project differ, since $\lambda_{\bar{m}}$ is private information of bank $\bar{m}$ while $\bar{\lambda}_{\bar{m}}$ is public information.

It is also a measurement of the heterogeneity of the projects. That is, the more heterogeneous the projects are the larger the difference could be between a private evaluation and a public evaluation. This proposition says that in an SBC economy if projects financed by the banks have a high enough heterogeneity such that the borrowing cost for the best illiquid bank is higher than the liquidation cost, and when there are many banks facing liquidity shocks, then a bank run contagion may be an equilibrium. A basic intuition for the result is the market breaks down due to the asymmetric information generated by the SBCs. When the quality of a good bank is private information and the bank is treated as an average in the interbank lending market, the bank may find borrowing to be too costly and thus will withdraw from the market. But this will generate externalities such that the average quality of the borrowers in the interbank lending market will deteriorate – which will induce more banks to withdraw from the market until there is a total collapse of the interbank lending market and a bank run contagion.

Proposition 2 *If* $\frac{\lambda_{\bar{m}}}{\bar{\lambda}_{\bar{m}}^2} \leq C_L$ *and* $\bar{\lambda}^2 \geq \frac{\lambda_m(I_1+I_2+I_3)}{\lambda Y+(1-\lambda)X}$*, then at equilibrium illiquid banks borrow in the interbank lending market and there is no contagious bank run in an SBC economy.*

Proof. When $\bar{\lambda}^2 \geq \frac{\lambda_m(I_1+I_2+I_3)}{\lambda Y+(1-\lambda)X}$ is satisfied, the banks borrowing in the interbank lending market will have a non-negative profit. Moreover, $\frac{\lambda_{\bar{m}}}{\bar{\lambda}_{\bar{m}}^2} \leq C_L$ implies that the borrowing cost for the best illiquid bank is below the liquidation cost. Thus, at equilibrium the bank's liquidity problem will be solved through borrowing. And all the other illiquid banks will do the same. ■

A low ratio of $\frac{\lambda_{\bar{m}}}{\bar{\lambda}_{\bar{m}}}$ implies a low heterogeneity of the projects. The condition of $\bar{\lambda}^2 \geq \frac{\lambda_m(I_1+I_2+I_3)}{\lambda Y+(1-\lambda)X}$ can be rewritten as $\bar{\lambda}^2 (\lambda Y + (1-\lambda)X) \geq \lambda_m (I_1 + I_2 + I_3)$. It means a high average quality of the projects. Specifically, it expresses that the average probability that the projects will be successful is high, and the expected return is high. This proposition says that if projects financed by the banks are more homogenous, such that the borrowing cost for the best illiquid bank (thus for all the illiquid banks) is lower than the liquidation cost, and the average quality of the projects is high, then at equilibrium the problems of all illiquid banks can be solved in the interbank lending market in an SBC economy. Thus, there should be no bank run in an SBC economy. The intuition is that when projects are more homogeneous, the asymmetric information problem is reduced (when projects are perfectly homogeneous, there will be no asymmetric information problem), thus the best illiquid bank will not face a too high cost of borrowing; with high average quality projects, the lenders can afford to lend at more favorable terms to all the illiquid banks which reduces the borrowing cost for all the illiquid banks.

These results have implications for the timing of a financial crisis in an SBC economy. When an economy is technically less developed such that most investment projects are characterized by imitations, the uncertainty of the projects is low and the bank run contagion condition will not be satisfied. When an SBC economy is more developed such that a large proportion of investment projects consists of high-tech or R&D-intensive projects which are more uncertain, the bank run contagion condition is satisfied. Our results thus can explain the seemingly paradoxical phenomenon between the East Asian "Miracle" on the one hand, and the East Asian financial crisis on the other. Note that the East Asian "Miracle" phase of the East Asian economies were prior to the 1990s when the project pool in those economies featured less uncertain imitations. Consistent with our results, there was virtually no liquidation, nor were there bank runs or financial contagion. Since the early 1990s, however, these economies became more developed and they moved onto technological frontiers and invested in more high-tech projects and in innovation. As a result, the uncertainty of their project pool became more heterogeneous. According to out theory, only then financial contagion became highly possible.

3.3 A Bank Run in an HBC Economy

Following our results for an HBC economy, at equilibrium all bad projects are stopped at date 1, and all good projects will be completed as long as there is enough liquidity to continue.

