Collusion and Commitment in Bank Bailout

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Abstract

Collusion and soft budget constraint are two conspicuous phenomena in transition economies' banking system. Literature has separately investigated those two phenomena from theoretical point of views. However, the cross-point of both phenomena has been neglected in the research of banking regulation. The present paper addresses this issue in a simple model of two-period contract with termination at the end of the first period. By comparing the two hierarchies -- "bank-firm" and "government-bank-firm", we show that the government's non-commitment and banking bailout cause inefficiency in the contact relationship. Moreover, after introducing collusion possibility, non-commitment of the government increases the stakes, or bribes, which the collusive bank can extract, and makes it more costly for the government to implement this contract. However, taking into account the fact that the bank is collusive, the government who aims to prevent collusion will switch to the other equilibrium where she sticks to her commitment and excludes collusion from the contract relationship. Here, collusion plays a role as a hardening budget constraint device. Some policy implications are suggested at the end.

Key words: soft budget constraint, collusion, moral hazard, commitment, transition, centralized economy.

JEL Classification: C72, D23, D82, G14, H72, L23, P31

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1. Introduction

Collusion and soft budget constraint are two conspicuous phenomena in transition economies' banking system. There is a lot of literature which has separately investigated these two subjects from theoretical point of views. However, the cross-point of these two subjects has been neglected in the research of banking regulation, and it is worthy to investigate whether there is any relationship between collusion and soft budget constraint if these two phenomena co-exist in transition economies, or furthermore, whether one of these phenomena amplifies the effect of the other.

S*oft budget constraint (SBC)* is actually a commitment issue in an economic system. Modern studies focus on the transitional economies' "lack of financial disciplines in the state sector" (Kornai, 1980, 1992). The unenforceable bankruptcy threats, as well as various subsidies, credits, and price-supports, etc., cause this lack of discipline, recognized by Kornai (1979, 1980)

The SBC episode is not the exclusive phenomenon in transition economics. The market economy cannot be immune to SBC. Notable recent examples of its mischief include the US government's bailouts in the Savings and Loans and the Long-Term Capital Management crisis, French government's bailout in Credit Lyonnais. Especially in the financial system, SBC has broken the boundary of the market economy and the centralized economy.

To model the soft budget constraint as a financial commitment problem is the mainstream approach which has been adopted by many transition economists. They focus on the inability to prevent an *ex ante* financial plan (or budget) from being renegotiated *ex post.* The second approach has also been used to model the soft budget constraint as instruments to solve a moral hazard problem. However, the first approach is a prevailing one and there are substantial empirical literatures that support the validity of this point of view.

First, the original work of Kornai (1980) characterizes soft budget constraints into two major features: (i) *ex post* renegotiation of firms' financial contracts; and (ii) a public ownership between the firms and the government (a "vertical relationship" in Kornai's phrase). He just presented the two features separately and did not look into the question whether there is any relationship between them.

However, Maskin and Xu (2001) show that these two features are intrinsically related. Moreover, they argue that both features are not only central to the fundamental problem of centralized economies, but also bear on major issues in economics more generally, such as the boundary of the firm (Coase,1937) and the capital structure of the firm (Modigliani and Miller,1958). As Coase said, the proper location of the boundary is determined by trading off the effectiveness of two co-ordination mechanisms, "administrative control" and "market". And a major factor affecting the trade-off is commitment. Maskin and Xu show that the decentralized nature of the market makes renegotiation in market relations harder than under administrative control. Moreover, as a typical thinking of a firm's optimal capital structure, debt imposes greater financial discipline than equity on managers since debt increases the chance that the firm goes to bankruptcy. Maskin and Xu show that this threat is compromised if the firm can renegotiate its way out of bankruptcy. Thus, the optimal debt/equity ratio turns on the hardness of the budget constraint imposed by debt.

Dewatripont-Maskin model (Dewatripont and Maskin, 1995) is one of the early theories to endogenize the soft budget constraint as a financial commitment problem. They stress dynamic commitment problems in the presence of irreversible investment. By analyzing the soft budget constraint under centralized and decentralized banking systems, they show that paternalism, which is cited by Kornai as the cause of SBC, is neither a necessary nor a sufficient condition for SBC. They provide other tools to understand SBC under paternalism but also beyond paternalism.

There are some other explanations of the soft budget constraint (for example, Shleifer and Vishny, 1994) which are related to the politics: the reason that a government bails out a firm or a bank comes from the fact that the political price of permitting bankruptcy is too high. The incentive to refinance a slow project will be even stronger than in the standard model since the benefit from refinancing is higher, or the social planner has some stakes in such a behavior. Especially in a banking system, the central bank will not just let the local banks go to bankruptcy and then she has to deal with systematical financial crisis. In any case, the central bank would like to rescue those local banks which are suffering from a huge amount of bad loans.

The earlier analysis of the bad loan problem has emphasized the need for bank recapitalization as the appropriate solution (Begg and Portes, 1993, Mitchell, 1994). However, such recapitalization could only occur once. Otherwise the expectation of future bailouts would seriously dampen banks' incentives. Accumulation of bad loans indeed strengthens pressure to bail out banks and the expectation of bailouts gives fewer incentives to banks to improve their loan portfolio. This is a clear example of the soft budget constraint syndrome.

The soft budget constraint of firms comes from the commitment of banking system. Therefore, in order to harden the firms' budget constraint, as Maskin and Xu (2001) mentioned in their article, we need to reform the banking system.

Faure-Grimaud and Rochet (1998) proposed a way to solve the soft budget constraints for banks in transition economies. As they stated, one can raise the cost of funds to banks through increasing the capital requirements, which can make it less attractive to refinance the bad projects. In addition, they studied two ways of privatization on soft budget constraints, through putting current or new management in charge of banks. Given that the current bank managers (supervisors) have a better knowledge of the existing loan portfolio than do newcomers, these managers have an advantage in extracting surplus from firms whenever refinancing occurs. This supervisor rent-seeking ability may exacerbate the soft budget constraint syndrome because it makes refinancing more likely. And so, they concluded, it may be better to put outsiders in charge precisely because their information is poorer.

Not only firms have the soft budget constraint problem, banks, as special firms, also have the soft budget constraint themselves. Whether to bail out failing banks is a crucial problem in all the banking systems. How to bail out the failing banks also affects the bank manager (supervisor)'s behavior with the firms. Aghion, Bolton and Fries (1996) argue that a major source of soft budget constraints is the bank managers (supervisors)' incentives to misreport their banks' loan losses, and this can lead to banking crises. In their model, the bank manager s (supervisors)' ex ante incentives to lend, as well as their ex post incentives to disclose a non-performing loan problem truthfully, could be strongly affected by different bank bailout rules. For "*a tough recapitalization*" policy followed by dismissal of the bank manager (supervisor), the manager will try to under-report or completely hide losses by rolling over bad loans, in order not to lose his job. Thus such a policy may result in worsening adverse selection problem and in softening firm's budget constraints. However, if the manager of a failing bank is not dismissed, which is called "*a soft recapitalization*", he has incentives to over liquidate the nonperforming firm, and will exaggerate his recapitalization requirements.

The collusion literature follows Tirole(1986). In his original work, Tirole broke up the former economists' tradition of ignorance of coalitions with side-contracting power in the design of incentive schemes. Furthermore, he conducted research on the efficiency losses that can result from collusion with side-payments in a principal-supervisor-agent hierarchy. The coalitions with implicit side-contracts are more easily to be implemented in a long-time relationship through a mechanism similar to reputation game. In this relationship, repeated games enhance not only productivity, but also opportunities for collusion. Although dismissing supervisor or other impediments may succeed in destroying coalitions, they may also be costly and induce incentive rents for the principal.

Another research on collusion has been carried out by Kofman and Lawarree(1993). They illustrated how collusion can be constrained by creating an alternative source of information. Unlike Tirole, they introduced a second supervisor (the same level as the first supervisor), whose sole purpose is to discourage deviant coalitions. Denoting the first supervisor as the internal auditor and the second one as the external auditor, they use imperfect audit technology which allows the internal auditor and the manager to collude. Auditors are useful only if they have good information and if the manager's liability is high. However, expected maximum deterrence is not desirable and production is suboptimal, even with unbounded punishments, risk-neutral agents, and costless auditing. Increase of punishment on the manager raises the bribe he can offer to the auditor, which raises the cost of preventing collusion.

Olsen and Torsvik (1998) studied collusive behavior as a second best solution for lack of commitment. They adopted the three-tier principle-supervisor-agent relationship used by Laffont and Tirole (1991) and extended it to a two-period dynamic version. In the second period, the principal may renegotiate her initial contract with the supervisor and the agent. This time-inconsistency problem may delay information revelation and induce efficiency loss. However, corruption has the side effect of functioning as a commitment device. Besides its negative static effects to the principal, corruption makes it in the principal's interest to reduce the agent's information rent when the future arrives. It alleviates the commitment problem. The relaxation effect that corruption imposes on the dynamic information revelation constraint can create long-time gains which offset the static efficiency loss.

The present paper is related to two areas of literature. One of them address that if insolvent banks are capitalized and bank managers are not dismissed, solvent banks have an incentive to overstate their levels of bad debt through excessive liquidation of loans in default in order to qualify for recapitalization. (see Aghion, Bolton, and Fries (1999)). Their misreporting is similar to our untruthfully revealing in the collusion case. We also show that recapitalization makes it more attractive for the bank manager to collude with the firm and to untruthfully reveal the information. However, our model is different from theirs since termination of bad-performing firm is optimal and credible in their model, but it is not always the case in ours. This loss of credibility is analyzed as non-commitment in our model. The other area of literature studies the collusive behavior as a second best solution for lack of commitment. (see Olsen and Torsvik(1998)). Their model focuses on the renegotiation of the initial contract and investigates on how collusion alleviates information revelation delay and efficiency loss because of this time-inconsistency problem. Similarly, we also find collusion has the effect of functioning as a commitment enhancing device. But our model concentrates on the commitment of terminating the bad-performing firm, which is a typical problem in the literature of the soft budget constraint, and investigates the collusion's effect on strengthening budget constraint.

