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Abstract

We present a two-period model, in which a bank chooses between collateral and non-collateral lending at a contractual date. Collateral lending, with costly collateral requirement, can provide two options for the bank, whether to terminate (and acquire a collateral value) or to refinance a project when it becomes poor. A threat of liquidation thus induces a borrower's effort. Non-collateral lending is less costly, however, always refinance a project once it has become poor. Refinancing involves bank monitoring, which surely increases the bank's returns and reduces the borrower's private benefits. When the use of collateral is too costly, the bank will always choose non-collateral lending. Otherwise, the banks' ex ante expectations of land prices have an important role in determining lending pattern. When high land prices are likely, the bank tends to choose collateral lending. We also examine the relationship between lending behavior and bank supervision (and regulation).

Key words: Bank lending; Collateral; Bank monitoring; Land price inflation; Soft-budget-constraints; Credit crunch

JEL classification: G21, G28, G32, G33, G38

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1 Introduction

The review in Tsuru (2001) has shown that the existing literature on relationship versus arm's length financing has concentrated almost exclusively on the firm's choice between these alternatives. The purpose of this paper is to present an alternative perspective, focusing not on the borrowers but on the lender's choice.

As stressed in Tsuru (2001), the efficient control mechanism of arm's length lending is ensured by explicit law enforcement and the provision of collateral from borrowers. In this paper, we focus especially on the role of collateral. We develop a two-period model, in which a bank can opt between collateral and non-collateral lending at a contractual date and we make this choice dependent on a number of economic conditions. In this model, we define collateral lending as secured lending with a collateral requirement, while non-collateral lending taken as the form of unsecured lending with no such requirement.

Under both types of lending, there is an option of refinancing in period 2 subject to bank monitoring. This option reduces the borrower's benefits and increases the bank's returns. Thus, the difference between the two types of lending is not based on the duration of lending relationships. This setting is consistent with the fact that long-term relationships between banks and borrowers often involve the provision of collateral (e.g. Elsas and Krahnen (2000)).

The merits of collateral lending lie in its option of acquiring collateral by terminating poor projects. The threat of termination can potentially induce the borrower's effort. The demerits of collateral lending is that collateral requirement is costly, since the bank incurs the costs of setting up collateral.

In contrast, non-collateral lending does not need costly collateral requirement at a contractual date, while the bank with non-collateral lending has no alternative but to refinance a project, once it has become poor. In this sense, non-collateral lending has a commitment to help a borrower in financial distress (e.g. Chemmanur and Fulghieri (1994), Bolton and Freixas (1997)).

Our basic model is a significantly modified version of the “soft-budget-constraints” models proposed by Berglof and Roland (1995, 1997, 1998). We incorporate several important new factors into their simple model, and, in particular, the choice of collateral level, and ex-post monitoring during refinancing. In addition, our model also investigates the effect that land price expectations have on collateral value and have on the choice between collateral and non-collateral lending. We show that when the use of collateral is not too costly and there is a strong probability of land price inflation, a bank is inclined to choose collateral lending. This aspect of the model seems to be of particular importance for Japanese banking, since Japan has experienced pronounced swings in land prices over the past two decades.

The model also shares a number of similarities with a model developed by Cremer (1995), which compares between employment relationships with and without monitoring. Arm’s length relationships in the labour markets, which are not committed to monitoring a worker’s performance, can elicit higher efforts via the threat of firing him based only on his performance. In contrast, monitoring-based relationships, which allow for the possibility of ex-post monitoring of a worker’s quality, can preserve the employment of an “unlucky” agent whose quality is high whose performance may be temporarily poor. In our model, collateral lending uses the threat of termination and is, therefore, more likely to induce borrower effort than non-collateral lending, as in the model of Cremer (1995). In contrast to Cremer’s model, however, the bank with collateral lending has not only an option to terminate, but also to refinance a poor project .

Our model allows us to discuss the role of government including the provision of bank supervision and of a regulatory framework, and the influence of these factors on the bank's decision to refinance poor projects. By explicitly introducing a bank's balance sheet in the analysis, we investigates the role of government monitoring and ex-post recapitalisation, an issue that seems relevant to Japan. We also examine the situation first discussed by Berglof and Roland (1997) in which soft budget constraints for old projects coexist with credit crunches for new projects. Our contribution is that we introduce into this analysis the impact of land price expectations and of the government's supervision and intervention.

The rest of this paper is organised as follows. Section 2 describes the basic set-up of the model. Section 3 presents the bank's optimal choice between collateral and non-collateral lending. Section 4 considers the case in which the firm can obtain land price information earlier than the bank. Section 5 discusses the role of government policies and their influence on the bank's choice, especially, between refinancing old and risky projects and financing new and safe ones. Finally, Section 6 shows a numerical analysis.

2 The Basic Model

Project's risk

There are two periods, one firm and one bank (Figure 1). At time 0 (the beginning of period 1), the firm engages in a project requiring one unit of capital. The firm has no capital of its own and must rely on bank financing. Neither the firm nor the bank know the quality of the project ("good" or "poor"), and thus, cannot distinguish between "good" and "poor" projects at time 0. But, they know the distribution of project quality: a proportion α $(0<\alpha<1)$ of projects is "good" and a proportion $(1-\alpha)$ is "poor". The bank and the firm are risk-neutral and thus maximise their expected profits. For simplicity, there is no discounting.

Bank's bargaining power

We assume that the bank has all the bargaining power and can make a take-it-or-leave-it offer to a firm, allowing all the verifiable returns. In this sense, our model is somewhat different from a standard debt contract with collateral requirement, in which interest rates and the level of collateral are determined simultaneously. Our model might be closer to a contract between a venture capitalist and an entrepreneur.

Choice of collateral at the beginning of period 1

The bank also decides whether to ask the firm to provide collateral. If it demands collateral from the firm, it should determine its amount (quantity), $C\,(0<C\leq 1)$ at time 0. The amount of collateral is not allowed to exceed the amount of capital provided by the bank, which is equal to one. This is a once-for-all decision at the contractual date (time 0). Once fixed, the quantity of collateral will remain unchanged later[1]. When the bank decides to demand collateral from the firm, we define this lending pattern as "collateral lending". If not, we call such a lending pattern as "non-collateral lending".

We assume that acquiring collateral is costly. When the bank demands collateral from the firm, it will incur the costs involved in discovering, evaluating and managing the borrower's assets that

[1] The value of collateral at time 0 is equal to $p_0 \times C = 1 \times C = C$. It will be $p_1 \times C$ at the end of period 1, as we will see.

can be used as collateral[2]. The costs of setting up such collateral are defined as $\mu(C)$, $0 < C \leq 1$. This is represented by a quadratic function, $\mu(C) = \frac{1}{2\delta}C^2$, where $\delta\ (>0)$ is the efficiency in setting up collateral. In particular, the use of real estate (land) collateral, which we will focus on later, involves relatively large costs of evaluating the collateral value and making necessary legal documentation[3].

The firm's effort and the project's outcome in period 1

Once the firm has started a project, it becomes aware of the quality. "Good" projects are carried out and, at the end of period 1, they yield verifiable returns R_g for the bank and private benefits B_g that accrue to the firm. Thus, if a project becomes successful, the bank and the firm will obtain R_g and B_g respectively.

In the mid of period 1, the firm with a "poor" project can, nevertheless, generate the same returns as those of a "good" project by exerting effort that costs E with a probability of β. E and β are fixed (exogenous) and the firm is not able to control them. The bank cannot observe the firm's effort nor the quality of the project before the end of period 1. If the firm exerts no effort, or makes effort, nonetheless, is "unlucky" with a probability of $(1-\beta)$, the project yields zero verifiable returns for the bank and private benefits B_p for the firm with the "poor" project at the end of period 1.

[2] Machauer and Weber (1998) and Elsas and Krahnen (2000) find that German house banks are more likely to obtain collateral than other banks and this may imply that house banks have more information advantage to discover assets that can be used as collateral.
[3] Other costs related to the use of collateral are those of maintaining the quality (value) of collateral during the contract period. Chan and Kanatas (1985) also stress the importance of costs associated with the use of collateral.

Termination versus refinancing decision at the end of period 1

At the end of period 1, the bank finally observes the project's returns. In addition, information on the price of the collateral (p_1, $p_0 = 1$ at time 0) is available to both the bank and the firm. Since we focus on real estate collateral, its price can be taken to be the price of land.

Suppose that there are two states of land price at the end of period 1, "high" ($p_1^H > 1$) and "low"($0 < p_1^L < 1$) and that their ex ante probabilities at time 0, are r and $1-r$ respectively ($0 \leq r \leq 1$). Thus, the expected land price is $p_1^e = rp_1^H + (1-r)p_1^L$. The ex ante possibility of high land prices, r will play an important role in determining lending pattern as discussed later.

Should the project turn out to "poor" at the end of period 1, the bank with collateral decides on whether to refinance or terminate it. If the "poor" project is terminated, it will offer a verifiable collateral value p_1C to the bank, while the firm makes a loss equal to $-p_1C$. Thus, the threat of termination can induce the firm to exert effort. We assume that the level of land price at the end of period 2 is fixed to that in the previous period, thus, $p_1 = p_2$.

Bank monitoring during refinancing

If the project is refinanced (by one additional unit of capital) in period 2, it will yield verifiable returns R_p to the bank. In addition, the bank can reduce the firm's private benefits, B_p and enhance the project's returns by monitoring the firm. M is the costs of monitoring effort. The bank can appropriate a share of the firm's private benefits that are assumed to be equal to $\varphi(M) = k\sqrt{M}$, with $0 < k$, where k stands for monitoring efficiency.

The returns for the bank that refinances are therefore $R_p + k\sqrt{M} - M$, while the benefits for the firm are $B_p - k\sqrt{M}\ (>0)$. If the bank refinances the firm, the bank maximises $R_p + k\sqrt{M} - M$. The (unique) optimal level of monitoring costs is M^*, which satisfies $\frac{k}{2\sqrt{M^*}} = 1$. Therefore, $M^* = \frac{k^2}{4}, \quad \varphi(M^*) = k\sqrt{M^*} = \frac{k^2}{2}$. The maximised monitoring benefits $k\sqrt{M^*}$ increase with k .

We define the bank's and firm's net benefits under monitoring as follows.

$$R_p^* = R_p + k\sqrt{M^*} - M^* = R_p + \frac{k^2}{4}\ (>1)$$

$$B_p^* = B_p - k\sqrt{M^*} = B_p - \frac{k^2}{2}$$

Assumptions of the model

Here, Table 1 shows a set of exogenous fixed variables in the model. Given the values of these exogenous variables, the bank decides whether to demand collateral from the firm and determines the optimal amount of collateral. If the project financed by collateral lending becomes "poor" at the end of period 1, the bank should determine whether to terminate or refinance the project. When the bank chooses refinancing, it will always engage in monitoring, since the bank can surely increase its returns by monitoring. Given the choice of the bank's lending pattern, the firm determines whether to exert effort or not when his project is poor. The firm does not have to choose an effort level, since it is given. Thus, the amount of collateral, C is only an endogenous decision variable in the model. It should be noted that the model of Berglof and Roland (1995) is a very special case of our model. When $\beta = 1,\ E = 0,\ p_1^H = p_1^L = 1, \mu = 0, k = 0$, our model is equivalent to theirs.

To make the model as simple and realistic as possible, we take the following assumptions:

Assumption 1:

$$R_g > R_p^* - 1$$

This assumption assures that the "good" project is always more profitable for than the refinancing one. Thus, the bank always prefers the "good" project and has no incentive to refinance the "good" project.