Without a loss of generality, we suppose that each bank invests in k projects and invests $(I_1+l)/2$ in each project, whereby k and l are to be determined endogenously later. Clearly, I_1 is required in order to try a new project (its initial investment at $t=0$); and l is the liquidity stored for each project. At $t=1$, a bank can sell l in the interbank market when it realizes that the project is bad; or the bank needs to borrow if the project is good and l is not enough for the project. For simplicity, we have assumed that a project is jointly financed by two banks equally. Thus, with an endowment of N, a bank can invest up to $N(1-\pi_1 C_1^*)$ in k real projects at $t=0$, where $k = \frac{2N(1-\pi_1 C_1^*)}{I_1+l}$. Each bank optimally chooses l to maximize its expected returns. That is,

$$\max_l \frac{2N(1-\pi_1 C_1^*)}{I_1+l}\left\{\lambda\left[Y - I_1 - l - \frac{(I_2+I_3-l)}{p}\right] + (1-\lambda)\left(\frac{l}{p} - I_1 - l\right)\right\}, \quad (1)$$

where, p is the price for liquidity. Banks trade liquidities in the interbank market at a price p for each share of bonds, where each share will be paid \$1 at date 3.

From the first order condition of the above program, we have the equilibrium liquidity price

$$p^* = \frac{I_1 + \lambda(I_2+I_3)}{\lambda Y} \leq 1.$$

From the market clearing condition

$$\lambda(I_2+I_3-l) = (1-\lambda)l,$$

we have the equilibrium liquidity for each project as

$$l^* = \lambda(I_2+I_3).$$

And the expected rate of return (at date 0) when a bank holds l^* liquidity for each project is,

$$\begin{aligned} R^H &= \frac{1}{I_1 + l^*}\left\{\lambda\left[Y - I_1 - l^* - \frac{(I_2 + I_3 - l^*)}{p}\right] + (1-\lambda)\left(\frac{l^*}{p} - I_1 - l^*\right)\right\} \\ &= \frac{\lambda Y}{I_1 + \lambda(I_2 + I_3)} - 1. \end{aligned}$$

Moreover, at (l^*, p^*) the rate of return from investing in projects, R^H, is the same as the rate of return from trading liquidity at the price p^*,

$$\frac{1}{p^*} - 1 = \frac{\lambda Y}{I_1 + \lambda(I_2 + I_3)} - 1.$$

That is, no bank has an incentive to deviate from (l^*, p^*): ex ante holding more than l^* liquidity for a later selling (at $t = 1$) in the interbank market will not generate a better return; nor will holding less than l^* liquidity to invest in more projects have a better return.

To meet an expected number of early withdrawals a bank's optimal investment decision is to store cash in the amount of $N\pi_1 C_1^*$, and to invest all the rest — in the amount of $N(1 - \pi_1 C_1^*)$ — into $k = \frac{2N(1-\pi_1 C_1^*)}{I_1+\lambda(I_2+I_3)}$ projects, whereby each project is jointly invested with another bank.

In the event that a project is a bad one and is aborted at date 1, the liquidity $\frac{1}{2}l^*$ is saved, and the bank may then sell the liquidity in the interbank market to earn a higher return. If a project is a good one and is to be continued at date 1, it will need $\frac{1}{2}(I_2 + I_3 - l^*)$ more liquidity for completion. When a bank faces j good projects and $k - j$ bad projects, its excessive liquidity due to technological shock is simply

$$\frac{1}{2}(k-j)l^* - \frac{1}{2}j(I_2 + I_3 - l^*) = \frac{1}{2}(k\lambda - j)(I_2 + I_3).$$

Obviously, a bank is a net liquidity provider in the interbank market if it has more bad projects, i.e., $k\lambda > j$. Otherwise, a bank is a net liquidity borrower.

Now let us look at the latter case where there are more good projects, i.e., $j > k\lambda$. If the number of early consumers in this bank is exactly $N\pi_1 C_1^*$, the bank needs to borrow

$$\frac{1}{2}(j - k\lambda)(I_2 + I_3)$$

amount of liquidity from the interbank market at the price p^*. Thus its rate of return calculated at date 1 is

$$\begin{aligned} R_g^H &= \frac{\frac{1}{2}jY - \frac{(j-k\lambda)(I_2+I_3)}{2p^*}}{\frac{1}{2}k[I_1+\lambda(I_2+I_3)]} - 1 \\ &= \frac{\lambda Y}{I_1+\lambda(I_2+I_3)} \frac{\frac{j}{k\lambda}I_1+\lambda(I_2+I_3)}{I_1+\lambda(I_2+I_3)} - 1 \\ &> \frac{\lambda Y}{I_1+\lambda(I_2+I_3)} - 1 \\ &= R^H. \end{aligned}$$