The structure of this paper is presented as follows: in section 2, we develop a dynamic model in which the soft budget constraint emerges because of the government's rescue. Further more, in section 3 we introduce the supervision technology and analyze how the SBC problem exacerbates the collusion problem. On the other hand, we illustrate how

SBC has been affected by the bank manager (supervisor)'s collusive behavior. At last, we arrive to the conclusion and policy implications in section 4.

2. The Model

The main idea of this section is to show how the government's bailout changes the bank's decision rule and the bank's commitment to the firm. In the next section, we will show how the government's capitalization policy makes it more attractive for the bank and the firm to collude in order to obtain the bribes and the rents plus the private benefits respectively. First, commitment in this dynamic moral hazard model is defined as stopping refinancing if the firm fails, which is similar to the termination rule in Bolton and Scharfstein (1990), whose key point is that investors can mitigate managerial incentive problems by committing to terminate funding if a firm's performance is poor. This commitment could be changed by the government's bailing out to the bank. At the same time, we lose *ex ante* efficiency because of the change of commitment and introducing of the public ownership will induce over investment. Second, the collusive behavior occurs if the government uses the bank as a supervisor who is in charge of the firm's project choice, where we adopt the supervision pattern in Holmstrom and Tirole(1997). The government's bailout, say, recapitalization of the bank, can make it attractive for the supervisor to hide the information concerning the firm's choice, and attractive for the firm to reap all the private benefits from choosing the bad project, as well as the rents from the supervisor's misreporting on the firm's choice. As a result, we find that the loss of commitment during the bank bailout leaves more stakes for the corrupt supervisor and the firm.

Above all, we assume that the firm has no cash himself and could only borrow F per period, which is the investment cost, if the bank agrees to lend. After the firm gets the loan, it invests into the good project or the bad project, both with the return R when it succeeds and the return 0 when it fails, where $R > F > 0$. Here all the returns are verifiable for the players. If the firm chooses the good (resp. bad) project, the probability of success is π_1 (resp. π_0), where $\pi_1 > \frac{1}{2} > \pi_0$ and $\pi_1 + \pi_0 > 1$. Without loss of generality, we assume that choosing the good project is socially efficient, which is $\pi_1 R > F$, but choosing the bad project is not, which is $\pi_0 R < F$. However, by choosing the bad project, the firm gets a private benefit B , where we assume that $0 < B < \Delta\pi R$, ($\Delta\pi = \pi_1 - \pi_0$), which means, the firm's private benefit from the bad project is lower than the social efficiency gain from choosing the good project in stead of the bad project. In addition, we also assume that $\pi_1 (R - B / \Delta\pi) \leq F$ and we will show how this assumption affects our results in the following sections.

The financial contract consists of the menu of repayments of the bank loans, $\{(\bar{t}_1, \underline{t}_1), (\bar{t}_{2S}, \underline{t}_{2S}), (\bar{t}_{2F}, \underline{t}_{2F})\}$, depending on whether the firm succeeds or not. In date 1, if it succeeds, the firm repays $\bar{t}_1$, and $\underline{t}_1$ if it fails. In date 2, the firm, which succeeded in date 1, repays $\bar{t}_{2S}$ (resp. $\underline{t}_{2S}$) if it succeeds again (resp. fails). Similarly, the firm, which failed in date 1, repays $\bar{t}_{2F}$ (resp. $\underline{t}_{2F}$) if it succeeds (resp. fails) in date 2. The repayments are presented in the following figure:

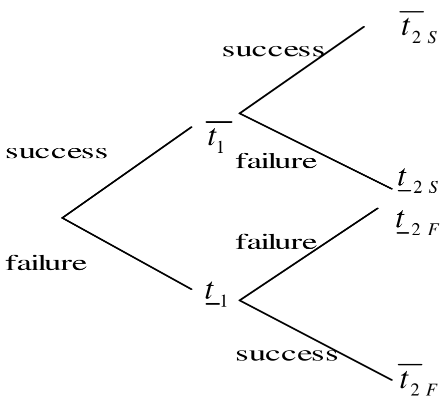


Figure 1

We denote $\beta_i \in \{0,1\}$ the probability that the bank (she) refinances the firm at the end of date 1 in a two-period dynamic model, where $i = f, s$, i.e. fail or succeed. We also have the liquidation value, which is normalized to 0 . For simplicity, we assume that the discount factor is 1, which means the second period is as important as the first period.

Furthermore, we assume that the firm is protected by limited liability and he cannot be asked to repay the loan more than the outcomes that he actually gets. In addition, we assume that the firm's choice is independent in both periods, which means, as stated, that the firm's choice of project at date 2 does not depend on his choice at date 1.

The bank is a profit maximizing monopoly bank, whose utility could be presented as her profit, and she makes a take-it-or-leave-it offer of a contract to the firm. This bank defines her termination rule specified in the contract for the sake of maximizing her profits. In the benchmark, where there is only the bank-firm relationship, we will develop the bank's optimal termination rule in the two-tier hierarchy, and check whether the bank can stick to this optimal termination rule. Then, we introduce the public ownership and investigate how commitment of termination has been changed by the government's public-ownership oriented rescue.

The government's maximization problem is to form a policy toward the recapitalization of banks. A constraint on this policy is that any bank can get the policy subsidy from the government when it is insolvent, but also has to submit the profit to the government. Therefore the government should design a policy, whose components are: (1) maximize the expected social welfare $U+V$, where U is the firm's utility and V is the bank's utility; (2) minimize the social cost of the transfer between the bank and the government through collecting the public fund, $\lambda_t T$, where T is the transfer between the government and the bank. Then the government's utility could be presented as follows:

$$W = U + V - \lambda_t T$$

where λ_t is the transaction cost of collecting the public fund.

In the next section, when using the bank as a supervisor, the government has to add another object: (3) induce information revelation of the bank in the monitoring the firm and prevent collusion.

2.1 Benchmark: no regulatory bailout

The timing is simple: at the beginning of date 1, the bank offers a contract to the firm $\{(\bar{t}_1, \underline{t}_1), (\bar{t}_{2S}, \underline{t}_{2S}), (\bar{t}_{2F}, \underline{t}_{2F}), \beta_i\}$. The firm can choose from the good/bad project. At the end of date 1, the outcome is realized and the bank applies her termination rule which was announced at the beginning of date 1; at date 2, provided it is refinanced, the firm chooses between the good project and the bad project and there is termination with probability 1 at the end of this period.

- **The Firm**

The firm is protected by limited liability which could be presented as follows:

$(\overline{LL})$ $\quad R \geq \overline{t}_j$

$(\underline{LL})$ $\quad 0 \geq \underline{t}_j$

Given that the firm gets refinancing for date 2, we focus on the case where effort is valuable for the bank, which always wants to implement a high level of effort. We can thus describe the second-period incentive constraints as:

$(IC)_{2S}$ $\quad (R - \overline{t}_{2S}) \geq \frac{B}{\Delta\pi} + (0 - \underline{t}_{2S})$ when the firm succeeds in date 1

$(IC)_{2F}$ $\quad (R - \overline{t}_{2F}) \geq \frac{B}{\Delta\pi} + (0 - \underline{t}_{2F})$ when the firm fails in date 1

If the firm chooses the good project in both periods, its utility could be presented as

$$U_{GG} = \pi_1(R - \overline{t}_1) + (1-\pi_1)(0 - \underline{t}_1) + \pi_1\beta_s[\pi_1(R - \overline{t}_{2S}) + (1-\pi_1)(0 - \underline{t}_{2S})] + (1-\pi_1)\beta_f[\pi_1(R - \overline{t}_{2F}) + (1-\pi_1)(0 - \underline{t}_{2F})]$$

and if the firm chooses the bad project in both periods, its utility could be presented as

$$U_{BB} = \pi_0(R - \overline{t}_1) + (1-\pi_0)(0 - \underline{t}_1) + B + \pi_0\beta_s[\pi_0(R - \overline{t}_{2S}) + (1-\pi_0)(0 - \underline{t}_{2S}) + B] + (1-\pi_0)\beta_f[\pi_0(R - \overline{t}_{2F}) + (1-\pi_0)(0 - \underline{t}_{2F}) + B]$$

If we want to induce the firm to choose the good project in both periods, we have to reward it enough through satisfying intertemporal incentive compatibility constraint:

$(IC)_{12}$ $\quad U_{GG} \geq U_{BB}$

In the appendix, we verify that if $(IC)_{12}$ is satisfied, the firm prefers choosing the good project in both periods to choosing the good project in one period but the bad project in the other period. Therefore, $(IC)_{12}$ is the only relevant intertemporal incentive compatibility constraint. (See the appendix for the proof)

- **The Bank**

The termination rule β_i could be regarded as an instrument that the bank imposes threat on the firm: If the firm chooses the bad project in date 1, it has higher probability of failure and the expected repayment is much less than the amount when it succeeds; knowing that, the bank can close the refinance channel to the firm in date 2 and make the firm lose the date-2 rent or the private benefit as a punishment.

First, we look at the bank's problem:

$$\underset{\beta_i, \overline{t}_j, \underline{t}_j}{Max}\, V = \pi_1 \overline{t}_1 + (1-\pi_1)\underline{t}_1 - F + \pi_1 \beta_s [\pi_1 \overline{t}_{2S} + (1-\pi_1)\underline{t}_{2S} - F] + (1-\pi_1)\beta_f [\pi_1 \overline{t}_{2F} + (1-\pi_1)\underline{t}_{2F} - F]$$

s.t.