Assumption 2:

$$R_p^* - 1 > 0 > R_p^* - 2$$

Suppose that the bank chooses non-collateral lending and the project becomes poor. This assumption ensures that the firm will always refinance the poor project, since its returns is larger than its additional costs (unit of capital). Refinancing, however, makes loss in an ex-ante sense.

Assumption 3:

$$p_1^L < R_p^* - 1$$

When this inequality holds, we can obtain $p_1^L C \leq p_1^L < R_p^* - 1$. This implies that if land prices are low, refinancing will be always more profitable than termination, and the bank chooses refinancing. The bank refinancing the poor project has no incentive to keep collateral and liquidate it in period 2, since the level of land prices will remain the same ("low") in period 2. Under this assumption, the bank providing collateral lending must terminate the poor project when land prices are high, otherwise, there would be no need for costly collateral requirement.

Assumption 4:

$$\delta(1-\alpha)(1-\beta)p_1^H \leq 1$$

As we will see later (See 2.3.1), this condition ensures that an optimal collateral value for the bank can be obtained by a internal solution of the constrained maximisation problem.

Assumption 5:

$$B_g - \frac{E}{\beta} > 0$$

This implies that the firm's effort is rewarded since its expected benefits (βB_g) are larger than its cost (E). Otherwise, the firm will have no incentive to exert effort.

Assumption 6:

Under collateral lending, the firm will always exert effort.

We assume this for simplicity of the model, otherwise, the bank's expected payoffs from collateral lending will be discontinuous. We will examine in detail on what conditions this assumption holds.

Assumption 7:

The participation constraints of the bank and firm always hold. In other words, the expected payoffs of the bank and the firm at time 0 are always non-negative whatever strategy each one will choose.

In the next subsection, we consider how the bank decides whether to demand collateral from the firm and determines its optimal level.

3 The bank's optimal choice between collateral and non-collateral lending

To determine a lending pattern, the bank calculates the expected payoffs from collateral and non-collateral lending at the beginning of the contract and compares the two. When those from collateral lending are larger, the bank will choose collateral lending and, otherwise, choose non-collateral lending.

The expected payoffs from collateral and non-collateral lending depend crucially on whether the firm exerts effort or not. When the bank chooses collateral lending, we assume that the firm always exerts effort (Assumption 6). In the case of non-collateral lending, we have to examine conditions on which the firm exerts effort.

3.1 Non-collateral lending

First, let us consider a case in which the bank does not demand collateral from the firm at time 0. The bank will then refinance the firm, whenever its project becomes unprofitable. We define this type of behaviour as non-collateral lending. Non-collateral lending does not require collateral and is thus less costly than collateral lending.

The firm will choose whether to exert effort or not, depending on its expected net private benefits from the two causes of action. When the net private benefits of exerting effort are higher than those expected from no effort but the provision of financing, we have:

$$B_p - \frac{k^2}{2} < \beta(B_g - E) + (1-\beta)(B_p - \frac{k^2}{2} - E),$$

thus,

$$B_p - \frac{k^2}{2} < B_g - \frac{E}{\beta}$$

The disciplinary case

This is equivalent to the following conditions.

(1) $B_g > B_p + \dfrac{E}{\beta}$

or ,

(2) $k > \sqrt{2(B_p - B_g + \dfrac{E}{\beta})}$ and $B_g \le B_p + \dfrac{E}{\beta}$

If the returns of the successful project for the bank, B_g *or* the bank's monitoring technology k is sufficiently high (i.e. larger than the above threshold values), the firm will surely make effort and only the "unlucky" firm (whose project, nonetheless, becomes unprofitable), will be refinanced. This is "disciplinary non-collateral lending"(DN).

The bank's expected payoffs from non-collateral lending(W^{DN}) are

$$\begin{aligned} W^{DN} &= \alpha R_g + (1-\alpha)\big(\beta R_g + (1-\beta)(R_p^* - 1)\big) - 1 \\ &= (\alpha + \beta - \alpha\beta) R_g + (1-\alpha)(1-\beta)(R_p^* - 1) - 1 \end{aligned}$$

The "SBC" case

Otherwise ($B_p - \dfrac{k^2}{2} \ge B_g - \dfrac{E}{\beta}$), the firm will exert no effort and always be financed. This is "SBC (soft-budget-constraints) non-collateral lending"(SN). This case holds when the returns of the successful project for the firm, B_g *and* the bank's monitoring technology k is sufficiently low, namely,

$$k \le \sqrt{2(B_p - B_g + \frac{E}{\beta})} \text{ and } B_g \le B_p + \frac{E}{\beta}$$

In this case, the expected payoffs from non-collateral lending (W^{SN}) are

$$W^{SN} = \alpha R_g + (1-\alpha)(R_p^* - 1) - 1$$

3.2 Collateral lending

Next, we consider the case of collateral lending. Due to Assumption 6, the firm will always exert efforts. When the project becomes poor at the end of period1, the decision of termination versus refinancing depends on a state of land prices at the end of period 1. Assumption 3 ensures that the bank will refinance the poor project if land prices are low. Otherwise (when land prices high), the bank must terminate the poor project. Thus, the bank's expected payoffs from collateral lending (W^C) is as follows.

$$W^C = \alpha R_g + (1-\alpha)\left[\beta R_g + (1-\beta)\left(r(p_1^H C) + (1-r)(R_p^* - 1)\right)\right] - \mu(C) - 1$$

Then, the bank can determine an optimal level (quantity) of collateral, C^* that maximises the bank's expected payoffs at time 0.

The optimal level of collateral

The bank's maximisation problem at time 0 is as follows.

$$\underset{0<C\le 1}{Max}\left[\alpha R_g + (1-\alpha)\left(\beta R_g + (1-\beta)(rp_1^H C + (1-r)(R_p^* - 1)\right) - \mu(C) - 1\right]$$

There is a unique optimal level of collateral C^* that satisfies the following condition.

$\mu'(C^*) = (1-\alpha)(1-\beta)rp_1^H$. Hence,

$$C^* = \delta(1-\alpha)(1-\beta)rp_1^H$$

Since $C_r^* = \delta(1-\alpha)(1-\beta)rp_1^H \le \delta(1-\alpha)(1-\beta)p_1^H \le 1$ (Assumption 4), This is a solution of the above maximisation problem.

In particular, we consider C^* as a function of r, $C^* = C_r^*$ below.

Thus, the expected payoffs from collateral lending (W_r^C) are rewritten as follows:

$$\begin{aligned} W_r^C &= \alpha R_g + (1-\alpha)\left[\beta R_g + (1-\beta)\left(r(p_1^H C_r^*) + (1-r)(R_p^* - 1)\right)\right] - \mu(C_r^*) - 1 \\ &= \frac{1}{2}\delta(1-\alpha)^2(1-\beta)^2(p_1^H)^2 r^2 - (1-\alpha)(1-\beta)(R_p^* - 1)(r-1) + (\alpha + \beta - \alpha\beta)R_g - 1 \end{aligned}$$

The optimal level of collateral, $C^* = \delta(1-\alpha)(1-\beta)rp_1^H$ is higher when (1) the probability (or the level) of a high land price (r, p_1^H) is higher, (2) the share of good projects (α) or the probability that the firm's effort is rewarded (β)is smaller, and (3) the efficiency in setting up collateral (δ) is higher.

The choice of termination in a state of high land prices

Given the optimal value of collateral, we have to examine the meanings of some assumptions. First, termination must be more profitable than refinancing, when land prices are high (Assumption 3). Otherwise, the bank has no incentive to arrange costly collateral requirement. Hence, the following assumption must hold.

$$p_1^H C_r^* > R_p^* - 1.$$

This condition is equivalent to the following inequality.

$$r > \frac{R_p^* - 1}{\delta(1-\alpha)(1-\beta)(p_1^H)^2} = r_C$$

Thus, the bank considers the possibility of choosing collateral lending only when the probability of high land prices (r) exceeds r_C.

Conditions on which Assumption 6 holds

Next, we examine the conditions on which Assumption 6 holds (the firm under collateral lending always exerts effort). To do that, we compare the firm's expected payoffs from effort (V^E) with those with no effort (V^{NE}) under collateral financing.

$$V^E = \beta(B_g - E) + (1-\beta)\left(r(-p_1^H C_r^* - E) + (1-r)(B_p - \frac{k^2}{2} - E) \right)$$

$$V^{NE} = r(-p_1^H C_r^*) + (1-r)(B_p - \frac{k^2}{2})$$

$$V^E - V^{NE} = \beta\left[B_g - \frac{E}{\beta} - \left(r^2(-\delta(1-\alpha)(1-\beta)(p_1^H)^2) + (1-r)(B_p - \frac{k^2}{2})\right)\right]$$

Thus, in the disciplinary case, $B_p - \frac{k^2}{2} < B_g - \frac{E}{\beta}$, we obtain $V^E - V^{NE} > 0$ and the firm always exerts effort.

Otherwise (the SBC case, $B_p - \frac{k^2}{2} > B_g - \frac{E}{\beta}$),
$V^E - V^{NE}|_{r=0} < 0$ and $V^E - V^{NE}|_{r=1} > 0$, since $B_g - \frac{E}{\beta} > 0$ (Assumption 5).

Hence, there is a unique value for the probability of high land prices, r_E such that $V^E - V^{NE} = 0,\ V^E - V^{NE} > 0$ if only $r_E < r$.

Suppose that $r_E < r_C$. Then, whenever the bank consider the possibility of collateral lending ($r_C < r$), the bank can expect the firm's effort. Thus, Assumption 6 can be replaced by the condition that $r_E < r_C$ holds in the SBC case. We will examine whether this assumption is compatible with other assumptions in a numerical example in Section 6.

In summary, the bank providing collateral lending will terminate the poor project if land prices are high, while it will refinance a "unlucky" firm that has exerted effort but whose project failed if land prices are low. In the next subsection, we will compare the bank's expected payoffs under collateral and non-collateral lending in order to know exactly when the bank will choose collateral lending.

3.3 Collateral versus non-collateral lending: The choice of lending pattern

As we have seen in the last subsection, there are the two cases in which the firm exerts effort or not under non-collateral lending. In each case, we have calculated the bank's expected payoffs from collateral and non-collateral lending. Thus, by comparing the two, the bank can determine its lending pattern.

The disciplinary case

First, we consider the disciplinary case ($B_p - \frac{k^2}{2} < B_g - \frac{E}{\beta}$). The bank's expected payoffs with collateral lending (W_r^C) and those with non-collateral lending (W^{DN}) are

$$W_r^C = \frac{1}{2}\delta(1-\alpha)^2(1-\beta)^2(p_1^H)^2 r^2 - (1-\alpha)(1-\beta)(R_p^* - 1)(r-1) + (\alpha + \beta - \alpha\beta)R_g - 1$$

$$W^{DN} = (\alpha + \beta - \alpha\beta)R_g + (1-\alpha)(1-\beta)(R_p^* - 1) - 1$$

We define δ_D and r_D as follows:

$$\delta_D = \frac{2(R_p^* - 1)}{(1-\alpha)(1-\beta)(p_1^H)^2} \ (> 0)$$

$$r_D = \frac{2(R_p^* - 1)}{\delta(1-\alpha)(1-\beta)(p_1^H)^2} \ (= 2r_C)$$

Thus, $r_C = \frac{\delta_D}{2\delta} = \frac{r_D}{2}$

Then, we obtain the following proposition.

Proposition 1:

Suppose the disciplinary case ($B_p - \frac{k^2}{2} < B_g - \frac{E}{\beta}$).