Given the public knowledge of the high rate of return of this bank, R_g^H, when it faces a number of early withdrawals which is more than $N\pi_1 C_1^*$, there will be no problem for this bank to borrow more via the interbank market. Because with a higher rate of return, $R_g^H > \frac{1}{p^*} - 1$, lenders know that this bank will be able to pay back the loan which is lent at p^*. Furthermore, because $C_1^* < C_2^*$, it is not worthwhile for any late consumers to withdraw money earlier (at date 1). Thus, at equilibrium there is no bank run to any bank with more good projects, i.e., $j > k\lambda$; moreover, all early consumers withdraw money at date 1, and all late consumers wait until date 3. Therefore, with symmetric information the interbank market will function well and will reduce the probability of a bank run.

Now let us look at the case where a bank has too many bad projects, i.e., $k\lambda \gg j$. Although some additional liquidity, $\frac{1}{2}kl^*$, is saved by liquidating bad projects which can be used to deal with an excess of early withdrawals, if this bank faces too many early withdrawals, it may have difficulties in dealing with this problem. Suppose the number of early withdrawals is more than

$$\pi_1 N + \frac{\frac{1}{2}(k\lambda - j)(I_2+I_3)}{C_1^*} = \pi_1 N + \left[\frac{N\lambda(1-\pi_1 C_1^*)}{I_1+\lambda(I_2+I_3)} - j\right]\frac{I_2+I_3}{C_1^*},$$

then the bank's cash would be depleted. Thus, it either has to borrow or to liquidate some of its assets to meet the liquidity demand, otherwise it will be confronted with a bank run. Given that liquidation of its k bad projects is observable, the lenders will not expect the bank to be able to repay the loans which are borrowed at p^*. If this bank tries to liquidate some of its good projects to raise cash, some late consumers who observe too many liquidations of this bank will be frustrated and will try to withdraw at date 1, which will worsen the liquidity problem and trigger a bank run. Thus a bank run can still occur with a positive probability in an HBC economy when there are severe technological and liquidity shocks.

Proposition 3 *In an HBC economy with symmetric information among bank managers, a bank run only occurs only when a bank faces severe technological or/and liquidity shocks; however, a bank run contagion is not possible.*

An HBC mechanism generates symmetric information among bank managers. With the symmetric information the interbank lending market should be able to provide liquidity to all illiquid banks that are not hit too badly by technological shocks. As a result, although a bank run cannot be completely avoided, a bank run contagion does not occur in an HBC economy. In sharp contrast, in an SBC economy where information about the quality of bank investments is private to each bank alone, the interbank market is a lemon market. As a result, either a bank run can be avoided completely when the projects are homogeneous; or when the projects are heterogeneous and there are liquidity shocks, there can be a bank run contagion equilibrium.

4. LENDER OF LAST RESORT AND SBC TRAP

4.1 SBC Trap

Particularly, when there is a bond market failure and costly early liquidation of good quality projects, it may be desirable for the government to do something to stabilize the bond market and to stop bank run contagions. However, the problem in an SBC economy is that the government also faces an adverse selection problem.

In this section, we examine government policies from the perspectives that these policies should minimize the social welfare losses, defined as the sum of the costs caused by bank run and policy implementation. We show that in an SBC economy, if keeps the financial institution unchanged, the best that the government can do is to rescue all the banks regardless of their qualities, thus creating soft-budget constraints in the banking system as well.

In the economy, the government's role is to be the lender of the last resort (LOLR) through providing low-cost loans to illiquid banks by issuing government loans.[6] The government, however, also faces informational problem in that it, like the interbank market, only has imperfect information about the solvency of each bank and is not able to distinguish good banks from bad ones, in particular during crisis.[7] In reality, many central bankers indeed expressed their frustrations in identifying solvency of illiquid banks. Unlike the interbank market, however, the government (or central bank) may be able to fix market failure problem by providing large amount of liquidity in a short time as LOLR.

To focus on the information problem faced by the government and noticing that the only asset an illiquid bank has is its investment in a risky project, we model the LOLR loans as the government selling its bond to illiquid banks, with the banks investments in the risky projects as (implicit) collateral. We suppose that the government's perception that the probability that an average illiquid bank is able to pay back is λ_G, and the government will sell the bond at a price of p^G to that illiquid bank. and the bank pays back the bond at date 3 contingent on the realization of the project,

$$\begin{cases} 1, & \text{if the project is good,} \\ 0, & \text{otherwise.} \end{cases}$$

Given the government's perception of the probability that an average bank can pay back is λ_G, an bond price $p^S = \lambda_G$ may keep the government break even.[8]

[6] Goodhart and Huang (1998) and Freixas (1999) are among the first models of the lender of last resort. These models do not deal with moral hazard problems as consequences of bailing out banks, e.g., the SBC problem.

