European Finance Review **7:** 409–435, 2003.

Deposit Collateral and the Role of Banks *

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Abstract. This paper explains the rationale behind deposit collateral that has not been discussed in the literature on financial contracting. In our model extending Hart and Moore (1998) to account for liquidity shocks, deposit collateral has potentially two important effects: the enhancement of pledgeability and the provision of liquidity. We show that only if liquidity shocks are stochastic, both effects are significant and overall efficiency is improved. This improvement is the raison d'être of deposit collateral. The result also establishes a unique role for banks, since deposit collateral can only be taken by these financial institutions. Furthermore, it is shown that the collateral can be implemented in the form of compensating balance requirements with or without commitment loans and is attached with less restrictive efficiency conditions than alternative lending arrangements.

Key words: banks, commitment loans, compensating balance requirement, deposit collateral, incomplete contract, liquidity, pledgeability,

JEL classification numbers: G21, G33

1. Introduction

Loans are often collateralized by some assets, which can be seized in the event of borrower's default. In the literature on financial contracting, collateral is usually considered as a signaling devise of heterogeneous borrowers (Bester, 1985; Besanko and Thakor, 1987; *inter alia*).[1] Although these studies make no distinction between different kinds of assets used as collateral, however, a wide range of real and financial assets are practically used as collateral, including equipment, inventories, automobiles, and securities. Of particular importance is the deposit collateral

* I would like to thank an anonymous referee for his/her useful comments, which contributed to significant improvements. I would also like to thank Nabil Maghrebi, Hidehiko Ishihara, and Simon Benninga (the editor) for their helpful suggestions. Comments by Shoji Kanoh, Shuichi Senbongi, Yoshiro Tsutsui, Yasuo Maeda, and the participants in the Contract Theory Workshop, the Monetary Economics Workshop, and the Thursday Seminar at Osaka University are greatly appreciated as well. An earlier version of this paper was presented at the annual meeting of the Japanese Economic Society (September, 2000).
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[1] For this and other roles of collateral, see Greenbaum and Thakor (1995, pp. 224–239).

(hereafter DC). The importance of DC is apparent in the 2001 "New Basel Capital Accord". The "standardized approach" to minimum capital requirements for banks in this accord accounts for what is defined as "cash on deposit with the lending bank" as one of several eligible collateral instruments that mitigate credit risk.[2] Deposits are sometimes used explicitly as collateral, as in the U.S. for example, where collateral in the form of business securities or deposits accounted for about ten to twenty percent of total loan collaterals by small businesses in 1998.[3] Deposits are deemed to be among the preferred assets to collateralize with in Japan, since they are less costly and easier to manage or liquidate.[4] The implicit use of deposit as collateral is also observed in case of defaults, where deposits by borrowers are often used to offset shortages in repayment.

Theoretically, however, the use of deposit as collateral remains difficult to justify. Under the assumptions of the agency theory of financial contracting or the pecking order theory of capital structure, it is more advantageous for borrowers to finance investments with internal rather than external funds, as the latter may result in agency problems due to asymmetric information. How to explain then the acceptance by borrowers of the requirement to keep DC funds instead of using them for investment financing? What is the rationale behind DC? Are there strong incentives for both banks and borrowers to make such agreements? And why should deposits be made in lending banks?

This paper is an attempt to demonstrate the usefulness of DC. It is demonstrated that contractual incompleteness and the presence of liquidity shocks constitute key factors in explaining the role of DC. We show that DC can mitigate inefficiency deriving from these problems, since it may not only enhance *pledgeability* but also provide *liquidity*. It is in this general framework that all of the questions raised above can be answered.

Our methodological approach is comparable to the theoretical setting by Hart and Moore (1998). In their model, the debtor faces a profitable investment opportunity but is short of funds, while the creditor has funds and no investment opportunity. Due to the incompleteness of contracts, they cannot make a binding agreement that forces the former to make repayments to the latter, so that the profitable investment project would not be carried out at all.[5] Such an inefficient outcome can be prevented by assigning to the creditor the right to liquidate the debtor's assets on default, thereby guaranteeing repayments up to the liquidation value. Even in the presence of this right, however, inefficiency can still remain. If debtor's assets are of little value, for example, repayments are insufficient after all

[2] See Bank for International Settlements (2001).

[3] According to statistics from the Survey of Small Business Finances (SSBF) in 1998, business securities or deposits consisted of 12.7, 21.5, 14.3, 15.4 and 11.6 percent of all the collateral for business purpose loans in the form of lines of credit, mortgages, motor vehicles, equipment and other loans, respectively.

[4] See Kinyu Tosho Consultant Inc. (1989).

[5] Similar results are obtained in Bolton and Scharfstein (1990).

and there is a shortage of pledgeability. In this case, no funds are offered, even if the project itself is profitable. This is called *ex ante* inefficiency.

In the present paper, an additional source of inefficiency is introduced. We draw attention to liquidity shocks, which are not considered in Hart and Moore's (1998) framework. In the model presented below, a stochastic liquidity shock may take place following the initial investment. In case of the shock occurrence, if a debtor does not have enough liquidity, the project is automatically terminated and no proceeds are received. However, it may be the case that the debtor cannot effectively be committed to making sufficient repayments so as to be able to borrow free cash to prepare against the shock. In this case, inefficient termination, or *interim* inefficiency occurs.

It is under these conditions that we demonstrate the important role of DC. We define DC as the funds retained by the creditor that may not only be pledged in the event of default but also be paid out upon liquidity shock occurrence. Since it can be pledged, *ex ante* inefficiency might be mitigated. If a debtor is not committed to making enough repayments due to the lack of pledgeability, DC indeed enhances it. This is the "pledgeability enhancement" effect of DC. Thus, it might seem at first glance that DC can improve efficiency only on this ground.

However, the result is not so simple. We can show that in the absence of any liquidity shocks or in the event of deterministic ones, the inefficiency that is present without DC cannot be reduced. Indeed introducing DC enhances the debtor's pledgeability in these cases. In order to make additional DC, however, incremental amounts of funds need to be raised. This requires additional pledgeability. Thus, there is no *net* increase in pledgeability. In other words, although DC can indeed enhance pledgeability, the enhancement is always less than that required for efficiency to be improved in a deterministic world. This implies that the usefulness of DC cannot be explained in the original setting of Hart and Moore (1998).

We can show, however, that DC *can* improve efficiency if the liquidity shock is stochastic. Even in this case, the direct effect of DC to enhance pledgeability is still insufficient to improve efficiency. If a stochastic liquidity shock is present, however, there is another indirect effect: If enough funds can be raised to meet the liquidity needs, interim inefficiency is prevented. This allows us to achieve a node that would not have been otherwise reached. Thus the debtor can utilize the pledgeability in this node as well. This is the "liquidity provision" effect of DC. In the presence of both direct and indirect effects, the overall enhancement of pledgeability with DC can be sufficient to improve efficiency. The core of the paper is to characterize the conditions under which DC improves efficiency.

We then show that the results of this paper also have important implications for the role of banks.[6] A deposit collateral can only be provided by financial institutions that can offer both depository and lending services at the same time, that

[6] For existing studies on the role of banks, see, for example, Bhattacharya and Thakor (1993) and Freixas and Rochet (1997).

is, *banks*. Thus, the improvement of efficiency explained in this paper is achieved exclusively by banks. In this sense, the present study emphasizes the unique role of banks. Moreover, since the model develops from the assumption of incomplete contracts, the present paper is a strand of the incomplete contract theory of banking, the usefulness of which is stressed by Rajan (1998)

Finally, we compare DC with other lending arrangements or covenants. It is demonstrated that DC in the present paper can also be interpreted as a compensating balance requirement, which is one of the common agreements attached to bank loans. This implies that the common form of lending practice can be simply interpreted as another way of DC implementation. We will also show that alternative arrangements such as additional lending without pre-commitment or minimum liquidity ratio cannot attain as much efficiency as DC does. This result demonstrates that DC is more valuable an instrument than alternative arrangements.

The remainder of the paper is structured as follows. In the next section, the general setting of the model is presented. Sections 3 and 4 characterize the problem and derive the efficiency conditions without and with DC, respectively. Section 5 discusses the main results of this paper. The cases with and without DC are compared to demonstrate the conditions under which DC becomes valuable. The implications of the results for the role of banks are also demonstrated in this section. Section 7 compares DC with other lending arrangements. Finally, Section 8 concludes the paper.

