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# Credible commitments, contract enforcement problems and banks: Intermediation as credibility assurance

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We consider contract enforceability problems in credit transactions and justify a bank as an organizational solution to market breakdown due to unenforceable contracts. Specifically, wc explain: (i) why loan commitments exist, and (ii) why banks exist lo sell such commitments. A loan commitment resolves moral hazard more efficiently than any combination of inside equity and spot credit. However, the market breaks down if commitment sellers arc individuals, because their promises to honor contracts are not credible. With a large bank, a perfect sequential equilibrium is obtained in which credibility is restored.

## 1. Introduction

Why do individuals buy insurance from insurance companies and rarely from other individuals? Why are individuals willing to pay up-front fees to firms or organizations for the future delivery of products or services (e.g. health clubs, professional organizations, hotels, etc.) but not to other individuals? Why is it that a person who pays an established commercial

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airline his full airfare weeks in advance of the flight is unlikely to behave similarly with an individual pilot offering to fly him in a private aircraft? Why is it that loan commitments are sold by banks and not by individuals?

We suggest the same answer to all these questions. Firms can credibly commit to supply a product or service in the future in exchange for current compensation. Individuals often cannot. More specifically, we show that the ability to credibly offer loan commitments – instruments that enable the borrower to pay an initial fee in exchange for the option to borrow up to a certain amount in the future at predetermined terms – in the presence of an inherent incentive to renege may in part be the raison d'être for banks. We also show that in the case of a sufficiently large bank that can make credible commitments, a bank loan commitment is better for the customer than an exchange-based option. In our model, as in Boot, Thakor and Udell (1987. BTU), loan commitments improve efficiency because they reduce moral hazard-related losses created by random interest rates. That paper, as well as numerous other papers that explain loan commitments, ignore the issue of contract enforceability, the central focus of this paper. We do not assume a priori that the bank will honor loan commitments. The bank may have an incentive to renege, since the borrower will exercise the commitment when the committed rate is below the spot market rate.

Beginning with Campbell (1978), numerous papers have attempted to explain why loan commitments exist. However, until recently, most have relied on either risk aversion [Thakor and Udell (1987). Melnick and Plaut (1986)] or transactions costs [Mason (1979)]. Some recent papers have assumed risk neutral settings. Examples are Berkovitch and Greenbaum (1989). Kanatas (1987), Boot, Thakor and Udell (1987). and Thakor (1989). Apart from the contract enforceability issue, a key difference between these papers and ours is that we endogenously explain why the bank issuing the commitment exists, whereas they take the bank as being exogenously given.

An important feature of our paper is that the (commitment) seller's incentive to honor its contract can be guaranteed neither through explicit legal remedies – as in Shavell (1980, 1984), Rogerson (1984), Konakayama, Mitsui and Watanabe (1986)[1] and Schweizer (1989) – nor through implicit, market-based reward/punishment mechanisms, as in Klein and Leffler (1981). This is not to say that these effects are not important, but we take this scenario as our starting point and show that an organizational solution to the contract enforcement problem works precisely when a non-organizational solution fails The idea is that it is more costly for an organization to not honor its contractual commitments than it is for an individual, even when both individual and organization are subject to the same structure of penalties for refusing to honor contracts. The potential market failure, when

[1] In these papers a prespecified 'damage rule' provides contract enforcement.

individuals will not honor contracts, is prevented by the emergence of organizations. Thus, our approach seems capable of more generally explaining why firms exist [Williamson (1975)]; the focus on financial intermediaries is for specificity. There are two key differences between our research and the recent literature on financial intermediary existence [e.g. Boyd and Prescott (1986). Diamond (1984). Millon and Thakor (1985) and Ramakrishnan and Thakor (1984)]. First, this literature *assumes* that contracts will be honored and rationalizes intermediary existence on the grounds that it reduces expected contracting costs by more efficiently resolving information-related problems. Second, the intermediaries in these papers function only in spot credit markets and hence do not permit an understanding of the role of institutions in the creation and sale of credit options. We consider these instruments important because over 80 percent of all commercial lending in the U.S. is currently done under loan commitments, the aggregate volume of which is over half a trillion dollars.

The paper is organized as follows. Section 2 presents the basic model and the lull-information equilibrium. Section 3 introduces moral hazard and rationalizes loan commitments under the assumption that commitments will always be honored. In section 4, contract enforcement problems are introduced and a rationale for the existence of banks as an organizational solution is provided. Section 5 concludes with some thoughts on a borrower's choice between a bank loan commitment and the purchase of a put option directly through an options exchange. Appendix A gives some details of derivations in the text and Appendix B contains all the proofs.

## 2. The model and the full information solution

Consider a perfectly competitive, two-period credit market populated by three types of agents: investors, bankers and borrowers. Investors have an endowment which can be lent to borrowers. Borrowers are endowed with projects which must be funded at the beginning of the second period. Bankers are endowed with illiquid wealth in the form of a project which requires no funding and which matures at the end of the second period. Bankers serve no role in the credit market until issues of contract enforcement are considered; so we will ignore them until section 4. All agents have linear preferences over non-negative wealth. Non-pecuniary penalties are disallowed and limited liability is assumed, so that consumption is bounded from below by zero.[2] Consequently, credit contracts in a competitive

[2] One reason lor bounding consumption from below by zero is that an arbitrarily luge penalty (e.g., hanging!) a n resolve any incentive or contract enforceability problems trivially. In our context, we do not consider such a hanh and unrealistic environment • useful starting point to reach any meaningful conclusions. Our assumptions imply that the borrower's utility over wealth u linear over non-negative wealth levels but concave over the entire real line $(-m, m)$ [see Rockafeller (1972)].