[7] To highlight our points, we make this extreme assumption that the government is not able to distinguish between good and bad banks. Our model's qualitative results will still hold if we relax this assumption to allow government have some blured ideas about banks' qualities.

[8] The assumption that government keeps break even is a bench mark case. It is straight forward

By setting bond price p^G the government can fix market failure problem in interbank market. Moreover, by setting a higher price, i.e. $p^G > \lambda_G$, the government can provide subsidies (cheaper loans) to illiquid banks. However, as long as the government is not able to differentiate the quality of the illiquid banks, there will be only one bond price, p^G, for all the illiquid banks. Thus, a better illiquid bank still face a higher marginal cost of borrowing than an average bank. Specifically, the marginal cost of borrowing government bailout bond for a bank m with a quality of λ_m is

$$C_B = \frac{\lambda_m}{\lambda_G p^G}.$$

That is, C_B increases with banks' quality, i.e. with λ_m.

It is easy to see that for given λ_G and C_L (marginal cost of liquidating prematural assets), if p^G is not high enough there exist a $\lambda^* \equiv p^G C_L \lambda_G$, such that for $\lambda_m > \lambda^*$, $C_B > C_L$. That is, all the banks with $\lambda_m > \lambda^*$ will not accept the government bailout bond (at price p^G) but chose to liquidate their prematural assets at a marginal cost C_L. However, different from the case without government intervention, as long as the government has enough reserve to support the fixed bond price p^G, liquidating prematural assets by better banks will not lead to the collapse of the interbank lending market.

We suppose that the government's objective is to select a bail-out strategy to halt bank runs with a minimum of social costs. However, given that the government does not know each bank's risk profile, the government should set p^G high enough to avoid social costs incurred by better banks' liquidating prematural assets. However, this implies that all the illiquid banks will be bailed out. We call this as a SBC trap.

Proposition 4 *If a government has enough reserve but does not improve the banks commitment capacities, the best this government can do in an SBC economy is to bail out all illiquid banks indiscriminately. This will prevent bank run but will also lead the economy into an SBC trap.*

to change this into the case that the government has a fixed buget to bailout banks.

A fundamental reason for such an SBC trap is the commitment problem of banks in an economy which generates lemon problems in the banking system. Moreover, this proposition illustrates that the soft-budget syndrome of government policy is generated from commitment problems of banks failing to stop bad projects. The government's soft-budget policy will induce more moral hazard problems from bank managers. In the end, the economy becomes a victim of this soft-budget constraint trap.

A scheme which induces stronger banks to seek government assistance, while leaving weaker banks to deal with bank runs requires the government to reverse its bond payment scheme such that a borrower should pay more in a deteriorating state than that in a good state. However, such a policy is not feasible as long as a failed bank has a limited liability when it faces a run or goes bankrupt. Perhaps this is why in reality we never encounter such a government policy when dealing with various banking crises, such as policies related to deposit insurance and the discount window.

In the above analysis the government has unlimited resources to bail out all the troubled banks, thus a bank run can still be prevented. If the number of illiquid banks is large and the government has a binding budget constraint to deal with them, however, the government would not be able to bail out all the banks. Given the lemon problem in the banking system, the best the government can do would be to bail out the banks randomly. In such a case, bank runs may occur and contagious risks cannot be eliminated. This is because without knowing the banks' quality and which bank will be bailed out by the government, late consumers face uncertainties of losing their deposits. In fact, the government refusal itself may be interpreted as a bad signal about the bank by the market, and this may explain what occurred to Finance One (a large financial institution) in Thailand. The Finance One went bankrupt in June 1997 after being denied help from the government, which in turn triggered a bank run contagion before the currency crisis (Corsetti et al., 1998).[9]

Thus, we have the following corollary:

[9] We thank Charles Goodhart for his suggestions regarding this elaboration and the example.

Corollary 1 *In an SBC economy, if the government does not have enough capacity to bail out all the illiquid banks, the best the government can do is to bail out banks randomly; as a result, there is a run on all those banks which do not receive government assistance.*

In contrast, in an HBC economy, both the market and the government are aware of the quality of the illiquid banks. Thus, if there is a need for the government to intervene, for instance, because of unexpected liquidity shocks, the government is able to bail out only the solvent illiquid banks. Therefore, in addition to the higher efficiency in a government rescue plan, the burden of the government's plan is much less because insolvent banks can be identified and do not need to be bailed out.

