Financial Institutions, Financial Contagion, and Financial Crises

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Abstract

This paper endogenizes financial contagion and financial crises from financial institutions. Financial crises can emanate from financial institutions which generate soft-budget constraints (SBC). The prevailing SBC in an economy distorts information such that the interbank lending market faces a “lemon” problem. The lemon problem in the lending market may contribute to bank run contagions and can lead to the collapse of the lending market and induce a run on the economy. Moreover, due to the lemon problem in the financial system, a rational government policy in this economy may lead to a SBC trap such that all the illiquid banks must be bailed out which may further enhance SBC syndrom. In comparison, an economy with a predominance of diversified financial institutions is characterized by hard-budget constraints (HBC). In this HBC economy, firms disclose timely information to the banks and to the financial market as a whole. Thus bank runs isolated and financial crisis are prevented.

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1. INTRODUCTION

The financial crisis in East Asia presents great challenges to economists. Before the crisis, the East Asian economies had been doing very well — economies had high growth rates, high savings rates, and sound fiscal policies. In addition to exogenous shocks which may have contributed to the overall problem, the question remains whether there were fundamental problems within the respective Asian economies which provided conditions for the crisis?

This paper attempts to analyze the financial institutional problems and to understand how those problems may have resulted in financial crises. The following are some of the more popular explanations for the Asian crisis: the run on the economies by panicked investors, similar to a run on banks by panicked depositors (Radelet and Sachs, 1998; Stiglitz, 1998); the moral hazard in banking (Krugman, 1998); and the collapse of a bubble economy (Edison et al., 1998; Blanchard and Watson, 1982). These arguments are useful to identify potential problems; nevertheless, the arguments may raise many more questions to be studied.

It has been observed that the financial crisis in Asia resulted fundamentally from the inability of their financial institutions to put a halt to loans to "bad" projects ex post. That is, the financial institutions provided "soft-budget constraints" (SBC) to firms, similar to what Kornai observes with respect to state enterprises in centralized economies (1980, 1986). We determine from the soft budget syndrome that it affects not only the efficiencies of a financial market, but more importantly, it distorts the market's information so that the interbank lending market is confronted with a "lemon" problem. The availability of information about bank quality is critical for the operation of the financial market in providing loans to illiquid banks. This lemon problem in the financial market may contribute to a bank run contagion that can then lead to the collapse of interbank lending markets and induce all investors to panic, thus a run on the economy.

In comparison, an economy with a predominance of diversified financial institutions
features hard-budget constraints (HBC) on rms (with a commitment to stop bad projects ex post). We determine that an HBC economy discloses timely business-related information from the rms to the banks, and to the financial market. Thus, in an HBC economy, bank runs can be stopped, contagious risks contained, and financial crisis prevented.

Our study focuses on the generation and transmission mechanism of bank run contagion in financial institutions with unsecured debts. Examples of unsecured debts are bank deposits, non-collateralized or non-insured loans. Our theory is complementary to Kiyotaki and Moore (1997) which studies 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. Our theory is also closely related to Kornai (1980, 1986), Dewatripont and Maskin (1995), Qian and Xu (1998) on the institutional problem involving soft-budget constraints and project selection; to Bolton and Scharfstein (1996) on the role of multi-creditors in solving commitment problem in financial contracts; to Bolton and Dybvig (1983) on banking system; and to Akerlof (1970) on the lemon problem.

Our major contributions to the literature are the following: we endogenize the lemon problem in the interbank lending market and the moral hazard problem between rms and financial institutions; we provide a mechanism for panic generation/transmission, bank run contagions, and financial crises. The banking moral hazard problem in our model is consistent with Krugman’s intuition regarding the Asian crisis (Krugman, 1998). Our mechanism provides a theoretical explanation for the observations of Radelet and Sachs (1998), and Stiglitz (1998).

In our model there are many banks which receive deposits and invest in projects. Banks rely on the interbank lending market to ease liquidity shortage problems when they face liquidity shocks. Although in order to focus on our main points we do not endogenize the number of banks, having many decentralized banks in the economy is necessary for the following reasons. First, in our theory a decentralized financial
system with many banks is a device to solve the commitment problem and to reduce contagion risks. Second, competition among banks is important for efficient allocation of financial resources in our model.

To be specific, in our model there are numerous depositors of the type described by Diamond-Dybvig (Diamond and Dybvig, 1983), who are divided into early consumers (who consume only at date 1) and late consumers (who consume only at date 3). Ex ante, all depositors are identical in that they do not know their own type until date 1, but they make their deposit decision ex ante. Moreover, there are many entrepreneurs who have innovative ideas, but they have to rely on banks to finance their projects. We consider that all projects proposed by entrepreneurs can be either unprofitable ex ante — a bad type; or profitable ex ante — a good type. The type of a project, however, is not known to an entrepreneur until date 1; and is not known to the bank(s) until date 2 after the earlier investments are sunk. A bad project would generate no return as it is, but it has the potential to generate an ex-post profitable (but ex-ante not profitable) return if it is reorganized at date 2 with the right reorganization strategy. In order to find the right strategy to reorganize a bad project, the involved bank(s) need to possess some particular information.

If a project is co-financed by multiple banks, the asymmetric information and conflict of interest between the banks make the ex-post cost of reorganizing a bad project too high so that a bad project will have to be liquidated. Moreover, such a threat of liquidation can deter entrepreneurs from continuing a bad project after privately learning the true type of the project. That is, multi-bank financing can be used as a commitment device to stop bad projects. We call an economy where all projects are financed by multiple banks a hard-budget constraint (HBC) economy. In contrast, if a project is financed by one bank, without asymmetric information, there is no commitment device to stop bad projects. An economy where all projects are financed by one bank is a soft-budget constraint (SBC) economy.\(^1\)

\(^1\)The above is a summary of the contractual foundation of SBC and HBC. Other contractual foundations of SBC/HBC, such as Dewatripont and Maskin (1995) or Segal (1998), can also be
In our model every bank stores the optimal amount of cash to meet expected early consumer withdrawals. The interbank lending market is an instrument for banks to solve liquidity problems when some of them face idiosyncratic liquidity shocks — excess early withdrawals in our model. In an HBC economy, all bad projects are liquidated at date 1, which is observable by the other banks as well. This institution makes the inter bank lending market transparent. That is, given the information, when a solvent bank (a bank with a good project) faces excess early withdrawals, there should be no difficulties for the bank to borrow. Therefore, bank runs are isolated to illiquid and insolvent banks (banks that face both technological shocks — those with a bad project — and liquidity shocks); solvent but illiquid banks do not face the threat of bank runs.

In an SBC economy, on the other hand, there will be a lemon problem in the interbank lending market. This is because without observable actions taken against bad projects, such as liquidation, a bank manager may be privy to project information, which is not available publicly in the marketplace. Thus, when a bank is confronted with liquidity shocks and needs to borrow from other banks, potential lenders will regard the quality of the borrowing bank’s investment project as average. This will make the borrowing cost for a better bank higher. We assume that a solvent bank has an option to liquidate part of its investment to meet early withdraw if borrowing cost is too high. Thus, when borrowing cost is high all better quality illiquid banks will leave the interbank lending market. This will lower the average quality of interbank lending market. Consequently, the borrowing costs will be increased for all the banks due the deterioration of the market. Then for relatively better banks the increased borrowing costs will make them to choose partial liquidation instead of borrowing. This in turn will further lower the quality of interbank market. The repetition of this process leads the collapse of the interbank bond market, which will trigger a bank run contagion.

When there is an interbank lending market failure, it may be desirable for the...
government to step in to provide loans to stop bank run contagions. Due to the lemon problem in an SBC economy, the optimal government policy is to bailout all the illiquid banks indiscriminately. However, when the government's bailout capacity is not sufficient, the best the government can do is to bailout banks randomly.