$(\overline{LL})$	$R \geq \overline{t}_j$
$(\underline{LL})$	$0 \geq \underline{t}_j$
$(IC)_{2S}$	$(R - \overline{t}_{2S}) \geq \frac{B}{\Delta\pi} + (0 - \underline{t}_{2S})$
$(IC)_{2F}$	$(R - \overline{t}_{2F}) \geq \frac{B}{\Delta\pi} + (0 - \underline{t}_{2F})$
$(IC)_{12}$	$U_{GG} \geq U_{BB}$

PROPOSITION 1 In this two-tier bank-firm relationship, the optimal contract is described as follows:

- The optimal termination rule of the private bank is: $\beta_s^* = 1$, $\beta_f^* = 0$;
- In date 2, the optimal repayments are $\underline{t}_{2S} = 0$, $\overline{t}_{2S} = R - \frac{1+\pi_0}{\pi_1^2 - \pi_0^2} B$, depending on the firm's performance in both periods (where S stands for success in date 1), and there is no repayment for the case when the firm fails in date-1.
- In date 1, the firm gets no rent and all the revenue is transfered to the bank. The optimal repayments are $\overline{t}_1 = R$, $\underline{t}_1 = 0$.
- the bank's profit with commitment is : $V = (1+\pi_1)(\pi_1 R - F) - \frac{\pi_1^2(\pi_0 + 1)}{\pi_1^2 - \pi_0^2} B$
- the bank would like to lend the credit to the firm if and only if

$$F \leq F_1 = \pi_1 R - \frac{\pi_1^2 (1+\pi_0)}{(\pi_1^2 - \pi_0^2)(1+\pi_1)} B$$

Remark:

Actually, by sticking to this optimal termination rule, the bank has to apply the liquidation when the firm fails in date 1 but chooses the good project in date 2, since we assume $\pi_1 (R - \frac{B}{\Delta\pi}) \leq F$, which means, at the end of date1 the expected project value if the firm chooses the good project in date 2 is less than the liquidation value. However, the bank gains by saving the rent that she has to leave to the firm in order to induce its effort. Therefore the optimal contract is renegotiation proof.

2.2 Rescue and Commitment

Now we introduce public ownership into the banking system. The owner of the bank is the national government and his goal is to square up the bank's loss and keep the bank in the safe situation. Specially when the bank faces the failed firm and gets negative payoff, the government can inject public fund, recapitalize the bank, and write-off the non-performing loans. It seems that the bank is protected by limited liability since the bank can get certain amount of profit when the firm succeed and get at least zero when the firm fails. On the other hand, the government can also use the profit of the bank as a political loan. Such kind of transfer is costly because of the transaction cost of public funds λ_t. We denote W the government's utility when he recapitalizes the bank, then the components of the government's bank bailout policy are: (1) maximize the expected social welfare (2) minimize the social cost of transfer between the bank and the government through collecting the public fund, $\lambda_t T$, where

$$T = \left|\pi_1 \bar{t}_1 + (1-\pi_1)\underline{t}_1 - F + \pi_1 \beta_s [\pi_1 \bar{t}_{2S} + (1-\pi_1)\underline{t}_{2S} - F] + (1-\pi_1)\beta_f [\pi_1 \bar{t}_{2F} + (1-\pi_1)\underline{t}_{2F} - F]\right|$$

Therefore the government's optimal program is:

$$\underset{\{\beta i, \bar{t}_j, \underline{t}_j\}}{Max}\ W = U + V - \lambda_t T = [1 + \pi_1 \beta_s + (1-\pi_1)\beta_f](\pi_1 R - F) - \lambda_t T$$

$$\text{S.t} \qquad (IC)_{2S}, (IC)_{2F}, (IC)_{12}, (\overline{LL}), (\underline{LL})$$

We have proposition 2 which states the new contract framework after we introduce the government:

PROPOSITION 2 when we have the "government-bank-firm" hierarchy, the optimal financial contract is modified as:

- Refinancing probabilities become: $\beta_s^P = 1, \beta_f^P = 1$
- The repayments are

$$\bar{t}_1 = R, \underline{t}_1 = 0,$$
$$\underline{t}_{2S} = 0, \underline{t}_{2F} = 0$$
$$\bar{t}_{2F} = R - \frac{B}{\Delta\pi}, \bar{t}_{2S} = R - \frac{1+\pi_1+\pi_0}{\pi_1^2 - \pi_0^2} B$$

- The government's utility is: $W = 2(1-\lambda_t)(\pi_1 R - F) + \dfrac{2\pi_1^2 + \pi_0}{\pi_1^2 - \pi_0^2}\lambda_t B$

- the bank would like to participate in this financial contract if and only if:

$$F \le F_2 = \pi_1 R + \frac{\lambda_t}{2(1-\lambda_t)} \frac{2\pi_1^2 + \pi_0}{\pi_1^2 - \pi_0^2} B$$

Remark:
We can see that with public ownership the termination of refinancing the failed firm is no longer credible even it is efficient to liquidate ex post. The government would like to continue refinancing for sake of social value of the project after he internalizes the firm and the bank's utilities. As we can say, there is no commitment on termination of refinancing the bad-performing firm and the soft budget constraint problem comes out of public ownership.

Moreover, it is easy to verify that $F_2 > F_1$, which means, when there exists public ownership and the government would like to recapitalize the bank in any case, the bank is less prudent and invests more than the case when she is a private bank without government bailout, because with public ownership the government will stand out to compensate the bank's loss and keep the bank in the safe situation.

Therefore, when the government comes to capitalize the bank, the termination at the end of date 1 is no longer credible. By anticipating this loss of commitment on termination, the firm might also lose the ex ante incentive to exert effort in two periods. The government needs to look for other instruments to restore the efficiency. One of them is the supervision technology used by the government in the next section.

3. Supervision Technology: Inspection and Correction

In the previous section 2.2 we find out that the government's public-ownership oriented rescue leads to the bank's non-commitment to stop refinancing the firm when it fails in date 1. This loss of commitment makes it more expensive for the government to induce effort since he loses threat on the firm when he loses commitment. Specially, when the private benefit is higher, the rent that the government has to leave to the firm to induce it to choose the good project augments. This augmentation of rent will enter the government's capitalization cost, as well as into the bank's utility, as a negative effect. Therefore, the government prefers looking for other kinds of threat to induce efforts.

In this section, we first introduce another instrument to restore the firm's incentive--the bank's supervision (inspection and correction), and then we look for the optimal contract design. Here the bank acts as a supervisor, as well as a credit lender. The simplest supervision case is studied in section 3.1 where there is no collusion in this two-tier hierarchy. In section 3.2, we introduce public ownership to the banking system and add the government as the third layer on the top. Under this three-tier hierarchy, we consider the possibility of collusion, where the firm will bribe the bank not to reveal the information which he finds or to misreport the information.

3.1 Supervision without collusion

In this section we only consider two-tier relationship between the bank and the firm. With the same assumptions in the benchmark, the additional inspection and correction are presented as follows: after the firm chooses the project, the bank will use supervision technology to inspect whether the firm has chosen the bad project. We assume that with probability ξ the bank (supervisor) finds the evidence $\sigma = \pi_0$ given the firm has chosen the bad project. After this inspection, the bank (supervisor) can make correction to eliminate the private benefit B and raise the probability of success from π_0 to $\pi_0' \leq \pi_1$. The cost of the supervisor's corrective action is normalized to 0. In other words, the supervisor can apply this inspection and correction costless. In this section, there is no space that collusive behavior can emerge from this two-tier hierarchy.

The sequence of events in this two-period model is illustrated in Figure 3:

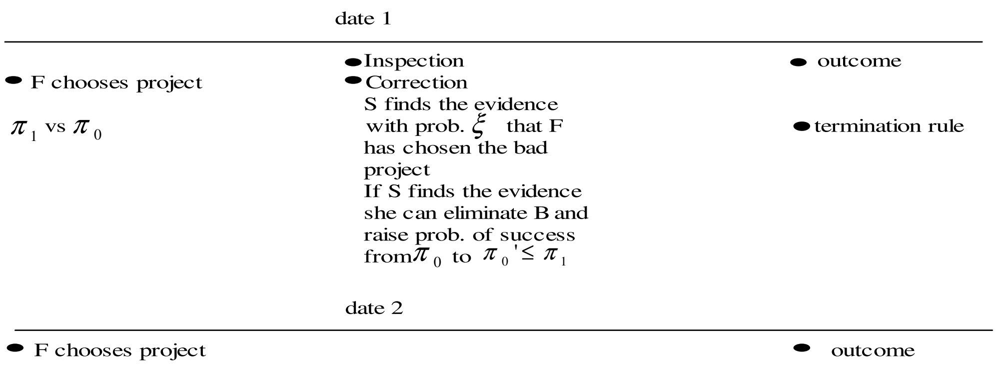


Figure 3

- **The Firm**

In date 1, if the firm chooses the bad project, in his inspection the supervisor will find the evidence $\sigma = \pi_0$ with probability ξ. After this inspection, the supervisor can make correction to eliminate the private benefit B and raise the probability of success from π_0 to $\pi_0' \le \pi_1$. In other words, we can also regard the probability of success under the supervisor's inspection and correction is $\bar{\pi} = \xi\pi_0 + (1-\xi)\pi_0'$. At this moment, the private benefit when the firm chooses the bad project decreases to $(1-\xi)B$ if the supervisor finds the evidence and eliminates ξB. As a consequence, the repayments in date 1 could be divided into two packages: one is with the evidence $\{\bar{t}_1^e, \underline{t}_1^e\}$, the other is without evidence $\{\bar{t}_1^n, \underline{t}_1^n\}$. The probabilities of continuation also correspond to these two packages, depending not only on success or failure, but also on with the evidence $\{\beta_{s,e}, \beta_{f,e}\}$ or without evidence $\{\beta_{s,n}, \beta_{f,n}\}$. Assume that the firm is protected by limited liability which is presented as follows:

$(\overline{LL})$ $\qquad R \ge \bar{t}_j$

$(\underline{LL})$ $\qquad 0 \ge \underline{t}_j$

With risk neutrality and no time impatience, it is optimal for the bank to leave the rent only at the end of date 2 and leave no rent to the firm at the end of date 1 no matter the supervisor finds the evidence or not. That is:

$$\bar{t}_1^e = \bar{t}_1^n = R,$$

$$\underline{t}_1^e = \underline{t}_1^n = 0.$$

In date 2, the firm's repayment packages also depend on whether the supervisor finds the evidence or not. We should add superscripts, "e" and "n", to the date-2 repayment variables.

$$\text{with the evidence} \{\bar{t}_{2S}^e, \underline{t}_{2S}^e; \bar{t}_{2F}^e, \underline{t}_{2F}^e\},$$

$$\text{without evidence } \{\bar{t}_{2S}^n, \underline{t}_{2S}^n; \bar{t}_{2F}^n, \underline{t}_{2F}^n\}$$