Corollary 2 *In an HBC economy, if the interbank bond markets cannot provide sufficient liquidity to illiquid banks, the government can always bail out solvent banks only. Consequently, contagious risks are much smaller than in an SBC economy.*

Our theory also has strong policy implications for the central bank's LOLR policy and financial system reform. With respect to potential moral hazard problems related to the central bank's bail-out policy, it is argued that focusing on large banks, i.e., the too-big-to-fail (TBTF) doctrine of LOLR (Goodhart and Huang, 1998) and a random LOLR policy (Freixas , 1999) may be preferable. Our theory implies that although a TBTF policy may be optimum when attention is restricted to a short run LOLR issue, it may not be a good policy in long run. This is because a TBTF policy may distort the bank managers' incentives and thus trigger inefficient bank mergers. When all the banks are large, not only will the TBTF policy not work properly, random operation of the LOLR will not be feasible either, since each one is too large to let it fail (what happened in Japan and Korea may shed some light on this). Even worse, if the number of banks is small in an economy, it is more likely that the SBC problem will prevail. Then the SBC problem will cause a lemon problem in the interbank lending market, and this may lead to an SBC trap for the economy. That is, the best that a rational government can do in an SBC economy when banks are in trouble is to bail out all of them indiscriminately. Therefore, the optimal LOLR policy should not be separated from financial institutional reforms. In the long run, reforms related to hardening the budget constraints are key to preventing the central bank's LOLR policy from degenerating into an SBC engine.

4.2 SBC Trap When LOLR Serving as a Screening Device

The previous discussion shows that in an SBC economy, the LOLR does not function due to the lack of information. The major problem which causes the failure of the interbank lending market is an information problem. One may wonder whether the problem could be avoided if the government could have a better designed LOLR policy. Specifically, it may be interesting to examine whether the LOLR policy could be used as a screening device by the government in SBC to sort out the information problem it faces such that solvent illiquid banks might be able to solve their liquidity problems in the interbank lending market.

Intuitively, in this scheme, an LOLR policy is divided into two parts: providing liquidity and screening banks. Here, we focus on screening banks. Instead of targeting solvent banks, the central bank's LOLR package targets insolvent banks. The bail-out scheme is such that the central bank bond is distributed to any bank that asks for help. The bond is associated with a profit tax, in that all the profits of a solvent bank will be taken away, thus making such help not worthwhile for a solvent bank. However, without a profit, an insolvent bank does not expect to pay anything to get help from the central bank. Thus, all the insolvent illiquid banks will ask for help and all the illiquid banks left in the market are solvent banks. Although the above scheme might be 'optimal' since only illiquid banks need to be bailed out by the government, this 'optimal' LOLR policy still leads to a SBC trap.

5. ON TRANSPARENCY AND FINANCIAL LIBERALIZATION

At a more general level, our results are closely related to another important policy issue: the transparency of the financial sector to the market and to the government. A widely held view emphasizes that policies improve the transparency of financial institutions. However, the lessons of centralized economies and the long debate over the viability of the centralized economies since the late 1930s (Lange vs. Hayek) both tell us that it is impossible to have transparency in all aspects of any economy. In light of such an impossibility, a key issue is which things are to be made transparent and how. Moreover, not only is it impossible to have transparency in all aspects of an economy, our theory suggests that targeting the wrong aspect of an economy to improve transparency can make things even worse.

Hayek outlined a principle whereby the market, not the government, can select and provide the right information for the economy to run efficiently. However, what this means in the context of financial crisis is unclear. One of our major contributions is that we provide a model to illustrate that an HBC mechanism makes solvency information transparent to the market and to the government. Thus, it makes the financial market more stable and helps the government to intervene correctly when necessary. Moreover, our theory implies that wrongly targeting transparency can result in disaster. This is because an HBC mechanism relies on the 'non-transparency' of the co-financiers' information regarding the reorganizing of a bad project. If this condition is changed but all other conditions stay the same due to a wrong policy, then the HBC mechanism is destroyed such that all the bad projects will be reorganized even when they are financed jointly. To summarize, the essential message of our theory regarding this issue is that the key policy to improve transparency correctly and effectively may not be a policy which directly targets information, but a policy which hardens budget constraints or a policy which lowers the institutional costs of multi-financier financing.

Another relevant policy issue concerns the liberalization of financial institutions. To analyze this case, we can change our model from an M-bank economy to a one-bank economy. According to our theory, a one-bank economy must be an SBC economy. Moreover, because all the deposits in the economy are pooled in one bank, the risks of facing a liquidity shock or a bank run will be greatly reduced. Theoretically, if the economy has a sufficiently large number of consumers, then the probability that there will be an excess of early withdrawals from the bank will be negligible. That is, although inefficient, this one-bank economy is almost immune to bank runs or financial crisis.