2. Model

2.1. INVESTMENT PROJECT

The present model is a variant of Hart and Moore's (1998) "diversion model". An entrepreneur (debtor, hereafter D) has an investment project, which lasts two periods. It requires investment funds I at date 0 to finance the purchase of one unit of assets. The project returns $R_t > 0$ per unit of assets at date $t = 1, 2$. There is no discounting of cash flows and the assumption is made that

$$R_1 + R_2 > I - w,$$

so that the project should be carried out. Given this assumption, if for some reasons the project cannot be financed, then it is the case of *ex ante inefficiency*.

During period 1, D may face a need for liquidity. With probability l, D has to pay K in addition to I to a third party. If D cannot pay, the assets are not installed and the project is automatically terminated with no payoffs for either agent. We assume that $l \in (0, 1]$ and $K \geq 0$. That is, we represent the case of no liquidity shock not by $l = 0$ but by $K = 0$.[7] In what follows, $\kappa = 1$ $(= 0)$ means that the

[7] This is a technical assumption just for ease of exposition. Even if we allow $l = 0$, we can show that the results are the same as when $K = 0$.

liquidity shock does (does not) take place. We assume that the presence or absence of the liquidity shock remains as private information for D.

To exclude irrelevant cases,

$$R_1 + R_2 > I - w + lK \tag{1}$$

will be assumed throughout the paper. That is, in an *ex ante* sense the project is profitable enough even if K is paid out. We also assume that the termination of the project is unprofitable *ex post*.

$$R_1 + R_2 > K. \tag{2}$$

From these assumptions, it is socially efficient to avoid interim termination. If D cannot pay K, *interim inefficiency* prevails.

At date 1, the assets installed during period 1 can be liquidated. If liquidation occurs, the assets are sold and yield L per unit of assets. What is important is that if the assets are totally liquidated at date 1, the return R_2 at date 2 will be completely lost. Following Hart and Moore (1998), we assume for expositional simplicity that the assets have no liquidation value at date 2.

Since the assets are divisible, partial liquidation is also feasible. Denote by $g \in [0, 1]$ the unit of assets that remains just before date 2 return is realized. In other words, a proportion $1 - g$ of the assets are liquidated by date 2. Then, date 1 and date 2 returns from the project will be R_1 and gR_2, respectively. The liquidation value $(1 - g)L$ is also obtained at date 1.

We assume that continuation at date 1 is socially desirable.

$$R_2 > L. \tag{3}$$

Under this assumption, liquidation, even a partial one, is socially inefficient. Unless $g = 1$, *ex post inefficiency* is present.

We also assume that

$$R_1 + R_2 > L + K. \tag{4}$$

This inequality insures that it is in D's benefit to continue the project when $\kappa = 1$, the exact meaning of which is shown in Section 7.2.

2.2. CONTRACT AND RENEGOTIATION

The debtor has an initial wealth w. Since $w < I$, however, D must raise funds from a creditor (hereafter C). The contract and renegotiation game proceeds as follows (see Figure 1). In order to cope with the liquidity shock, D will borrow funds to the extent of $B \geq I - w$ at date 0. For notational simplicity, we define $T \equiv B - I + w \geq 0$ as the amount that D borrows in excess of initial investment requirements in order

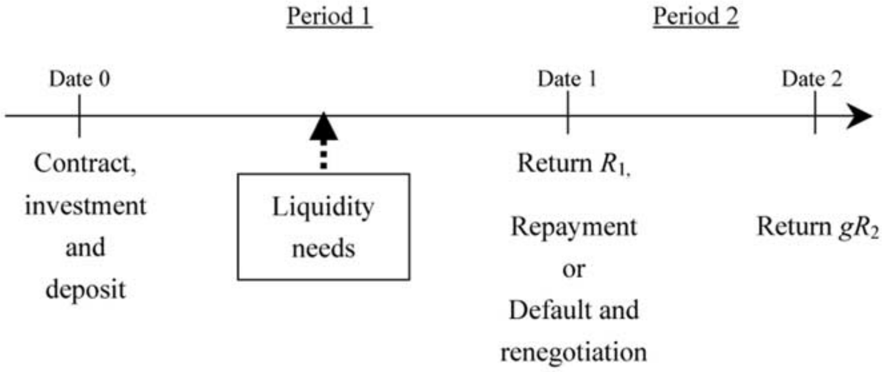

Figure 1. Sequence of events.

to be injected in case of shock occurrence.[8] Following Hart and Moore (1998), T is "nonrecourse Financing". We assume that D cannot be committed to the non-diversion of T by any contractual means. If C is a bank, however, all or part of T can be retained as deposit collateral (DC), which is represented by S ($\in [0, T]$). In case of default, C can recover this value. A more detailed characterization of DC will be given in Section 4.

The returns R_1 and R_2 first accrues to D. In order to make repayments to C, therefore, D must design a payback agreement, or contract at date 0. However, the debtor can divert the project returns R_t and the nonrecourse financing T. Thus, the contractual arrangement must give D an appropriate incentive to make repayments. The returns R_1 and R_2, as well as the liquidation value L are not verifiable by outsiders. This feature excludes them from being written in any contract. Therefore, without DC arrangements, contracts can only specify the total amount of loans $I - w + T$ made at date 0 and the promised repayments P at date 1.

Under the contractual terms, if interim termination is avoided and R_1 is realized at date 1, the default and renegotiation decisions follow. First of all, D has to repay P at date 1. Instead of making such repayments, however, D can default and make a take-it-or-leave-it renegotiation offer to C. If the offer is accepted, payments are made and the project continues. In case of rejection, C obtains the liquidation value of the remaining assets and D obtains all the residual cash holdings. This result follows from the "diversion" assumption.

In order to make original or alternatively newly agreed upon repayments at date 1, D can liquidate any portion of the assets. The debtor can do so without C's approval. However, since inequality (3) is assumed and D has all the bargaining power in finalizing the contract, D will try to avoid liquidation and make repayment using cash holdings.

[8] To prevent interim termination, alternative arrangements are also possible. By not lending excess cash in advance, for example, it is possible for C to make additional lending only after the state $\kappa = 1$ is realized. We will compare such arrangements with the current one in Section 7.2 and show that the latter is more useful.

In the following, however, we will focus on the case in which partial liquidation is unnecessary and *ex post* inefficiency does not matter. For this purpose, we assume that R_1 is sufficiently large.[9] This assumption is made for the sake of simplicity because DC never improves *ex post* efficiency. Allowing for small values for R_1 overshadows the main points of this paper, while it is possible to demonstrate that DC improves overall efficiency even in the absence of this assumption.

At date 2, D will not pay anything to C. This is due to the assumption that the assets are of no liquidation value at date 2. However, as in Hart and Moore, this is without loss of generality in the analysis.[10]

3. Contracting without Deposit Collateral

3.1. DEBTOR'S DEFAULT DECISION

We first solve the problem without DC backward. Suppose that there was no interim termination. Given P, D then decides whether to default or not. In case of default, D makes a take-it-or-leave-it offer which preserves L for C, since otherwise C rejects the offer and the second period return is ruined. The creditor accepts the offer and obtains L. If D does not default, on the other hand, C's revenue is P.

Since D's payoff is negatively correlated to C's, D will make repayments if

$$P \leq L.$$

If $P > L$, D will default. In summary, C receives $\hat{P} \equiv \min\{P, L\}$.

Given assumption (3), D tries to pay $\hat{P}$ as much as possible from cash holdings, which consist of the remaining amount of excess cash borrowed at date 0 and the first period return R_1. Since the former depends on κ, it is denoted as $T_1(\kappa)$, the exact value of which is to be calculated below. If $T_1(\kappa) + R_1$ is not enough to cover the repayments $\hat{P}$, D will liquidate the assets. That is, *ex post* inefficiency prevails.

However, given the simplifying assumption that R_1 is large enough, we can focus on the case in which *ex post* inefficiency does not matter, $\hat{P} \leq T_1(\kappa) + R_1$. In this case, D pays $\hat{P}$ from $T_1(\kappa) + R_1$ and obtains the remaining cash of $T_1(\kappa) + R_1 - \hat{P}$ and date 2 return R_2. There is no liquidation ($g = 1$).[11]

[9] For example, $R_1 > K + L$ suffices. See Section 3.1.

[10] In Hart and Moore (1998), there is a reinvestment opportunity available for D. Its rate of return between dates 1 and 2 is s where $s \in [1, R_2/L]$. Although only the case $s = 1$ is considered in this paper, the results are qualitatively the same as in other cases.