The remainder of the paper is organized as follows. Section 2 establishes the basic structure of the model. Section 3 analyzes the relationship between financial institutions and soft- and hard-budget constraints, and Section 4 investigates how bank run contagions are created under a soft-budget constraint and when it can lead to financial crisis. Section 5 examines government policy, in particular, central bank's lender of the last resort policy, and endogenizes a soft-budget constraint trap. Section 6 discusses policy implications on transparency of financial institutions and liberalization of financial sector. The final section, Section 7, concludes with some qualifications and elaborations of our theory, a brief literature survey, and a brief discussion of the financial institution arrangement in Korea and Taiwan to show the relevance of financial institutions to financial crisis.

2. THE MODEL

In our economy, there are many entrepreneurs, M banks and bank managers, and N ≤ 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, μ percentage of the projects are a good type, and the rest are a bad type. Ex ante, neither entrepreneurs or banks know which project is good and which project is 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 $I_t \leq 1$: The technology of the
project has a constant return to scale. A good project generates an ex-ante pro-\(Y > I_1 + I_2 + I_3\); 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 unpro-\(I_3 < X < I_2 + I_3\), that is, it is ex-ante unpro-\(X\), and \(I_3 < X < I_2 + I_3\), that is, it is ex-ante unpro-\(X\), and \(I_3 < X < I_2 + I_3\), that is, it is ex-ante unpro-

dable. The expected return from a project in the pool is positive, that is, \((1_i, X + I_1) > 0\):

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

We assume that an entrepreneur gets a private bene-\(t\) \(b_t\) 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 bene-\(t\), \(b_t > 0\): At date 2, if a bad project is liquidated, the entrepreneur gets an even lower private bene-\(t\) \(b_{2b}\), where \(0 < b_{2b} < b_t\). At date 3, if a bad project is reorganized and completed, it will generate a private bene-\(t\) \(b_{3b} > b_t\) to the entrepreneur; in the case of a good project, it will generate a private bene-\(t\), \(b_{3g} > b_{3b}\), to the entrepreneur. To summarize, we have \(b_{3g} > b_{3b} > b_t > b_{2b}\).

In this economy, bank managers are hired to manage banks, to make investment decisions, and to monitor bank investments in \(\ldots\) rns. They are risk-neutral and they have incentives not to be identiﬁed as bad managers (e.g., career concerns).\(^2\)

All the \(M\) banks in the economy are ex-ante identical, each has an initial endowment of \(Z\), and \(N\) depositors each deposit $1 in the bank. Thus each bank’s assets are \(Z + N\). 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

\(^2\)The later is a simpliﬁcation assumption and can be relaxed.
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 until $t = 1$. Moreover, each depositor is endowed with $1$. They make their investment decision based on an ex-ante belief about the riskiness of the banking system and about the market equilibrium return on deposit. They supposedly do not have the required expertise to be entrepreneurs or bank managers, nor do they monitor banks because of high surveillance costs.

Each depositor’s preference is defined as

$$U = \frac{1}{2} u(C_1) + \frac{1}{2} \frac{1}{2} u(C_2);$$

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 $t = 3$; $\frac{1}{2}$ is the probability of a depositor being a type 1 or type 2 consumers, and $\frac{1}{2} + \frac{1}{2} = 1$; $\frac{1}{2} < 1$ is the discount factor; $\beta$ is the probability that an investment project is good; $\frac{1}{2} \beta R > 1$; where $R$ is the return from investment; and $u' > 0$, $u'' < 0$, and $(Cu')^0 = u' + Cu'' < 0$.

Now we summarize the timing of the game as follows:

2. **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 $1$. Depositors make savings decision with a bank.

2. **Date 1:** The entrepreneur learns the type of the project, and may stop the project. In that case the entrepreneur 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 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. Early consumers withdraw money from the banks,
late consumers make their decisions whether to withdraw or to keep deposits in the banks. A bank facing too many early withdrawals has to borrow, otherwise it has to abort the project, resulting in no return.

2 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 it is a bad project, a decision whether to liquidate or to reorganize has to be made.
  \[ \text{if a project is liquidated the bank(s) gets zero and the entrepreneur gets } b_{2b} < b_3; \text{ otherwise,} \]
  \[ \text{if a project is reorganized, } I_3 \text{ will be invested.} \]

2 After investing $I_3$, signals $s_A$ and $s_B$ are observed by the investor(s) and a reorganization strategy is chosen based on the signals.

2 Date 3: All projects are completed,

- for a good project, return $Y$ goes to the bank(s), entrepreneur gets $b_{3b} > b_3$;
- for a bad project, return $X$ goes to the bank(s), entrepreneur gets $b_{3g} > B_{3b}$;
- late consumers collect their rewards.

### 3. Financial Institutions and Soft-Budget Constraints

In this section, we demonstrate that if investment decisions are made by one bank there are intrinsic problems in making commitments to liquidate bad projects, thus leading to soft-budget constraints; if investment decisions are made by multiple banks, this can help to form commitment devices, thus creating hard-budget constraints.

When an entrepreneur proposes a project to a bank, 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 later 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 in the case of government-coordinated financing where the government makes the decisions, or 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 the cases where there are diversified and decentralized financial institutions and multiple banks/investors are involved in investment decisions.

We model a special case of multi-bank co-financing: two-bank co-financing (the extension from two to many is straightforward). We assume that banks A and B have different technological or banking market specialties.

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. That is, from the perspective of the financing decision there is no difference between these two financing methods. Consequently, in the rest of the paper we will focus on the case of bad projects.

Since the return from a completed bad project, $X$, under the best possible reorganization strategy is illustrated by $I_3 < X < I_2 + I_3$, it is not efficient to undertake a bad project ex ante, but it may be efficient to reorganize it ex post. Therefore, at date 2 a decision has to be made by the bank(s) regarding a bad project: either to reorganize it or to liquidate it.

We assume that there are two strategies $a$ and $b$ to reorganize a bad project during the third period, but only one of them can generate a profit ex post. The right decision of bank(s) in selecting a reorganization strategy depends on their information. We suppose that in the case of co-financing, banks A and B will observe different information, represented by signals $s_A$ and $s_B$ respectively, where $s_j \in [s_l; s_u], s_l < s_u$ and $J = A, B$, after $I_3$ is invested.\(^3\)

\(^3\)There are many possible reasons why banks A and B may have different information ex post if they co-finance, but any bank can have full information ex post if any one of them finances a project.
The following are the basic assumptions regarding how reorganization strategies are related to information $s_A$ and $s_B$. We start from efficiency conditions. The first efficiency condition (A-1.1) is that strategy $b$ makes the project ex-post profitable if the value of signal $s_A$ is higher than the value of $s_B$; and strategy $a$ makes the project ex-post profitable if the value of signal $s_A$ is lower than that of $s_B$.

The second efficiency condition (A-1.2) is that the outcome of a wrong strategy is so faulty that the expected net payoffs of randomizing between the two strategies is worse than liquidation.