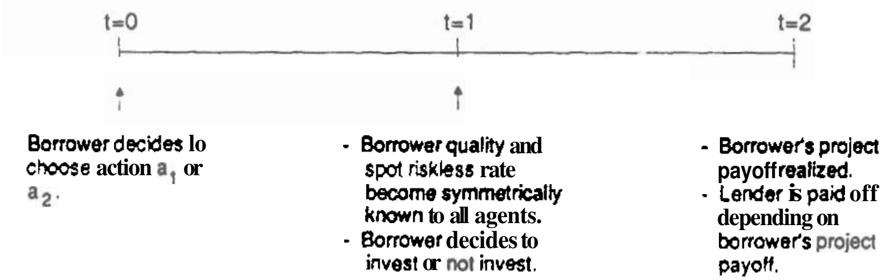


*Fig.* 1. **Sequence of events**

market maximize the net expected profits of borrowers, subject to break-even constraints for investors.

We consider a two-period model (see fig. 1). The first period lasts from $t=0$ to $t=1$, the second period lasts from $t=1$ to $t=2$. Borrowers are endowed at $t=0$ with options to invest in projects at $t=1$. Each of these projects requires a \$1 investment at $t=1$. The project pays off at $t=2$ and the payoff distribution depends on an action choice of the borrower. Specifically, at $t=0$, the borrower can undertake one of two actions, $a_1$, or $a_2$, with $a_1>a_2>0$. The action choice affects the payoff distribution of the borrower's project at $t=1$. The action $a_i$ is the developmental activity that precedes the actual investment in the project. It includes R&D, pre-product introduction advertising, sales promotions through featured campaigns, etc. The borrower's costs of undertaking $a_i$ are $V(a_i)$, with $m>V(a_1)>V(a_2)>0$. We shall assume henceforth that the borrower's reservation utility of zero is always exceeded by the equilibrium utility associated with $a_1$ or $a_2$.[3]

Having chosen its action at $t=0$, the borrower faces three types of uncertainties. First, it does not know the actual (random) cash flow that will be realized at $t=2$. Second, it does not even know the probability distribution of this cash flow; this will be revealed to it only at $t=1$.[4] The reason is that this probability distribution is affected both by the borrower's action choice at $t=0$ and by some technological 'quality' parameter related to the project. This technological parameter will become known only at $t=1$. Third, the borrower and the lender are currently unaware of the riskless spot rate that will occur at $t=1$, although its probability distribution is common knowledge. Given these uncertainties, the borrower makes two observations at $t=1$. One observation is of the technological quality parameter, $k$, of its

[3]Other than choosing a positive action $a\in(a_1,a_2)$, the borrower may also decide to do nothing i.e., choose $a=0$. In this case, $V(0)=0$ and the project the borrower invests in at $t=1$ will yield a cash flow of zero almost surely at $t=2$. Thus, autarky is a possibility but is dominated by any positive action choice.

[4]This random cash flow is the outcome of the borrower's action choice at $t=0$ and its capital investment at $t=1$.

project. Let $k \in \{G, B\}$, where G indicates 'good' quality and $B$ indicates 'bad' quality; k is a summary statistic representing market demand conditions. production costs, etc., that the borrower was unaware of initially but learns prior to investing capital in the project.[5] Viewed at $t=0$, all agents have homogeneous beliefs about $k$, as represented by the probabilities: $\Pr(k=G)=\Psi$ and $\Pr(k=B)=1-\Psi$, $\Psi \in (0,1)$. The realization of k is independent across borrowers. The second observation the borrower makes is of the spot riskless rate. Conditional on the single period spot riskless interest factor of $R_f$ at $t=0$, the single spot riskless interest factor, R, at t=1 can take one of two possible values, $R_l$ or $R_h$. We assume $1<R_l<R_h<\infty$. Viewed at $t=0$, all agents have homogeneous beliefs about R, as represented by the probabilities: $\Pr(R=R_l)=\theta \in (0,1)$, and $\Pr(R=R_h)=1-\theta$. We assume that $\theta R_l+(1-\theta)R_h=R_f$. We will refer to R as the random variable representing the spot riskless factor at $t=1$ and $R_j \in \{R_l, R_h\}$ as its realization. For any borrower. k and R arc independent random variables and their realizations at $t=1$ are common knowledge. Thus, at t=0 we should use $R_f$ as the single period discount factor, and at $t=1$ we should use either $R_l$ or $R_h$ as the single period discount factor, depending on which state has been realized. Payoffs to be realized at t=2 are discounted back to t=0 at $(R'_f)^2$, i.e., the annualized two-period discount factor is $R'_f$. This discount factor satisfies $(1/(R'_f)^2)=(1-\theta)(R_fR_h)^{-1}+\theta(R_fR_l)^{-1}$, which can be shown to hold by using the usual arbitrage arguments.[6] With this, $R'_f<R_f$.[7]

Having observed k at $t=1$, the borrower knows the cash flow distribution of its investment opportunity, the only remaining uncertainty is the actual cash flow that will be realized at $t=2$. Specifically, the cash flow will be $X(a_i,k)$ with probability (w.p.) $p(a_i)$ and zero w.p. $1-p(a_i)$, with $X(a_1,k)>X(a_2,k)$ $\forall k \in \{G, B\}$ and $X(a_i,G)>X(a_i,B)$ $\forall a_i \in \{a_1,a_2\}$. For any two borrowers with the same a, and the same $k$, the project cash flows are identically and independently distributed (i.i.d.) random variables. With its observations of k and $R_j$ in hand, the borrower now makes its investment and credit utilization decisions.