[11] It is possible to consider the case in which R_1 is not sufficient and $\hat{P} > T_1(\kappa) + R_1$. In this case, D cannot pay $\hat{P}$ from its cash holdings and D partially liquidates the assets so as to make repayments. The analysis is complicated as R_2 does not necessarily realize fully.

3.2. LIQUIDITY NEEDS

From assumption (4), D has an incentive to continue the project when a liquidity shock takes place. In order to do so, D has to hold free cash. If $T \geq K$, on one hand,

$$T_1(1) = T - K,$$

and

$$T_1(0) = T.$$

If on the other hand D is short of cash ($T < K$), then $T_1(0) = T$ and the project is terminated if $\kappa = 1$.

3.3. CONTRACT DESIGN

Based on the discussion thus far, D solves the following problem at date 0.

$$\max_{P,T} \quad J(T)l(R_1 + T - K - \min\{P, L\} + R_2) + (1 - l)(R_1 + T - \min\{P, L\} + R_2), \tag{5}$$

$$\text{subject to} J(T)l \cdot \min\{P, L\} + (1 - l) \cdot \min\{P, L\} \geq T + I - w, \tag{6}$$

where

$$J(x) \equiv \begin{cases} 1 \text{ if } x \geq K, \\ 0 \text{ if } x < K. \end{cases}$$

The debtor's expected profit is represented by (**??**). It consists of all cash flows net of all repayments including those due to the liquidity shock, if any. No profit is obtained, however, if $T < K$ in case of shock occurrence. Inequality (6) represents C's participation constraint, which means that the repayments up to the amounts pledgeable must cover the total funds borrowed.

3.4. EFFICIENCY CONDITIONS WITHOUT DEPOSIT COLLATERAL

3.4.1. *Types of efficiency*

The role of DC is best demonstrated by its mitigating effects on inefficiency. Based on the assumptions made in Section 2, it is shown that there are potentially two kinds of inefficiency.[12]

[12] Under the simplifying assumption made before, we do not consider the case in which *ex post* inefficiency takes place.

- *Ex ante inefficiency* (the project is not financed).
- *Interim termination* (D cannot pay K when $\kappa = 1$).

Ex ante inefficiency takes place if the participation constraint cannot be satisfied. This may happen when D cannot guarantee enough repayments to C due to the incompleteness of contract. Even if D promises to make sufficient repayments, it is *ex post* beneficial for D to default and request reduction of repayments. The creditor rationally expects this and rejects the initial contract. Thus a socially beneficial project may not be financed if L is small.

Interim termination takes place if D cannot borrow K in excess of $I - w$. Under assumptions (1) and (2), the project should be continued even if $\kappa = 1$. In order to do so, D must have cash at least to the extent of K. However, borrowing $T \geq K$ in addition to $I - w$ requires more pledgeability than borrowing only $I - w$. If pledgeability is sufficient to borrow $I - w$ but not to the extent of $T \geq K$, interim termination can take place, even if *ex ante* efficiency is achieved.

In the following, we will formally derive the efficiency conditions when DC is not available. These conditions are to be compared in Section 5.1 with those when DC is available.

3.4.2. Ex ante *efficiency*

From the participation constraint, the condition for *ex ante* efficiency (*Ex Ante* Efficiency Condition) is as follows.

[EAEC] There exist P and $T \geq 0$ such that inequality (6) holds.

This condition must be satisfied because the expected profit of C would be negative otherwise. Since the expected revenue of C (the left-hand side of Equation (6)) jumps at $T = K$, it is convenient to examine the different cases where $T \in [0, K)$ and $T \geq K$ separately.

A. *Ex ante* efficiency for $T \in [0, K)$

In this case, Equation (6) can be rewritten as

$$(1 - l) \cdot \min\{P, L\} \geq T + I - w. \tag{7}$$

It can then be shown that when

$$(1 - l)L \geq I - w, \tag{8}$$

there exist $P \geq 0$ and $T \in [0, K)$ such that Equation (7) holds. This inequality is the reduced form condition for C to participate in this contract for $T \in [0, K)$. The left-hand side of inequality (8) represents the maximum possible amount that D can be committed to making repayment of. Due to the incompleteness of contracts, C is guaranteed repayments only up to L. Furthermore, as $T \in [0, K)$, no repayments are made if the liquidity shock takes place. Thus the maximum amount of repayments is $(1 - l)L$. Inequality (8) means that the maximum of repayments is sufficient to cover the funds borrowed.

B. *Ex ante* efficiency for $T \geq K$

In this case, Equation (6) can be rewritten as

$$\min\{P, L\} \geq T + I - w. \tag{9}$$

As with Equation (7), it can be shown that there exist $P \geq 0$ and $T \geq K$ that satisfy (9) when the following reduced form condition for C to participate in the contract holds.

$$L \geq K + I - w. \tag{10}$$

Again, the left-hand side of inequality (10) represents the maximum of C's revenue, which is equal to the maximum possible amount D can be committed to making repayment of. As $T \geq K$, repayments are made irrespective of whether $\kappa = 1$ or $\kappa = 0$. Inequality (10) implies that the maximum revenue is greater than the minimum amount borrowed (when $T = K$).

3.4.3. *Interim continuation*

We then proceed to derive the condition for interim continuation. When $\kappa = 1$, the condition (No Interim Termination Condition) is expressed as follows.

[NITC]

$$T \geq K.$$

If this inequality fails to hold, D will not be able to pay K and the project will be terminated when $\kappa = 1$, even if Equation (6) holds for some P and $T \geq 0$ and the project is duly financed.

The reduced form condition for interim continuation is easy to obtain as it only requires the satisfaction of [EAEC] and [NITC] simultaneously. We have already shown above that this is possible if and only if inequality (10) is satisfied.

We can summarize, at this level of analysis, the conditions under which different events are bound to take place.

- If inequality (10) holds! *Ex ante* efficiency, no interim termination.
- If inequality (8) holds but inequality (10) does not! *Ex ante* efficiency, interim termination. Note that in this case, the subgame in which $\kappa = 1$ is off the equilibrium path.
- If neither inequality (8) nor inequality (10) holds! *Ex ante* inefficiency.

4. Deposit Collateral

4.1. CHARACTERIZATION OF DEPOSIT COLLATERAL

Now suppose that C can take deposits, or C is a bank. Then C and D can use DC represented by S ($\in [0, T]$), which must be retained as D's deposits in C. As a description of actual agreements, it is formally characterized as follows. First, we suppose that C can seize DC if D declares default and renegotiation fails at date 1. This can be called the "pledgeability enhancement" property of DC. This assumption reflects the fact that DC is nothing but collateral.

Second, we suppose that DC can be paid out when D has to make payments to other parties. In other words, it can be withdrawn when a liquidity shock takes place during period 1. This can be called the "liquidity provision" aspect of DC. This supposition is justified since it is in D's personal deposit account with C that DC is maintained.

However, since it is not observable for C whether the liquidity shock takes place indeed, D has an incentive to withdraw and divert DC even when no liquidity shock takes place. Thus, it is impossible for C to limit withdrawal exclusively on the shock occurrence.

Nevertheless, if $T \geq K$ and $T-S \geq K$, C knows that D can cope with the shock without withdrawing DC and will deny such withdrawal. Moreover, if $T < K$, C knows that even by withdrawing DC, D cannot cope with the shock. Thus, C will deny withdrawal to preserve the collateral. Thus it is only in the case of $T \geq K$ and $T - S < K$ that C cannot discern whether D is requesting withdrawal when $\kappa = 0$ or $\kappa = 1$. Still, even in this third case, it is plausible to assume that C may allow for withdrawal. Formally we assume that the allowance decision is socially desirable with probability $a \in [0, 1]$. That is, if withdrawal is requested when $\kappa = 1$, it is allowed with probability a, while if requested when $\kappa = 0$, it is allowed with probability $1 - a$. Since we are assuming that D has all the bargaining power, upon allowance decision by C, D withdraws S, the maximum possible amount that can be withdrawn.

It may be asked why the bank's decision on whether to allow withdrawal is being modeled exogenously as a random strategy that coincides with some "socially efficient" value instead of the bank's own best choice. This model can be thought of as a simplified version of a more elaborate model in which the bank has private access to information signals correct with probability a about whether the liquidity shock occurred. Based on these signals, the bank can endogenously decide whether to allow withdrawal or not. Since banking practices are based on close relationships with borrowers, the assumption of banks obtaining some informative signals is plausible. It is also reasonable because the funds to cope with liquidity shocks are usually transferred from the borrower's deposit account in the bank itself. This enables the bank to identify the recipients of the funds transfers, which may lead to the efficient allowance/rejection decisions.