Compared with the one-bank economy, however, as we have shown, an M-bank SBC economy is very sensitive to a bank run contagion due to the lemon problem in the interbank lending market. This comparison has important implications for policies/reforms of the banking system. The basic message is that liberalization of financial institutions must be contingent on measures to harden the budget constraints. If liberalized banks are operating under an SBC, a liberalization policy alone may greatly destabilize the financial system! This simple analysis captures some characteristics of reform/liberalization of banking systems. For instance, a major reform measure in the transition from a centralized economy to a market economy is to change the banking system from a one-bank system (at least conceptually one can regard all state banks as branches of one bank – the state bank) into a multi-bank system. Many of the banking system liberalization reforms in East Asia prior to 1997 were carried out in this spirit. According to our theory, a banking system reform designed to enhance competition as described above can induce huge contagious risks to the system if the system is not designed to harden budget constraints simultaneously.

6. CORRUPTION AND FINANCIAL CRISIS

To highlight our points, in our basic model we assume that there is no corruption in the economy. All the problems are generated from corruption-free and 'pure' economic institutions. However, it is acknowledged that there is serious corruption in many economies, such as in some East Asian economies, and it is a firmly held belief that the financial crises in some economies, particularly the Philippines and Thailand and probably also in Malaysia, were related to corruption. Now we are going to relax this assumption in a casual way to look at how corruption affects financial institutions and the likelihood of a financial crisis.

There are two aspects of corruption that can be introduced into our model to generate relevant results. The first aspect is that corruption itself can be a mechanism of an SBC (Shleifer and Vishny, 1993). That is, when it is discovered that a project is a bad one at date 2, in a corrupted economy firms and/or financial institutions have the option of bribing the government to bail out the project regardless of profitability (the option will be even stronger if bailing out a project is ex post profitable). That is, with the presence of corruption there will be a more serious SBC syndrome. Moreover, with serious corruption it may be very difficult for multi-financier institution, e.g., an equity market to operate due to the lack of contract enforcement and the lack of transparency in the market. That is, HBC mechanisms may be destroyed or out-competed by corruption mechanisms.

If the impact of corruption is restricted to the above aspect, all of our theoretical results will be qualitatively unchanged. However, there is indeed another aspect of corruption that can enter into our model, that is, corruption can affect the selection of projects. It turns out that this aspect will significantly alter our theoretical results regarding the timing of a financial crisis.

To illustrate this, we suppose that at date 0 there is an asymmetric information such that entrepreneurs know the distribution better; moreover, some risky projects may be beneficial to some entrepreneurs. In a corrupted economy an entrepreneur may bribe the bank so that the project will be financed. In that case, the selected projects will be riskier and more heterogeneous than the corruption-free projects, like those in our basic model. Thus, even in a less developed economy like the Philippines or Thailand, many high-risk projects may be selected. When corruption not only results in more serious SBC problems but also results in the selection of more risky projects, then our theory will predict that the economy will be more likely to encounter a financial crisis.

7. CONCLUDING REMARKS

This paper endogenizes contagious risks and financial crises from financial institutions. We began our analysis by deriving soft- (and hard-) budget constraints from different financial institutions. Then we showed how a soft-budget constraint generates informational asymmetries among banks about their solvency, a factor which inevitably leads to a "lemon" problem in the interbank lending market. The lemon problem in the interbank lending market impedes particularly strong banks from securing loans to solve liquidity shortage problems when they face liquidity shocks. Thus, bank runs may occur, which further exacerbate the lemon problem and can lead to a collapse of the entire banking system. In contrast, under hard-budget constraints information about the quality of the banks is disclosed to the whole banking system in a timely manner. This allows the interbank lending markets to function effectively in providing loans to illiquid but solvent banks. Thus, solvent banks will be rescued and financial crisis avoided.

Our theory sheds some light to reconcile the seemingly paradoxical phenomenon between the East Asian "miracle" in the three decades prior to 1997 and the East Asian "financial crisis" in the period after 1997. In the period of early development, that is, the catching-up period of the 1960s to the early 1990s, the uncertainty of projects was low due to the nature of technological imitation. In this case, our theory predicts that the efficiency of an SBC economy is not lower than that of an HBC economy; moreover, there are no project liquidations and no bank runs. That is, an SBC economy appears even to outperform an HBC economy and may attract a number of investments. However, if for some reason the uncertainty of the projects rises precipitously, for example, when an economy is on technological frontiers and attempts innovation (e.g., South Korea since the early 1990s), the negative effects of an SBC economy will dominate, finally leading to trouble in the financial system.