Under full information, the lender can costlessly observe both the borrower's action choice and its return in the successful state. If the borrower self-finances, its incremental expected utility, relative to investing in a riskless asset, is

$$\{p(a_i)(\Psi X(a_i,G)+\{1-\Psi\}X(a_i,B))\}(R'_f)^{-2}-V(a_i)-R_f^{-1}. \tag{1}$$

[5]For instance, 'bad' quality means that the *combination* of market demand conditions (low demand) and production costs (high) is adverse.

[6]For a proof, see Appendix A.

[7]The observation that $R'_f<R_f$ corrects an error in our earlier paper [Boot, Thakor and Udell (1987)] where we bad assumed $R'_f=R_f$.

We assume that the borrower's first best action choice is a,, implying

$$\{p(a_1)(\Psi X(a_1, G) + \{1-\Psi\}X(a_1, B))\}(R'_f)^{-2} - V(a_1)$$
$$> \{p(a_2)(\Psi X(a_2, G) + \{1-\Psi\}X(a_2, B))\}(R'_f)^{-2} - V(a_2). \qquad \text{(PR-I)}$$

The borrower's liquidity, $L$, is insufficient to permit complete self-financing. An amount $1-LR_f>0$ must be borrowed at $t=1$. The borrower's expected utility can now be written as

$$\mathrm{E}\,U(a_i) = \{p(a_i)(\Psi X(a_i, G) + \{1-\Psi\}X(a_i, B))\}(R'_f)^{2}$$
$$- p(a_i)\lambda_1 - V(a_i) - LR_f R_f^{-1}, \qquad (2)$$

where

$$\lambda_1 \equiv (1-LR_f)(\theta r(a_i|R_l)(R_f R_l)^{-1} + (1-\theta\}r(a_i|R_h)(R_f R_h)^{-1}).$$

In (2), $\lambda_1$ is the borrower's (discounted) expected repayment obligation to the bank where $r(a_i|R_j)$ is the loan interest factor charged by the lender' and $LR_f R_f^{-1} = L$ is the present value of the liquidity (equity) the borrower relinquishes by investing in the project. The borrower's decision problem is to choose its optimal action $a_i$ to satisfy

$$a_i^* \in \underset{a_i \in \{a_1, a_2\}}{\operatorname{argmax}}\ \mathrm{E}\,U(a_i).$$

It is straightforward to verify that $a_i^*$ is chosen to yield the borrower the same expected utility it enjoys when it has sufficient liquidity to completely self-finance, i.e., the first best. To see this, note that lenders price their spot loans to cam zero expected profits in a competitive market. Thus,

$$r(a_i|R_j) = R_j(p(a_i))^{-1} \quad \forall\, a_i \in \{a_1, a_2\},\ R_j \in \{R_l, R_h\}. \qquad (4)$$

Using (4) and a little algebra, we obtain

$$\mathrm{E}\,U(a_i) = \{p(a_i)(\Psi X(a_i, G) + \{1-\Psi\}X(a_i, B))\}(R'_f)^{-2} - V(a_i) - R_f^{-1},$$

which is the same as its expected utility with complete self-financing expressed in (1). Thus, $a_i^* = a_1$, and the first best is attained.

'We assume that the return in the successful state, regardless of the chosen action, always exceeds the repayment obligation.

## 3. Monl b w d and a rationale for loan commitments (no ex post contract enforcement problems)

We have just seen that the absence of moral hazard permits spot credit to be used without welfare depletion. We now assume that the borrower's action choice as well as cash flow realization is unobservable to the lender; the lender can observe success or failure of the project? Initially, we consider a (fulfilled expectations) competitive Nash equilibrium (N.E.) when borrowing is limited to only spot market contracting. However, when forward contracting is permitted, we show that borrowing under a loan commitment, in the absence of credibility issues, dominates the spot-market solution. We first specify a set of parametric restrictions that will narrow down the set of potential Nash equilibria, enabling sharper focus on intuition. Assume for now that a borrower takes a $1 loan at $t=1$, i.e., it docs not use its initial liquidity, which we may assume is consumed immediately after $t=0$.

### 3.1. Additional *features* of the *model and* parametric *restrictions*

We start out with conditions specifying the profitability of projects.

$$\text{(i)}\quad X(a_j,k)-r(a_i|R_l)>0 \quad \forall a_i,a_j\in\{a_1,a_2\}\ \forall k\in\{G,B\},$$

$$\text{(ii)}\quad X(a_2,k)-r(a_i|R_h)<0 \quad \forall a_i\in\{a_1,a_2\}\ \forall k\in\{G,B\}, \qquad \text{(PR-2)}$$

$$X(a_1,B)-r(a_i|R_h)<0 \quad \forall a_i\in\{a_1,a_2\},$$

$$\text{(iii)}\quad X(a_1,G)-r(a_i|R_h)>0 \quad \forall a_i\in\{a_1,a_2\}.$$

The condition (PR-2) indicates that if the riskless spot rate is low, projects will always be undertaken [see (i)]. If the spot rate is high, projects will only be undertaken if $a_1$ has been chosen and the project's technological quality is good [see (ii) and (iii)].[10]