In the elaborate model, it is necessary to examine in more details the bank's incentive compatibility constraints that ensure the "efficient" decision. The bank may have an incentive to prohibit withdrawal even when the signal shows that the shock has occurred. This is the case when the bank's private benefit from retaining pledgeability exceeds the private cost from interim termination. Also, the bank may have an incentive to allow withdrawal even when the signal suggests the absence of the shock. This happens when the bank's private benefit from preventing interim termination exceeds the private cost from the deterioration in pledgeability. The incentive compatibility constraints that avoid this socially inefficient behavior indeed limit to some extent the usefulness of DC under certain parameter conditions. However, despite these limitations, it can be demonstrated that these constraints are slack and DC is still valuable in other general parameter conditions.[13] Thus in order to avoid further complexity in the exposition below, we will focus only on the simplified model.

4.2. DEBTOR'S DEFAULT DECISION

Now let us solve the problem in the same way as Section 3. Consider first the date 1 decisions following the interim continuation. Due to the possibility of the liquidity shock and DC being withdrawn, the full amount of S may not be pledged at date 1. Let $\eta = 1$ ($\eta = 0$) denote the state of nature in which DC is (is not) withdrawn. Denote by $S(\eta)$ the amount of DC that can be pledged effectively at the renegotiation stage. Then, C's revenue in the renegotiation stage becomes

$$L^{\mathrm{DC}}(\eta) = L + S(\eta).$$

If D makes repayments on the other hand, C's revenue will be limited to P. In summary, C receives $\hat{P}^{\mathrm{DC}} \equiv \min\{P, L^{\mathrm{DC}}(\eta)\}$.

The exact value of $S(\eta)$ is derived as follows. When $\eta = 0$, on one hand, it is easily shown that $S(0) = S$. When $\eta = 1$, on the other hand, the amount to be withdrawn is S and $S(1) = 0$. Note that $L^{\mathrm{DC}}(\eta)|_{S=0} = L$ for $\eta = 0, 1$. Note also that the possible benefit of introducing DC is evident. Since $L^{\mathrm{DC}}(\eta)$ weakly increases with S for $\eta = 0, 1$, DC can enhance pledgeability.

As is the case without DC, D tries to pay $\hat{P}^{\mathrm{DC}}$ from the first period return R_1 plus the remaining amount of cash flow borrowed at date 0. As before, we will focus on the case in which partial liquidation does not happen.

4.3. LIQUIDITY NEEDS AND WITHDRAWAL REQUEST

Next, we focus on C's decision about whether to permit DC withdrawal. First, if $T \geq K$ and $T - S \geq K$, C knows that D can cope with the liquidity shock

[13] Indeed it is still possible to show that under the conditions specified in example 1 below, these incentive compatibility constraints are slack.

even without having to withdraw DC. Thus C rejects any request of withdrawal and $\eta = 0$ is obtained. Second, if $T < K$, C knows that D cannot cope with the liquidity shock even by withdrawing DC. In this case, C rejects D's withdrawal request and tries to retain as much collateral as possible. Thus we obtain $\eta = 0$. Finally, if $T \geq K$ and $T - S < K$, C does not know whether $\kappa = 0$ or $\kappa = 1$. Upon D's request of withdrawing S, DC is withdrawn with probability a if $\kappa = 1$ and with $1 - a$ if $\kappa = 0$.

Let us turn to D's decision about whether to request withdrawal or not. Since D knows whether $\kappa = 0$ or $\kappa = 1$, denote the probability of the withdrawal ϕ_κ. If $T \geq K$ and $T - S \geq K$, or $T < K$, D knows that any request will be rejected. Since D is then indifferent whether to request or not, we assume that $\phi_\kappa = 0$ for $\kappa = 0, 1$. If $T \geq K$ and $T - S < K$, irrespective of whether $\kappa = 0$ or $\kappa = 1$, it is optimal at this stage to request the withdrawal of S, since it may decrease C's pledgeability and D may have to pay less. This means that $\phi_0 = \phi_1 = 1$ in this case.

4.4. CONTRACT DESIGN

We can summarize the results obtained thus far as follows.

1. If $T \geq K$ and $T - S < K$

If $\kappa = 1$, on one hand, D requests withdrawal of S, or $\phi_1 = 1$. With probability a, the request is accepted and the project continues. By paying K out, the amount of D's cash holdings is $T - K$. Thus, the amount to be pledged is $L^{\mathrm{DC}}(1) = L$. With probability $1 - a$, the request is rejected. Due to the shortage of liquidity, the project is bound to be terminated.

If $\kappa = 0$, on the other hand, D requests withdrawal of S and $\phi_0 = 1$. With probability $1-a$ the request is accepted. The amount of D's cash holdings becomes T. This implies that the amount of pledgeability becomes $L^{\mathrm{DC}}(1) = L$. With probability a, the request is rejected. The amount of D's cash holdings does not change and is $T - S$. In this case, D can be committed to making repayments of $L^{\mathrm{DC}}(0) = L + S(0) = L + S$.

2. If $T \geq K$ and $T - S \geq K$

If $\kappa = 1$, D does not request any withdrawal, or $\phi_1 = 0$. By paying K out, the amount of D's cash holdings becomes $T - S - K$. The amount pledgeable is $L^{\mathrm{DC}}(0) = L + S(0) = L + S$. If $\kappa = 0$, D does not request any withdrawal either and $\phi_0 = 0$. The amount of D's cash holdings becomes $T - S$. In this case, $L^{\mathrm{DC}}(0) = L + S(0) = L + S$ is the amount pledgeable for C.

3. If $T < K$

If $\kappa = 1$, D does not request any withdrawal, or $\phi_1 = 0$. Due to the shortage of liquidity, the project is terminated. If $\kappa = 0$, D does not request any withdrawal either and $\phi_0 = 0$. The amount of D's cash holdings becomes $T - S$. The amount of pledgeability is $L^{DC}(0) = L + S(0) = L + S$.

Given these results, D's problem at date 0 can now be stated as follows.

$$\begin{aligned}\max_{P,T,S} \quad & \Big[J(T)(1 - J(T - S))la + J(T)(1 - J(T - S))(1 - l)(1 - a) \Big] \\ & \cdot \Big\{ R_1 - \min\{P, L\} + R_2 \Big\} \\ & + \Big[J(T)(1 - J(T - S))(1 - l)a + J(T)J(T - S)l \\ & + \{J(T)J(T - S)(1 - l) + (1 - J(T))(1 - l)\} \Big] \\ & \cdot \Big\{ RR_1 + T - S - \min\{P, L + S\} + R_2 \Big\}, \end{aligned} \tag{11}$$

$$\begin{aligned}\text{subject to} \quad & \Big[J(T)(1 - J(T - S))la + J(T)(1 - J(T - S))(1 - l)(1 - a) \Big] \\ & \cdot \min\{P, L\} \\ & + \Big[J(T)(1 - J(T - S))(1 - l)a + J(T)J(T - S)l \\ & + J(T)J(T - S)(1 - l) + (1 - J(T))(1 - l) \Big] \\ & \cdot \min\{P, L + S\} \geq T + I - w, \end{aligned} \tag{12}$$

and

$$0 \leq S \leq T, \tag{13}$$

where

$$J(x) = \begin{cases} 1 \text{ if } x \geq K, \\ 0 \text{ if } x < K. \end{cases}$$

Equation (11) is D's expected revenue and inequality (12) is the corresponding participation constraint for C. Both expression depend on (i) whether the liquidity shock is present or not (with probability l or $1 - l$), (ii) whether $T \geq K$ or $T < K$ ($J(T) = 1$ or 0), (iii) whether $T - S \geq K$ or $T - S < K$ ($J(T - S) = 1$ or 0) and (iv) whether C can allow withdrawals in an efficient way or not (with probability a or $1 - a$). Inequality (13) is the feasibility condition for DC.

4.5. EFFICIENCY CONDITIONS WITH DEPOSIT COLLATERAL

The efficiency conditions when DC is present can be derived following the same approach as the analysis of the contract in its absence.