Some final remarks about our theory are in order. First, although our theory is based on a very basic model to improve our general understanding of financial crises and is not designed specifically to understand the East Asian financial crisis, it provides an explanation for this recent crisis. In particular, Korean and Taiwan economies are good examples to illustrate how financial crises may be related to financial institutions. Korea and Taiwan are at similar development stages, geographically close, and they also have similar technologies, labor inputs, and high savings. For instance, in each economy the share of trade in GNP is much higher than that of the world average; and in each case there has been a transformation from a traditional economy to one that is oriented toward high-tech. However, while Korea is at the center of the East Asian crisis, Taiwan has been much less affected — even though it too has been attacked by international speculators. One possibility to explain this difference may be the substantially different financial institutions in the two economies.

It is well documented that Korean development has been characterized by the establishment of large conglomerates (chaebols) through government-coordinated bank loans. In a typical case, financing decisions for projects in Korea are made by the government or by the principal bank among a group of investing banks. For example, in the 1970s the Korean government promoted investment in the heavy and chemical industries by selecting projects and providing subsidized loans. In the 1980s the government promoted specialization in the largest chaebols through a similar financing approach.[10] Although there were complaints that with the predominance

[10] In the two decades since the early 1970s, more than half of Korean domestic credits were distributed as government policy loans with low rates (Stern et al., 1995; Cho and Kim, 1995). A closely related fact is that Korean firms were over-leveraged as their average debt-equity ratio was among the highest in the world beginning in the 1970s (Borensztein and Lee, 1998; Lee, 1998). Before the outbreak of the 1997 crisis the average debt-equity ratio of the thirty top chaebols was about 4.5. Moreover, recent econometric work shows that a significant part of the total credit in Korea was not

of government-coordinated bank financing, credits were not allocated efficiently to Korean firms,[11] the great success in the period of the 1960s to the mid-1990s is evident.

However, on the other hand, closely related to government involvement in providing subsidized credits, because of the lack of financial discipline in the corporate sector, there was almost no bankruptcy prior to 1997 (particularly for the chaebols). From panel data of more than 40,000 Korean manufacturing plants for the 1983 - 93 period, Aw et al. (1998) discover that the productivity of plants being closed down was about the same as those that remained in operating. This suggests that decisions involving the closure of plants were not related to efficiency considerations, i.e., there was no financial discipline in Korean plants.

The losses from projects financed by bank loans caused serious problems for Korean banks. At the end of 1986, nonperforming loans at the five largest commercial banks amounted to three times the total net worth of those banks (Park and Kim, 1994). To relieve the troubled banks, between 1985 and 1987 the Bank of Korea provided them with more than 3 trillion won in subsidized loans (Nam, 1994).

To reform the inefficient loan allocation scheme, the Korean government established a credit control system called a "principal transactions" banking system in the mid-1970s. Under this system, the bank that was most involved financially with each chaebol was designated as the principal transactions bank to coordinate all lending activities. Any new credit to be issued by any bank to the chaebol was supposed to be evaluated by the principal bank. However, this principal transactions banking system was not substantially different from the government-coordinated financing scheme. It was reminiscent of the persistent soft-budget constraint syndrome in centralized

used productively (Demetriades and Fattouh, 1998).

[11] Using panel data of thirty-two Korean manufacturing sectors in the period from 1969 to 1996, Borensztein and Lee (1998) show that credit was allocated preferentially to the sectors with larger firms, with exports, and with lower economic performance. Examining firm-level data for the 1984 - 86 period, Dailami and Kim (1994) discover that subsidized credit encouraged the chaebols to hold more financial assets and real estate investments, but not actual productive assets.

economies before and after reforms (Kornai, 1980 and 1986). Implicitly complaining about the chronic problem of a lack of financial discipline in Korean chaebols, some Korean economists claim that the excessive leveraged expansion ultimately resulted in the insolvency of five of the top thirty chaebols (Park, 1997), thus triggering the financial crisis.

In comparison, Taiwan firms relied on much more diversified financial sources. As a consequence, the average debt-equity ratio of all Taiwan firms during the 1985 - 1992 period was about 1.4 and the ratio of the large firms was even lower (about 1.2) (Semkow, 1994, p.84). While small- and medium-sized firms financed by dispersed financial institutions were predominant; the market share of the 100 largest firms in Taiwan was approximately 22 percent in the late 1970s and early 1980s, while the comparable share in Korea was about 45 percent (Lee, 1998, p.230).