'At $t=2$, the borrower observes the Mud realization of its project cash flow. Under asymmetric information, however. the lender only observes whether or not the borrower's project was successful, *not* the actual cash flow. If the lender extends 1 loan at a given interest rate, then all it knows ‐ or can agree with the borrower upon ‐ is that the return in the successful state exceeds the promised repayment, and is zero in the unsuccessful state. This means that the ex port information set of the borrower is partitioned finer than the bank's. These assumptions imply that ex post payoff-contingent contracts [Bhattacharya (1980)] are precluded. Moreover, given ex post unobservability, the optimal contract between the bank and the borrower is debt [Gale and Hellwig (1985)]. However, our analysis should be viewed as taking a debt contract as *given*, since we do not address complications arising from the ootimal verification strategy possibly being random [Mookherjee and P'ng (1989)].

[10] Note that $(X(a_i,k)-r(a_i|R_h))<0$ lor some values $a_i\in\{a_1,a_2\}$ and $k\in\{G,B\}$. This also affects the self-financing case because investing in the riskless asset then strictly dominates investing in the project. In bur analysis we work-with a modified version of (PR-1) which is stated in Appendix A.

The central aspect of our analysis is moral hazard, which exists because if the lender assumes that the borrower has undertaken the (first best) action *a,* at $t=0$ and prices the spot loan accordingly, the borrower *anticipates* this and chooses *a,*. The following restriction ensures this:

$$p(a_2)\{\theta\Psi(X(a_2,G)-r(a_1|R_l))+\theta(1-\Psi)(X(a_2,B)-r(a_1|R_l))\}(R_fR_l)^{-1}-V(a_2)$$
$$>p(a_1)\{\theta\Psi(X(a_1,G)-r(a_1|R_l))(R_fR_l)^{-1}$$
$$+\theta(1-\Psi)(X(a_1,B)-r(a_1|R_l))(R_fR_l)^{-1}$$
$$+\Psi(1-\theta)(X(a_1,G)-r(a_1|R_h))(R_fR_h)^{-1}\}-V(a_1). \qquad \text{(PR-3)}$$

The condition (PR-3) says that moral hazard destroys the incentive compatibility of the first best contract. The moral hazard exists because we have *risky* debt and limited liability.

Finally, we have two additional parametric restrictions. One says that if the borrower antidpates at $t=0$ that it can only borrow and undertake the project in the high interest state. it would have no incentive to take any action to develop project. That is,

$$\Psi(1-\theta)p(a_i)(X(a_i,G)-r(a_i|R_h))(R_fR_h)^{-1}-V(a_i)<0$$
$$\forall a_i\in\{a_1,a_2\}. \qquad \text{(PR-4)}$$

The other restriction is complementary. If the borrower now anticipates at $t=0$ that it can only borrow and undertake the project in the low interest state, it will have an incentive to take at least action *a,*. The restriction is

$$p(a_2)\{\theta\Psi(X(a_2,G)-r(a_2|R_l))+\theta(1-\Psi)(X(a_2,B)-r(a_2|R_l))\}$$
$$\times(R_fR_l)^{-1}-V(a_2)>0. \qquad \text{(PR-5)}$$

We assume that (PR-1) through (PR-5) hold throughout. It is easy to verify that the set of parameters for which these restrictions hold is non-empty.

### *3.2. The loan market with only spot credit*

In Lemma 1 we summarize the Nash equilibria that are attainable if the borrower has access to only spot credit.

**Lemma 1.** *There exists at least one competitive N.E. in the spot credit market. The N.E. yielding the borrower its highest expected utility involves the*

Table 1

Description of states at $t=1$ and borrower takedown behavior.[a]

| State | Probability | Borrower decisions | |
|---|---|---|---|
| | | Anion a, | Anion $a_2$ |
| $\xi_{gl} \equiv (G, R_l)$ | $\Psi\theta$ | Invest, no LC take down | Invest, no LC take down |
| $\xi_{gh} \equiv (G, R_h)$ | $\Psi[1-\theta]$ | Invest, take down LC | Invest, take down LC (do not invest without LC) |
| $\xi_{bl} \equiv (B, R_l)$ | $[1-\Psi]\theta$ | Invest, no LC take down | Invest, no LC take down |
| $\xi_{bh} \equiv (B, R_h)$ | $[1-\Psi][1-\theta]$ | Do not invest; commitment seller can also decline to lend under LC | Do not invest |

'LC means loan commitment'.

*borrower choosing a,, and the lender charging $r(a_2|R_j)$ for $R_j \in (R_l, R_h)$. In this equilibrium the borrower's expected utility is lower thanfirst best.*

This result is intuitive. The borrower's ex ante perception of the competitive spot borrowing rate (at $t=1$) affects its expected share of the terminal cash flow, and docs not indua a choice of the first best action, $a_1$, at $t=0$. The key observation is that the borrower's marginal return to effort is diminishing in the loan interest rate.[11]

### 3.3. The loan market with loan commitments

Now consider an environment in which forward contracting is permitted. Investors – endowed with initial liquidity $R_f^{-1}$ – can issue loan commitments at $t=0$ under which they promise to lend at $t=1$ up to \$1 at a fixed rate of 6 with $\delta \in (R_l(p(a_1))^{-1}, R_h(p(a_1)^{-1})$. While this is a fixed rate loan commitment, our analysis extends to variable rate commitments with some rigidity in the commitment rate relative to the borrower's spot borrowing rate. An example is a prime-plus commitment with a fixed add-on. The investor/commitment seller (c.s. henceforth) receives a commitment fee of $g$ at $t=0$. If state $\xi_{gh}$ occurs, the borrower can draw down under the commitment at $t=1$. In states $\xi_{gl}$, $\xi_{bl}$ and $\xi_{bh}$, the loan commitment is not taken down. Our results in the next section will verify this. Table 1 summarizes the different states and the borrower's takedown and investment behavior in those states.