Therefore, with the evidence, the bank would leave no rent to the firm in date 2 no matter it succeeds or fails, in order that the bank can apply the severest punishment to the firm who chooses the bad project and add more incentive into date 1. The repayments are as same as in date 1:

$$\overline{t}_{2S}^{e} = \overline{t}_{2F}^{e} = R,$$

$$\underline{t}_{2S}^{e} = \underline{t}_{2F}^{e} = 0.$$

If the supervisor finds no evidence, the firm's date-2 incentive compatibility constraints are as same as those in section 2:

$(IC)_{2S}$ $\qquad (R - \overline{t}_{2S}^{n}) \geq \frac{B}{\Delta\pi} + (0 - \underline{t}_{2S}^{n})$ when the firm succeeds in date 1

$(IC)_{2F}$ $\qquad (R - \overline{t}_{2F}^{n}) \geq \frac{B}{\Delta\pi} + (0 - \underline{t}_{2F}^{n})$ when the firm fails in date 1

Combining limited liability constraints, we can find that $\underline{t}_{2S}^{n} \geq 0, \underline{t}_{2F}^{n} \geq 0$ and $(IC)_{2F}$ are binding, which give three repayments:

$$\underline{t}_{2S}^{n} = \underline{t}_{2F}^{n} = 0$$

$$\overline{t}_{2F}^{n} = R - \frac{B}{\Delta\pi}$$

Now, let us look at the intertemporal incentive compatibility constraints:

If the firm chooses the good project in both periods, and its performance could not be found as evidence in the supervisor's inspection, its utility could be presented as

$$U_{GG} = \pi_1(R - \overline{t}_1^{\,n}) + (1-\pi_1)(0 - \underline{t}_1^{n}) + \pi_1\beta_{s,n}[\pi_1(R - \overline{t}_{2S}^{n}) + (1-\pi_1)(0 - \underline{t}_{2S}^{n})]$$

$$+(1-\pi_1)\beta_{f,n}[\pi_1(R - \overline{t}_{2F}^{n}) + (1-\pi_1)(0 - \underline{t}_{2F}^{n})]$$

If the firm chooses the bad project in both periods, its performance could be detected and corrected with probability ξ by the supervisor in date 1. Its utility is therefore:

$$U_{CB} = \xi[\pi_0^{'}(R - \overline{t}_1^{\,e}) + (1-\pi_0^{'})(0 - \underline{t}_1^{e})] + (1-\xi)[\pi_0(R - \overline{t}_1^{\,e}) + (1-\pi_0)(0 - \underline{t}_1^{e}) + B]$$

$$+\xi\{\pi_0^{'}\beta_{s,e}[\pi_0(R - \overline{t}_{2S}^{e}) + (1-\pi_0)(0 - \underline{t}_{2S}^{e}) + B] + (1-\pi_0^{'})\beta_{f,e}[\pi_0(R - \overline{t}_{2F}^{e}) + (1-\pi_0)(0 - \underline{t}_{2F}^{e}) + B]\}$$

$$+(1-\xi)\{\pi_0\beta_{s,n}[\pi_0(R - \overline{t}_{2S}^{n}) + (1-\pi_0)(0 - \underline{t}_{2S}^{n}) + B] + (1-\pi_0)\beta_{f,n}[\pi_0(R - \overline{t}_{2F}^{n}) + (1-\pi_0)(0 - \underline{t}_{2F}^{n}) + B]\}$$

If the bank wants to induce the firm to choose the good project in both periods, she has to reward the firm enough to satisfy this intertemporal incentive compatibility constraint:

$(IC)_{12}'$ $\qquad U_{GG} \geq U_{CB}$

As same as in section 2, it is easy to verify that if $(IC)_{12}'$ is satisfied, the firm prefers choosing the good project in both periods to choosing the good project in one period but the bad project in the other and being corrected by the supervisor. Therefore, $(IC)_{12}'$ is the only relevant intertemporal incentive compatibility constraint.

- **The Bank**

Here the bank acts not only as a lender, but also a supervisor. The bank's objective function is changed due to the supervision technology. However, it is still in the bank's interest to induce the firm to choose the good project in both periods and on the equilibrium path the bank could not find any evidence. Supervision plays a rule of threat and helps the bank to leave less rent to the firm in the optimal contract.

$$\underset{\beta_i,\bar{t}_j,\underline{t}_j}{Max}\, \pi_1\bar{t}_1^{\,n} + (1-\pi_1)\underline{t}_1^n - F + \pi_1\beta_{s,n}[\pi_1\bar{t}_{2S}^n + (1-\pi_1)\underline{t}_{2S}^n - F] + (1-\pi_1)\beta_{f,n}[\pi_1\bar{t}_{2F}^n + (1-\pi_1)\underline{t}_{2F}^n - F]$$

$$\text{s.t.} \qquad (\overline{LL})\ (\underline{LL})\ (IC)_{2S}\ (IC)_{2F}\ (IC)_{12}'$$

We summarize the results in the following proposition 3.

PROPOSITION 3 when we have bank-firm relationship with supervision technology, the optimal financial contract is modified as:

- when the bank finds evidence in date 1, refinancing probabilities are: $\beta_{s,e} = 0$, $\beta_{f,e} = 0$; when the bank finds no evidence in date 1, the optimal termination rule of the bank should be $\beta_{s,n} = 1$, $\beta_{f,n} = 0$;.
- The optimal repayments when there is the evidence $\bar{t}_1^{\,e} = R$, $\underline{t}_1^e = 0$; when there is no evidence $\underline{t}_1^n = 0$, $\bar{t}_1^{\,n} = R$, $\bar{t}_{2S}^n = R - \dfrac{(1+\pi_0)(1-\xi)}{\pi_1^2 - (1-\xi)\pi_0^2}B$.
- the bank's profit under supervision technology is :
$$V^S = (1+\pi_1)(\pi_1 R - F) - \frac{\pi_1^2(\pi_0+1)(1-\xi)}{\pi_1^2-(1-\xi)\pi_0^2}B$$
- the bank would like to lend the credit to the firm if and only if
$$F \le F_3 = \pi_1 R - \frac{\pi_1^2(\pi_0+1)(1-\xi)}{\pi_1^2-(1-\xi)\pi_0^2}B$$

Remark:

The firm will not get refinanced when there is the evidence, no matter it succeeds or fails. Under this contract framework, we can then put the harshest punishment if the firm chooses the bad project. Therefore, we add more incentive into the contract and save more rent.

We can compare F_3 with F_1 in proposition 1. It is not surprising that $F_3 > F_1$, which means when there is supervision, the bank significantly saves the rent that he has to leave to the firm and has relatively higher utility than the case when there is no supervision. Therefore when she breaks even, the bank has more ability to lend, which is shown in figure 4.

(insert figure 4 here)

3.2 Supervision and public ownership

3.2.1 Collusion free supervision

In this section, we introduce public ownership into the banking system with the same pattern as that in section 2.2, and the bank plays a supervision rule too. First, we assume that the bank is benevolent. Therefore, the government does not need to give her any rent to induce her to reveal the information and not to get captured by the firm. The reward from the government to the bank is only to cover her reserved utility s_0 and let her participate into this financial contract.

$$(SIR) \qquad\qquad S \geq s_0$$

The transaction cost, λ_t, has also been taken into account when the government reward the bank S. In addition, we assume that the government can commit to reward the supervisor in any case, i.e. the supervisor's salary does not depend on whether she finds the evidence or not.

As same as before, the government is always the backup to square up the bank's loss and to keep the bank in the safe situation. Specially when the bank faces the failed firm and can not break even, the government can recapitalize the bank, pay the bill and settle the bank's loss to zero. Such kind of recapitalization is costly because of the transaction cost of public funds λ_t. The utility of the government is the combination of both the bank and the firm's utilities, minus the disutility of public funds transaction:

$$W = U + V - \lambda_t (T + S)$$
$$= [1 + \pi_1 \beta_{s,n} + (1-\pi_1)\beta_{f,n}](\pi_1 R - F) - \lambda_t \{\pi_1 \overline{t}_1^n - F + \pi_1 \beta_{s,n}(\pi_1 \overline{t}_{2S}^n - F) + (1-\pi_1)\beta_{f,n}(\pi_1 \overline{t}_{2F}^n - F) + s_0\}$$

As same as before, the government has to satisfy the following constraints:

$$(IC)_{2S}, (IC)_{2F}, (IC)_{12}, (\overline{LL}), (\underline{LL}), (SIR)$$

Using the same analysis as in section 3.1, we have proposition 4 which sets up the new contract framework after we introduce public ownership:

PROPOSITION 4 when we have the "government-bank-firm" hierarchy and the bank also acts as a supervisor, the optimal financial contract is modified as:

- When the bank finds evidence in date 1, refinancing probabilities are: $\beta_{s,e} = 0$, $\beta_{f,e} = 0$; When the bank finds no evidence in date 1, the optimal termination rule of the bank should be $\beta_{s,n} = 1$, $\beta_{f,n} = 1$.
- The optimal repayments are as same as in proposition 3, except $\overline{t}_{2S}^n = R - \frac{(1-\xi)(2\pi_1 - \pi_0^2 - \pi_0)/\Delta\pi + (\pi_0 + \pi_1 - 1)}{\pi_1^2 - (1-\xi)\pi_0^2} B$, $\overline{t}_{2F}^n = R - \frac{B}{\Delta\pi}$.
- The government's utility under supervision is : $W^S = 2(1+\lambda_t)(\pi_1 R - F) + \lambda_t \left\{ \frac{(1-\pi_1)\pi_1}{\Delta\pi} B + \frac{\pi_1^2[(1-\xi)(2\pi_1 - \pi_0^2 - \pi_0)/\Delta\pi + (\pi_1 + \pi_0 - 1)]}{\pi_1^2 - (1-\xi)\pi_0^2} B - s_0 \right\}$
- The bank would like to lend the credit to the firm if and only if $F \le F_4 = \pi_1 R + \frac{\lambda_t}{2(1+\lambda_t)} \left\{ \frac{(1-\pi_1)\pi_1}{\Delta\pi} B + \frac{\pi_1^2[(1-\xi)(2\pi_1 - \pi_0^2 - \pi_0)/\Delta\pi + (\pi_1 + \pi_0 - 1)]}{\pi_1^2 - (1-\xi)\pi_0^2} B - s_0 \right\}$

Remark

By comparing the rents which are left to the firm in both packages (with the evidence and without evidence), we find out that supervision technology helps the government to save the rent $(R - \overline{t}_{2S}^n)$ which, otherwise, should be left to the firm in order to induce efforts. In other words, the government improves his welfare by using this supervision technology if s_0 is relatively small.