4.5.1. Ex ante *efficiency*

The participation constraint is now expressed as (12). Therefore the *ex ante* efficiency condition is

> **[EAEC']** There exist $P \geq 0$, $T \geq 0$ and $S \in [0, T]$ such that Equation (12) holds.

Since C's expected profit depends on $J(T)$ and $J(T - S)$, it is convenient to examine the following three cases depending on the relative value of T.

A. *Ex ante* efficiency for $T \in [0, K)$
In this case, $J(T) = J(T - S) = 0$ and Equation (12) can be rewritten as follows.

$$(1 - l) \cdot \min\{P, L + S\} \geq T + I - w. \tag{14}$$

It is easy to show that we can find $P, T \in [0, K)$ and $S \in [0, T]$ to satisfy (14) if and only if

$$(1 - l)L \geq I - w. \tag{15}$$

Interestingly, this condition is identical to that without DC (inequality (8)).

B. *Ex ante* efficiency for $T \in [K, K + S)$
In this case, $J(T) = 1$ and $J(T - S) = 0$. Thus, Equation (12) can be rewritten as follows.

$$\begin{aligned} la \;\cdot\; & \min\{P, L\} + (1 - l)a \cdot \min\{P, L + S\} \\ & + (1 - l)(1 - a) \cdot \min\{P, L\} \geq T + I - w. \end{aligned} \tag{16}$$

We can show that if and only if

$$(1 - l(1 - a))L - (1 - (1 - l)a)K \geq I - w, \tag{17}$$

there exist $P, T \in [K, K + S)$ and $S \in [0, T]$ such that condition (16) holds. The difference between inequalities (10) and (17) is the key to understanding the significance of the results in this paper. Therefore, we will interpret (17) and discuss the difference fully in Section 5.1. There we will show that it is if and only if inequality (**??**) holds but inequality (17) does not that DC can be valuable.

C. *Ex ante* efficiency for $T \geq K + S$

In this case, $J(T) = J(T - S) = 1$ and Equation (12) can be rewritten as follows.

$$l \cdot \min\{P, L + S\} + (1 - l) \cdot \min\{P, L + S\} \geq T + I - w. \tag{18}$$

For P, $T \leq K + S$ and $S \in [0, T]$ to exist so as to satisfy (18), the following inequality must hold.

$$L \geq K + I - w. \tag{19}$$

Again, this condition is the same as inequality (10) obtained in the absence of DC.

4.5.2. *Interim continuation*

The condition for interim continuation when $\kappa = 1$ is as before expressed by

[NITC']

$T \geq K$.

Thus, inequality (17) or (19) represents the reduced form condition for interim continuation.

We can summarize the results obtained so far as follows.

- If inequality (17) or (19) holds! *Ex ante* efficiency, no interim termination.
- If inequality (15) holds but neither inequality (17) nor (19) does! *Ex ante* efficiency, interim termination.
- If neither inequality (15), (17) nor (19) holds! *Ex ante* inefficiency.

5. The Role of Deposit Collateral

5.1. LIQUIDITY PROVISION AND PLEDGEABILITY ENHANCEMENT

The role of DC is shown to be significant if efficiency can be improved through its introduction. This is clearly demonstrated when one of the efficiency conditions derived in Section 3.4 does not hold whereas the corresponding condition derived in Section 4.5 holds.

First, we can show the following as a preliminary result.

For $T \in [0, K)$, when the participation constraint cannot be satisfied without DC (inequality (8) fails to hold), it will not be satisfied with it either.

Proof. Obvious from the fact that inequality (15) is the same as (8). □

This result is highlighted by focusing on the case that D sets $T = 0$, in which D's indebtedness and required pledgeability are at minimum. If inequality (8) does not hold, D must enhance pledgeability by at least $I - w - (1 - l)L$. This is impossible, however, since S must be equal to zero as $T = 0$. Then what if D pledges $S \geq I - w - (1 - l)L$ by borrowing more ($T \geq I - w - (1 - l)L$)? In this case, not only the amount of pledgeability but also the amount D needs to repay increases. For all $T \in [0, K)$, the increased pledgeability ($(1 - l)T$ at most) is always less than the increase in repayments (T). Thus, it is impossible for D to pledge enough for C to participate.

The result implies that the mere enhancement of pledgeability is not enough for DC to be valuable. Indeed DC has the pledgeability enhancement effect. However, it is always insufficient to improve efficiency.

Nevertheless, we can show that for $T \geq K$, there is an additional effect in introducing DC. The next result shows that due to this effect DC can be indeed valuable under certain conditions.

PROPOSITION 2. If and only if (17) holds and (10) does not, so that

$$(1 - l(1 - a))L - (1 - (1 - l)a)K \geq I - w > L - K, \tag{20}$$

the efficiency is improved through the introduction of DC.

Proof. Obvious from the derivations of inequalities (10) and (17). □

This is the main result of this paper which demonstrates the necessary and sufficient condition for DC to be useful. This proposition implies that DC improves *ex ante* efficiency if (8) does not hold, while only interim inefficiency is improved if (8) holds. It is only when this proposition does not hold that DC is useless. In this final case, DC cannot attain higher efficiency than standard debt contracts à la Hart and Moore (1998).

To interpret this result, suppose that D sets $T = K$ so that the indebtedness and required pledgeability are at minimum (as long as $T \geq K$). If inequality (10) does not hold, D must enhance pledgeability by at least $K + I - w - L$. Contrary to the case of $T \in [0, K)$, this is rather possible. As $T = K$ in the present case, D can increase S to the limit of K when the liquidity shock is absent and DC is not withdrawn (which occurs with probability $(1 - l)$ times a). However, it is impossible to pledge L when D cannot withdraw DC in spite of the occurrence of liquidity shock (with probability l times $(1 - a)$). Inequality (17) means that the incremental pledgeability ($=(1 - l)aK - l(1 - a)L$) exceeds the shortage of it without DC ($=K + I - w - L$).

The comparison between Propositions 1 and 2 implies that there is an important difference between the cases where $T < K$ and $T \geq K$. When inequality (8) does not hold, Proposition 2 implies that the pledgeability enhanced by DC is always less than that required for $T \in [0, K)$. Proposition 2 however means that the same does not hold for $T \geq K$.

To get an intuition about this point, suppose that neither inequality (7) nor (9) holds and without DC, *ex ante* inefficiency prevails both for $T \in [0, K)$ and $T \geq K$. In this case, we can infer from these inequalities that there is a shortage in pledgeability of which size is equal to $\{T + I - w\} - (1 - l)L$ for $T \in [0, K)$ and

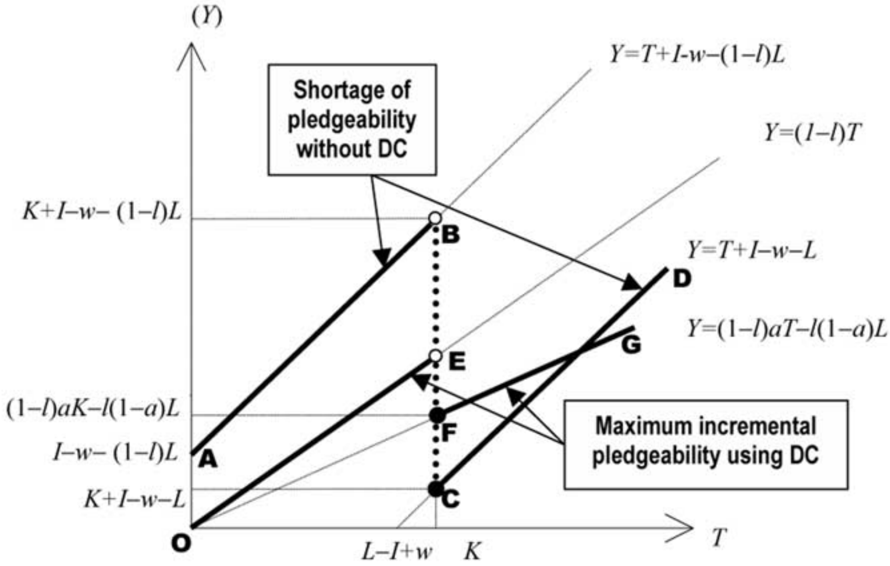

Figure 2. The shortage of pledgeability without deposit collateral that causes *ex ante* inefficiency is represented by ABCD, while the maximum incremental pledgeability using deposit collateral by OEFG. Due to the liquidity provision effect, the former jumps at $T = K$ and can be compensated by the latter which represents the pledgeability enhancement effect.