*Theorem 1. Assuming that the c.s. will always honor its commitment, there exists a loan commitment contract that Induces the borrower to choose a first best action and yields the commitment seller zero expected profit. Moreover,*

[11] See also Chan and Thakor (1987).

there exist values of the borrower's initial liquidity, $L$, for which this loan commitment contract strictly Pareto dominates any spot credit market equilibrium (attainable with partial equity *financing*) and produces *a first* best *level* of expected utility for the borrower.

(The proof of Theorem 1 is available from the authors upon request.)

This result generalizes the results of BTU. Contracting with a loan commitment achieves first best. and accomplishes this when equity cannot. Specifically, the borrower could either use its initial liquidity as equity in conjunction with spot borrowing, or use it to purchase a loan commitment at $t=0$ which requires a fee of $g$. Theorem 1 states that, for sufficiently low levels of initial liquidity, only the loan commitment achieves first best. The intuition is that the loan commitment reduces the distortionary effect of random interest rates by setting the commitment rate, 6, low enough to ensure a marginal return to effort that prompts an action choice of $a_1$.

To see why a loan commitment yields the borrower its first best expected utility, we proceed as follows. The c.s. will set 6 just low enough to ensure that the borrower's marginal return to effort is at least as great as the level needed to ensure a choice of $a_1$ at $t=0$, thereby eliminating the distortionary effect of the loan interest rate. Of course, at this rate, the c.s. suffers an expected loss on the loan. To recoup, the c.s. charges a commitment fee $g$ at $t=0$. The commitment fee has no inantive effect because it is paid 'up-front' and represents a 'sunk cost' that docs not affect the borrower's action choice. Partial (inside) equity financing with a spot loan is not as effective as a loan commitment. Note that a fixed rate loan commitment pegs the interest rate at the same level regardless of the spot rate. Thus, it reduces the customer's repayment obligation by different percentages in the low and high interest rate states, providing a greater percentage reduction in the high interest rate state in which the distortionary effect of the loan interest rate is the most severe with spot credit. Partial equity financing, on the other hand, reduces the borrower's repayment obligation *evenly* across both the low and the high interest rate states, which is less efficient. That is, equity financing is less effective in reducing distortions than a loan commitment.

## 4 Loan commitments with ex post contract enforcement problems: A raison d'être for banks

We have demonstrated that loan commitments represent a powerful contractual solution to a moral hazard problem in the credit market. In this section, however, we establish that the bilateral commitment contract discussed in section 3 is untenable when contract enforceability is considered and loan commitmenis are issued by individuals. When loan commitments are issued by bank, on the other hand, we show that credibility problems can be resolved and the first best restored. In our organizational solution, banks are large in the sense that they are owned by many bankers, they issue many loan commitments, and they are funded by many investors (who become depositors).

## 4.1. The contract enforcement problem

The option-like feature of a loan commitment implies that the c.s. provides a subsidized loan when the borrower exercises the commitment.[12] This creates an incentive for the c.s. to renege on its promise to lend under the commitment. In practice the c.s. docs have some leeway in determining whether or not to honor the commitment. In particular, if it can establish that the borrower's financial condition deteriorated materially between the time of issue of the loan commitment and the time of takedown, then it could invoke the 'material adverse change' (MAC) clause and be legally unencumbered from its obligation. Of course, there must be costs for the c.s. if it refuses to honor the commitment, otherwise, the commitment would never be honored. These costs could be loss of reputation, explicit legal damages, etc. An exorbitantly high cost for not honoring the commitment will guarantee compliance and trivialize the contract enforcement problem. However, arbitrarily high penalties will generally not be feasible. We will shortly discuss 'appropriate' penalties.

Under what circumstances is it reasonable to assume, in the context of our model, that the c.s. could costlessly not lend under the commitment? One obvious circumstance is the occurrence of state $\xi_{bh}$. In this state, the borrower's project has a negative expected cash flow even if a, had been chosen at $t=0$.[13] We assume that if the borrower wants to exercise the commitment and the c.s. declines to lend in a state other than $\xi_{bh}$, then a costly but perfect ex post audit can be conducted by the courts to determine the borrower's realized project payoff.[14] Because a borrower's type realization at $t=1$ is common knowledge, an audit of the realized cash flow, conditional on project success, will permit an exact inference of the borrower's action choice. If the borrower is found to have chosen a,. then the ca. must pay damages to the borrower. But if a, is detected, the c.s. can keep the commitment fee and pay nothing to the borrower. That is, a borrower that chose a, can be interpreted as having a 'materially deteriorated'

[12] See also Campbell (1978) and Thakor, Hong and Greenbaum (1981).