Finally, we make a conflict of interest condition (A-2) such that a higher value of $s_A$ is more beneficial to bank $A$ if the project is reorganized under strategy $a$ than under strategy $b$ and vice versa. This assumption implies that each bank $J$ has an incentive to use strategy $j$ if its own signal value is higher.\(^4\)

Example 1 Suppose a project is to be reorganized at date $2$, $I_3 = 109$ should be invested. From the table, if $s_A$ and $s_B$ are 0.6 and 0.4 respectively, it is clear that only strategy $b$ is ex-post efficient $(45+65>109)$, thus it should be chosen. However, if $s_A$ is increased to 0.7, although still only strategy $b$ generates an ex-post efficient result, bank $A$'s payoff increases more if strategy $a$ is used. That is, bank $A$ may have an incentive to underreport $s_A$ to increase the chances that strategy $a$ will be alone. One possible reason is that observing information $s_A$ and $s_B$ ex post requires a knowledge of $s_A$ and $s_B$ which can only be observed earlier and which is essential for the profit of a good project. Given their specialities, bank $A$ can observe $s_A$ with no costs, but has to pay a cost $c_A$ to observe signal $s_B$; and bank $B$ can observe $s_B$ with no costs, but has to pay a cost $c_B$ to observe signal $s_A$. Therefore, in the case that banks $A$ and $B$ co-finance a project, they can collect $s_A$ and $s_B$ without incurring costs. In the case of single-bank financing, bank $J$ will collect signal $s_J$ and pay cost $c$ to collect information $s_J^i$, where $J; j^i = A; B$ and $J \neq j^i$; unless there are some other reasons, such as an item in the contract, which prevent the two banks from sharing information.

The assumption that $s_J$ can only be observed after $I_3$ is invested is not essential in the model. Its role is to rule out mixed strategies which will complicate the model without providing more insight (it is rare to observe mixed strategies in financial decisions). Moreover, it is quite realistic.

\(^4\)For the formal expressions of (A-1) and (A-2), see the Appendix.
used if she privately observes that $s_A$ is moving up.

<table>
<thead>
<tr>
<th>$s_A$</th>
<th>$s_B$</th>
<th>$V_A^a$</th>
<th>$V_B^a$</th>
<th>$V_A^b$</th>
<th>$V_B^b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:6</td>
<td>0:4</td>
<td>40</td>
<td>60</td>
<td>45</td>
<td>65</td>
</tr>
<tr>
<td>0:7</td>
<td>0:4</td>
<td>48</td>
<td>60</td>
<td>47</td>
<td>65</td>
</tr>
</tbody>
</table>

In the case of multi-bank co-financing, ex-post the two banks have to share their private information as long as they decide to reorganize a bad project. Given the private nature of the information, and the conflicts of interests between the two banks, if the two banks share the information and the compensation is overly expensive, the information can then be transferred. This is equivalent to saying that bank $B$ will buy private information $s_A$ from bank $A$ when the price that bank $B$ has to pay, $T(s_A; s_B)$, is not too high. The logic is the same if bank $A$ buys $s_B$ from bank $B$.

### 3.1 Multi-Bank Co-Financing

In analyzing investment decision making in multi-bank co-financing, we start with the refinancing decision at date 2 and then consider the entrepreneur’s investment decision at date 1. At date 2, when the two banks discover that the project is a bad one, they should decide whether to liquidate or to reorganize (i.e., the banks assign a probability of $p$ to re-finance the project$^5$). If they decide to reorganize the project, they will invest $I_3$ into the bad project. Then information $s_A$ and $s_B$ are observed by the two banks respectively and the banks need to decide an optimal reorganization strategy based on what they observed (i.e., the banks assign probabilities of $1 - q(s_A; s_B)$ and $q(s_A; s_B)$ to use reorganization strategy $a$ and $b$ respectively).

In the following we show formally that under conditions (A-1) and (A-2), when a bad project is revealed to the co-investors — the two banks — at date 2, the conflicts between these two banks make it impossible for them to agree on an efficient reorganization scheme.

$^5$For example, if their decision is to definitely liquidate the project, they assign $p = 0$: 

12
Proposition 1: Under conditions (A-1) and (A-2), and under multi-bank co-funding, all bad projects will be liquidated at date 2.

Proof. See the Appendix.

The central message of this proposition is that the informational asymmetry and conflicts of interest between two banks in funding a project can make the costs of reorganizing a project so high that liquidation is always better than reorganization. That is, multi-bank funding can be used as an ex-post commitment device to stop bad projects.

The rationale behind this proposition is the following. Let us look at the case where bank $B$ buys information $s_A$ from bank $A$ by paying $T(s_A; s_B)$ to bank $A$ (the case where bank $A$ buys information $s_B$ from bank $B$ is exactly symmetrical). That is, an optimal compensation scheme $T(s_A; s_B)$ is designed such that if $A$ tells the true value of $s_A$ then $A$ will be better off than doing otherwise — the incentive compatibility condition (IC). If we look at the (IC) in the case where the value of $s_A$ is higher than $s_B$, and the (IC) in the opposite case, and then combine them together with the conflict of interest condition (A-2), we find that under the optimal compensation scheme $T(s_A; s_B)$, the incentives of $A$ will lead to a condition that for any given value of $s_B$, the higher the value of $s_A$, the less likely that strategy $b$ should be used. The efficiency condition (A-1.1), however, implies that for any given value of $s_B$, the higher the value of $s_A$, the better to use strategy $b$ more often. The only reconciliation between these two conditions is to keep the probability of using strategy $b$ independent from signal $s_A$, but the efficiency condition (A-1.2) says that this kind of reorganization will make losses ex post, thus it is worse than liquidation.6

The commitment to liquidate bad projects by the multi-banks’ co-funding has a deterrent effect on entrepreneurs who have bad projects. Afraid of further losses

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6For the sake of simplicity, in the proof of this proposition, only the case of co-funding by two banks is analyzed. It is straightforward to extend this to co-funding by more banks. In addition, the more banks that are involved, the easier it is to satisfy the conditions of asymmetric information and conflicts of interests, thus the more likely to have the result.
by hiding bad news, 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., $b_{2b} < b_2$. To summarize, we have the following result:

**Corollary 1** Under multi-bank co-financing, entrepreneurs will stop bad projects at date 1 'voluntarily.'

### 3.2 Single-Bank Financing

We again begin our analysis with the refinancing decision at date 2 and then consider the entrepreneur's investment decision at date 1. Note that under single-bank refinancing, the bank will have all the information $s_A$ and $s_B$ and will be able to use this information to choose an ex-post efficient strategy to reorganize the project such that payoff $X(s_A; s_B)$ is greater than the ex-post cost of refinancing, $I_3$. Therefore, the bank is not able to commit to terminating a bad project ex post.

Moreover, the fact that the bank cannot 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 always 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.

**Proposition 2** Under assumption (A-1), all single bank-refinanced bad projects will be reorganized ex post.

The intuition behind this result is that without conflicts of interest and informational asymmetry on the side of the bank, single-bank refinancing is not able to solve the asymmetric information problem between the bank and the entrepreneur due to
the lack of a commitment to liquidate bad projects.

4. SOFT-BUDGET CONSTRAINTS AND FINANCIAL CRISSES

To make our basic point in the simplest possible way, we first abstract government away from our model, and we also make some simplification assumptions. We will incorporate the role of government into our model later. In fact, most of our simplification assumptions can be relaxed without compromising our results qualitatively.

4.1 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.\(^7\)

Similar to that of Diamond and Dybvig, in our model a market equilibrium in which all agents trade can Pareto dominate that of autarchy; but the market equilibrium does not provide perfect insurance against liquidity shock. The main reason is that complete contingent markets do not exist, because the state of the economy (who are the early consumers and who are the late consumers) is not observable ex ante.