(1) When $\delta \le \delta_D$, *the bank always chooses non-collateral financing.*

(2) When $\delta > \delta_D$, *there exists a unique value of* r_D $(0 < r_D = 2r_C < 1)$ *which satisfies that* $W^{DN} = W_r^C$. *The bank chooses collateral lending (non-collateral lending) when* $r \ge r_D$ ($r \le r_D$).

Proof: See appendix 1.

It should be noted that $r_C < r_D \ (= 2r_C)$. This ensures that the bank's choice of collateral lending is consistent with Assumption 3. Proposition 1 implies that regardless of an expectation of future land prices, non-collateral lending is always beneficial than non-collateral lending when the bank's efficiency in setting up collateral is very low, since collateral requirement is too costly for the bank. If the bank's efficiency in setting up collateral is high, an expectation of future land prices will determine lending pattern. If high land prices are likely, the bank will tend to choose collateral lending, otherwise it is inclined to choose non-collateral lending (see Figure 2).

The SBC case

Next, we examine the SBC case ($B_p - \frac{k^2}{2} > B_g - \frac{E}{\beta}$). In this case, the firm exerts no effort when the bank chooses non-collateral lending, but it does so under collateral lending (Assumption 6).

The bank's expected payoffs from collateral lending in the SBC case are equal to those of the disciplinary one (W_r^C). Those from non-collateral lending (W^{SN}) are

$W^{SN} = \alpha R_g + (1-\alpha)(R_p^* - 1) - 1$

We define $\underline{\delta_S}$ and $\overline{\delta_S}$ as follows:

$$\underline{\delta_S} = \frac{2((R_p^* - 1) - \beta R_g)}{(1-\alpha)(1-\beta)^2 (p_1^H)^2}$$

$$\overline{\delta_S} = \frac{(R_p^* - 1)^2}{2(1-\alpha)\beta(R_g - (R_p^* - 1))(p_1^H)^2} \ (> 0)$$

For simplicity, we only consider the case that δ is sufficiently small such that $\delta < \overline{\delta_S}$ [4].

Proposition 2:

Suppose the SBC case ($B_p - \frac{k^2}{2} > B_g - \frac{E}{\beta}$*).*

(1) When $\delta \le \underline{\delta_S}$ *, the bank always chooses non-collateral financing.*

(2) When $\underline{\delta_S} < \delta < \overline{\delta_S}$ *, there exists a unique value of* r_S $(r_C < r_S < 1)$ *which satisfies* $W^{SN} = W_r^C$ *. The bank chooses collateral lending (non-collateral lending) when* $r \ge r_S$ *(*$r \le r_S$*).*

(3) $\underline{\delta_S} < \delta_D$*,* $r_S < r_D$*. Hence, the bank is more likely to choose collateral lending in the SBC case*

[4] Otherwise, the expected payoffs from collateral lending are strictly higher than those from non-collateral lending.

than in the disciplinary case.

Proof: See Appendix 1.

Again, it should be noted that $r_C < r_S$. This ensures that the bank's choice of collateral lending is consistent with Assumption 3. The basic implications of Proposition 2 are the same with those of Proposition 1. The threshold values of the bank's efficiency in setting up collateral (δ) and the probability of high land prices (r) determine the bank's lending pattern. These threshold values of δ and r in the SBC case are, however, lower than those in the disciplinary case ($\underline{\delta_S} < \delta_D$, $r_S < r_D$). Since only a threat of termination under collateral lending can induce the firm's effort in the SBC case, the bank is more likely to prefer collateral lending.

The payoffs from the SBC case (W^{SN}) are always lower than those from the disciplinary case (W^{DN}), since the firm under non-collateral lending exerts effort only in the disciplinary case. Figure 2 shows the bank's payoffs with respect to the probability of a high land price when $\underline{\delta_S} < \delta_D < \delta < \overline{\delta_S}$ (also see Table 2 for the bank's and firm's payoffs in each case).

Determinants of r_D and r_S

Here, we examine a number of factors affecting the threshold values of r_D and r_S. First, $r_D = \dfrac{2(R_p^* - 1)}{\delta(1-\alpha)(1-\beta)(p_1^H)^2}$ in the disciplinary case, depends on the following characteristics of the project and of the bank:

Thus, the expected payoffs for the bank is discontinuous at r_C. We do not consider such a case here.

The threshold value of r_D is lower (and the bank is thus more likely to choose collateral lending), when we have

(1) a riskier project (smaller α and β, thus C_r^* is larger))

(2) a higher efficiency in setting up collateral, δ

(3) a lower efficiency in bank's monitoring (lower k, thus, smaller R_p^*).

In the SBC case, however, the effects these parameters have on the level of r_S is not as straightforward. We will examine the case of r_S in the section presenting a numerical analysis (Section 6).

Some simplifications of the model

Before summarising our results, we consider some simplifications of the model. First, let us assume that the firm has no opportunity in exerting effort even if the quality of its project is found to be poor. Then, there is no difference between the disciplinary case (Proposition 1) and the SBC one (Proposition 2). The threshold values of r or δ can be obtained by substituting β for zero in Proposition 1 (or 2).

Second, we examine the case in which the bank has no option to refinance a poor project. The bank choosing collateral lending will terminate a project whenever it becomes poor at the end of period 1. It is easy to show that the bank always chooses collateral lending and its choice is independent from the values of r and δ (for more details, see Appendix 2).

Third, with relaxing the above condition, let us assume that only the bank choosing non-collateral lending can refinance a poor project while the bank under collateral lending cannot[5]. In this case, again, the bank choosing collateral lending will terminate a project whenever it becomes poor. Thus, the firm financed by collateral lending always exerts effort. The choice between collateral and non-collateral lending depends solely on the expected land price at the end of period 1 (p_1^e) (for more details, see Appendix 2).

3.4 Summary

Finally, we summarise the results of Propositions 1 and 2. When the bank chooses lending pattern at time 0, there are three steps it must takes:

First, the bank should try to ascertain the firm's incentive to exert efforts should the bank be willing to refinance a poor project. The two possible cases are the disciplinary one ($B_p - \frac{k^2}{2} < B_g - \frac{E}{\beta}$), in which non-collateral lending can induce effort by the firm and the SBC one ($B_p - \frac{k^2}{2} > B_g - \frac{E}{\beta}$), in which the firm has no incentive to make effort under non-collateral lending. The disciplinary case is more likely to occur the higher is the efficiency of bank's monitoring procedures (the larger is k) or the greater are relative payoffs of success (the larger is B_g / B_p).

Second, the bank must assesse its efficiency in setting up collateral (δ), since this has an important implication for the bank's choice. Collateral lending is less beneficial than non-collateral lending when the bank's efficiency in setting up collateral is low. In the disciplinary case,

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[5] In reality, it is difficult to prevent the bank committed to collateral lending from refinancing a poor project when land prices are low, since refinancing will surely improve the bank's payoff. Thus, our basic model allows the bank choosing collateral lending to refinance a poor project in the second period.

the bank always chooses non-collateral lending when $\delta \leq \delta_D$. In the SBC case, the bank always chooses non-collateral lending when $\delta \leq \underline{\delta_S}$.

Third, assessing that its efficiency in setting up collateral δ is sufficiently high ($\delta > \delta_D$ in the disciplinary case or $\underline{\delta_S} < \delta < \overline{\delta_S}$ in the SBC case), the bank's expectations of future land prices (r) will determine the choice of lending pattern. If high land prices are likely, the value of collateral at the end of period 1 will be large and termination might thus be more profitable than refinancing. The payoffs from collateral lending increase with r. In the disciplinary case, the bank chooses collateral (non-collateral) lending when $r \geq r_D (r \leq r_D)$. In the SBC case, the bank chooses collateral (non-collateral) lending when $r \geq r_S (r \leq r_S)$.

4 The timing of land price information arrival and the optimal choice of lending

In this section, let us consider a different assumption on the timing of land price information arrival and the optimal choice of lending pattern. We have previously assumed that the bank and the firm observe land prices at the end of period 1. We call this assumption the "symmetric" case of land price information. In the following, we modify this assumption and suppose that only the firm knows the actual land price (p_1) before it decides effort level in period 1. We define this as the "asymmetric" case of land price information.

In the disciplinary case ($B_p - \frac{k^2}{2} < B_g - \frac{E}{\beta}$), the firm will exert effort even if can observe a state of low land price in advance, since refinancing is simply not beneficial for it. Thus, the outcomes of the disciplinary case are the same as those with the symmetric case of land price information. Hence, we consider only the SBC case in this section.

4.1 Collateral versus non-collateral lending in the asymmetric case of land price information

Suppose the SBC case ($B_p - \varphi(M^*) > B_g - \dfrac{E}{\beta}$). When r is sufficiently large, the bank is more likely to choose collateral lending, which in the symmetric case will always induces firm effort. When the firm, in the asymmetric case, observes a low land price (p_1^L), it will, however, have no incentive to exert effort since it will expect that the bank will propose a more profitable refinancing option rather than realising a low value collateral. This is "SBC collateral lending" (SC). The bank's expected payoffs (W^{SC}) is as follows:

$$W^{SC} = \alpha R_g + (1-\alpha)\lfloor r\left(\beta R_g + (1-\beta)p_1^H C\right) + (1-r)\left(R_P^* - 1\right)\rfloor - \mu(C) - 1$$

We have to calculate the optimal level of collateral. The bank's maximisation problem at time 0 is as follows.

$$\underset{0<C\le 1}{Max}\left[\alpha R_g + (1-\alpha)\lfloor r\left(\beta R_g + (1-\beta)p_1^H C\right) + (1-r)\left(R_P^* - 1\right)\rfloor - \mu(C) - 1\right]$$

There is a unique optimal level of collateral C^S that satisfies the following condition.

$\mu'(C^S) = (1-\alpha)(1-\beta)rp_1^H$. Hence,

$$C^S = \delta(1-\alpha)(1-\beta)rp_1^H = C^*$$

The optimal level of collateral (C^S) is equal to C^*, that in the symmetric case of land price information. The expected payoffs from collateral lending (W_r^{SC}) are rewritten as follows:

$$
\begin{aligned}
W_r^{SC} &= \alpha R_g + (1-\alpha)\lfloor r\left(\beta R_g + (1-\beta)p_1^H C^S\right) + (1-r)\left(R_P^* - 1\right)\rfloor - \mu(C^S) - 1 \\
&= \frac{1}{2}\delta(1-\alpha)^2(1-\beta)^2(p_1^H)^2 r^2 - (1-\alpha)\left((R_p^* - 1) - \beta R_g\right)r + \alpha R_g + (1-\alpha)(R_p^* - 1) - 1
\end{aligned}
$$

The timing of land price information does not, on the other hand, affect SBC relationship lending; its payoffs (W^{SN}) are

$$W^{SN} = \alpha R_g + (1-\alpha)(R_p^* - 1) - 1$$

Proposition 3:

Suppose the SBC case ($B_p - \frac{k^2}{2} > B_g - \frac{E}{\beta}$) and that only the firm knows the actual land price (p_1) before it decides effort level in period 1 (the asymmetric case of land price information). In addition, we assume that $(R_p^* - 1) - \beta R_g > 0$[6].

(1) When $\delta \leq \underline{\delta_S}$ $\left(= \frac{2((R_p^* - 1) - \beta R_g)}{(1-\alpha)(1-\beta)^2(p_1^H)^2} > 0\right)$, the bank always chooses non-collateral lending.