[13] We view the realization of the states $\xi_i$, $i \in \{gl, gh, bl, bh\}$ as being specific to the bank's loan commitment customer. When the loan commitment customer finds itself in state $\xi_{bh}$, the spot riskless rate for all borrowers is $R_h$. Note that since the ks are (pairwise) independent across borrowers, them will be borrowers who find themselves in state $\xi_{gh}$ even when our bank's commitment customer finds itself in state $\xi_{bh}$.

[14] It is immaterial who bears the audit cost incurred by the court. Assuming that it is borne by the losing party only adds mom notation.

financial condition. Note, however, that if the borrower is unsuccessful, its realized cash flow is zero regardless of its type and action choice. Having oberved project failure, an audit of the cash flow would be useless since it is common knowledge that the cash flow is zero and non-informative about the agent's action choice.

In states $\xi_{gl}$ and $\xi_{bl}$, the borrower optimally decides to let the commitment expire unexercised. Thus, the only state relevant for us is $\xi_{gh}$. If state $\xi_{gh}$ occurs and the c.s. reneges, the borrower has two choices. It can either do nothing or take legal action against the c.s. The borrower decides on its legal action at $t=2$ after observing its cash flow. A borrower who observes project success but had chosen $a_l$ at $t=0$ will optimally decide to do nothing since he is worse off by suing. Also, a borrower who observes project failure will not sue. In either case, the c.s. can keep its revenues. Of course, a borrower who chose $a_l$ at $t=0$ and is successful at $t=2$ will want to sue a c.s. that reneges in state $\xi_{gh}$. In this case, there are two questions. What will be the likely outcome? And, if the borrower wins, what will be the penalty imposed on the c.s.? As stated earlier, contingent on project success, a borrower suing in state $\xi_{gh}$ will win if he chose $a_l$. The question of the 'appropriate' penalty is more difficult. Therefore, we will consider the most stringent possible penalty: confiscation of the entire net worth of the c.s. Given this legal penalty structure, we now consider the viability of three different types of c.s.'s.

### 4.2. *A loan commitment as a bilateral credit exchange: The non-bank case*

This is the case considered in section 3 in which an investor and a borrower contract directly with each other. The difficulty with this arrangement is that the investor could collect the commitment fee and simply proceed to consume its cash endowment of $R_f^{-1}$ at $t=0$. The commitment would then not be honored at $t=1$ and no legal enforcement mechanism could remedy the situation. Thus, this approach is inefficient.

### 4.3. *A loan commitment as a bilateral exchange: The single banker–single borrower case*

An alternative to a bilateral investor–borrower contract is the case where a single banker intermediates between a single investor (hereafter referred to as a depositor) and a single borrower. The advantage of having a banker intermediate between a borrower and a depositor is that it can acquire funds from a depositor at $t=0$ and thus prevent the depositor from consuming its endowment at $t=0$. Of course, incentives must be provided to ensure that the bank honors the commitment. Under this arrangement, the banker (now the c.s.) promises to lend up to \$1 should the borrower wish to take such a loan at $t=1$. The funds to support this commitment are raised through a two-period certificate of deposit (CD) purchased by a depositor (our original investor).

We now characterize those agents who can become a bank. Potential bankers may or may not be endowed with projects at $t=0$. 'Endowed' bankers have projects (equity) that do not require investment – either capital or labor – and yield a fixed payoff of $S>0$ at $t=2$. However, the payoff is completely unobservable to all except the banker who owns the project. Thus, this agent can consume this payoff without detection. This can only be prevented if a court of law takes possession of it.[15] In that case, the court can divert $S'$ to some other agent. We assume that $S' \in (0, S)$, and is very small due to high verification and title transfer costs. In our formal analysis we put an upper bound on the payoff of the banker's project endowment. That is,

$$S \in (0, \bar{S}), \tag{PR-6}$$

where $\bar{S}$ is defined in the proof of Theorem 2. Bankers without project endowments are obsewationally indistinguishable at t=O from endowed bankers. Thus, they could mimic these agents. A verification cost of $v$ could be incurred to perfectly distinguish both types. Initially, however. we will assume that they can be distinguished at a cost of $v=0$. However, note that the verification cost v will prevent trivial solutions in which bankers resolve their credibility problem by joining together and building up sufficient equity (despite the upper bound on $S$) such that a specific number of (credible) loan commitments can be sustained. These issues are discussed later.

A deposit contract must be designed to support the bilateral loan commitment contract between the banker and the borrower. The deposit contract must provide an expected two-period return lo the depositor of $(R'_f)^2 - 1$. It must also take into account the possibility of the bank reneging. Since the depositor is not party to the c.s. decision to renege, the courts are unlikely to take away as a penalty assets that support the depositor's claim. We assume that the depositor's funds are protected by legally binding 'me-first' rules.

For an individual banker who issues a loan commitment at $t=0$, the deposit contract is as follows. The c.s. issues a two-period CD at $t=0$ and raises $R_f^{-1}$. At $t=0$, the c.s. invests in the riskless asset, so that it has \$1 in loanable funds available at $t=1$. At $t=1$, the c.s. lends \$1 under the loan commitment if state $\xi_{gh}$ occurs for the borrower. At $t=2$, depositors can only

[15] As in costly state verification models [e.g., Gale and Hellwig (1985)], we assume that some assets have values that are difficult to verify. Examples in our context are relatively illiquid assets such as certain types of inventories, some types of office furniture, tangible executive privileges like art objects and plush carpets in offices, etc.