$\{T + I - w\} - L$ for $T \geq K$. In Figure 2, these are represented by ABCD. Now we can see the jump lL at $T = K$. This jump comes from the commitment by D to pledging at the state $\kappa = 1$, L times the probability (l). That is, contrary to the case of $T \in [0, K)$, this state is *on* the equilibrium path if $T \geq K$. This is due to the *liquidity provision effect* of DC. On the other hand, the use of DC enables D to increase the amount of pledgeability, which is due to the *pledgeability enhancement effect* of DC. By comparing inequalities (7) and (14), and inequalities (9) and (16), and by noticing that S must not exceed T, we can demonstrate that the maximum net increase in pledgeability by introducing DC is $(1 - l)T$ for $T \in [0, K)$ and $(1 - l)aT - l(1 - a)L$ for $T \geq K$. In Figure 2, this increase is represented by OEFG. We can understand that if and only if inequality (17) holds, this increase in pledgeability due to DC covers the shortage of pledgeability when DC is not used.

Here, a numerical example helps to illustrate that DC does attain optimal outcome.

EXAMPLE 1. $I - w = 180$, $K = 150$, $R_1 = 500$, $R_2 = 400$, $L = 300$, $l = 0.5$ and $a = 0.8$.
In this example, neither inequality (8) nor inequality (10) holds and the participation constraint is not satisfied without DC. This is the case in which *ex ante* inefficiency is present. By setting $T = S = 150$ and $P = 400$, for example, inequality (16) holds and DC improves efficiency.

5.2. EMPIRICAL IMPLICATIONS

Based on the propositions obtained above, we can conduct some comparative statics analysis to derive important empirical implications. First, the following corollary can be demonstrated.

COROLLARY 1. When the liquidity shock is always present ($l = 1$) or does not take place at all ($K = 0$), DC plays no role.

Proof. Suppose that inequality (10) does not hold, since this is necessary for DC to be valuable. If there is no liquidity shock ($K = 0$), inequality (17) becomes $(1 - l(1 - a))L \geq I - w$. This contradicts the supposition that (10) does not hold. Next, if the shock is always present ($l = 1$), inequality (17) becomes $aL - K \geq I - w$. This also contradicts the supposition that (10) does not hold. □

This corollary shows that DC is important if and only if the liquidity shock is *stochastic*. If it is deterministic, the liquidity provision effect of DC is not present and there is no jump in the shortage of pledgeability. Thus, as long as the participation constraint cannot be satisfied without DC, it cannot be satisfied with DC either.

We can also derive the following result.

COROLLARY 2. When the bank's decision on the request of withdrawal always leads to inefficiency from social point of view ($a = 0$), DC plays no role.

Proof. Suppose inequality (10) does not hold. If $a = 0$, inequality (17) becomes $(1 - l)L - K \geq I - w$. This contradicts the supposition that (10) does not hold. □

This corollary is easy to understand because in order for DC to be valuable, banks must have the ability to deny undesirable withdrawals. If they cannot manage withdrawals in an efficient way, the beneficial aspects of DC are completely eliminated.

Furthermore, Proposition 2 implies that, *ceteris paribus*, DC is more likely to be used as the accuracy of C's decision upon request of DC withdrawal increases, as the probability of shock occurrence decreases, or as the size of liquidity shock increases. Even if D provides DC to the extent of the liquidity shock, the pledgeability level is not increased when DC cannot be withdrawn in spite of the shock occurrence ($\kappa = 1$ and $\eta = 0$) with probability $l(1 - a)$. On the contrary, the pledgeability increases and augments C's guaranteed revenue to the extent of K under the condition that with probability $(1 - l)a$, DC remains unwithdrawn and no shock takes place ($\kappa = 0$ and $\eta = 0$). Together, these pledgeability results imply that the guaranteed revenue increases with the accuracy of bank's allowance decision (a), decreases with the probability of shock occurrence (l), and increases with the size of liquidity shock (K).

6. Deposit Collateral and the Role of Banks

It is possible here to shed light on the contributions of this paper to the literature on the role of banks. Studies on the role of banks have developed along different foci.[14] First, the traditional theory on the role of banks focuses on the reduction of transactions costs as in the study by Benston and Smith (1976). Second, the provision of liquidity insurance has also received increased attention as in Bryant (1980) and Diamond and Dybvig (1983). Third, the production of information has been the subject of numerous studies by Leland and Pyle (1977), Diamond (1984), Ramakrishnan and Thakor (1984), *inter alia*.

The present paper makes another contribution to this literature, since the reported results have important implications for banks. It is shown that banks can provide funds to entrepreneurs under less restrictive conditions than market investors do. This is made possible through the liquidity provision effect and the pledgeability enhancement effect of DC.

It is also essential to note that this role can only be played by financial intermediaries which offer simultaneously the lending and deposit services. In other words, the benefit of DC cannot be attained by other non-depository financial intermediaries or nonbanks. It is not available with respect to direct financing from capital markets, either. Normatively, this important result implies that commercial lending and depository services should not be provided separately.

There are several studies that focus on the merit of combining loan provision and deposit taking. First, Calomiris and Kahn (1991) show that demand deposits motivate *depositors* to monitor a bank with risky assets (loans), while Qi (1998) argues that demand deposits provide *banks themselves* with a greater incentive to monitor their loans. In both studies, demand deposits have the role of mitigating problems due to informational asymmetry concerning project returns. In contrast, the merit of combining loan granting and deposit taking in the present study lies in the capability of exerting the pledgeability and the liquidity provision effects simultaneously through DC.

Second, Kashyap et al. (2002) also discuss the merit of tying up lending and deposit services. The authors note the fact that loan commitments are, once extended, similar in nature to demand deposits that would be withdrawn on a random basis. As long as deposit withdrawals and commitment takedowns are imperfectly correlated, banks can reduce the holding of unprofitable liquid assets by making commitment loans and deposit-taking at the same time. In contrast to their study, the role of banks presented in this paper is valid with respect not only to commitment loans but also to other forms of loans.

Third, in a model based on Hart and Moore (1994), Myers and Rajan (1998) define liquidity in terms of pledgeability and show that it is beneficial for banks with excessively liquid assets (reserves for deposits) to increase their holding of less liquid assets (loans). The more liquid assets a project requires, the easier it is

[14] Bhattacharya and Thakor (1993) and Freixas and Rochet (1997) are excellent surveys.

to finance it, since the debtor can be committed to making sufficient repayments. This is the merit of having assets with higher liquidity. However, they also show that there is a "dark side" in having assets with greater liquidity. In their model, the increased liquidity of assets provides a higher incentive for banks to dispose of such assets on short-notice liquidation prior to the repayment date. The liquidation value is assumed to be always lower than the expected cash flows from the alternative holding of such liquid assets. This analysis suggests that the higher liquidity of assets favors such inefficient transformation, thus the dark side of liquidity.

In such a situation, Myers and Rajan (1998) demonstrate that there is a merit for banks with liquid assets to invest also into illiquid assets. By adding illiquid assets to liquid ones, the overall degree of liquidity decreases, inefficient transformation is reduced, and the tradeoff between the latter and pledgeability is moderated. Their main focus is thus on the enhancement of total pledgeability by combining different projects with different degrees of liquidity, while our focus is on the enhancement of a project's pledgeability by embedding DC in the contract.

Fourth, Diamond and Rajan (2000, 2001) demonstrate that there is another merit for banks in raising funds via demand deposits. A bank with a close relationship with a borrower can liquidate the borrower's assets at a higher value. This makes it possible for the borrower to raise more funds from this bank than from other banks or investors. However, if the bank itself is susceptible to a liquidity shock, the bank may have to sell the loan. In such a case, the bank cannot promise not to use its higher liquidation ability on behalf of the new lender. This jeopardizes the benefit from the bank's higher liquidation skills and its higher capabilities to provide more funds than market investors. In this case, one way to commit for banks to deploying their skills for the benefit of the new lender is for them to raise their own funds via demand deposits. This is justifiable on the basis that the bank's threat to withdraw the special skills can be penalized by depositors' run. The merit of taking deposits as well as granting loans in Diamond and Rajan (2000, 2001) is thus a disciplining effect of the former that makes it easy to increase the volume of the latter.