(2) *When $\underline{\delta_S} < \delta$, there exists a unique value of $r_S^S = \frac{2\left((R_p^* - 1) - \beta R_g\right)}{\delta(1-\alpha)(1-\beta)^2(p_1^H)^2}$* $\left(0 < r_S^S = \frac{\underline{\delta_S}}{\delta} < 1\right)$ *which satisfies $W^{SN} = W_r^{SC}$. The bank chooses collateral lending (non-collateral lending) when $r \geq r_S^S$ ($r \leq r_S^S$).*

[6] Otherwise, the expected payoffs from collateral lending are strictly higher than those from non-collateral lending. Thus, the expected payoffs for the bank is discontinuous at r_C. We do not consider such a case here.

(3) $r_S < r_S^S < r_D$. *Hence, the bank is less likely to choose collateral lending in the asymmetric case than in the symmetric case.*

Proof: See Appendix 1.

In the asymmetric case of land price information, the bank's payoffs under collateral lending (W_r^{SC}) are lower than those in the symmetric case (W_r^C) (since the firm makes no effort at a state of low land price in the asymmetric case), while those under non-collateral lending are the same. Thus, the threshold value of r is higher in the asymmetric case than in the symmetric one ($r_S < r_S^S$). Hence, non-collateral lending is more likely to be chosen in the asymmetric case than in the symmetric case (see Figure 3).

4.2 The bank's ex ante commitment to terminate a poor project

If the bank can commit itself ex ante to terminate any project that ends up as being poor[7], the firm can be expected to always exert effort. Therefore, such a commitment potentially increases its expected payoffs in the asymmetric case when the firm can observe the realisation of land price in advance. We define this type of lending as "committed collateral lending" (CC). In this case, the bank's payoffs (W_r^{CC}) are

$$W_r^{CC} = \alpha R_g + (1-\alpha)\left(\beta R_g + (1-\beta)p_1^e C\right) - \mu(C) - 1$$

Then, we have to solve the following maximisation problem:

[7] A credibility of such a commitment is an important issue. For example, small banks that can provide only a unit of capital might be able to make a credible commitment.

$$\underset{0<C\leq 1}{Max}\left[\alpha R_g+(1-\alpha)\left(\beta R_g+(1-\beta)p_1^e C\right)-\mu(C)-1\right]$$

We have to calculate the optimal level of collateral, C^M, which satisfies the following condition:

$$\mu'(C^M)=(1-\alpha)(1-\beta)p_1^e$$

Hence, $C^M=\delta(1-\alpha)(1-\beta)p_1^e=\delta(1-\alpha)(1-\beta)(rp_1^H+(1-r)p_1^L)\ (\leq\delta(1-\alpha)(1-\beta)rp_1^H=C^S)$

Since $C^M\leq\delta(1-\alpha)(1-\beta)p_1^H\leq 1$ (Assumption 4), C^M is a solution of the above maximisation problem. It should be noted that the optimal level of collateral with "committed collateral lending" (C^M) is larger than that with collateral lending (C^S).

Incorporating the optimal value of collateral into the bank's payoffs from "committed collateral lending"(W_r^{CC}),

$$\begin{aligned}W_r^{CC}&=\alpha R_g+(1-\alpha)\left(\beta R_g+(1-\beta)p_1^e C^M\right)-\mu(C^M)-1\\&=\alpha R_g+(1-\alpha)\beta R_g+(1-\alpha)(1-\beta)rp_1^H C^M+(1-\alpha)(1-\beta)(1-r)p_1^L C^M-\mu(C^M)-1\end{aligned}$$

The bank's payoffs under "SBC collateral lending" (W_r^{SC}) can be rewritten as follows.

$$W_r^{SC}=\alpha R_g+(1-\alpha)\beta rR_g+(1-\alpha)(1-\beta)rp_1^H C^S+(1-\alpha)(1-r)\left(R_P^*-1\right)-\mu(C^S)-1$$

By comparing W_r^{CC} with W_r^{SC}, the relative benefits of committed collateral lending is presented as follows:

(1) The bank can induce the firm to exert effort even when land prices turn out to be low.

Relative benefits: $(1-\alpha)\beta(1-r)R_g$

(2) The bank obtains a higher value of collateral if land prices are high.

Relative benefits: $(1-\alpha)(1-\beta)rp_1^H(C^M - C^S)$

The relative costs of committed collateral lending are:

(1) Even when land prices are low, the bank must terminate the project and obtain collateral, which is less valuable than the refinancing option.

Relative costs: $(1-\alpha)(1-r)\left((R_p^* - 1) - (1-\beta)p_1^L C^M\right)$

(2) Committed collateral lending requires a higher optimal level of collateral at time 0, and thus is more costly for the bank.

Relative costs: $\mu(C^M) - \mu(C^S)$

It is theoretically ambiguous to tell when committed collateral lending is more beneficial than SBC collateral lending. When we focus on the major benefits ($(1-\alpha)\beta(1-r)R_g$) and costs ($(1-\alpha)(1-r)\left((R_p^* - 1) - (1-\beta)p_1^L C^M\right)$) of committed collateral lending, we can predict that the banks may prefer committed collateral lending, when β is sufficiently large. To investigate further the choice between the two lending patterns, we will present a numerical analysis in Section 6.

4.3 Summary

In summary, when the firm can observe the state of land price information before it decides on its level of effort, it has an informational advantage in the SBC case. If it observes a state of low land prices, it will never exert effort, since refinancing is beneficial for both the bank and the firm.

Hence, the bank's expected payoffs under collateral lending in the asymmetric case are lower than those in the symmetric case.

The optimal choice of the bank's lending pattern is as follows. When $\delta \leq \underline{\delta_S}$, the bank chooses non-collateral lending regardless of r, the probability of high land prices, while in the case of $\delta > \underline{\delta_S}$, the bank chooses non-collateral lending when $r \leq r_S^S$ and collateral lending when $r \geq r_S^S$.

"Committed collateral lending" might potentially improve the bank's expected benefits. It generates, however, other costs and the overall net additional benefits obtained by switching from "SBC collateral lending" to committed lending are theoretically ambiguous.

5 The coexistence of soft budget constraints and credit crunches: The influence of gambling for resurrection by banks and bailouts by the government

In this section, by modifying the basic model in several points, we will focus on a situation in which a bank's refinancing option is risky in the sense that its benefits depends on land price developments. We, then, consider the effect of the government's supervision and regulatory frameworks (including bailouts) on the bank's lending choice between refinancing old (and risky) projects and financing new (and safe) projects.

Our main finding is as follows. Even if the refinancing option is unprofitable ex ante and there exists an alternative profitable new and safe project, the bank will tend to refinance the risky project, if it expects that the government will not detect such risky lending and will, therefore, bail out insolvent banks.

This result is a typical case of the soft-budget-constraints (SBCs) problems. In addition, This model can well describe a situation in which SBCs for existing poor projects and credit crunches for new projects can coexist. In this sense, our model is similar to a theoretical model of Berglof and Roland (1998) in which banks prefer refinancing poor projects to funding new, bur similar projects. In contrast, we examine the choice between the two different projects (a risky old project and a new safe project).

At the same time, our model can well describe moral hazard behaviour of weakly capitalised banks, namely, “gambling for resurrection” under the deposit insurance system. In this sense, our model is close to the story of Hoshi (2000 b). In his simple numerical example, he shows that weakly capitalised banks have an incentive to increase their (risky) loans, if their capital positions are not disclosed. When capital ratio (net worth) is very low and their outstanding loans are risky, banks that want to prevent her bankruptcy by all means, may try to reduce the size of loans. However, when the disclosure of non-performing loans are insufficient or lax, weak capitalised banks have a good incentive to expand loans and to take high risks (“gambling for resurrection”), since managers of banks are protected by limited liability.

5.1 The risky refinancing model

We modify the basic model as follows (Figure 4) (and call this modified model “the risky refinancing model”):

Assumption 8:

$\mu = 0$ *and, thus, the amount of collateral that the bank requires is fixed.*

First, we assume that the costs of setting up collateral is zero. Then, the bank can demand the level of collateral as much as it wants. Let us define C^R (≤ 1) as the maximum level of collateral that the firm can provide. Thus, the amount of collateral in this model is fixed to C^R

Assumption 9:

$\beta = 0$

Second, we assume that the probability of transferring a poor project into a successful one thanks to effort is equal to zero. Thus, the firm has no incentive to exert effort.

Assumption 10:

(1) $R_p = 0$*, (2)* $k = 0$*, and (3) the bank that refinances the poor project, will only obtain* $p_2^H C^R$ *with a probability of r and* $p_2^L C^R$ *with a probability of 1-r at the end of period 2.*

Third, we assume that the refinancing option is "risky". In the basic model, the bank that has refinanced a poor project, can get at least R_p with certainty (and more through its monitoring activities). The level of land prices at the end of period 2 is fixed to that at the end of period 1. In contrast, here the project is so poor that it will generate no returns (the bank's monitoring technology has no value for this project ($k = 0$)). The bank only obtains $p_2^H C^R$ with a probability of r and $p_2^L C^R$ with a probability of 1-r at the end of period 2, depending on the states of land prices at the end of period 2. For simplicity, we assume that $p_1^H = p_2^H = p^H$, $p_1^l = p_2^L = p^L$ and the ex ante probability of high land prices remains the same in period 2. The bank's expected returns from refinancing is $rp^H C^R + (1-r)p^L C^R$ and thus, the refinancing option is riskier than that it is in the basic model.

Collateral lending is always more beneficial than non-collateral lending in the risky refinancing model, since collateral lending is cost-free and can only provide an opportunity of refinancing the poor project. In such a case, when will the bank refinance the risky project?

If land prices are high at the end of period 1, the bank chooses to terminate the poor project, since the expected net payoffs from refinancing are always smaller than those from termination as follows:

$$(rp^H C^R + (1-r)p^L C^R - 1) - p^H C^R = -(1-r)(p^H - p^L)C^R - 1 < 0$$

When land prices are low, the relative merits of refinancing versus termination are as follows:

$$(rp^H C^R + (1-r)p^L C^R - 1) - p^L C^R = r(p^H - p^L)C^R - 1$$

Thus, when r is sufficiently high so that $r \geq \frac{1}{(p^H - p^L)C^R} = r_R$, the bank has an incentive to refinance the poor project and to wait for land prices to pick up in the next period, in the hope of obtaining a higher collateral value.

Hence, we obtain the following proposition:

Proposition 4:

Let us consider "the risky refinancing model" with Assumptions 8-10.

(1) The bank always chooses collateral lending (with the fixed level of collateral, C^R*).*

(2) If land prices are high at the end of period 1, the bank chooses to terminate the poor project.

(3) In a state of low land prices, the bank chooses refinancing if $r \geq r_R$ *and the bank prefers to terminate the poor project and obtain* $p^L C^R$ *otherwise (*$r < r_R$ *).*

In a multi-period setting, we can show that the bank with more optimistic expectations of future land prices will refinance the poor project repeatedly until a high state of land prices finally occurs. The risky refinancing model may describe the situation in which loans to the real estate sectors becomes non-performing because of land price deflation (as has typically been seen in Japan over the past decade). The success of real estate projects depends exclusively on land price movements rather than on the firm's effort or on the bank's monitoring.

5.2 The bank's choice between refinancing an old project and financing a new project

Next, we consider the case of an unprofitable refinancing option combined with alternative lending option. In other words,

Assumption 11:

(1) Refinancing is unprofitable. $(rp^H C^R + (1-r) p^L C^R) - 1 < 0$

(2) At the beginning of period 2, the bank can choose to finance a new and safe project that generates returns of $R_M (>1)$ *.*

In this case, the bank may terminate the old poor project (even if land prices are low) and provide loans to a new project, when the return from the new project, R_M is sufficiently high.