Table 2

Payoffs of depositors, commitment seller and borrower for different states (except $\xi_{gh}$), all payoffs discounted to $t=0$ (assume borrower chooses $a_1$).

| State | | Depositor's payoff | Commitment seller's (c.s.) payoff | Borrower's payoff from spot borrowing |
|---|---|---|---|---|
| At $t=1$ | At $t=2$ | | | |
| $\xi_{gl}$ | Project succeeds | $g+[R_f]^{-1}$ | $[R_f R_l]^{-1}S$ | $\{X(a_1, G)-R_l[p(a_1)]^{-1}\}[R_f R_l]^{-1} - V(a_1)-g$ |
| | Project fails | | | $-V(a_1)-g$ |
| $\xi_{bl}$ | Project succeeds | $g+[R_f]^{-1}$ | $[R_f R_l]^{-1}S$ | $\{X(a_1, B)-R_l[p(a_1)]^{-1}\}[R_f R_l]^{-1} - V(a_1)-g$ |
| | Project fails | | | $-V(a_1)-g$ |
| $\xi_{bh}$ | Project succeeds | | | $-V(a_1)-g$ |
| | Project fails | $g+[R_f]^{-1}$ | $[R_f R_h]^{-1}S$ | $-V(a_1)-g$ |

be paid $gR_fR_h$ if the project fails. Note that since the commitment fee is invested in the riskless asset at $t=0$, $gR_fR_h$ is its compounded value at $t=2$ if state $\xi_{gh}$ occurs. If states $\xi_{gl}$, $\xi_{bl}$ or $\xi_{bh}$ occur, or if $\xi_{gh}$ occurs and the c.s. reneges, the loan commitment is not taken down and the c.s. invests its \$1 in the riskless asset at $t=1$.[16] In states $\xi_{gl}$ and $\xi_{bl}$, the c.s. pays $gR_fR_l+R_l$ to the depositor, whereas in state $\xi_{bh}$, the c.s. pays $gR_fR_h+R_h$ to the depositor. In state $\xi_{gh}$, when the c.s. reneges, the c.s. pays the depositor $gR_fR_h+p(a_1)\delta$ in accordance with 'me first' rules. Table 2 summarizes the payoffs to the c.s., the borrower and the depositor at $t=2$ in states $\xi_{gl}$, $\xi_{bl}$ and $\xi_{bh}$, and for the different strategies the c.s. could pursue. Table 2a presents this information for state $\xi_{gh}$. These payoffs are for $a=a_1$; those for $a=a_2$ can be written analogously. In the tables all cash flows are discounted to $t=0$ values.

Having formalized the nature of the bilateral single banker-single borrower loan commitment, we can now analyze equilibrium in the game between the c.s., the borrower and the depositor. In this game the informed agent – the borrower – moves first. We characterize a sequential equilibrium which survives the Grossman and Perry (1986) perfect sequential equilibrium (PSE) refinement. We will call this a competitive PSE with a loan commitment (CPSELC). The interested reader is referred to figs. B.1 and B.2 for descriptions of the extensive form. We now state the following result.

*Theorem 2. With a bilateral loan commitment contract between an individual c.s. and a borrower, the c.s. will renege. Thus, the only CPSELC involves the borrower not accepting the contract at any positive price.*

[16] Allowing the c.s. to invest in risky spot loans at $t=1$ does not materially change the results.

**Table 2a**

**Payoffs of depositors, commitment seller and borrower lor state $\zeta_{gh}$ and different strategies (all payoffs discounted to $t=0$).**

| States at $t=2$ | Payoff lo depositors of commitment seller | | Commitment seller's payoff | |
|---|---|---|---|---|
| Commitment holder | C.s. honors LC | C.s. reneges | C.s. honors LC | C.s. reneges |
| Project succeeds | $g+\delta[R_f R_h]^{-1}$ | $g+p(a_1)\delta[R_f R_h]^{-1}$ | $S[R_f R_h]^{-1}$ | 0 |
| Project fails | $g$ | $g+p(a_1)\delta[R_f R_h]^{-1}$ | $S[R_f R_h]^{-1}$ | $\{R_h-p(a_1)\delta+S\}[R_f R_h]^{-1}$ |

| States at $t=2$ | Commitment holder's payoff | |
|---|---|---|
| Commitment holder | C.s. honors LC | C.s. reneges |
| Project succeeds | $\{X(a_1,G)-\delta\}\times[R_f R_h]^{-1}-V(a_1)-g$ | $(X(a_1,G)+R_h-R_h[p(a_1)]^{-1}+S'-p(a_1)\delta)\times[R_f R_h]^{-1}-g-V(a_1)$ |
| Project fails | $-V(a_1)-g$ | $-V(a_1)-g$ |

The market with bilateral credit exchange breaks down because the c.s. is unable to make a credible promise to lend under the commitment in states in which the borrower wishes to take it down. This happens despite the availability of legal recourse to the borrower and the possible penalizing of the c.s. for unjustifiable failure to perform. Legal recourse is ineffective because the maximum legal penalty is less than the gain to the c.s. from reneging. To see why, note that the commitment fee is set at $t=0$ to equal the expected present value of the subsidy to the borrower under the commitment. Thus, once the borrower is in the state in which takedown is profitable (state $\zeta_{gh}$), the subsidy on the loan exceeds the commitment fee. By not honoring the commitment – and investing in the riskless asset instead – the c.s. can gain even if successful legal action by the borrower forces it to relinquish all of its wealth. Of course, this rests on S not being too high. We will show that even when S is not high enough to ensure contract enforceability with an individual c.s., it can do so with a bank.