Firms in Taiwan, however, were subject to effective financial discipline, with the result that there were frequent bankruptcies in the corporate sector. Inefficient firms were indeed punished: the productivity of closed-down (disciplined) firms was 11.4 percent to 15.5 percent lower than that of other firms (Aw et al., 1998).

Second, in order to study financial crises from a purely economic view in this paper, we provide an institutional foundation of soft-budget constraints where there are no political problems and every agent maximizes his own economic gain. However, this does not mean that our theory of financial crises cannot be applied to other institutions. In fact, our theory of financial crises is general enough it can be applied any institutional foundation in an SBC economy (e.g., a foundation based on political considerations, Segal, 1998) and can produce the same qualitative results.

Finally, a brief comparison of our work with some of the literature is due here. Our study focuses on the generation and transmission mechanism of bank run contagion in financial institutions with unsecured debts. Examples of unsecured debts are non-collateralized or non-insured loans. Our theory is complementary to Kiyotaki and Moore (1997) who study how credit constraints interact with asset prices when debts are secured by collateral assets. They study how that interaction serves as a transmission mechanism through which temporary shocks can generate large and persistent fluctuations in outputs. Allen and Gale (1998) in the Diamond and Dybvig one-bank framework show that bank runs are related to the business cycle, rather than being the results of simple "sunspots." We are in agreement with their view that fundamentals affect financial crises, and we argue that financial institutions are just such a fundamental factor, especially in a multi-bank banking system. The financial contagion in Allen and Gale (1999) is caused by the interconnectedness of investors in an incomplete market. Chang and Velasco (1998) extend the Diamond and Dybvig model into an open economy model. They show that the illiquidity of the domestic financial system is at the center of the financial crisis in emerging markets. We regard the Chang and Velasco model as complementary to our theory. In fact, we can readily apply their approach to extend our model and explain how domestic financial institutions interact with international financial issues and how an over-borrowing syndrome in the sense of McKinnon and Pill (1997) is generated. Morris and Shin (1999), through analyzing and pricing the coordination failure among creditors, also reach similar conclusions to ours on transparency in that a greater provision of information to the market does not necessarily mitigate the coordination problem.

Edison et al. (1998) study how a major exogenous shock, such as the burst of an asset bubble or a currency shock (a sudden devaluation), can lead to financial collapse. As a comparison, in our model there is no exogenous bubble, although the collapse of the financial system in our economy may make people feel as though a bubble has burst. Chan-Lau and Chen (1998) argue that when banks stop monitoring their lending properly, small changes in the economic outlook can produce large fluctuations. In our model, even though banks are constantly monitoring their investments regardless of a boom or a crash, the monitoring itself may not be able to produce all the needed information, and we thus argue that a proper institution is required. Avery and Zemsky (1998), Calvo and Mendoza (1995), and Chari and Kehoe (1996) all study the volatility of financial markets as the herding behavior of investors, which has a theoretical foundation in Banerjee (1992) and Bikhchandani et al (1992). Rigobon (1998) studies the overreaction of investors as a result of a learning problem, where the informational content of signals changes through the business cycles.

From our theory, we derive that an optimal government policy to prevent a financial crisis in an SBC economy is to bail-out all illiquid banks. This can be explained by the soft-budget syndrome of government policy with respect to the banking system, which is rooted in financial institutions. Another immediate important policy implication from our theory for financial system reform and for financial-crisis-prevention policy is that the transparency of the banking system is critical. However, transparency cannot be achieved by imposing government regulations alone; instead, it can only be achieved by reforming the financial institutions to tighten the budget constraints at the micro level.

Moreover, our theory has implications for many policy solutions proposed in the literature. In the following we provide a brief summary of our implications for Dewatripont-Tirole (Dewatripont and Tirole, 1994) policies (DT policy for short) to deal with bank failures. The first set of DT policies are: 1) to liquidate illiquid banks; 2) to allow solvent and liquid banks to take over illiquid banks; and 3) to provide loans to illiquid banks. Our theory demonstrates that in an HBC economy, with sufficient information about the solvency of illiquid banks, the government should consider the trade-off between closing down illiquid banks and letting solvent liquid banks take over illiquid banks; or it should provide loans to solvent illiquid banks. However, in an SBC economy, without information about the solvency of the banks, the government has no other choice but to provide loans to all illiquid banks or to provide loans to a proportion of them randomly. With respect to nationalizing illiquid banks, our theory implies that this may work as an emergency measure if nationalization has an informational value such that with control rights the government will be able to identify solvent banks. However, this will probably not work in the long run because a nationalized bank will likely be conducive to an SBC environment.

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