Introduction of the bank's balance sheet

We now consider the bank's balance sheet explicitly (see Table 3) (This is useful also because it will allow us to analyse the interaction between government policy and the bank's strategy.). At time 0, the bank has a unit of assets and deposits, D and equity (net worth), $E_0 = 1 - D$. In period one, the bank provides a unit of capital from its assets. In period 2, the bank can raise a unit of deposits with no cost and offer a unit of capital to the firm. The bank maximises its expected own capital. This is equivalent to the bank's maximisation of net expected returns in the basic model.

Next, we investigate the bank's choice between refinancing and new lending when land prices are low at the end of period 1. At that time, there are no returns and the (termination) value of the project is $p^L C^R$. Thus, the bank's capital position at the end of period 1 is

$$E_1 = p^L C^R - D.$$

When the bank terminates this poor project and finances a new project, its own capital is

$$E_2^M = p^L C^R + R_M - D - 1$$

Remember that refinancing generates no returns and the bank can only get a collateral value if it terminates the project at the end of period 2 (Assumption 10). When the bank refinances the poor project and land prices rise (fall) at the end of period 2, its own capital position is respectively,

$$E_2^H = p^H C^R - D - 1$$

$$E_2^L = p^L C^R - D - 1$$

Thus, the expected capital position is

$$E_2^T = rE_2^H + (1-r)E_2^L$$

We assume the following conditions.

Assumption 12:

(1) $E_1 = p^L C^R - D > 0$.

(2) $E_2^H = p^H C^R - D - 1 > 0$,

$E_2^L = p^L C^R - D - 1 < 0$

The first part of this assumption says that the bank's capital at the end of period 1 is assumed to be positive. Thus, the bank that finances a new project will keep its own capital positive, since $E_2^M = p^L C^R + R_M - D - 1 > 0$. The second part implies that the bank's capital position becomes positive (negative) when the refinancing project meets high (low) land prices. The bank's expected capital position at the end of period 2 for the refinancing project (E_2^T) is, however, negative ($E_2^T = rE_2^H + (1-r)E_2^L < 0$), since refinancing is unprofitable ($(rp^H C^R + (1-r)p^L C^R) - 1 < 0$).

Then, we obtain the following proposition:

Proposition 5:

Suppose the risky refinancing model with Assumptions 8-12. Then, the bank will always terminate a poor project at the end of period 1 (regardless of land prices) and finance a new one.

5.3 The effect of government policy on the bank's lending behaviour

Finally, we consider how government policy can affect the bank's lending choice between refinancing a poor project and financing a new one. We introduce a government, which can or cannot monitor the bank's balance sheets at the end of periods 1 and 2. If it can, it will enforce prudential policy by stopping risky lending, which might lead to a negative net worth of the bank, or it will bail out the bank through a capital injection should it detect insolvency (a negative net position).

Monitored case

Let us assume that the government can monitor the bank's balance sheets at the end of periods 1 and 2. Even if the bank prefers refinancing, the government, detecting the possibility of the bank's insolvency at the end of period 2, and can stop the refinancing option. Thus, the bank is forced to terminate the existing project and to finance a safe one. Its capital position at the end of period 2 is $E_2^M = p^L C^R + R_M - D - 1 > 0$.

Unmonitored case

In this case, we assume that the government is able to monitor the bank's balance sheets at the end of period 2 but not at the end of period 1. Thus, it cannot stop risky refinancing. In addition, refinancing might be more profitable for the bank, since, should it become insolvent, the government will have to bail it out by injecting necessary capital through the deposit insurance system[8]. This implies that with the realisation of low land prices in period 2, the government will have to provide capital injections to the amount of $I = -E_2^L = D + 1 - p^L C^R$.

Therefore, the downside risk of refinancing is perfectly insured by the government. The bank's expected own capital by refinancing under this case (E_2^{NT}) is

[8] We assume that the bank managers are not dismissed even if the bank is recapitalised. Thus, the bank is willing to accept capital injections when it becomes insolvent.

$$E_2^{NT} = rE_2^H + (1-r)\times 0 = rE_2^H > 0$$

Thus, the bank's choice between refinancing the poor project and financing a new one depends on the comparison of E_2^{NT} and E_2^M.

$$E_2^{NT} > (\le)\ E_2^M \quad \Leftrightarrow \quad r > (\le)\ \frac{p^L C^R + R_M - D - 1}{p^H C^R - D - 1} = r_M$$

It is noted that the threshold value, r_M increases with R_M.

Then, we obtain the following proposition:

Proposition 6:

Suppose the risky refinancing model with assumptions 8-12. In addition, the government has an imperfect ability to monitor the bank's balance sheet (monitor only in period 2), however, must inject necessary capital to insolvent banks in period 2 through the deposit insurance system.

(1) When $r > r_M \left(= \frac{p^L C^R + R_M - D - 1}{p^H C^R - D - 1}\right)$*, the bank chooses "gambling for resurrection", namely, risky refinancing, which would never have been allowed, had the government been able to monitor the bank at the end of period 1. The bank has no incentive to finance a new project that would be more profitable without deposit insurance system.*

(2) When $r \le r_M$*, the bank chooses to finance a new and safe project.*

(3) The lower are the returns from the safe project, R_M *, the bank is more likely to choose risky refinancing.*

Thus, the combination of imperfect monitoring by the government and the deposit insurance system can provide an opportunity for a risky refinancing option to the bank. The bank with optimistic expectations on land prices is more likely to engage in risky refinancing.

5.4 Summary

In this subsection, we have considered the risky refinancing model (collateral lending with a risky refinancing option), since its payoffs are equal to changeable collateral values linked to fluctuating land price movements. When the expected value of the collateral is sufficiently high, the bank will be inclined to refinance a poor project continuously until a high state of land prices occurs (Proposition 4).

Even if the refinancing option is unprofitable ex ante and there exists an alternative profitable new and safe project, the bank will tend to refinance the risky project if it expects that the government will not detect such risky lending and will, therefore, bail out insolvent banks. The refinancing option is thus more profitable ex post than the new lending option, thereby to expected capital injection from the authorities (Proposition 6).

This model can well describe a situation in which soft-budget-constraints (SBCs) for existing poor projects and credit crunches for new projects can coexist. In contrast, when information on the balance sheets of banks are disclosed and the government's prudential policy can effectively detect the banks' risk-taking behaviour, the problems posed by the coexistence of SBCs and credit crunches might be less severe.

6 The numerical analysis

6.1 The basic example

In this section, we present several numerical examples of the basic model's parameters and consider the implications of our model discussed in Sections 1-4, especially, theoretically ambiguous answers. Table 4 shows numerical examples of the parameters that are chosen so as to satisfy the following assumptions of our model introduced earlier.

(1) $R_g > R_p^* - 1 > \beta R_g > 0 > R_p^* - 2$ (Assumption 1, 2 and Section 4)

(2) $p_1^H > 1,\ \ p_1^L < R_p^* - 1$ (Assumption 3)

(3) $\delta(1-\alpha)(1-\beta)p_1^H \leq 1$ (Assumption 4)

(4) $B_g - \dfrac{E}{\beta} > 0$ (Assumption 5)

A difference between the SBC case and the disciplinary case (1) is that B_g is greater in the disciplinary case (B_g = 0.7) than in the SBC case (B_g = 0.5). When we compare the SBC and the disciplinary cases (2), the monitoring efficiency of the bank, k, is higher in the disciplinary case (k = 1.1) than in the SBC case (k = 1). The higher is the efficiency of the bank's monitoring, the more likely is it that the disciplinary case will occur.

Table 5 shows the threshold values of r, which determine the choice of lending in each case, since all three cases satisfy $\delta > \delta_D$ or $\underline{\delta_S} < \delta < \overline{\delta_S}$. It is noted that $r_E < r_C$, as we have assumed (Assumptions 3 and 6). In addition, We obtain that $r_C < r_S < r_S^S < r_D$, as derived (Propositions 1-3).

Thus, with the SBC case, the bank chooses non-collateral lending when $r \le 0.555$ and collateral lending when $r \ge 0.556$. With the disciplinary case (1), the bank chooses non-collateral lending when $r \le 0.833$ and collateral lending when $r \ge 0.834$.

6.2 The effects of some parameters on the threshold value of r_S

The disciplinary case, the threshold value of r_D that determines the lending choice can be obtained by a very simple solution using parameters such as α, β, δ, k . The solution of r_S is, however, more complicated and the relationships with these parameters are not obvious. Table 6 shows the impact on it of varying the values of each parameter, keeping the other variables fixed. Table 6 finds that r_S increases with α and k while it decreases with β and δ.

The effect of changes α, δ, k on r_S is similar to that on r_D, while changing β has an opposite impact on r_S: r_S is negatively correlated with β. In the SBC case, the firm only exerts effort when the bank chooses collateral lending. Thus, the bank's expected payoffs from non-collateral lending are not related to β, but those of collateral lending increase with β. Hence, a higher value of β makes collateral lending more profitable, thus, lowering the value of r_S. Among these parameters, the sensitivity of r_S to β is significantly higher than its sensitivity to other parameters.

6.3 SBC collateral lending vs. committed collateral lending

In the asymmetric case of land price information, the bank choose committed collateral lending, under which it will always terminate a poor project regardless of the state of land prices. Under what condition will such a course of action be more beneficial? Our theoretical prediction is that commitment should be more profitable for the bank, when β is sufficiently large. However, it is not easy to determine the threshold value of β.

Table 7 presents some combinations of r and β, under which the expected payoffs from committed collateral lending (W_r^{CC}) are greater than those from the SBC case (W_r^{SC}) and shows differences in the two payoffs ($W_r^{CC} - W_r^{SC}$). We compare the two payoffs when r is greater than r_B. Given the other parameters in the numerical example of the SBC case mentioned above, the value of β should be at least as high as 0.31 in order to ensure that $W_r^{CC} > W_r^{SC}$. Holding $r\ (> r_B)$ fixed, $W_r^{CC} - W_r^{SC}$ is higher, thus, the advantage of the committed collateral lending is greater, when β is higher.

Appendix 1 Proofs of Propositions 1 – 3

1.1 Proof of Proposition 1

In the disciplinary case ($B_p - \frac{k^2}{2} < B_g - \frac{E}{\beta}$), the bank's expected payoffs with collateral lending (W_r^C) are

$$W_r^C = \alpha R_g + (1-\alpha)\left[\beta R_g + (1-\beta)\left(r(p_1^H C_r^*) + (1-r)(R_p^* - 1)\right)\right] - \mu(C_r^*) - 1$$
$$= \frac{1}{2}\delta(1-\alpha)^2(1-\beta)^2(p_1^H)^2 r^2 - (1-\alpha)(1-\beta)(R_p^* - 1)(r-1) + (\alpha + \beta - \alpha\beta)R_g - 1$$

On the other hand, those with non-collateral lending (W^{DN}) are

$$W^{DN} = \alpha R_g + (1-\alpha)\left(\beta R_g + (1-\beta)(R_p^* - 1)\right) - 1$$
$$= (\alpha + \beta - \alpha\beta)R_g + (1-\alpha)(1-\beta)(R_p^* - 1) - 1$$

$$W^{DN} - W_r^C = -\frac{1}{2}\delta(1-\alpha)^2(1-\beta)^2(p_1^H)^2 r^2 + (1-\alpha)(1-\beta)(R_p^* - 1)r$$

$$W^{DN} - W_r^A\,|_{r=r_C} = \mu(C_{r_C}^*) > 0 \quad \text{, when } r = r_C$$

$$W^{DN} - W_r^C\,|_{r=1} = \frac{(1-\alpha)(1-\beta)\left(2(R_p^* - 1) - \delta(1-\alpha)(1-\beta)(p_1^H)^2\right)}{2}$$
$$= \frac{(1-\alpha)^2(1-\beta)^2(p_1^H)^2(\delta_D - \delta)}{2}, \qquad \delta_D = \frac{2(R_p^* - 1)}{(1-\alpha)(1-\beta)(p_1^H)^2}\ (>0)$$

,when $r = 1$.