In addition, if other things don't change, the increase of probability of finding the evidence ξ will decrease the rent $(R - \overline{t}_{2S}^n)$, which should be left to the firm. That means, more efficient supervision technology will definitely decrease the rent in this financial contract. This is exactly the case that, in most developed countries where more advanced auditing and other information revelation systems are available, the principal does not have to give so much rent to the agent in order to induce efforts if supervision technology is applied.

Moreover, it is not difficult to find that the increase of $\Delta\pi$ will decrease the rents not only in the supervision case, but also in the non-supervision case, *caeteris paribus*. This can explain why it is more difficult to induce efforts in most developing countries in their financial contracts. In fact, most developing countries don't have many good projects with higher probability of success. Generally, the difference between success and failure of each project is relatively smaller compared to the average level in majority of developed countries. Therefore, the principal has to leave more rents to the agent to induce effort.

Furthermore, introducing public ownership into the banking system changes the termination rule even though there is a supervision technology. It is just as same as the case where the government has leniency towards the firm and subsidies the firm through the bank. As a consequence, there is space for the bank and the firm to extract subsidies from the government which are used for bailout. This is the case in the next subsection where we take into account the collusive behavior of the supervisor bank.

3.2.2 Collusion and Commitment

In this subsection, we relax the assumption that the bank is benevolent and does not accept the bribe from the firm. With this collusive supervisor, not only do we compare the results with those when there is collusion-free supervision, but also we look at how the bribe varies according to the changes of commitment after introducing public ownership. At last, we find that the government would like to restore commitment, i.e. to stop refinancing the bad-performing firm, in order to save the reward to the supervisor for preventing collusion. In other words, the possibility of collusion forces the government to harden the budget constraint.

In date 1, when the supervisor finds the evidence and also declares that the firm has chosen the bad project, the continuation possibilities are $\beta_{s,e} = 0$, $\beta_{f,e} = 0$ and there is no rent left to the firm in date 2, which could be regarded as a quite rigorous punishment. On the contrary, if the supervisor declares that she finds nothing, the continuation possibilities are $\beta_{s,n} = 1$, $\beta_{f,n} = 1$ and there is rent left if the firm succeeds in date 2. Therefore, the firm has more advantages if there is no declared evidence. In order to get refinancing and reap the date-2 rent, the firm is willing to pay the supervisor not to make the inspection and correction. Thus, the bank (supervisor) and the firm may collude and hide the information from the government. On one hand, the supervisor will be indifferent towards releasing information which will cause the firm to lose possibility of refinancing, as well as the date-2 rent; On the other hand, the firm will be ready to "buy the supervisor's silence"[‡]. Following Laffont and Tirole (1990) we assume there are transaction costs connected to side contracting between the bank (supervisor) and the firm; if the firm transfers one unit of wealth to the bank (supervisor) this is worth only $k < 1$ units to the bank (supervisor). The parameter k can be interpreted as a measure of how easy it is for the bank (supervisor) and the firm to engage in collusion. We denote $k = \frac{1}{1+\lambda_c}$. λ_c is the transaction cost of side transfers, reflecting the risks of being caught, the inefficiencies of bargaining and the costs incurred to avoid being identified. They are taken here as exogenous. For $k = 0$ it is impossible for the firm to make any transfer to the bank (supervisor), so collusion in the form considered here would not be feasible.(Any amount transferred from the firm would be lost, or at least valued at zero by the supervisor.) As the transaction costs decrease, k increases, and it becomes "easier" for the two parties to collude. Let b denote the transfer from the firm to the bank (supervisor). And we also assume that the bank (supervisor) has all the bargaining power in the side contract and she makes a *take-it-or-leave-it* offer to the firm. For simplicity, we assume that the side contract the supervisor offered to the firm is a short time contract and only valid for one period.

Collusion-proof contract

In order to deter collusion between the bank (supervisor) and the firm, the transfer of the government to the bank when the latter uncovers a bad project should satisfy collusion proofness condition:

[‡] The similar auditing model is presented by Kofman and Lawarree (1993).

$$(CP) \qquad S \geq s_0 + kb$$

Obviously, the bribe b should be the total stake of the firm in this financial contract: if the supervisor reveals the information she has found, the firm has the repayment package-with the evidence; otherwise, if the supervisor finds nothing or she pretends to declare that she find nothing, the firm has the repayment package-without evidence. The total stake is the rent difference between these two packages.

Given the firm chooses the bad project in both periods, we denote U^n the firm's intertemporal utility when there is no supervisor's revelation, and U^e the firm's intertemporal utility when there is supervisor's revelation.

$$U^n = B + \pi_0 \beta_{s,n}[\pi_0(R - \bar{t}_{2S}^n) + B] + (1-\pi_0)\beta_{f,n}[\pi_0(R - \bar{t}_{2F}^n) + B]$$

$$U^e = 0 + \bar{\pi}\beta_{s,e}[\bar{\pi}(R - \bar{t}_{2S}^e) + B] + (1-\bar{\pi})\beta_{f,e}[\bar{\pi}(R - \bar{t}_{2F}^e) + B]$$

If the supervisor finds the evidence, the firm can gain rent $b = U^n - U^e$ by bribing the supervisor to hide the evidence. As the bank (supervisor) has all the bargaining power in this side contract, all the rent must go into the pocket of the bank. Therefore, in order to prevent collusion between the bank and the firm, the government's reward to the bank should not be lower than this amount.

Therefore, the optimization program of the government is:

$$\underset{\{\beta_i, \bar{t}_j, \underline{t}_j, S\}}{Max} W = V + U - \lambda_t (T + S)$$

$$\text{S.t. } (IC)_{2S}, (IC)_{2F}, (IC)_{12}', (\overline{LL}), (\underline{LL}), (SIR), (CP)$$

Before looking for the optimal contract, we can first consider the contract framework when there is no commitment on the termination, i.e. $\beta_{f,n} = 1$. Meanwhile, we take into account the collusive behavior between the supervisor and the firm. The contract structure is as same as that in proposition 4, except the change of the salary for supervisor: S changes from s_o to $s_0 + kb$.

Recall that in section 2.1, commitment on the termination, i.e. $\beta_{f,n} = 0$, as an efficient instrument of threat, helps the principal to reduce the rent left to the firm. The loss of commitment comes from the public ownership of the banking system and the government's maximization of the social value of the project. This social value dominates the effect of decreased rents. However, when there is possibility of collusion, these decreased rents not only affect the bribe that the firm can offer to the supervisor, but also affect the rewards that the government has to pay the supervisor to deter collusion. Both effects might dominate the social value of the project.

Furthermore, we look at the contract structure when there is commitment on the termination under the supervision technology and the collusion possibility

- Refinancing probabilities are: $\beta_{s,e}^{MC}=0$, $\beta_{f,e}^{MC}=0$, $\beta_{s,n}^{MC}=1$, $\beta_{f,n}^{MC}=0$, where there is commitment on the bank's original termination rule (here M stands for monitor (supervision) technology and C stands for commitment)

The optimal payments are divided into two packages, depending on whether the supervisor finds the evidence or not. If the supervisor finds the evidence, the repayments belong to the package-"with the evidence":

$$\overline{t}_1^{\,e}=R\,,\underline{t}_1^{\,e}=0$$

If the supervisor finds no evidence, the repayments belong to the package-"without evidence":

$$\overline{t}_{2S}^{\,n}=R-\frac{(1-\xi)(1+\pi_0)}{\pi_1^2-(1-\xi)\pi_0^2}B\,,\underline{t}_{2S}^{\,n}=0$$

$$\overline{t}_1^{\,n}=R\,,\ \underline{t}_1^{\,n}=0$$

Therefore, the bribe in the contract with commitment is:

$$b^C=(1+\pi_0)B+\frac{(1-\xi)(1+\pi_0)}{\pi_1^2-(1-\xi)\pi_0^2}\pi_0^2B \qquad (1)$$

We compare this bribe with that when the termination rule is $\beta_{s,n}^{MN}=1$, $\beta_{f,n}^{MN}=1$, which means there is no-commitment to stop refinancing.

$$b^N=2B+\left\{\frac{(1-\xi)(2\pi_1-\pi_0^2-\pi_0)/\Delta\pi+(\pi_0+\pi_1-1)}{\pi_1^2-(1-\xi)\pi_0^2}\pi_0^2+\frac{(1-\pi_0)\pi_0}{\Delta\pi}\right\}B \qquad (2)$$

We have $b^N>b^C$ after the comparison. Intuitively, if there is supervision technology, the government has a trade-off between continuation and saving collusion-proofness reward (i.e. reducing potential bribe). In other words, being afraid of collusion prevailing in the banking system and paying too much reward to prevent collusion could make the government harden the budget constraint, i.e. restore the commitment to stop refinancing the bad-performing firm at the end of date 1.