Since DC makes it difficult for deposits to be withdrawn on demand in the present model, one might wonder whether the disciplinary effect of Diamond and Rajan is undermined. However, the deposits in question in this paper, S, are not made by outside investors as in Diamond and Rajan (2000, 2001), but by debtors themselves. Deposits in the sense of Diamond and Rajan should be taken when the bank raises funds for the purpose of financing $I - w$. Although discussion of banks' capital structure decisions is not made, it is of course possible to force the bank to raise these funds via deposits. But this falls beyond the scope of this paper, which focuses on the enhancement of pledgeability by embedding DC *in* the loan contract.

Finally, it should be stressed that the main source of the inefficiency mitigated by the bank in the present study is the incompleteness of contracts. In fact, Rajan (1998) stresses the importance of the incomplete contract approach to the role of banks adopted by Diamond and Rajan (2000, 2001) and Myers and Rajan (1998).

The present results add to this literature by showing that banks can overcome the problem caused by the incompleteness of contracts through the use of DC. It is in this sense that the present study can be considered as one strand of the "incomplete contract theory" of banking.

7. Deposit Collateral and Lending Arrangements

7.1. COMPENSATING BALANCE REQUIREMENT

Although our primary concern is to show why DC is useful, it is interesting to compare it with other financing arrangements or covenants. First, deposit collateral in the present paper can also be interpreted as a compensating balance requirement (hereafter CBR), which is defined as "an obligation by the borrower to maintain deposits at the lending bank" (Greenbaum and Thakor, 1995, p. 248) or "a proportion of a loan that a borrower cannot actively use for expenditures" (Saunders, 1999, p. 211). As one of the common agreements that accompany bank loans, CBR can be regarded in the present theoretical framework, as the equivalent of DC.

Note that the actual CBR is frequently used together with the commitment loan or line of credit, which is "a promise to lend up to a prespecified amount to a prespecified customer at prespecified terms" (Greenbaum and Thakor, 1995, p. 320).[15] A commitment loan can be modeled as an agreement that allows D to borrow up to some amount of funds whenever needed. To implement DC with a loan commitment in the present model, it suffices to assume that D borrows $I - w + S$, makes compensating deposits (DC) S, and sets a credit line up to $T - S$ at date 0. In this case, D always requires additional lending of $T - S$ at date 1 according to the agreement.

In summary, the generalized approach of the present paper has the merit of shedding light on the fact that these two different forms of lending practices can be seen as theoretical equivalence.

Furthermore, the economic rationale behind CBR in the present paper extends beyond the merits discussed in the existing studies. Conventionally, CBR is considered as a devise to enhance the effective interest rates on loans. Along these lines of argument, there are the so-called "rationality" studies (Hellwig, 1961), Davis and Guttentag (1962), Shapiro and Baxter (1964), Wrightsman (1973, 1974), Puckett (1974), Kolodny et al. (1977), Lam and Boudreaux (1981, 1983), *inter alia*, which examine the conditions under which the use of CBR can be considered as *rational*. Rationality is arguably obtained when neither the lender's interest income decreases nor the borrower's interest expense increases when CBR is introduced. However, since the optimization approach is not adopted in these models, such studies provide "no economic justification for the use of compensating balances"(Sealey and Heinkel, 1985).

[15] This fact can be verified for the case of the U.S., for example, from the statistics from the Survey of Small Business Finances (SSBF).

On the other hand, Frost (1970), Mullins (1976), Meinster (1977), and Sealey and Heinkel (1985) tried to explain why "CBR" is used from the viewpoint of lenders' or borrowers' optimization problems. It is shown that the main role of "CBR" is one of "liquidity provision". By retaining some amount of demand deposits as "CBR", borrowers can deal with sudden liquidity needs. They show that the trade-off between this benefit and the opportunity cost of retaining unprofitable demand deposits determines the level of "CBR".

Despite the terminology, there are seemingly some shortcomings with this explanation, which identifies "CBR" with a "voluntary balance" rather than a requirement. In these studies, firms that want to hedge against liquidity risk make the deposits on voluntary basis. No enforcing arrangements or covenants are required then. Moreover, even if there is a need for liquidity, it is not necessarily provided in the form of deposits at the lending bank, because funds deposited in other banks can play the same role. The present paper does not suffer from such limitation since it can be shown that CBR is arranged to be deposited in the lending bank.

Finally, the literature develops along another view expressed by James (1981), where banks offer commitment loans for borrowers who face the eventual deterioration in credit risk. There are two types of borrowers with different probabilities of deterioration, the distribution of which remains private information. To mitigate this problem of asymmetric information, the bank requires the firms to choose from two ways of compensation for the provision of the commitment loan: fees or compensating deposits. It is this choice that reveals the firms' type. This explanation is consistent with the fact that compensating balances are frequently required along with loan commitments.

There are, however, alternative devises that can reveal borrower's type. In fact, studies as in Bester (1985), Besanko and Thakor (1987), and Milde and Riley (1988), *inter alia*, show that collateral or loan size can be used as a signaling devise, which are more common and easy to use. Furthermore, a compensating balance requirement in James (1981) is a passive devise of compensating the service of loan commitments. In the present paper, CBR, viewed as a particular form of DC implementation, has the more active role of liquidity provision and enhancement of pledgeability. It is shown that the CBR is the better instrument.

7.2. OTHER LENDING ARRANGEMENTS

Finally, we successively compare alternative arrangements to cope with liquidity shocks with DC to show that the latter is more useful a devise.

Additional lending without pre-commitment

First, C can provide liquidity not by lending excessively in advance as above but by making an additional lending only when the shock takes place. In the current setting, this can be characterized as follows. For expositional simplicity, consider the case of $T = 0$. At the repayment stage, C's payoff is the same as before and is

$\hat{P} = \min\{P, L\}$. If C meets the demand of additional lending upon liquidity shock occurrence, the optimal outcome can be attained.

However, there are difficulties which stem mainly from the asymmetry of information concerning the occurrence of the liquidity shock. It is impossible for C to lend only when $\kappa = 1$. At most, banks can make a shock-contingent lending decision reaching a level of efficiency as high as that obtained with DC.

Furthermore, there is a crucial difference between these devises, which is the necessity of the incentive constraint for C. It is represented in our model as $K \leq \min\{P, L\}$. In the case of additional lending, it is C that determines whether to inject K or not. If $L < K$, C has no incentive to lend K on additional basis. In the case of DC to the contrary, it is D who decides whether to inject K or not as the funds to cope with the shock are lent in advance. Therefore, even if $L < K$, D can always pay K as long as the return from the project is large enough (assumption (4) holds). These considerations imply that DC is generically more useful than additional lending.

Commitment loan without compensating balance requirement

Given the generic properties of DC, it is also interesting to compare the results with a commitment loan that does not accompany CBR. As stated earlier, the commitment loan can be modeled as the agreement that D can borrow whenever needed. This type of loan commitment is modeled in Holmström and Tirole (1998).[16] This is the same as the additional lending characterized above except for one distinction: the choice concerning the injection of K is made by D. The former discussion might imply that this is exactly the same as DC and thus there is a temptation to conclude that DC and commitment loans, which have been considered irrelevant and analyzed separately, are essentially equivalent devises.

This is not true, however because there is an important difference between them. Whereas the pledgeability remains the same, since D has an unconditional right to borrow, D can and does request lending whether $\kappa = 0$ or $\kappa = 1$, and C cannot reject this demand. On such expectations, C's participation constraint becomes more severe than in the case of DC. To illustrate this, suppose again that $T = 0$. The participation constraint in this case is not $\min\{P, L\} \geq I - w + lK$ but

$$\min\{P, L\} \geq I - w + K,$$

since D always exercises the right to borrow K. Accordingly, *ex ante* and interim inefficiencies are prevented if and only if

$$L \geq I - w + K,$$

[16] Other approaches to commitment loans include Boot et al. (1987), Berkovitch and Greenbaum (1991), Duan and Yoon (1993), Morgan (1993), Maksimovic (1990), Shockley (1995), and Houston and Venkataraman (1996), *inter alia*.

which is equivalent to inequality (10). This is more restrictive than inequality (17), the comparative condition for DC.[17]

Minimum liquidity ratio

Finally, Holmström and Tirole (1998) show that a covenant of "minimum liquidity ratio", which requires a borrower to keep some amount of liquid assets, has the same functions as the commitment loan. This indeed resembles what is analyzed in the previous sections with $T \geq K$. However, since their analysis extends to the environment in which project return is verifiable, the "pledgeability" aspect of DC is omitted. Thus, the same shortcomings levied against the existing studies on compensating balance requirements apply. In particular, it is unclear why the "minimum liquidity" has to be deposited at the lending bank.