(1) When $\delta \le \delta_D$, we obtain $W^{DN} - W_r^C\,|_{r=1} \ge 0$, Thus, $W^{DN} \ge W_r^C$ always hold.

(2) When, $\delta > \delta_D$, $W^{DN} - W_r^C\,|_{r=1} < 0$ holds. $r_C = \frac{\delta_D}{2\delta} < \frac{1}{2}$. Thus, there exists a unique value of

$r_D = \dfrac{2(R_p^* - 1)}{\delta(1-\alpha)(1-\beta)(p_1^H)^2}$ $(= 2r_C < 1)$ which satisfies that $W^{DN} = W_r^C$. If $r \geq r_D$, $W^{DN} \leq W_r^C$, otherwise ($r \leq r_D$), $W^{DN} \geq W_r^C$.

QED

1.2 Proof of Proposition 2

In the SBC case ($B_p - \dfrac{k^2}{2} > B_g - \dfrac{E}{\beta}$), the bank's expected payoffs with collateral lending are equal to those of the disciplinary case (W_r^C). Those with non-collateral lending (W^{SN}) are

$$W^{SN} = \alpha R_g + (1-\alpha)(R_p^* - 1) - 1$$

Thus,

$$W^{SN} - W_r^C = -\frac{1}{2}\delta(1-\alpha)^2(1-\beta)^2(p_1^H)^2 r^2 + (1-\alpha)(1-\beta)(R_p^* - 1)r - \beta(1-\alpha)(R_g - (R_p^* - 1))$$

$$W^{SN} - W_r^C \,|_{r=r_C} = \frac{(R_g - (R_p^* - 1))}{\delta}\left(\overline{\delta_S} - \delta\right)$$

$$\overline{\delta_S} = \frac{(R_p^* - 1)^2}{2(1-\alpha)\beta(R_g - (R_p^* - 1))(p_1^H)^2}$$

, when $r = r_C$

$$W^{SN} - W_r^C \,|_{r=1} = \frac{(1-\alpha)^2(1-\beta)^2(p_1^H)^2}{2}\left(\underline{\delta_S} - \delta\right)$$

$$\underline{\delta_S} = \frac{2((R_p^* - 1) - \beta R_g)}{(1-\alpha)(1-\beta)^2(p_1^H)^2}$$

, when $r = 1$.

Since, $\delta < \overline{\delta_S}$, $W^{SN} - W_r^C|_{r=r_C} > 0$.

(1) When $\delta \leq \underline{\delta_S}$, we obtain $W^{SN} - W_r^C|_{r=1} \geq 0$, Thus, $W^{SN} \geq W_r^C$ always hold.

(2) When $\underline{\delta_S} < \delta < \overline{\delta_S}$, $W^{SN} - W_r^C|_{r=1} < 0$ holds. Thus, there exists a unique value of r_S $(r_C < r_S < 1)$ which satisfies: $W^{SN} = W_r^C$. If $r \geq r_S$, $W^{SN} \leq W_r^C$, otherwise ($r \leq r_S$), $W^{SN} \geq W_r^C$.

(3) $\underline{\delta_S} < \delta_D$ and $r_S < r_D$, since $\delta_D - \underline{\delta_S} = \dfrac{\beta\left((R_p^* - 1) - R_g\right)}{(1-\alpha)(1-\beta)^2(p_1^H)^2} > 0$ and $W^{SN} < W^{DN}$

QED

1.3 Proof of Proposition 3

We compare SBC collateral lending with SBC non-collateral lending.

$$W^{SN} - W_r^{SC} = -\frac{1}{2}\delta(1-\alpha)^2(1-\beta)^2(p_1^H)^2 r^2 + (1-\alpha)\left((R_p^* - 1) - \beta R_g\right)r$$

Thus,

$$W^{SN} - W_r^{SC}|_{r=0} = 0$$

$$W^{SN} - W_r^{SC}|_{r=1} = -\frac{1}{2}\delta(1-\alpha)^2(1-\beta)^2(p_1^H)^2 + (1-\alpha)\left((R_p^* - 1) - \beta R_g\right)$$

Since $(R_p^* - 1) - \beta R_g > 0$, there exists $r_S^S = \dfrac{2\left((R_p^* - 1) - \beta R_g\right)}{\delta(1-\alpha)(1-\beta)^2 (p_1^H)^2} (> 0)$, which satisfies

$W^{SN} - W_r^{SC} = 0$ and $W^{SN} - W_r^{SC} \geq (\leq) 0$ for $0 \leq r \leq r_S^S (r \geq r_S^S)$.

In this case,

$$r_S^S < 1 \Leftrightarrow W^{SN} - W_r^{SC} |_{r=1} < 0 \Leftrightarrow \delta > \frac{2\left((R_p^* - 1) - \beta R_g\right)}{(1-\alpha)(1-\beta)^2 (p_1^H)^2} = \underline{\delta_S} (> 0) .$$

As a result,

(1) When $\delta \leq \underline{\delta_S}$, $W^{SN} \geq W_r^{SC} (0 \leq^{\forall} r \leq 1)$.

(2) When $\delta > \underline{\delta_S}$, $W^{SN} \leq W_r^{SC}$ if $r \geq r_S^S$ and $W^{SN} \geq W_r^{SC}$, otherwise ($r \leq r_S^S$).

(3)

$$r_D - r_S^S = \frac{2\left((R_p^* - 1) - \dfrac{(R_p^* - 1) - \beta R_g}{(1-\beta)} \right)}{\delta(1-\alpha)(1-\beta)(p_1^H)^2} = \frac{2\beta\left(R_g - (R_p^* - 1)\right)}{\delta(1-\alpha)(1-\beta)^2 (p_1^H)^2} > 0 .$$

$$W_r^C - W_r^{SC} = (1-\alpha)\beta(1-r)\left(R_g - (R_p^* - 1)\right) > 0$$

Thus, we obtain $r_S < r_S^S < r_D$.

QED

Appendix 2 Some simplifications of the model

2.1 The case without an option of refinancing (NR)

In this case, the bank under collateral lending will always terminate a project when it becomes poor, and thus, the firm will always exert effort when the bank chooses collateral lending. The bank's expected payoff (W_{NR}^{C}) is as follows, given the value of collateral, C.

$$W_{NR}^{C} = \alpha R_g + (1-\alpha)(\beta R_g + (1-\beta) p_1^e C) - \mu(C) - 1$$

The bank chooses the optimal value of collateral, C^{NR} that maximises its payoff, W_{NR}^{C}. Thus,

$$C^{NR} = \delta(1-\alpha)(1-\beta) p_1^e$$

The bank's expected payoff under non-collateral lending is W_{NR}^{DN} and W_{NR}^{SN} in the disciplinary and SBC case respectively. Thus,

$$W_{NR}^{DN} = \alpha R_g + (1-\alpha)\beta R_g - 1$$

$$W_{NR}^{SN} = \alpha R_g - 1$$

Then,

$$\begin{aligned} W_{NR}^{C} - W_{NR}^{DN} &= (1-\alpha)(1-\beta) p_1^e C^{NR} - \mu(C^{NR}) \\ &= \frac{1}{2}\delta(1-\alpha)^2(1-\beta)^2(p_1^e)^2 > 0 \end{aligned}$$

Therefore,

$$W_{NR}^{C} > W_{NR}^{DN} > W_{NR}^{SN}$$

This implies that the bank always chooses collateral lending.

2.2 The case in which non-collateral lending has an option to refinance the poor project, while collateral one does not (NRC)

In this case, the bank under collateral lending will terminate the poor project regardless of land prices at the end of period 1. The bank's expected payoff from collateral lending (W_{NRC}^{C}) is equal to that in the above case (W_{NR}^{C}).

$$W_{NRC}^{C} = W_{NR}^{C} = \alpha R_g + (1-\alpha)(\beta R_g + (1-\beta)\, p_1^e C^{NR}) - \mu(C^{NR}) - 1$$
$$= \frac{1}{2}\delta(1-\alpha)^2(1-\beta)^2(p_1^e)^2 + (\alpha + \beta - \alpha\beta)R_g - 1$$

The bank's expected payoff under non-collateral lending is W_{NRC}^{DN} and W_{NRC}^{SN} in the disciplinary and SBC case respectively. Thus,

$$W_{NRC}^{DN} = (\alpha + \beta - \alpha\beta)R_g + (1-\alpha)(1-\beta)(R_p^* - 1) - 1$$

$$W_{NRC}^{SN} = \alpha R_g + (1-\alpha)(R_p^* - 1) - 1$$

$$W_{NRC}^{C} - W_{NRC}^{DN} = \frac{1}{2}\delta(1-\alpha)^2(1-\beta)^2(p_1^e)^2 - (1-\alpha)(1-\beta)(R_p^* - 1)$$

Thus,

$$W_{NRC}^{C} > W_{NRC}^{DN} \Leftrightarrow p_1^e > \left(\frac{2(R_p^* - 1)}{\delta(1-\alpha)(1-\beta)}\right)^{1/2}$$

$$W_{NRC}^{C} - W_{NRC}^{SN} = \frac{1}{2}\delta(1-\alpha)^2(1-\beta)^2(p_1^e)^2 - (1-\alpha)((R_p^* - 1) - \beta R_g)$$

$$W_{NRC}^{C} > W_{NRC}^{SN} \Leftrightarrow p_1^e > \left(\frac{2((R_p^* - 1) - \beta R_g)}{\delta(1-\alpha)(1-\beta)^2}\right)^{1/2}$$

Therefore,

(1) The bank chooses collateral (non-collateral) lending when $p_1^e > \left(\frac{2(R_p^* - 1)}{\delta(1-\alpha)(1-\beta)}\right)^{1/2}$ ($p_1^e \leq \left(\frac{2(R_p^* - 1)}{\delta(1-\alpha)(1-\beta)}\right)^{1/2}$) in the disciplinary case.

(2) The bank chooses collateral (non-collateral) lending when $p_1^e > \left(\frac{2((R_p^* - 1) - \beta R_g)}{\delta(1-\alpha)(1-\beta)^2}\right)^{1/2}$ ($p_1^e \leq \left(\frac{2((R_p^* - 1) - \beta R_g)}{\delta(1-\alpha)(1-\beta)^2}\right)^{1/2}$) in the SBC case.