At date 0, consumers make a deposit decision by solving

$$
\max_{C_1} U = \frac{1}{4} u(C_1) + \frac{1}{4} \frac{1}{2} u(C_2) \\
\text{s.t. } 1 = \frac{1}{4} C_1 + \frac{1}{2} C_2 = R
$$

In general, the first order condition of this problem is

$$
u^0(C_1) = \frac{1}{4} Ru^0(C_2)$$

Following Diamond and Dybvig we assume that $Cu^0(C)$ is a decreasing function of

\(^7\)Note that unlike the Diamond and Dybvig model, which has a positive and deterministic return, in our model the return is stochastic, with an expected positive value.
C (that is \( \mu^0 + Cu^0 < 0 \)), thus for \( \frac{1}{2} < 1 \) and \( \frac{1}{2} R > 1 \), we have
\[
\mu^0(1) > \frac{1}{2} \mu^0(1) > \frac{1}{2} R \mu^0(R): 
\]
Consequently, an ex-ante optimal market equilibrium can only be achieved by increasing \( C_1 \) and decreasing \( C_2 \), that is
\[
C_1^\mu > 1; \quad C_2^\mu < R; 
\]
A bank can implement the market solution through a deposit contract (Diamond and Dybvig, 1983). That is for $1 deposit at \( t = 0 \), a depositor receives either \( C_1^\mu \) at \( t = 1 \), or \( C_2^\mu \) at the end of the exercise. The bank holds \( \frac{1}{2} C_1^\mu \) (as cash) at no extra cost, and invests the rest in illiquid technology which yields a higher return. This ex-ante optimal deposit contract is a pure strategy Nash equilibrium. That is, an early consumer always wants to consume at \( t = 1 \), but a late consumer has no incentive to withdraw early. This is because as long as \( \frac{1}{2} R > 1 \), \( \mu^0(C_1^\mu) = \frac{1}{2} R \mu^0(C_2^\mu) \) holds if \( C_1^\mu < C_2^\mu \), and any deviation does not pay, as long as other late consumers do not deviate.

However, there may be a bank run equilibrium, that is, a simultaneous deviation of all late consumers. In this case, the bank has to liquidate its project (which has zero value for simplicity) if borrowing from an interbank market is not possible or too expensive. As a result, the assets of the bank are not enough to meet all the withdrawals. The bank will fail and nothing will be left for late consumers when they withdraw later than others. Anticipating this, all late consumers will withdraw at \( t = 1 \), and the initial fear of a bank run becomes self-fulfilling. A key for the existence of a bank run equilibrium is the possibility that a bank cannot solve its liquidity shortage problem by borrowing from an interbank market. This turns out to be a key condition to extend Diamond and Dybvig’s framework from a one-bank economy to a multi-bank economy.

In our multi-bank economy the total number of depositors is finite, with \( N \) de-
positors in each bank and the realized numbers of type 1 and 2 depositors for each bank are random draws from binomial distributions of \( \frac{1}{4} \) and \( \frac{1}{2} = 1 \) respectively. In the next two subsections, we will analyze the possibility of financial crisis in economies with and HBC or an SBC. We start from the problem faced by the bank manager in an HBC economy.

4.2 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 are completed. Therefore, every bank knows that all continued projects are good ones. The ex-ante expected deposit return in such an economy is:

\[
R^H = \frac{Y \cdot I_1 + (I_2 + I_3)}{I_1 + I_2 + I_3} > 1:
\]

To meet an expected number of early withdrawals a bank’s optimal investment decision is to store cash in the amount of \( N \cdot \frac{1}{4} C_1^n \), and to invest all the rest — in the amount of \( N(1 \cdot \frac{1}{4} C_1^n) \) — into a project. Every bank co-invests with another bank in one project, given the symmetry of the banks, and the investment is made in the following way,

\[
N(1 \cdot \frac{1}{4} C_1^n) = \frac{I_1 + I_2 + I_3}{2}.
\]

In the event that a project is a bad one and aborted at date 1, the realized value from the investment is zero.\(^8\) In this case, if there are more than \( \frac{1}{4} N + \frac{Z + I_2 + I_3}{C_1^n} \) depositors trying to withdraw at date 1 (think of the depositors who are waiting after the \( \frac{1}{4} N + \frac{Z + I_2 + I_3}{C_1^n} \)th depositors in the withdrawal queue), the bank would run out of cash because of the excessive demand for withdrawals. Because it is known that this bank has a bad project and will not be able to pay back its loan, it will

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\(^8\)Note that even if there are not too many early consumers, a bank run may still occur when late consumers are able to observe the liquidation of bad projects. For the sake of simplicity, we do not allow the bank to start another project at date 1. Moreover, this setup avoids giving an HBC economy too great of an advantage over an SBC economy, which would also divert our focus in the analysis.
not be able to borrow in the interbank market. Thus a bank run can occur with a positive probability in an HBC economy, when there are both technological shocks and liquidity shocks.

Now let us look at the case where a bank manager is informed at date 1 that the project is a good one, which will generate a good positive return at date 3. In this case, when there is an unexpected excess early withdrawals, the bank can borrow from other banks.

We suppose that other banks in the economy also know that this bank has invested in a good project, and thus can definitely generate a return at

$$R_H^g = \frac{Y_i I_1 + I_2 + I_3}{I_1 + I_2 + I_3} > 1;$$

In this case, when the bank with a good project faces excess early withdrawals, there will be no difficulties for the bank to borrow from other banks. Therefore, the bank can solve its liquidity shortage problem by borrowing from other banks so that a bank run is avoided.

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

The last point of the above proposition is more interesting. An HBC economy does not experience a bank run contagion simply because with symmetric information among bank managers, the interbank lending market should be able to provide liquidity to all illiquid banks that are not hit by technological shock. As a result, a bank run contagion does not occur in an HBC economy.

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9 The bank can issue a risk-free bond to borrow from other banks. The bond has a price p per share, and a value of $1 at date 3. p is determined by the competitive bank lending market. In equilibrium p < 1; otherwise the banks would hold all assets in cash. Moreover, as long as $R_H^g > 1$, there is sufficient demand for such a bond. Furthermore, because $C_1 < C_2$, it is not worthwhile for any late consumers to withdraw money earlier (at date 1). Thus, the equilibrium is such that all early consumers withdraw money at date 1, and all late consumers wait until date 3.
4.3 Financial Crisis in an SBC Economy

Following our earlier results, in an SBC economy without a commitment to liquidate bad projects at date 2, entrepreneurs with bad projects will cheat at date 1. Thus, at date 1 bank managers in an SBC economy do not know the type of the project that they are financing. However, every bank manager has a better understanding of the risk of their own project. That is, at date 1, the manager of bank \( m \) (\( m = 1, \ldots, M \)); through his monitoring for one period of time, has better information than at date 0, such that he knows that the probability that his project is a good one is \( \beta_m \). But this is his private information.\(^{10}\) We rank the qualities of all the banks as \( 1 < \beta_2 < \beta_3 < \cdots < \beta_M \) and denote the average quality as \( \bar{\beta} = \frac{1}{M} \sum_{m=1}^{M} \beta_m \). Therefore, concerning all other banks’ projects, the best that a bank manager can determine is their average \( \bar{\beta} \).

Anticipating the expected withdrawal at date 1, a bank’s optimal investment decision is to hold \( N \bar{\beta} \) in cash and invest \( N (1 - \bar{\beta}) \). Or, the expected investment of a bank is

\[
N (1 - \bar{\beta}) = I_1 + I_2 + I_3.
\]

Therefore, if the number of depositors who withdraw at date 1 is no more than the expected number \( \bar{\beta} N \), the bank will have enough cash to handle the withdrawals; if the number of early withdrawals is more than \( \bar{\beta} N \), however, bank will have to either borrow from the interbank market or to liquidate part of its investment. The manager of an illiquid bank will choose the one with the less costs.