PROPOSITION 5 When there is possibility of collusion, the government will consider the trade-off between continuing and saving collusion-proofness reward. Such costly rewards make the government restore the commitment on the stop refinancing the bad-performing firm. The optimal contract is presented as follows:

- Refinancing probabilities are: $\beta_{s,n}^{MC} = 1$, $\beta_{f,n}^{MC} = \beta_{s,e}^{MC} = \beta_{f,e}^{MC} = 0$;
- The optimal payments are divided into two packages, depending on whether the supervisor finds the evidence. If the supervisor finds the evidence, the repayments belong to the package-with evidence:

$$\overline{t}_1^{e} = R, \underline{t}_1^{e} = 0$$

  If the supervisor finds no evidence, the repayments belong to the package-without evidence:

$$\underline{t}_{2S}^{n} = \underline{t}_1^{n} = 0, \overline{t}_1^{n} = R$$

$$\overline{t}_{2S}^{n} = R - \frac{(1+\pi_0)(1-\xi)}{\pi_1^2 - (1-\xi)\pi_0^2} B$$

- The government's utility is: $W^{MC} = (1-\lambda_t)(1+\pi_1)(\pi_1 R - F) + \lambda_t (EB - kb^C - s_0)$ where $E = \frac{(1-\xi)(1+\pi_0)\pi_1^2}{\pi_1^2 - (1-\xi)\pi_0^2}$ and b^C is presented in (1)
- Given the government will bail out the bank when she is in trouble, the bank wants to participate into this financial contract if :

$$F \le F_5^C = \pi_1 R + \frac{\lambda_t}{1-\lambda_t}\frac{EB - kb^C - s_0}{1+\pi_1}$$

Remark

We can compare the government's utility and loan threshold with those when there is no commitment.

$$W^{MN} = 2(1-\lambda_t)(\pi_1 R - F) + \lambda_t (GB - kb^N - s_0)$$

where $G = [\frac{(1-\xi)(2\pi_1 - \pi_0^2 - \pi_0)/\Delta\pi + (\pi_0 + \pi_1 - 1)}{\pi_1^2 - (1-\xi)\pi_0^2} + \frac{(1-\pi_1)\pi_1}{\Delta\pi}]B$ and b^N is presented in (2)

$$F \le F_5^{NC} = \pi_1 R + \frac{\lambda_t}{1-\lambda_t}\frac{GB - kb^N - s_0}{2}$$

Now we make the approximation: since the difference between b^C and b^N is more significant than the difference between 2 and $\left(1+\pi_1\right)$, so is the difference between G and E, we can approximately only compare $GB-kb^N$ and $EB-kb^C$. It is not difficult to verify that $GB-kb^N < EB-kb^C$. Here we come into a conclusion: $F_5^C > F_5^{NC}$, which is presented in figure 4.

(insert figure 4 here)

Furthermore, let us look at the non-performing loans under the public-ownership oriented rescue. Recall that the government's utility is presented as follows:

$$W = V + U - \lambda_t (T + S)$$

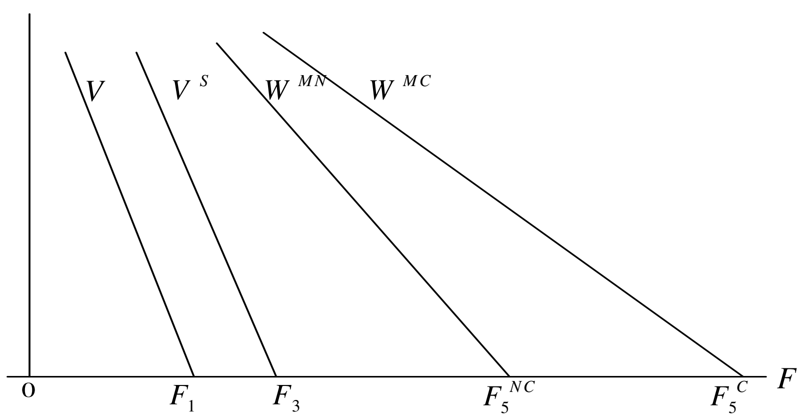
The bank's non-performing loans, which have been written-off by the government, are denoted as $NPLs = |V|$ when V is negative and the government bails out the bank. Now we consider two countries whose transaction costs of the side contract are k_1, k_2 respectively. If other things are equal, $k_1 < k_2$ means country 1 has more efficient banking supervision system and it is more difficult for the bank to collude with the firm in country 1. Therefore, collusion-proofness rewards are less costly in country 1 than in country 2. The efficiency gain from restoring commitment on termination in country 2 is higher than that in country 1. Given that the government in country 2 chooses to restore commitment but the government in country 1 does not, assuming they all reward the bank to prevent collusion, the bank's non-performing loans in country 1, however, are higher than those in country 2, i.e. $|V_1| > |V_2|$. This result contrasts to the empirical work of Bath, Caprio and Levine (2002), which finds that more efficient monitoring, say, private monitoring of banks, are associated with less non-performing loans. It is not difficult to explain the conflict between our result and theirs. First, from the analysis in section 2 we find that public ownership and the government's lenient bailout cause non-performing loans, otherwise the bank alone will choose lower loan threshold to break even. Second, under more efficient monitoring of banks, the government pays less to prevent collusion. As a consequence, in his break-even condition, the government has more space to recapitalize the bank and to write off more non-performing loans. Our model shows the substitution between banking regulation and supervision, where the former's effect might dominate the latter's effect. However, special banking regulations, such as government's bailout and preventing collusion are not taken into account by Bath, Caprio and Levine, probably because of data availability. All these missing factors will definitely affect the amount of non-performing loans. Therefore, it is not so surprising that there might be opposite results.

4 Conclusion

This paper studies how the soft budget constraint, which prevails in the banking system of transition economies, affects the collusion problem, and how collusion, however, functions as a hardening budget constraint device. First, we show that public ownership and the government's rescue cause the soft budget constraint problem on the local level, i.e. between the bank and the firm, which is specified as the commitment to terminate refinancing the bad-performing firm at the end of date 1 in a two-period model. As the soft budget constraint emerges, there are more rents in the financial contract and SBC makes it more attractive for the bank (supervisor) to collude with the firm, i.e. SBC exacerbates the collusion problem and makes it more costly for the government to prevent collusion through rewarding the bank. On the other hand, more costly collusion-proofness reward imposes more pressure on the government to restore commitment, i.e. to harden budget constraint. As a result, collusion becomes an efficient device to alleviate the soft budget constraint problem in the public- owned banking system.

The analysis in this paper can endow us some policy implications. Above all, forcing accurate information disclosure in the supervision technology can efficiently decrease the rent in the financial contract. In our model, it is the increase of ξ, which decreases the rents not only in the non-commitment case, but also in the commitment case. Second, if there is always government's bailout to the insolvent bank, efficient monitoring by the bank will not definitely lead to few non-performing loans. This shows the substitution between the banking regulation and supervision, which have been widely thought complementary to each other. Specifically, it is the case in our model where the country with more efficient banking supervision, whose k is lower, might have higher level of non-performing loans. Third, collusion serves as a commitment-enhancing device only if the government chooses to reward the bank to prevent collusion. If the government chooses punishment instead of reward, it is not always the case that collusion has a positive side effect. The last but not least, restoring more efficiency depends on the *ex ante* government's commitment not to rescue the bank, i.e. solving the soft budget constraint problem on the government-bank level. In order to make this *ex ante* commitment more credible, one way is to introduce privatization to the banking system and to break up the public ownership of the bank. Allowing some part of private shares in the state owned bank will improve the prudence of each loan decision and help to harden budget constraints. This is an application of the well-known idea that the incentives of an agent can be improved if the principal's objective function is less comprehensive than the social welfare, and in particular, if it is insensitive to the private interests of the agent. Another way is decentralization of credit and introducing bankruptcy into the banking system. Decentralization of credit makes each local bank under liquidity constraints. Introducing bankruptcy of banks cuts the way of rescue that the local bank might pursue from the government (the central bank). These devices will help to harden budget constraints and make the creditor more prudent. However, this bankruptcy policy should not be so radical because the central bank also acts as *lender of last resort*. Therefore, the central bank would restrict bankruptcy to small banks and bailout to very large banks for a too-large-to-fail point of view.

Figure 4



APPENDIX

A.1 Verify $(IC)_{12}$'s relevance in section 2

- If the firm prefers choosing the good project in both periods to choosing the bad project in both periods, we have the firm's preference: $(G;G_s,G_f)\succ(B;B_s,B_f)$

Recall the firm's incentive constraints in date-2 are:

$(IC)_{2S}$ $\quad (R-\overline{t}_{2S})\geq\frac{B}{\Delta\pi}+(0-\underline{t}_{2S})$ when the firm succeeds in date 1

$(IC)_{2F}$ $\quad (R-\overline{t}_{2F})\geq\frac{B}{\Delta\pi}+(0-\underline{t}_{2F})$ when the firm fails in date 1

and the firm's limited liability constraints:

$(\overline{LL})$ $\quad R\geq\overline{t}_j$

$(\underline{LL})$ $\quad 0\geq\underline{t}_j$

Supposing $(IC)_{12}$ is the only relevant intertemporal incentive constraint, we have $(IC)_{2F}$, $(\overline{LL})$, $(\underline{LL})$, $(IC)_{12}$ binding.

The first optimal repayments of the firm are as follows:

$$\underline{t}_1=\underline{t}_{2S}=\underline{t}_{2F}=0,\quad \overline{t}_1=R,$$

$$\overline{t}_{2F}=R-\frac{B}{\Delta\pi},\qquad \overline{t}_{2S}^{(1)}=R-\frac{1+\pi_0\beta_s+\pi_1\beta_f}{(\pi_1^2-\pi_0^2)\beta_s}B$$

it is easy to verify that $(IC)_{2S}$ is satisfied under this optimal repayments structure.

- If the firm prefers choosing the good project in both periods to choosing the good project in date-1 but the bad project in date-2, we have the firm's preference: $(G;G_s,G_f)\succ(G;B_s,B_f)$

Supposing $U_{GG}\geq U_{GB}$ is the only relevant intertemporal incentive constraint:

$$\pi_1(R-\overline{t}_1)+(1-\pi_1)(0-\underline{t}_1)+\pi_1\beta_s[\pi_1(R-\overline{t}_{2S})+(1-\pi_1)(0-\underline{t}_{2S})]$$
$$+(1-\pi_1)\beta_f[\pi_1(R-\overline{t}_{2F})+(1-\pi_1)(0-\underline{t}_{2F})]$$
$$\geq\quad \pi_1(R-\overline{t}_1)+(1-\pi_1)(0-\underline{t}_1)+\pi_1\beta_s[\pi_0(R-\overline{t}_{2S})+(1-\pi_0)(0-\underline{t}_{2S})+B]$$
$$+(1-\pi_1)\beta_f[\pi_0(R-\overline{t}_{2F})+(1-\pi_0)(0-\underline{t}_{2F})+B]$$

Combining the other constraints $(IC)_{2F}$, $(\overline{LL})$, $(\underline{LL})$, we could get the firm's repayments structure and the constraint $(IC)_{2S}$ is satisfied under this repayments structure.:

$$\underline{t}_1 = \underline{t}_{2S} = \underline{t}_{2F} = 0, \quad \overline{t}_1 = R,$$

$$\overline{t}_{2F} = R - \frac{B}{\Delta\pi}, \qquad \overline{t}_{2S}^{(2)} = R - \frac{B}{\Delta\pi}$$

It is not difficult to find that the only change of repayments is $\overline{t}_{2S}$, where $\overline{t}_{2S}^{(2)} \geq \overline{t}_{2S}^{(1)}$. That means the firm can get more rent under the first repayment structure. In other words, under the first optimal repayment structure, the intertemporal incentive constraint $U_{GG} \geq U_{GB}$ is satisfied automatically. Therefore, this constraint $U_{GG} \geq U_{GB}$ is not relevant.