8. Conclusion

In this paper, we have shown why deposit collateral (DC) is used. Extending Hart and Moore's (1998) model, we have demonstrated that DC has two significant effects: the enhancement of pledgeability and the provision of liquidity. It is if and only if the liquidity shock is stochastic that both effects are present and DC improves efficiency. We have also shown that this arrangement can be implemented as a compensating balance requirement with or without loan commitment. Furthermore, DC is theoretically more efficient a devise than other lending arrangements. On these grounds, the present study provides some theoretical contribution to the literature on lender-borrower relationship.

The reported evidence also provides some interesting implications for a better understanding of the role of banks. The rationale behind DC puts into perspective the unique role of banks. The improvement of efficiency via DC can only be attained by a particular type of financial institutions, that is *banks*, who are in the position to offer both depository and lending services at the same time. Since the model is developed within the general framework of contractual incompleteness, the results of this study constitute an integral part of the incomplete contract theory of banking.

[17] Note that there are differences between the commitment loan à la Holmström and Tirole (1998) as characterized above and actual practice. Usually, borrowers initially pay some fee and establish a certain loan limit, within which D can borrow unrestrictedly by the predefined terms of the contract (including the interest rate). In contrast, there are no fees paid in advance in the case of the commitment loan modeled above. Moreover, even if K is injected, the incompleteness of contracts prevents C from obtaining additional interest accruals so that C's revenue is the same irrespective of whether an additional lending is made or not. This is not the case with actual commitment loans. A more detailed description of actual commitment loans is found in Greenbaum and Thakor (1995).

References

Bank for International Settlements (2001) The New Basel Capital Accord. Available at http://www.bis.org/publ/bcbsca.htm.

Benston, G. and Smith, C. W. (1976) A transactions cost approach to the theory of financial intermediation, *Journal of Finance* **31**, 215–231.

Berkovitch, E. and Greenbaum, S. I. (1991) The loan commitment as an optimal financing contract, *Journal of Financial and Quantitative Analysis* **26**, 83–95.

Besanko, D. and Thakor, A. V. (1987) Collateral and rationing: Sorting equilibria in monopolistic and competitive credit markets, *International Economic Review* **28**, 671–690.

Bester, H. (1985) Screening vs. rationing in credit markets with imperfect information, *American Economic Review* **57**, 850–855.

Bhattacharya, S. and Thakor, A. V. (1993) Contemporary banking theory, *Journal of Financial Intermediation* **3**, 2–50.

Bolton, P. and Scharfstein, P. S. (1990) A theory of predation based on agency problems in financial contracting, *American Economic Review* **93**, 93–106.

Boot, A., Thakor, A. V., and Udell, G. F. (1987) Competition, risk neutrality and loan commitments, *Journal of Banking and Finance* **11**, 449–471.

Bryant, J. (1980) A model of reserves, bank runs and deposit insurance, *Journal of Banking and Finance* **43**, 749–761.

Calomiris, C. W. and Kahn, C. M. (1991) The role of demandable debt in structuring optimal banking arrangements, *American Economic Review* **81**, 497–513.

Davis, R. G. and Guttentag, J. M. (1962) Are compensating balance requirements irrational? *Journal of Finance* **17**, pp. 121–126.

Diamond, D. W. (1984) Financial intermediation and delegated monitoring, *Review of Economic Studies* **51**, 393–414.

Diamond, D. W. and Dybvig, P. (1983) Bank runs, deposit insurance, and liquidity, *Journal of Political Economy* **91**, 401–419.

Diamond, D. W. and Rajan, R. G. (2000) AA theory of bank capital, *Journal of Finance* **55**, 2431–2465.

Diamond, D. W. and Rajan, R. G. (2001) Liquidity risk, liquidity creation, and financial fragility: A theory of banking, *Journal of Political Economy* **109**, 287–327.

Duan, J. C. and Yoon, S. H. (1993) Loan commitments, investment decisions and the signalling Equilibrium, *Journal of Banking and Finance* **17**, 645–661.

Freixas, X. and Rochet, J. C. (1997) *Microeconomics of Banking*, MIT Press, Cambridge, MA.

Frost, P. A. (1970) Banking services, minimum cash balances, and the firm's demand for money, *Journal of Finance* **25**, 1029–1039.

Greenbaum, S. I. and Thakor, A. V. (1995) *Contemporary Financial Intermediation*, Dryden Press.

Hart, O. and Moore, J. (1994) A theory of debt based on the inalienability of human capital, *Quarterly Journal of Economics* **109**, 841–879.

Hart, O. and Moore, J. (1998) Default and renegotiation: A dynamic model of debt, *Quarterly Journal of Economics* **CXIII**, 1–41.

Hellwig, D. (1961) A note on compensating balance requirements, *Journal of Finance* **16**, 80–84.

Holmström, B. and Tirole, J. (1998) Private and public supply of liquidity, *Journal of Political Economy* **106**, 1–40.

Houston, J. F. and Venkataraman, S. (1996) Liquidation under moral hazard: Optimal debt maturity and loan commitments, *Journal of Banking and Finance* **20**, 115–133.

James, C. Self-selection and the pricing of bank services: An analysis of the market for loan commitments and the role of compensating balance requirements, *Journal of Financial and Quantitative Analysis* **16**, 725–746.

Kashyap, A. K., Rajan, R., and Stein, J. C. (2002) Banks as liquidity providers: An explanation for the coexistence of lending and deposit-taking, *Journal of Finance* **57**, 33–73.

Kinyu Tosho Consultant Inc. (1989) *Collateral Practice, Vol. 1: Deposits and Securities* (in Japanese), Tokyo.

Kolodny, R., Seeley, P., and Polakoff, M. E. (1977) The effect of compensating balance requirements on the profitability of borrowers and lenders, *Journal of Financial and Quantitative Analysis* **12**, 801–815.

Lam, C. H. and Boudreaux, K. J. (1981) Compensating balance, rationality, and optimality, *Journal of Banking and Finance* **5**, 451–466.

Lam, C. H. and Boudreaux, K. J. (1983) Compensating balances, deficiency fees, and lines of credit, *Journal of Banking and Finance* **7**, 307–322.

Leland, H. E. and Pyle, D. H. (1977) Informational asymmetries, financial structure and financial intermediation, *Journal of Finance* **32**, 371–387.

Maksimovic, V. (1993) Product market imperfections and loan commitments, *Journal of Finance* **XLV**, 1641–1653.

Meinster, D. R. (1977) The demand for compensating balances, *Southern Economic Journal* **43**, 1538–1546.

Milde, H. and Riley, J. G. (1988) Signaling in credit markets, *Quarterly Journal of Economics* **102**, 101–129.

Morgan, D. P. (1993) Financial contracts when costs and returns are private, *Journal of Monetary Economics* **31**, 129–146.

Mullins, D. W., Jr. (1976) Restrictions on the rate of interest on demand deposits and a theory of compensation balances, *Journal of Finance* **31**, 233–252.

Myers, S. C. and Rajan, R. G. (1998) The paradox of liquidity, *Quarterly Journal of Economics* **113**, 733–771.

Puckett, R. H. (1974) Rationality and compensating balances: Comment, *Southern Economic Journal* **40**, 672–673.

Qi, J. (1998) Deposit liquidity and bank monitoring, *Journal of Financial Intermediation* **7**, 198–218.

Rajan, R. (1998) The past and future of commercial banking viewed through an incomplete contract lens, *Journal of Money, Credit, and Banking* **30**, 524–550.

Ramakrishnan, R. T. and Thakor, A. V. (1984) Information reliability and a theory of financial intermediation, *Review of Economic Studies* **51**, 415–432.

Saunders, A. (1999) *Financial Institutions Management: A Modern Perspective*, 3rd edn, McGraw-Hill.

Sealey, C. W. and Heinkel, R. (1985) Asymmetric information and a theory of compensating balances, *Journal of Banking and Finance* **9**, 193–205.

Shapiro, H. T. and Baxter, N. D. (1964) Compensating-balance requirements: The theory and its implications, *Southern Economic Journal* **30**, 261–267.

Shockley, R. L. (1995) Bank loan commitments and corporate leverage, *Journal of Financial Intermediation* **4**, 271–301.

Wrightsman, D. (1973) On the rationality of compensating balance requirements, *Southern Economic Journal*, January.

Wrightsman, D. (1974) Rationality and compensating balances: Reply, *Southern Economic Journal* **40**, 673–674.