To calculate the costs of borrowing from the interbank market, we notice that a bond issued by an illiquid bank is a risky one. In the case that a bad project is realized, the bond-issuing bank is not able to pay anything for the bond. Moreover, due to the asymmetric information among banks, the quality of a bond issued by

\(^{10}\)To focus on our point we do not model peer monitoring in interbank lending in the sense of Rochet and Tirole (1996). In fact, as long as peer monitoring is more blurred than then bank’s own monitoring, our basic result will not be changed qualitatively.
an illiquid bank is only known to the bank manager himself, and it is not known by other bank managers. Therefore, the market value of the bond will be different from the private value of the bond, or the value for the bond-issuing bank. Specifically, given that the bank quality is private information of the bond issuing bank, the equilibrium bond market price will be based on the average quality, $\bar{\theta}$. The bond issued by bank $m$ has the following structure: for an expected value of $1$, contingent on the realization of the project at date 3, the bond pays, 
\[ \mathbb{I} \begin{cases} \frac{1}{\bar{\theta}}, & \text{if the project is good;} \\
0, & \text{otherwise.} \end{cases} \]
Moreover, the price of the bond is $p^s \frac{1}{\bar{\theta}} < 1$. Obviously, the lower the $\frac{1}{\bar{\theta}}$, the lower the $p^s$.

Due to the asymmetric information in the bond market, with different quality projects, every bond-issuing bank faces a different expected cost in issuing a bond. This is because with a higher quality project, a bank expects to pay $\frac{1}{\bar{\theta}}$ at a probability of $\bar{\theta}_m$. That is, if $\bar{\theta}_m > \frac{1}{\bar{\theta}}$, a bank with a $\bar{\theta}_m$ quality project would pay a cost which is higher than average by 
\[ \frac{1}{\bar{\theta}} - \bar{\theta}_m = \frac{1}{\bar{\theta}_m} - \bar{\theta}_m. \]
Similarly, if $\bar{\theta}_m < \frac{1}{\bar{\theta}}$, a bank with a $\bar{\theta}_m$ quality project would have a lower than average cost. Therefore, in such a “lemon” bond market, banks with lower than average quality projects have a higher incentive to issue bonds when they face liquidity shocks, while banks with higher than average quality face higher costs to do so.

We now calculate the expected return from issuing bonds for bank $m$. With the price of $p^s$ for each share of the bond, $\frac{nC^s_1}{p^s}$ shares of bonds are needed to raise total $nC^s_1$ amount of money to pay $n$ excess early withdrawal depositors. Given that the bond pays $\frac{1}{\bar{\theta}}$ if the project is good, which has a probability of $\bar{\theta}_m$, the expected cost of issuing a bond is $\frac{\frac{1}{\bar{\theta}} nC^s_1}{p^s}$: Specifically, the expected net return to bank $m$ by issuing a bond is 
\[ E(R) = Z + (1 - \bar{\theta}_m)X + \bar{\theta}_m Y + \frac{1}{\bar{\theta}_m} \sum_{i=1}^{\bar{\theta}_m} I_i + \frac{n}{C^s_2} \sum_{i=1}^{\bar{\theta}_m} nC^s_1 \frac{1}{p^s}: \]
Then, given $p^{s^i}_{1,i} \eta$ increases in $\eta$, we can easily see that, for any $\eta_m$, there is a $\eta^n$ such that
\[
\frac{d}{dn} E(R) = C^n_{2,i} \frac{\eta_m}{p^{s,i}_s} C^n_{1,i} > 0, \text{ if } \eta > \eta^n.
\]

It is easy to see that if the uncertainty of the projects is low, i.e., $\eta_M$ is small and $\eta_M$ is close to one, then $p^{s,i}_s$ is close to one for any $\eta_m \in [\eta; 1; M]$. Thus, the expected return from issuing a bond increases in $n$ and it is always worthwhile to borrow for all illiquid banks. Therefore, a bank run never occurs.

**Proposition 4** In an SBC economy if the uncertainty of the project pool is low, $\eta > \eta^n$, a bank run never occurs.

This result indicates that if the banks of an SBC economy are investing in safer projects, i.e. $\eta > \eta^n$; there will be neither project liquidation nor bank run. This result is in contrast to that in HBC economy whereby bad projects are always liquidated regardless of the safety of the project portfolio. Moreover, illiquid and insolvent banks may still suffer bank runs even when a project portfolio is relatively safe. That is, an SBC economy appears better than an HBC economy when the project pool of the banks in the economy is less uncertain.

If the uncertainty of the project in SBC economy is high, then we have
\[
\frac{d}{dn} E(R) = C^n_{2,i} \frac{\eta_m}{p^{s,i}_s} C^n_{1,i} < 0, \text{ if } \eta < \eta^n.
\]

Particularly, if $\eta$ is substantially lower than $\eta_M$, then there are some banks with a $\eta_m$ high enough to have their expected returns decrease in $n$. For those banks facing excessive early withdrawals, their expected returns from borrowing turns to negative.

From zero-expected return, we can calculate the cut-off point $n$,
\[
\eta(\eta, m) = \frac{Z + (1_i \eta) X + \eta Y_i l_1 i l_2 i l_3 i l_4 i (1_i \eta) N C^n_{2,i}}{\frac{\eta_m}{p^{s,i}_s} C^n_{1,i} C^n_{2,i}}.
\]

(1)

When the perceived quality of a project is higher than average and the excess number of early withdrawals is larger than the cut-off point, $n > \eta(\eta, m)$, issuing a bond generates a negative expected return, although doing so can lead to a later liquidation.
As an alternative, a bank can consider to raise fund by liquidating part of its investment (Diamond and Rajan, 1998). In our setting, this means to liquidate some fund from $I_2$ and $I_3$. For bank $m$, portion of its remaining investment $(I_2 + I_3)$ is needed to raise total $nC_i$ amount of money to pay $n$ excess early withdrawal depositors, with $nC_i = \Theta(I_2 + I_3)$. Given that the project is good with a probability of $\gamma_m$, the net return to bank $m$ by partially liquidating its investment position is:

$$E^i R^c = Z + k(1_i \Theta[(1_i ,m)X + ,mY] i l_1 i l_2 i l_3 i [(1_i \gamma)N i n]C_i^2;$$

where $k < 1$ due to the loss from the process of liquidation. We claim that for a better quality bank, partial liquidation can be a better option than borrowing.

Lemma 1 There exists a cut-off point $b$, such that all banks with better quality than $b$ will choose partial liquidation rather than issuing bond in the interbank market to meet the early withdrawals.

Proof. Noticing first that

$$E^i R^c = Z + k(1_i \Theta[(1_i ,m)X + ,mY] i l_1 i l_2 i l_3 i [(1_i \gamma)N i n]C_i^2;$$

and hence

$$\frac{\Theta}{\Theta_m} E^i R^c \ E (R) = \frac{1}{\Pi} \frac{1}{\Pi} [1_i \gamma (Y_i X)] \frac{1}{l_2 + l_3} nC_i^2 i (1_i k)(Y_i X) > 0$$

holds for $n > \Pi$, where

$$\Pi = b(1_i \gamma (Y_i X)) \frac{1}{l_2 + l_3} C_i^2.$$

In this case, there exists a cut-off point, $b$, where at $b$

$$\frac{b}{\Pi} \frac{b}{\Pi} [kX + b(Y_i X)] \frac{1}{l_2 + l_3} nC_i^2 i (1_i k)(X + b(Y_i X)) = 0;$$

such that for $\gamma_m > b$, they choose to use partial liquidation to meet the early withdrawals, and vise versa.
This lemma shows that any illiquid bank $m$ with a quality $\gamma_m > b$ chooses partial liquidation rather than issuing bond in the interbank market. As a result, better quality banks leave the interbank lending market, and the average quality of interbank lending make becomes even lower because those banks that still borrow in the interbank market are the ones with a quality below $b$: Consequently, either the bond price in the interbank market, $p^S$, will be lowered or the same price bond would require a higher payment in good state, and in any case the borrowing costs will be higher. A higher borrowing costs will induce more banks switch to the choice of partial liquidation, which in turn will further lower the quality of interbank market. When the repetition of this process reaches a critical point, the interbank market completely collapses, as shown in the lemma below.