- If the firm prefers choosing the good project in both periods to choosing the bad project in date-1 but the good project in date-2, we have the firm's preference: $(G; G_s, G_f) \succ (B; G_s, G_f)$.

Supposing $U_{GG} \geq U_{BG}$ is the only relevant intertemporal incentive constraint:

$$\pi_1(R-\overline{t}_1) + (1-\pi_1)(0-\underline{t}_1) + \pi_1\beta_s[\pi_1(R-\overline{t}_{2S}) + (1-\pi_1)(0-\underline{t}_{2S})]$$
$$+(1-\pi_1)\beta_f[\pi_1(R-\overline{t}_{2F}) + (1-\pi_1)(0-\underline{t}_{2F})]$$
$$\geq \quad \pi_0(R-\overline{t}_1) + (1-\pi_0)(0-\underline{t}_1) + B + \pi_0\beta_s[\pi_1(R-\overline{t}_{2S}) + (1-\pi_1)(0-\underline{t}_{2S})]$$
$$+(1-\pi_0)\beta_f[\pi_1(R-\overline{t}_{2F}) + (1-\pi_1)(0-\underline{t}_{2F})]$$

Combining the other constraints $(IC)_{2F}$, $(\overline{LL})$, $(\underline{LL})$, we could get the firm's repayments structure, and the constraint $(IC)_{2S}$ is satisfied under this repayments structure.:

$$\underline{t}_1 = \underline{t}_{2S} = \underline{t}_{2F} = 0, \quad \overline{t}_1 = R,$$

$$\overline{t}_{2F} = R - \frac{B}{\Delta\pi}, \qquad \overline{t}_{2S}^{(3)} = R - \frac{1+\pi_1\beta_f}{\pi_1\Delta\pi}B$$

as the same reasoning as before, the change of repayments shows us $\overline{t}_{2S}^{(3)} \geq \overline{t}_{2S}^{(1)}$. That means under the first optimal repayment structure, the intertemporal incentive constraint $U_{GG} \geq U_{BG}$ is also satisfied. Therefore, this constraint $U_{GG} \geq U_{BG}$ is not relevant.

To conclude, the optimal repayments structure is got under the relevant constraints:

$$(IC)_{2F}, \ (\overline{LL}), \ (\underline{LL}), \ (IC)_{12}$$

A.2 Proof of Proposition 1

Clearly, the bank wants to induce the firm to choose the good project for both periods. She can obtain this result by leaving the firm enough rent. Therefore the dominant strategy is to give the firm rent when it succeeds and to leave no rent otherwise.

By solving backward, we first look at the incentive compatibility constraints in date 2 given that the firm has got the refinancing.

$$(IC)_{2S} \qquad (R-\overline{t}_{2S}) \geq \frac{B}{\Delta\pi} + (0-\underline{t}_{2S})$$

$$(IC)_{2F} \qquad (R-\overline{t}_{2F}) \geq \frac{B}{\Delta\pi} + (0-\underline{t}_{2F})$$

We have shown in A.1 that $(IC)_{2F}$ is binding at the optimal, and $(IC)_{2S}$ is irrelevant. We have the relationship between $\overline{t}_{2F}$ and $\underline{t}_{2F}$ through $(IC)_{2F}$. Then we look at the intertemporel incentive compatibility constraint for date 1 and date 2.

We denote λ the Lagrangian multiplier for constraint $(IC)_{12}$. The Lagrangian for this optimal programming problem could be presented as:

$$L = V + \lambda(U_{GG} - U_{BB})$$

First, as we should leave rent to the firm who succeeds in both periods, that is through $\overline{t}_{2S}$, the solution of $\overline{t}_{2S}$ should be an interior solution. By this reasoning, we have

$$\frac{\partial L}{\partial \overline{t}_{2S}} = \beta_s \pi_1 [\pi_1 - \lambda\Delta\pi(1+\frac{\pi_0}{\pi_1})] = 0 \qquad (1)$$

we can easily have the value of λ through equation (1):

$$\lambda = \frac{\pi_1^2}{\pi_1^2 - \pi_0^2} > 0$$

from this result, we can directly have a result that the incentive compatibility constraint $(IC)_{12}$ is binding.

Second, we put the value of λ into $\frac{\partial L}{\partial \overline{t}_1}, \frac{\partial L}{\partial \underline{t}_{2S}}, \frac{\partial L}{\partial \underline{t}_{2F}}, \frac{\partial L}{\partial \underline{t}_1}$ and here come the results:

$$\frac{\partial L}{\partial \overline{t}_1} > 0 \text{, but } \frac{\partial L}{\partial \underline{t}_{2S}} < 0, \frac{\partial L}{\partial \underline{t}_{2F}} < 0, \frac{\partial L}{\partial \underline{t}_1} < 0$$

Therefore, we have only the corner solutions for these variables.

Taking into account limited liability constraints, the bank wants to get repayment as high as possible. Precisely, for $(\underline{LL})$, the relevant constraints are binding and we have

$$\underline{t}_1 = \underline{t}_{2S} = \underline{t}_{2F} = 0$$

and these results can also help to relax the incentive compatibility constraint.

For $(\overline{LL})$, the relevant constraints are binding except $R \geq \overline{t}_{2S}$. We have:

$$\overline{t}_1 = R$$

And these results can also help to relax the incentive compatibility constraint.

In addition, we can get the solution for $\overline{t}_{2F}$ through $(IC)_{2F}$ binding:

$$\overline{t}_{2F} = R - \frac{B}{\Delta\pi}$$

Under the trade-off between leaving rent and inducing effort, we have verified that incentive compatibility constraint is also binding. Here we get:

$$\overline{t}_{2S} = R - \frac{1 + \pi_0\beta_s + \pi_1\beta_f}{(\pi_1^2 - \pi_0^2)\beta_s} B$$

Therefore, the bank's profit is :

$$V = \pi_1 R - F - \frac{\pi_1^2}{\pi_1^2 - \pi_0^2} B + [\pi_1 R - F - \frac{\pi_1\pi_0}{\pi_1^2 - \pi_0^2} B]\pi_1\beta_s + \{(1-\pi_1)[\pi_1(R - \frac{B}{\Delta\pi}) - F] - \frac{\pi_1^3}{\pi_1^2 - \pi_0^2} B\}\beta_f$$

Derive V with respect to β_s and β_f:

$$\frac{\partial V}{\partial \beta_s} = \pi_1(\pi_1 R - F - \frac{\pi_1\pi_0}{\pi_1^2 - \pi_0^2} B)$$

$$\frac{\partial V}{\partial \beta_f} = (1-\pi_1)[\pi_1(R - \frac{B}{\Delta\pi}) - F] - \frac{\pi_1^3}{\pi_1^2 - \pi_0^2} B$$

Recall that we have the assumptions $\pi_1(R - \frac{B}{\Delta\pi}) < F$, $\pi_1 > \frac{1}{2} > \pi_0$ and $\pi_1 + \pi_0 > 1$, we immediately have $\frac{\partial V}{\partial \beta_f} < 0$ .For $\frac{\partial V}{\partial \beta_s}$, the positive sign is obtained when

$$R \geq \hat{R}_0 = \frac{\pi_0}{\pi_1^2 - \pi_0^2} B + \frac{F}{\pi_1},$$

Therefore we have the optimal termination rule:

$$\beta_s* = 1, \beta_f* = 0$$

As a consequence, when the optimal termination rule is $\beta_s{*}=1, \beta_f{*}=0$, the repayment when the firm succeeds in both periods is

$$\bar{t}_{2S} = R - \frac{1+\pi_0}{\pi_1^2 - \pi_0^2} B$$

Now, we look at the bank's profit under the full commitment to termination:

$$V = \pi_1(1+\pi_1)R - \frac{\pi_1^2(\pi_0+1)}{\pi_1^2-\pi_0^2} B - (1+\pi_1)F$$

The bank wants to participate in this financial contract only if:

$$F \le F_1 = \pi_1 R - \frac{\pi_1^2(1+\pi_0)}{(\pi_1^2-\pi_0^2)(1+\pi_1)} B$$

Q.E.D

Proof of Proposition 2

In order to induce the firm to choose the good project for both periods, the government can get leave the firm enough rent. Consequently, the dominant strategy is to give the firm rent when it succeeds and leave no rent in any other cases.

By solving backward, we first look at the incentive compatibility constraints in date 2 given that the firm has got the refinancing.

$(IC)_{2S}$ $$(R-\bar{t}_{2S}) \ge \frac{B}{\Delta\pi} + (0 - \underline{t}_{2S})$$

$(IC)_{2F}$ $$(R-\bar{t}_{2F}) \ge \frac{B}{\Delta\pi} + (0 - \underline{t}_{2F})$$

Suppose that $(IC)_{2F}$ is binding at the optimal, and $(IC)_{2S}$ is irrelevant. We have the relationship between $\bar{t}_{2F}$ and $\underline{t}_{2F}$ through $(IC)_{2F}$. Then we look at the intertemporel incentive compatibility constraint for date 1 and date 2.