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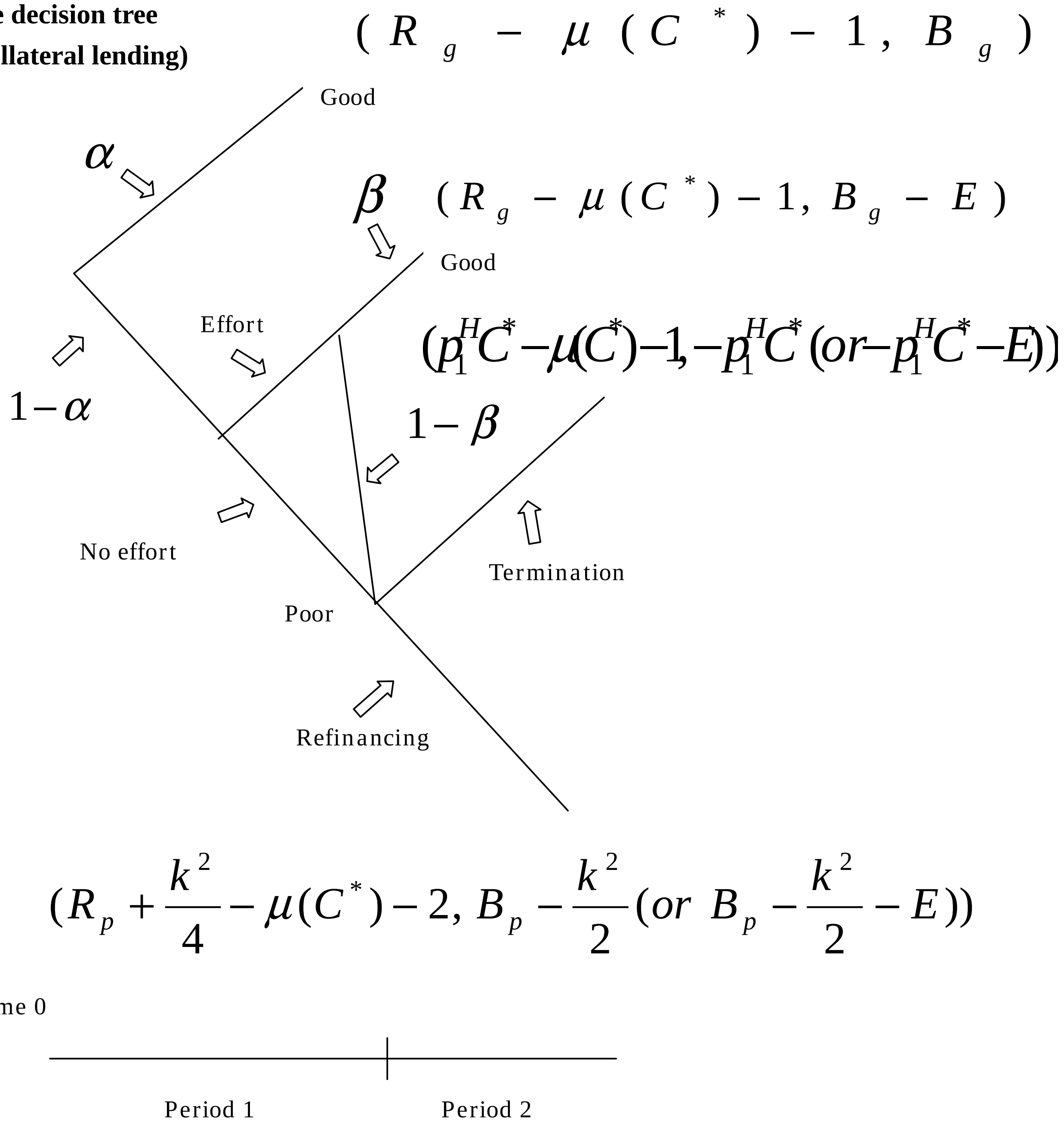
Figure 1
The decision tree
(Collateral lending)



Note:

1. (The bank's net pay-off, the borrower's net pay-off)

2. In the case of non-collateral lending, There is no option for termination and $\mu(C^*) = 0\ (C^* = 0)$.

Figure 2 The bank's payoffs with respect to the probability of high land prices r in the symmetric case of land information

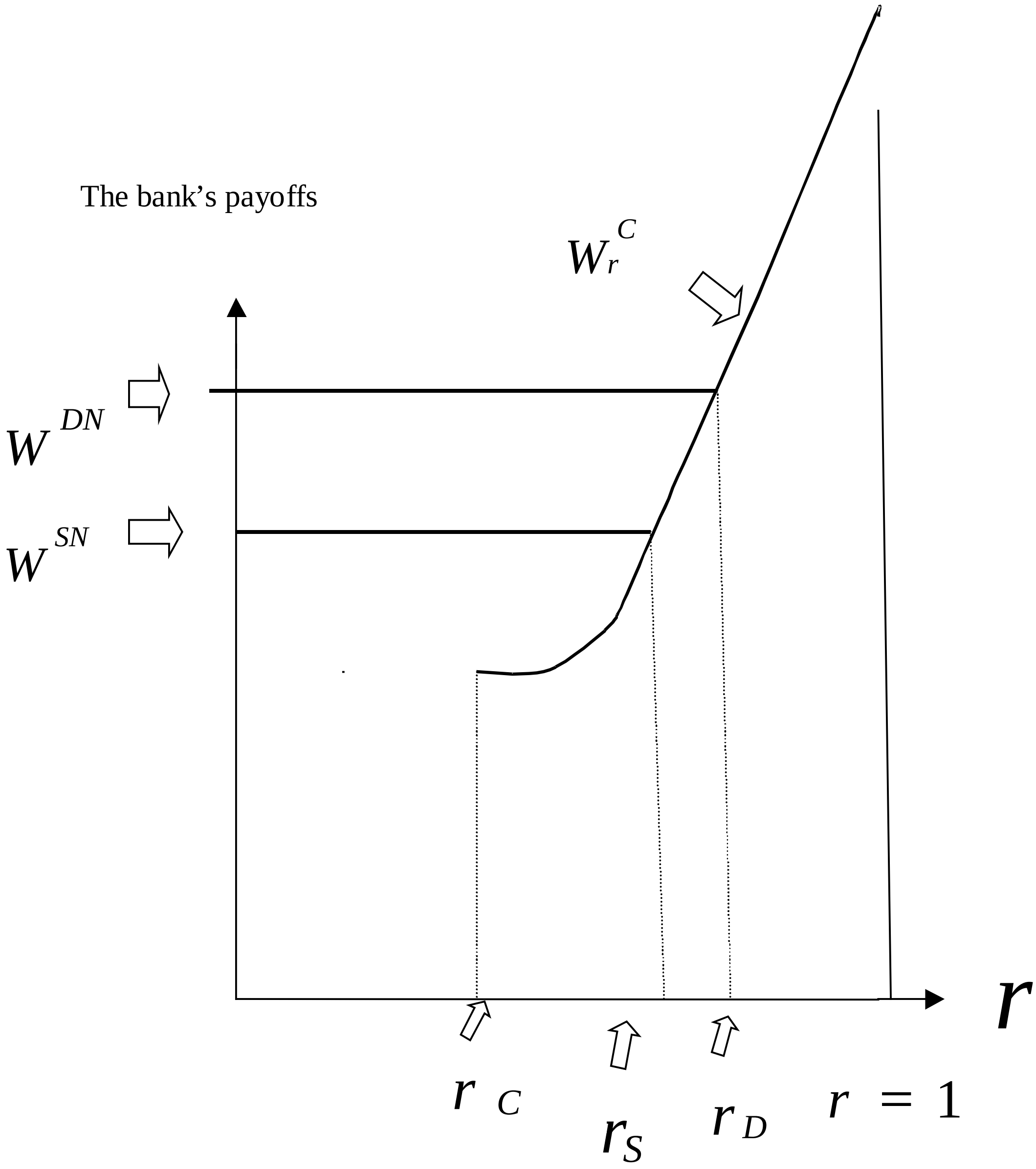


Figure 3 The bank's payoffs with respect to the probability of high land prices in the asymmetric case of land price information