Lemma 2. There exists a cut-off point $b$, such that if the average quality of the remaining banks in the interbank market is below $b$, the interbank market completely collapses.

Proof. After better quality banks have left the interbank market, the average quality of banks remaining in the interbank market is further worsened. For them, borrowing from interbank market remains to be the only choice. When the average quality of the remaining banks (with lower quality) reaches a critical level, $b$, even borrowing from interbank market becomes impossible. To see this, notice that the total amount of expected return for bank $m$ with quality $\gamma_m$ is only $Z + (1 - \gamma_m)X + \gamma_m Y + I_1 + I_2 + I_3$, while each $1$-value bond it intends to buy require a payment of $\frac{1}{\gamma}$. To cover $n$ excessive early withdrawals, it need to borrow $\frac{nc^S_3}{p^S}$ units of $1$-value bond, which require a total payment of $\frac{nc^S_3}{p^S}$. In addition, the bank has to pay $[(1 - \frac{1}{\gamma})N - n]C_2^g$ to the remaining depositors. If $\gamma < b$, where at $b$,

$$Z + (1 - \frac{b}{\gamma})X + \frac{b}{\gamma} Y + I_1 + I_2 + I_3 + \frac{1}{\gamma} \frac{nc^S_3}{p^S} + [(1 - \frac{1}{\gamma})N - n]C_2^g = 0;$$

depositors can easily figure out that an average bank with quality $\gamma$ is not able to pay to its depositors or lenders, even if there is no any information asymmetry in the
interbank market. Thus, they should start a run on the interbank system. □

By now, we are ready to present our main result regarding financial contagion in SBC, as a proposition below.

Proposition 5 In an SBC economy if \( \frac{1}{\gamma} < \frac{1}{\mu} \); excess early withdrawals may cause bank run contagions, which can lead to a collapse of the banking system when the average quality of banks remains in the interbank market reaches \( b \).

Our results of Propositions 4 and 5 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 featured by imitations, the uncertainty of the projects will be 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 is high tech or R&D-intensive projects which are more uncertain, however, the bank run contagion condition is satisfied. Our results thus can explain the seemingly paradoxical phenomena between the Asian “miracle” on the one hand, and Asian financial crisis on the other. Notice that the Asian “miracle” phase of the East Asian economies was before the 1990s when the project pool in those economies featured less uncertain imitations. Consistent with our Proposition 4, there was virtually no liquidation, nor bank run, nor financial contagion. Since the early 1990s, however, these economies became more developed and they moved onto technological frontiers and invested more in high-tech projects and in innovation. As a result, the uncertainty of their project pool became more uncertain, i.e. \( \frac{1}{\gamma} < \frac{1}{\mu} \). According to Proposition 5, financial contagion becomes a possibility.

In sharp contrast, in an HBC economy where information about bank investment quality is revealed to all bank managers at date 1, because of the liquidation of bad projects, bank runs are always restricted to insolvent banks. Thus, the bond market will never degenerate, and such a run on the banking system will never occur!
5. LENDER OF LAST RESORT AND SBC TRAP

5.1 SBC Trap

Given the risks of bank run contagions in an SBC economy, it is conceivable that
the government may step in to bail out failing banks in order to reduce bank runs
and to stop contagions. 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: without knowing the type of the projects at date 1, the problem remains
in order to determine the optimal government policy to bail out illiquid banks.

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,
without changing the financial institution, the best that the government can do is
either to rescue all the banks regardless of their qualities, thus creating soft-budget
constraints in the banking system which can further lead to an eventual collapse
of the economy; or to save lower quality banks by playing the role of the lender of
last resort (LOLR) while leave good quality banks solving their own problem in the
improved interbank markets, thus creating soft-budget constraints in the banking
system for bad banks especially, which can also lead to an eventual collapse of the
economy; or to rescue none of them, thus leaving the banking system vulnerable to
contagious risks and financial crisis.

In the economy, the government’s role is to be LOLR to provide low-cost loans
to illiquid banks by issuing government loans.\(^\text{11}\) The government, however, also
faces its own informational problem in that it, like the interbank market, only has
\(^{11}\text{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, i.e., the SBC problem.
imperfect information about the solvency of each bank and is not able to distinguish
good banks from bad ones, in particular during crisis. Indeed, many central bankers
indeed expressed their frustrations in identifying solvency of illiquid banks. Unlike
the interbank market, however, the government (or central bank) should be able to
provide large amount of liquidity in a very short time by using its LOLR facilities
and its monopoly power in money supply.

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 can model
the LOLR loans as the government selling its bond to any illiquid bank, with the
bank’s investment in the risky project as (implicit) collateral. The bond lends a price
of $p_G$ to the bank, and the bank pays back the bond at date 3

$$8 < \frac{1}{\bar{G}} \quad \text{when the project is good;}$$

$$0; \quad \text{when the project is bad.}$$

The government chooses $\frac{1}{\bar{G}}$ to lend low-cost loans to an illiquid bank $m$ such that
its expected payback is less than what it is borrowing, that is,

$$\frac{1}{\bar{G}} < \frac{1}{\bar{m}};$$

The cost of issuing this government bond to illiquid banks is,

$$\frac{1}{\bar{G}} \bar{m} \cdot \frac{1}{\bar{G}} \bar{G} = \frac{1}{\bar{G}} \bar{G} \bar{m} > 0;$$

for all banks with $\bar{m} < \bar{G}$.

The expected return to bank $m$ from buying the government loan is

$$E(R) = Z + (1_{1,m})X + \bar{m}Y + I_{1,m} I_{2,m} I_{3,m} [(1_{1,\frac{1}{2}G})N n] C_{\bar{G}}^n \frac{\bar{m} nC_1^m}{p_G^2};$$

26
For any given excess number of early withdrawals \( n; \) from the expected return we can calculate a cut-off point \( \beta_m \) such that when the quality of a bank \( m \) is higher than bank \( \hat{m} \), or \( \beta_m > \beta_{\hat{m}} \), buying a government bond (receiving a government loan) would generate a negative expected return for bank \( m \).

\[
\beta_m = \frac{\rho G f Z + X + I_1 + I_2 + I_3 + [n (1 - \frac{1}{4}) N] C_2^g}{nC_3^g (Y + X + I_3) \rho G}.
\]

Now suppose there are \( m \) banks (this number is not very small) in the economy, all having \( n \) excess early withdrawals and the quality of these \( m \) banks are sorted as \( \beta_1 < \beta_2 < \ldots < \beta_m \). Due to the lemon problem in the bond market, without the assistance of the government, these illiquid banks may all have bank runs, which in all possibility may result in a panic of more late depositors who will decide to withdraw as well. Then there will be more bank runs, which will trigger additional panic. Finally, this deteriorating situation will lead to run on the economy.

If the government decides to bail out some of the illiquid banks by issuing bonds, then for the given \( n \) there exists an \( \hat{m} \) such that all \( \hat{m} \) illiquid banks will have a non-negative return from buying the government bond; but all other \( m \neq \hat{m} \) illiquid banks will have a negative expected return from buying the government bond. That is, if the scheme is designed such that \( \beta_G = \beta_{\hat{m}} \), all the illiquid banks that are in a better financial position than \( \hat{m} \) will choose not to be rescued by the government scheme and will experience a bank run; and all the weaker banks will be rescued by the government scheme. However, a run on the \( m \neq \hat{m} \) more healthy banks by depositors may trigger a panic among late consumption depositors who will make runs on other banks as well. Without any additional government intervention, this may result in a run as well on all the other banks in the economy, so that all banks in the set \( M \cap N \) will be subject to bank runs, where \( M \) signifies the set of all the banks in the economy; and \( N \) denotes the set of banks which are bailed out by the government bond scheme.