We denote μ the Lagrangian multiplier for constraint $(IC)_{12}$.Using the same optimal programming method as in the proof of Proposition 1, we have Lagrangian function of the government's optimal programming problem:

$$L = U + V - \lambda_t T + \mu(U_{GG} - U_{BB})$$

First, as we should leave rent to the firm who succeeds in both periods, that is through $\bar{t}_{2S}$, the solution of $\bar{t}_{2S}$ should be an interior solution. By this reasoning, we have

$$\frac{\partial L}{\partial \overline{t}_{2S}} = \beta_s \pi_1 [-\lambda_t \pi_1 + \mu \Delta \pi (1 + \frac{\pi_0}{\pi_1})] = 0 \qquad (1)$$

We can easily have the value of μ through equation (1):

$$\mu = \frac{\lambda_t \pi_1^2}{\pi_1^2 - \pi_0^2} > 0$$

From this result, we can directly have a result that the incentive compatibility constraint $(IC)_{12}$ is binding.

Second, we put the value of λ into $\frac{\partial L}{\partial \overline{t}_1}, \frac{\partial L}{\partial \underline{t}_{2S}}, \frac{\partial L}{\partial \underline{t}_{2F}}, \frac{\partial L}{\partial \underline{t}_1}$ and here come the results:

$$\frac{\partial L}{\partial \overline{t}_1} > 0 \text{, but } \frac{\partial L}{\partial \underline{t}_{2S}} < 0, \frac{\partial L}{\partial \underline{t}_{2F}} < 0, \frac{\partial L}{\partial \underline{t}_1} < 0$$

Therefore, we have only the corner solutions for these variables.

Taking into account limited liability constraints, the bank wants to get repayment as high as possible. Precisely, for $(\underline{LL})$, the relevant constraints are binding and we have

$$\underline{t}_1 = \underline{t}_{2S} = \underline{t}_{2F} = 0$$

and these results can also help to relax the incentive compatibility constraint.

For $(\overline{LL})$, the relevant constraints are binding except $R \geq \overline{t}_{2S}$. We have:

$$\overline{t}_1 = \overline{t}_{2F} = R$$

And these results can also help to relax the incentive compatibility constraint.

In addition, we can get the solution for $\overline{t}_{2F}$ through $(IC)_{2F}$ binding:

$$\overline{t}_{2F} = R - \frac{B}{\Delta \pi}$$

Therefore, we have the first expression of $\overline{t}_{2S}$

$$\overline{t}_{2S} = R - \frac{1 + \pi_0 \beta_s + \pi_1 \beta_f}{(\pi_1^2 - \pi_0^2) \beta_s} B$$

Now we look at the effect of termination rule on the government's objective function:

$$\frac{\partial W}{\partial \beta_s} = \pi_1 [(1 - \lambda_t)(\pi_1 R - F) + \frac{\pi_1 \pi_0}{\pi_1^2 - \pi_0^2} \lambda_t B] > 0$$

$$\frac{\partial W}{\partial \beta_f} = (1 - \pi_1)(1 - \lambda_t)(\pi_1 R - F) + \lambda_t [\frac{\pi_1 (1 - \pi_1)}{\Delta \pi} B + \frac{\pi_1^3}{\pi_1^2 - \pi_0^2} B] > 0$$

For the effect of β_s, with the assumption $\pi_1 R > F$, we can easily verify that $\frac{\partial W}{\partial \beta_s} > 0$, which means that the optimal termination rule when the firm succeeds in date-1 is to refinance the firm in date 2, i.e. $\beta_s = 1$; For the effect of β_f, with the assumption $\pi_1 R > F$, we can also verify that $\frac{\partial W}{\partial \beta_f} > 0$. As a consequence, the optimal termination rule when the firm fails at the end of date-1 is $\beta_f = 1$.

To summarize, when we introduce the public ownership to the bank, the optimal termination rule is changed into

$$\beta_s^{\ P} = 1, \beta_f^{\ P} = 1$$

where P stands for public bank.

As a result, the repayment when the firm succeeds in both periods is :

$$\overline{t}_{2S}^{\ P} = R - \frac{1 + \pi_0 + \pi_1}{\pi_1^2 - \pi_0^2} B$$

which is as same as the result in Proposition 2.

The government's total utility is:

$$W = 2(1 - \lambda_t)(\pi_1 R - F) + \frac{2\pi_1^2 + \pi_0}{\pi_1^2 - \pi_0^2} \lambda_t B$$

The threshold of the credit for the bank to participate in this financial contract is:

$$F \le F_2 = \pi_1 R + \frac{\lambda_t}{2(1 - \lambda_t)} \frac{2\pi_1^2 + \pi_0}{\pi_1^2 - \pi_0^2} B$$

Q.E.D

Proof of Proposition 3

As same as in proposition 1, the bank wants to induce the firm to choose the good project for both periods. She can obtain this result by leaving the firm enough rent. Therefore the dominant strategy is to give the firm rent when it succeeds and to leave no rent otherwise. With the evidence, the bank would leave no rent to the firm in date 2 no matter it succeeds or fails, in order that the bank can apply the severest punishment to the firm to choose the bad project and add more incentive into date 1. The repayments are as same as in date 1:

$$\overline{t}_{2S}^{e} = \overline{t}_{2F}^{e} = R,$$

$$\underline{t}_{2S}^{e} = \underline{t}_{2F}^{e} = 0.$$

Without evidence, we use the standard way to solve backward. First we look at the incentive compatibility constraints in date 2 given that the firm has got the refinancing.

$(IC)_{2S}$ $\qquad (R - \overline{t}_{2S}^{n}) \geq \frac{B}{\Delta\pi} + (0 - \underline{t}_{2S}^{n})$

$(IC)_{2F}$ $\qquad (R - \overline{t}_{2F}^{n}) \geq \frac{B}{\Delta\pi} + (0 - \underline{t}_{2F}^{n})$

We have shown in A.1 that $(IC)_{2F}$ is binding at the optimal, and $(IC)_{2S}$ is irrelevant. We have the relationship between $\overline{t}_{2F}$ and $\underline{t}_{2F}$ through $(IC)_{2F}$. Combining limited liability constraints, we can find $\underline{t}_{2S}^{n} \geq 0; \underline{t}_{2F}^{n} \geq 0$; $(IC)_{2F}$ binding. These give us three repayments:

$$\underline{t}_{2S}^{n} = \underline{t}_{2F}^{n} = 0$$

$$\overline{t}_{2F}^{n} = R - \frac{B}{\Delta\pi}$$

Then we look at the intertemporel incentive compatibility constraint for date 1 and date 2.

$(IC)_{12}'$ $\qquad U_{GG} \geq U_{BB}$

as same as in A.1, it is not difficult to verify that $(IC)_{12}'$ is the only relevant intertemporal incentive compatibility constraint. Therefore, we have:

$$\overline{t}_{2S}^{n} = R - \frac{(1-\xi) + \xi[\pi_0'\beta_{s,e} + (1-\pi_0')\beta_{f,e}] + (1-\xi)\pi_0\beta_{s,n} + [(1-\xi)(1-\pi_0)\pi_1/\Delta\pi + (\pi_0 + \pi_1 - 1)]\beta_f}{[\pi_1^2 - (1-\xi)\pi_0^2]\beta_{s,n}} B$$

the supervisor bank's profit could be presented as:

$$V^S = \pi_1 R - F + \pi_1\beta_{s,n}(\pi_1\overline{t}_{2S}^{n} - F) + (1-\pi_1)\beta_{f,n}[\pi_1(R - \frac{B}{\Delta\pi}) - F]$$

Derive V^S with respect to $\beta_{s,e}$, $\beta_{f,e}$, $\beta_{s,n}$ and $\beta_{f,n}$:

$$\frac{\partial V^S}{\partial \beta_{s,n}} = \pi_1[\pi_1 R - F - \frac{(1-\xi)\pi_1\pi_0}{\pi_1^2 - (1-\xi)\pi_0^2} B] > 0$$

$$\frac{\partial V^S}{\partial \beta_{s,e}} = -\frac{\xi\pi_1^2\pi_0'}{\pi_1^2 - (1-\xi)\pi_0^2} B < 0$$

$$\frac{\partial V^S}{\partial \beta_{f,e}} = -\frac{\xi\pi_1^2(1-\pi_0')}{\pi_1^2 - (1-\xi)\pi_0^2} B < 0$$

$$\frac{\partial V^S}{\partial \beta_{f,n}} = (1-\pi_1)[\pi_1(R-\frac{B}{\Delta\pi})-F] - \frac{\pi_1^2[(1-\xi)(1-\pi_0)\pi_1/\Delta\pi + (\pi_1+\pi_0-1)]}{\pi_1^2-(1-\xi)\pi_0^2}B$$

it is easy to find that $\frac{\partial V^S}{\partial \beta_{f,n}} < 0$, $\frac{\partial V^S}{\partial \beta_{s,e}} < 0$, $\frac{\partial V^S}{\partial \beta_{f,e}} < 0$ and the optimal termination rule under supervision is $\beta_{s,e} = 0$, $\beta_{f,e} = 0$, $\beta_{f,n} = 0$. We need more conditions to decide the sign of $\frac{\partial V^S}{\partial \beta_{s,n}}$: $\frac{\partial V^S}{\partial \beta_{s,n}} > 0$ i.e. $\beta_{s,n} = 1$ if and only if

$$R \geq \hat{R}_1 = \frac{(1-\xi)\pi_0}{\pi_1^2-(1-\xi)\pi_0^2}B + \frac{F}{\pi_1}$$

we compare this threshold of R with that when there is no supervision: $\hat{R}_1 < \hat{R}_0$

therefore, we can show the final expression of $\overline{t}_{2S}^n$

$$\overline{t}_{2S}^n = R - \frac{(1+\pi_0)(1-\xi)}{\pi_1^2-(1-\xi)\pi_0^2}B \qquad \text{when } R \geq \hat{R}_1$$

the optimal termination rule is $\beta_{s,e} = \beta_{f,e} = \beta_{f,n} = 0$, $\beta_{s,n} = 1$

therefore, the supervisor bank's profit is finally:

$$V^S = (1+\pi_1)(\pi_1 R - F) - \frac{\pi_1^2(\pi_0+1)(1-\xi)}{\pi_1^2-(1-\xi)\pi_0^2}B$$

the bank wants to participate in this financial contract only if:

$$F \leq F_3 = \pi_1 R - \frac{\pi_1^2(\pi_0+1)(1-\xi)}{\pi_1^2-(1-\xi)\pi_0^2}B$$

Q.E.D

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