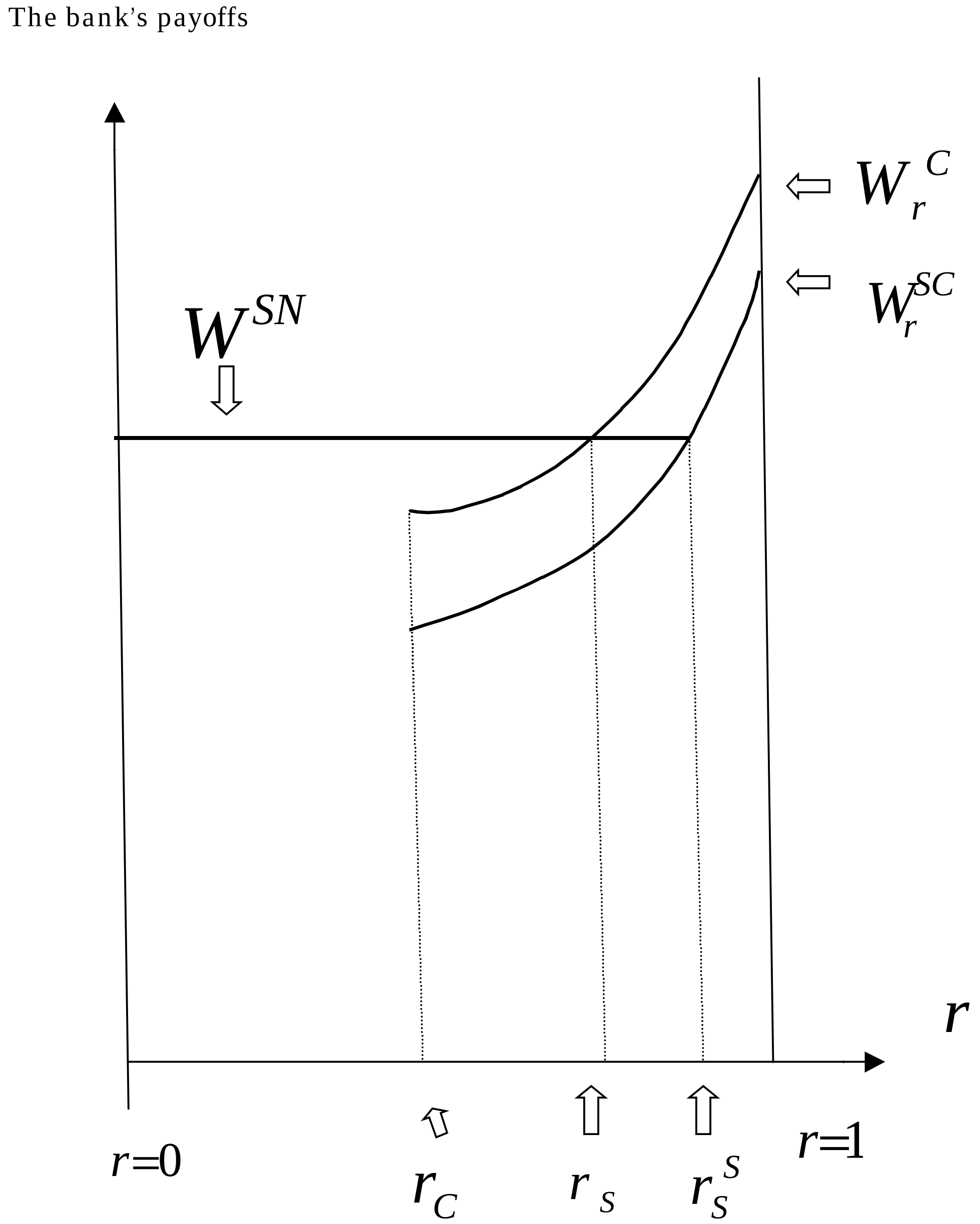


Figure 4
The risky refinancing model

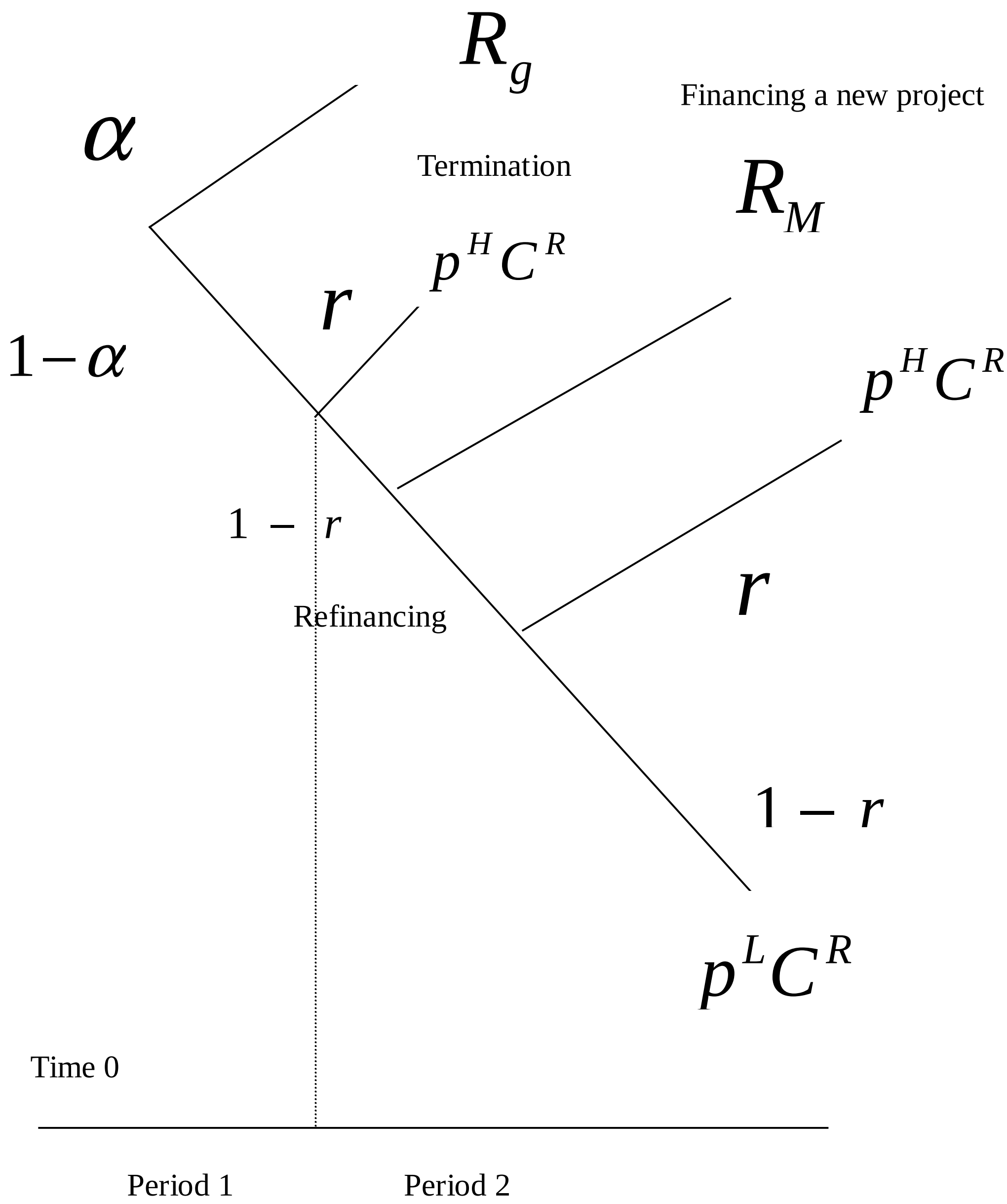


Table 1 Exogenous variables in the model

α: The proportion of "good" projects ($0 < \alpha < 1$)

β: The probability that the firm's effort is rewarded ($0 < \beta < 1$)

δ: The bank's efficiency in setting up collateral ($\delta > 0$)

k: The bank's efficiency in monitoring the firm ($k > 0$)

r: The ex ante probability of high land prices ($0 \le r \le 1$)

p_1^H, p_1^L: The levels of high and low land prices at the end of period 1 respectively ($p_1^H > 1$, $0 < p_1^L < 1$)

R_g, R_p: The bank's share of returns when the project is successful and poor respectively ($R_g > 0$, $R_p > 0$)

B_g, B_p: The firm's private benefits when the project is successful and poor respectively ($B_g > 0$, $B_p > 0$)

E: The costs of the firm's effort ($E > 0$)

Table 2 Summary of the theoretical results

1. The choice of lending pattern in the symmetric case of land price information

(1) The "disciplinary" case ($B_p - \frac{k^2}{2} < B_g - \frac{E}{\beta}$)

Lending pattern	Necessary conditions	Bank's strategy: Payoffs at time 0	Firm's strategy: Payoffs at time 0
Disciplinary collateral lending	$\delta > \delta_D$ $r \geq r_D$	Demanding collateral Terminating at high land price and refinancing at low land price $W_r^C =$ $\alpha R_g + (1-\alpha)\left[\beta R_g + (1-\beta)\left(r p_1^H C^* + (1-r)(R_p + \frac{k^2}{4} - 1)\right)\right] - \mu(C^*) - 1$	Always exerting effort $\alpha B_g + (1-\alpha)\left[\beta B_g + (1-\beta)\left(r(-p_1^H C^*) + (1-r)(B_p - \frac{k^2}{2})\right) - E\right]$
Disciplinary non-collateral lending	(1) $\delta \leq \delta_D$ or (2) $\delta > \delta_D$ $r \leq r_D$	No collateral Always refinancing $W^{DN} =$ $\alpha R_g + (1-\alpha)\left(\beta R_g + (1-\beta)(R_p + \frac{k^2}{4} - 1)\right) - 1$	Always exerting efforts $\alpha B_g + (1-\alpha)(\beta B_g + (1-\beta)(B_p - \frac{k^2}{2}) - E)$

(2) The "SBC" case ($B_p - \frac{k^2}{2} > B_g - \frac{E}{\beta}$)

Lending pattern	Necessary conditions	Bank's strategy: Payoffs at time 0	Firm's strategy: Payoffs at time 0
Disciplinary collateral lending	$\underline{\delta_S} < \delta < \overline{\delta_S}$ $r \geq r_s$	Demanding collateral Terminating at high land price and refinancing at low land price $W_r^C =$ $\alpha R_g + (1-\alpha)\left[\beta R_g + (1-\beta)\left(r p_1^H C^* + (1-r)(R_p + \frac{k^2}{4} - 1)\right)\right] - \mu(C^*) - 1$	Always exerting effort $\alpha B_g + (1-\alpha)\left[\beta B_g + (1-\beta)\left(r(-p_1^H C^*) + (1-r)(B_p - \frac{k^2}{2})\right) - E\right]$
SBC non-collateral lending	(2) $\delta \leq \underline{\delta_S}$ or (2) $\underline{\delta_S} < \delta < \overline{\delta_S}$ $r \leq r_S$	No collateral Always refinancing $W^{SN} =$ $\alpha R_g + (1-\alpha)(R_p + \frac{k^2}{4} - 1) - 1$	Always exerting no effort $\alpha B_g + (1-\alpha)\left(B_p - \frac{k^2}{2}\right)$

2. The choice of lending pattern in the asymmetric case of land price information

(1) The "disciplinary" case ($B_p - \frac{k^2}{2} < B_g - \frac{E}{\beta}$)

The same as the above case

(2) The "SBC" case ($B_p - \frac{k^2}{2} > B_g - \frac{E}{\beta}$)

Lending pattern	Necessary conditions	Bank's strategy: Payoffs at time 0	Firm's strategy: Payoffs at time 0
SBC collateral lending	$\underline{\delta_S} < \delta$ $r \geq r_S^S$	Demanding collateral Terminating at high land price and refinancing at low land price $W_r^{SC} =$ $\alpha R_g + (1-\alpha)\left[r\left(\beta R_g + (1-\beta)(p_1^H C^S)\right) + (1-r)\left(R_p + \frac{k^2}{4} - 1 \right) \right] - \mu(C^S) - 1$	Exerting effort at high land price and no effort at low land price $\alpha B_g + (1-\alpha)\left[r\left(\beta B_g + (1-\beta)(-p_1^H C^S) - E\right) + (1-r)\left(B_p - \frac{k^2}{2} \right) \right]$
SBC non-collateral lending	(1) $\delta \leq \underline{\delta_S}$ (2) $\underline{\delta_S} < \delta$ $r \leq r_S^S$	No collateral Always refinancing $W^{SN} =$ $\alpha R_g + (1-\alpha)(R_p + \frac{k^2}{4} - 1) - 1$	Always exerting no effort $\alpha B_g + (1-\alpha)\left(B_p - \frac{k^2}{2} \right)$

Table 3. The balance sheets of the bank

Assets	Liabilities
Loans	Deposits
	Net worth (capital position)

(a) At time 0

Assets	Liabilities
1	D
	1-D

(b) At the end of period 1

With a state of high land prices

Assets	Liabilities
$p^H C^R$	D
	$p^H C^R - D$

With a state of low land prices

Assets	Liabilities
$p^L C^R$	D
	$p^L C^R - D$

(c) At the end of period 2

With financing of a new project

Assets	Liabilities
$p^L C^R + R_M$	$D+1$
	$p^L C^R + R_M - D - 1$

With refinancing an old project and facing a state of high land prices

Assets	Liabilities
$p^H C^R$	$D+1$
	$p^H C^R - D - 1$

With refinancing an old project and facing a state of low land prices

Assets	Liabilities
$p^L C^R$	$D+1$
	$p^L C^R - D - 1 (< 0)$

With refinancing, facing low land prices, and capital injection by the government

Assets	Liabilities
$D+1$	$D+1$
	0

Table 4. A numerical example of the model's parameters

	α	β	δ	k	p_1^H	p_1^L	R_g	R_p	R_p^*-1	B_g	B_p	E	$B_g - \frac{E}{\beta}$	$B_p - \frac{k^2}{2}$
SBC case	0.5	0.1	1	1	2	0.5	2	0.5	0.75	0.5	1	0.01	0.4	0.5
Disciplinary case (1)	0.5	0.1	1	1	2	0.5	2	0.5	0.75	0.7	1	0.01	0.6	0.5
Disciplinary case (2)	0.5	0.1	1	1.1	2	0.5	2	0.5	0.803	0.5	1	0.01	0.4	0.395

Table 5. Threshold values of δ and r

	δ_D	$\underline{\delta_S}$	$\overline{\delta_S}$	r_E	r_C	r_S	r_S^S	r_D
SBC and disciplinary case (1)	0.833	0.679	1.125	0.135	0.417	0.556	0.679	0.833
Disciplinary case (2)	0.892	0.744	1.344	-	0.446	-	-	0.892

Table 6. The threshold values of r_S for varying values of other parameters

α	r_S
0.45	0.435
0.55	0.670
0.65	0.961

β	r_S
0.05	0.689
0.08	0.627
0.11	0.484

δ	r_S
0.7	0.961
0.9	0.670
0.11	0.435

k	r_S
1	0.556
1.2	0.774
1.4	0.972

Table 7. The difference in the payoffs from committed and SBC collateral lending ($W_r^{CC} - W_r^{SC}$)

$r \setminus \beta$	0.31	0.35	0.45	0.50	0.55
r_B	0.543	0.577	0.682	0.750	0.833
0.6	0.00495	0.0175			
0.7	0.00683	0.0159	0.0392		
0.8	0.00664	0.0124	0.0275	0.0353	
0.9	0.00436	0.0071	0.0144	0.0182	0.0221
1	0.0	0.0	0.0	0.0	0.0

Note: When $r = 1$, $W_r^{CC} = W_r^{SC}$