For the sake of simplicity, we suppose that the government is able to issue bonds only once, and all the banks in the economy which are not bailed out by the govern-
ment will be subject to bank runs. As long as the number of illiquid banks which are not being bailed out is large, their bank runs can trigger an economy-wide bank run. Then the expected costs of bailing out in banks in the set \( N \) is
\[
E(C_N) = \sum_{m \in N} (\frac{\gamma_i}{\gamma_m})^{\frac{\gamma_m C_p}{\rho^G}}.
\]
Note that \( E(C_N) \) is decreasing with \( \gamma_m \). That is, the lower the quality of a bank \( \gamma \) decreases, the higher the costs of saving it. Moreover, the expected cost of letting all the other banks (in the set \( M \cap N \)) experience runs is
\[
E(C_{N^0}) = \sum_{m \in M \cap N} [(1 - \frac{\gamma_i}{\gamma_m})X + \gamma_m Y_{i^2} + I_{i^3}].
\]
Note that \( E(C_{N^0}) \) is an increasing function of \( \gamma_m \). That is, the higher the quality of a bank \( \gamma \) increases, the higher the cost of a bank run. We suppose that the government's objective is to design a bail-out scheme by issuing a government bond to minimize the expected total costs, \( E(C) \), which include the expected costs of bailing out \( N \) banks and the expected costs of allowing a run on all other banks. Obviously, the expected social costs are:
\[
E(C) = E(C_N) + E(C_{N^0}).
\]
Even without looking at a model, one can determine that it is desirable to select a government 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, it faces a “lemon” problem even though the government bond market will not collapse since it is supported by a government which maximizes social welfare. With this lemon problem, as we have shown above, for any given bond price \( p^G \) and pay schedule \( \frac{1}{\gamma_i} \), only weaker banks with \( \gamma < \gamma_G \) would benefit from the government subsidy and thus would be willing to request government assistance. Meanwhile, all the stronger banks with \( \gamma > \gamma_G \) would be penalized by the government bail-out scheme, and thus would not be willing to ask for government assistance.\(^{12}\) As a result, for any selective

\(^{12}\)Recall that the ranking of the qualities of all the banks in the economy is as follows, \( \gamma_1 < \gamma_2 < \ldots \).
bail-out scheme \( G \), where \( \frac{1}{3} < G < \frac{1}{M} \), all the stronger banks will suffer bank runs while all the weaker banks will be bailed out. Therefore, the social costs of selectively bailing out are higher than bailing out all the illiquid banks. We record this outcome in the following proposition.

**Proposition 6** As long as the financial institution is not changed to harden the budget constraints, a rational government policy in an SBC economy leads the economy into a soft-budget constraint trap whereby all illiquid banks are bailed out by the government indiscriminately.

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

\[ \frac{1}{3} < G < \frac{1}{M} \]

Moreover, \( E(C_N) \) is an increasing function of \( m \) and \( E(C_N) \) is a decreasing function of \( m \). That is, the best quality bank, the one with a quality \( \frac{1}{M} \), has the highest bank run cost and the lowest bail-out cost among all the banks; and the lowest quality bank, the one with a quality \( \frac{1}{1} \), has the lowest bank run cost but the highest bail-out cost among all the banks.
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).\footnote{We thank Charles Goodhart for his suggestions regarding this elaboration and the example.}

Thus, we have the following corollary:

Corollary 2 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 3 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.

5.2 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 bailout 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.

6. 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 policies that improve transparencies of financing institutions. However, the lessons of centralized economies and the long debate over the viability of centralized economies since the late 1930s (Lange vs. Hayek) both tell us that it is impossible to have transparency in all the aspects of any economy. In light of such an impossibility, what and how to make things transparent is a key issue. Moreover, not only is it impossible to have transparency in all the aspects of an economy, our theory suggests that targeting a wrong aspect to improve transparency can make things even worse.

Hayek outlined a principle whereby 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 not clear. 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
The financial market more stable and helps the government to intervene correctly when necessary. Moreover, our theory implies that wrongly targeting transparency can end in disaster. This is because an HBC mechanism relies on the 'non-transparency' of the co-financiers' information regarding reorganizing 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 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 institutional costs of multi-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 risk 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 excess 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 the liberalization of financial institutions must be conditional on measures to harden the budget constraints. If liberalized banks are operating under 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...
Many of the banking system liberalization reforms in East Asia before 1997 shared this spirit as well. 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.

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 information asymmetry 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 break out, 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 timely. This allows the interbank lending markets to function well 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 phenomena 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 an HBC economy; moreover, there are no project liquidation and no bank run. That is, an SBC economy appears even to outperform an HBC economy, and it may attract a number of investments. However, if for some reason the uncertainty of the projects

34
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 one's general understanding of financial crises and it is not designed specially for the East Asian financial crisis, it provides an explanation for the recent Asian 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 both economies the share of trade in GNP is much higher than that of the world average; and in both cases the economy has been transformed from a traditional one into a high tech oriented one. 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. Although there were complaints that with a predominance of government

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14 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, a recent econometric work shows that a significant part of the total credit in Korea was
coordinated bank financing, credits were not allocated efficiently to Korean firms\textsuperscript{15}.

However, on the other hand, closely related to the government involvement in providing subsidized credits, because of the lack of financial discipline in the corporate sector, there was almost no bankruptcy before 1997 (particularly for chaebols). From panel data of more than 40,000 Korean manufacturing plants for the 1983 - 93 period, Aw, Chung, and Roberts (1998) discover that the productivity of plants being closed down was about the same as those in operation. This suggests that decisions involving closure of plants were not related to efficiency considerations, i.e., there was no financial discipline in Korea 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 which 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 economies before and after reforms (Kornai, 1980 and 1986). Implic-

\textsuperscript{15}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 worse economic performance. Examining firm level data for the 1984 - 86 period, Dailami and Kim (1994) discover that subsidized credit encouraged chaebols to hold more financial assets and real estate investments, but not actual productive assets.
Itly complaining about the chronic problem of lack of financial discipline in Korean chaebols, some Korean economists claim that the excessive leveraged expansion ultimately resulted in the insolvency 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 largest 100 firms in Taiwan was approximately 22 percent in the late 1970s and early 1980s, and the comparable share was about 45 percent in Korea (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 that any institutional foundation of an SBC economy (e.g. a foundation based on political considerations, Segal, 1998) applies and can produce the same qualitative results.

Finally, a brief comparison of our work with some of the literature is due here. Aghion, Bolton and Dewatripont (1999) develop a theory of bank failure contagion. They also focus on the issue of the interbank market and the contagion is caused by pure liquidity shortage. 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 to complement 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 the similar conclusions on transparency to ours in that 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 if a bubble has burst. Chan-Lau and Chen (1998) argue that when banks stop properly monitoring their lending, small changes in the economic outlook can produce large fluctuations. In our model, however, banks are constantly monitoring their investments regardless of a boom or a crush, but 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 the investors as the 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 the illiquid banks. This can be explained by the soft-budget syndrome of government policy with respect to the banking system,
which is rooted in nancial institutions. Another immediate important policy impli-
cation from our theory for nancial system reform and for nancial-crisis-prevention
policy is that the transparency of the banking system is critical. However, trans-
parency cannot be achieved by imposing government regulations alone; instead, it
can only be achieved by reforming the nancial institutions to tighten budget con-
straints at the micro level.

Moreover, our theory has implications for many policy solutions proposed in the lit-
erature. In the following we give a brief summary of our implications for Dewatripont-
Tirole (Dewatripont and Tirole, 1994) policies (DT policy for short) to deal with bank
failures. The rst 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 suf cient infor-
mation about the solvency of illiquid banks, the government should consider the trade-o between closing down illiquid banks and letting solvent liquid banks take over illiquid
banks; or to 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 the 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 may be able to identify solvent
banks. However, this will probably not work in the long run because a nationalized
bank will likely induce an SBC environment.
REFERENCES


Appendix

The formal expression of the efficiency assumptions are the following. Assumption A-1.1:

\[ X^b(s_A; s_B) - I_3 > 0 > X^a(s_A; s_B) - I_3; \text{ when } s_A > s_B; \]

\[ X^b(s_A; s_B) - I_3 = X^a(s_A; s_B) - I_3 = 0; \text{ when } s_A = s_B; \]

\[ X^a(s_A; s_B) - I_3 > 0 > X^b(s_A; s_B) - I_3; \text{ when } s_A < s_B; \]

where \( X^j(s_A; s_B) \) is the total payoff of the reorganized project enjoyed by the bank(s) when strategy \( j \) is in action. In the case of co-financing, we denote the payoff under strategy \( j \) to bank \( J \) by \( X^j_J(s_A; s_B) \), where \( j = a \) or \( b \) and \( J = A \) or \( B \): Thus, \( X^j(s_A; s_B) = V^a_A(s_A; s_B) + V^b_B(s_A; s_B) \).\(^{16}\)

Assumption A-1.2:

\[ qX^b(s_A; s_B) + (1 - q)X^a(s_A; s_B) - I_3 < 0 \] (A-1.2)

where \( q = \Pr(s_A > s_B) \).\(^{17}\)

Conflict interest assumption A-2: for any \( s^h > s^l \),

\[ V^a_A(s^h_A; s_B) > V^b_A(s^h_A; s_B) > V^b_B(s^h_A; s_B) > V^a_B(s^h_A; s_B) > V^a_B(s^l_A; s_B) > V^b_B(s^l_A; s_B) > V^b_A(s^l_A; s_B); \]

(A-2.1)

(A-2.2)

Proof of Proposition 4.1\(^{18}\)

We show that if each bank \( J \) is able to observe only \( s^J \) (\( J = A \) or \( B \)) after \( I_3 \) is invested, under (A-1) and (A-2) there is no efficient incentive compatible scheme \( q(s_A; s_B) \) and \( T(s_A; s_B) \) which can induce bank \( J \) to tell the true value of \( s^J \); thus there is no efficient scheme to reorganize the project. As a result, the banks choose to liquidate the bad project.

\(^{16}\)If we relax assumption (A-1.1) such that if signal \( s_A \) is higher than \( s_B \); strategy \( b \) always makes the project more profitable ex post than strategy \( a \) and some times only strategy \( b \) makes the project profitable ex post; and vice versa, our results will not be changed qualitatively.

\(^{17}\)Any randomization based on \( q \in [0;1] \) and \( q \neq 0 \) cannot get a better result than (A-1.2).

\(^{18}\)The proof of this proposition is influenced by Maskin (1992) which shows that an information asymmetry between two parties can make auctions inefficient.
In the following proof, we first analyze bank A’s incentive problem. For this purpose, we set $s$ at an arbitrary value $s^a$ 2 (0; 1).

Given compensation scheme $T(s_A; s_B)$ and strategy $q(s_A; s_B)$, bank A should tell the truth only if the expected payoff of doing so is not worse than false reporting. That is, the incentive compatibility (IC) condition is:

$$q(s_A; s_B) V^b_A(s_A; s_B) + (1 - q(s_A; s_B)) V^a_A(s_A; s_B) + T(s_A; s_B)$$

$$q(b_A; s_B) V^b_A(s_A; s_B) + (1 - q(b_A; s_B)) V^a_A(s_A; s_B) + T(b_A; s_B);$$

where $b_A$ is the false report of the signal.

In the case that the information $s_A = s^b_A > s^a$, the IC is

$$q(s^b_A; s_B) V^b_A(s^b_A; s_B) + 1 - q(s^b_A; s_B) V^a_A(s^b_A; s_B) + T(s^b_A; s_B)$$

$$q(s^l_A; s_B) V^l_A(s^l_A; s_B) + 1 - q(s^l_A; s_B) V^a_A(s^l_A; s_B) + T(s^l_A; s_B);$$

that is,

$$T(s^l_A; s_B) + T(s^b_A; s_B) , 3 q(s^l_A; s_B) i q(s^b_A; s_B) , b_A^b_A(s^b_A; s_B) +$$

$$q(s^b_A; s_B) i q(s^l_A; s_B) v_A^b_A(s^l_A; s_B) ;$$

The IC for A’s information $s_A = s^l_A < s^a$ is:

$$q(s^l_A; s_B) V^l_A(s^l_A; s_B) + 1 - q(s^l_A; s_B) V^a_A(s^l_A; s_B) + T(s^l_A; s_B)$$

$$q(s^b_A; s_B) V^b_A(s^b_A; s_B) + 1 - q(s^b_A; s_B) V^a_A(s^b_A; s_B) + T(s^b_A; s_B);$$

that is,

$$T(s^l_A; s_B) , T(s^b_A; s_B) , 3 q(s^l_A; s_B) i q(s^b_A; s_B) V^l_A(s^l_A; s_B)$$

$$V^a_A(s^b_A; s_B) ;$$

The IC conditions (1) and (2) imply

$$T(s^l_A; s_B) , T(s^b_A; s_B) , 3 q(s^l_A; s_B) i q(s^b_A; s_B) V^b_A(s^b_A; s_B)$$

$$3 q(s^l_A; s_B) i q(s^b_A; s_B) V^a_A(s^b_A; s_B) ;$$

$$T(s^b_A; s_B) , T(s^l_A; s_B) , 3 q(s^l_A; s_B) i q(s^b_A; s_B) V^l_A(s^l_A; s_B)$$

$$3 q(s^l_A; s_B) i q(s^b_A; s_B) V^a_A(s^l_A; s_B);$$
or,

\[ q(s_A; s_B) \leq q(s'_A; s_B) \quad \forall q \in [0,1] \]

According to (A-2.1), \( V^A(s^a_A; s_B) > V^A(s^b_A; s_B) > 0 \). Thus, the incentive compatibility implies \( q(s^a_A; s_B) > q(s^b_A; s_B) \), i.e., \( q(s^b_A; s_B) \) should not increase in \( s_A \).

However, by (A-1), for any given \( s_B \) when \( s_A \) increases from \( s_A < s_B \) to \( s_A > s_B \), for any \( q(s_A; s_B) = \delta \), where \( \delta \geq 0 \), is a constant, the efficiency can be improved by increasing \( q \), i.e. \( q + \delta \), where \( \delta > 0 \). Thus, the efficiency requires \( q(s_A; s_B) \) to be non-decreasing in \( s_A \).

Therefore, the only possible scheme of \( q(s_A; s_B) \) which may satisfy both IC and the efficiency requirement is to keep \( q(s_A; s_B) \) constant, i.e. \( q(s_A; s_B) = \delta \). It is obvious that for any \( \delta \geq 0 \), reorganization based on any \( q \) is worse than liquidation. However, by (A-1.2), a reorganization decision based on \( q \) is worse than liquidation.

The case of bank B can be proved by symmetry.

Given the above results, any randomization between liquidation and reorganization at date 2 will be worse than liquidation. Thus, the probability of liquidation is \( 1 - p = 1 \).