### *4.4. Loan commitments issued by a bank*

The simplest resolution of the contract enforceability problem is for the c.s.

to be a bank with N ($\geqq 2$) equityholders (investors), *1* borrower and *1* depositor. With N sufficiently large, the bank will honor its commitment since the value of its lost projects will exceed the gain from reneging. However, if $v>0$, this resolution is inefficient relative to an alternative we will discuss shortly. The reason is that verification costs – required to distinguish endowed bankers from those not endowed – are borne by the borrower in equilibrium, and having many equityholders per borrower increases the per capita incidence of verification costs.

Consider now a ***large bank*** that sells commitments to a countable infinity of borrowers. This bank has exactly as many depositors and equityholders as it has borrowers. Thus, the per capita incidence of verification costs will now only be $v$. Assume, for simplicity, that $v=0$. All borrowers start out being identical at $t=0$, with each assessing a probability of $\Psi$ of realizing $k=G$. As in Boyd and Prescott *(1986)*. our bank is 'large' in that it has a countable infinity of equityholders, depositors and borrowers, and 'small' in that it has no monopoly power. The latter is achieved by assuming that the fraction of all agents that deals with any bank is zero.

When a bank deals with multiple commitment buyers at $t=0$, the deposit contract negotiated at $t=0$ must be modified to reflect this multiplicity. To ensure comparability with the non-bank case, we keep the spirit of the deposit contract unchanged. That is, it is again a claim to a risky payoff. To understand the deposit contract, note that it is no longer convenient to refer to depositors' payoffs in states $\xi_{gl}$ through $\xi_{bh}$; these states are borrower-specific and we have many borrowers. We will, therefore, refer to depositors' payoffs in the high and the low spot rate states. At $t=1$, if $R=R_l$, *no* borrower takes down its commitment. The bank thus invests all of its deposit funds in the riskless asset at $R_l$. Similar to the non-bank case, depositors are promised a per capita payoff of $gR_fR_l+R_l$. At $t=1$, if $R=R_h$, borrowers with $k=G$ will take down their commitments; the fraction of such borrowers is $\Psi$. The remaining borrowers let their commitments expire unexercised. The deposit funds made available by such borrowers are invested in the riskless asset yielding $R_h$ per dollar invested. Thus, if the bank honors all of its exercised commitments, depositors get $\delta+gR_fR_h$ on every commitment borrower whose project is successful and $gR_fR_h$ on every commitment borrower whose project fails. On the remaining funds, depositors get $R_h+gR_fR_h$. On a per capita basis, therefore, the depositors' (expected) payoff is $gR_fR_h+p(a_1)\Psi\delta+\{1-\Psi\}R_h$, conditional on $R=R_h$, whereas the bank's per capita expected payoff is S.

At $t=0$ then, the expected present value of the payoff to depositors is

$$\theta\{gR_fR_l+R_l\}(R_lR_f)^{-1}+(1-\theta)\{gR_fR_h+p(a_1)\Psi\delta+(1-\Psi)R_h\}(R_hR_f)^{-1}.$$

The terms in parentheses with negative exponents are discount factors. We can simplify the above expression and re-write it as

$$g+\theta R_f^{-1}+(1-\theta)\{R_h-\Psi(R_h-p(a_1)\delta)\}(R_hR_f)^{-1}.$$

In a competitive loan commitment market, if one assumes that the bank will honor its commitment when the customer takes it down, then the usual no-arbitrage considerations dictate that the commitment should be priced to satisfy

$$g=\Psi(1-\theta)p(a_1)(r(a_1|R_h)-\delta)(R_fR_h)^{-1},$$

where $r(a_1|R_h)=R_h(p(a_1))^{-1}$. Substituting (6) into (5) and simplifying. we can now see that the depositors' expected payoff at t=O is $R_f^{-1}$, the amount of deposits raised by the bank.

Before formalizing banks, we will sketch the intuition behind why a bank can help to restore credibility. Let N be the number of loan commitment sellers (equityholders) in the coalition we call a bank. Let N, be the number of commitments taken down and $N_r \leqq N_t$ the number of commitments on which the bank reneges. Let u' be the incremental per capita gain to the bank from reneging as opposed to not reneging. assuming the borrower has chosen a,. We can now write

$$u'=\xi_1-S, \quad \text{where } \xi_1\equiv\{(1-p(a_1))^{N_r}\}N_rN^{-1}(R_h-\delta p(a_1)+S).$$

To understand $\xi_1$, note that if the bank reneges and escapes legal punishment (this occurs with probability 1 – ha,), which is the probability that the borrower's project fails), then its contractual obligation to depositors is $\delta p(a_1)$, whereas its gross payoff is $R_h+S$. The probability that no borrower's project will succeed is $(1-p(a_1))^{N_r}$ and the total expected payoff over the reneged commitments is $N_r(1-p(a_1))^{N_r}(R_h-p(a_1)\delta+S)$. Per loan commitment issued then, this expected payoff is given by $\xi_1$. If the bank does renege on any commitment, its payoff is S. Thus, u' gives the per capita difference between the payoffs from reneging and not reneging. Now. if the bank is very large $(N\to\infty)$ and reneges on all its commitments, $\lim_{N_r}[1-p(a_1)]^{N_r}=0$. Thus, $\lim_{N_r\to\infty}\xi_1=0$, implying $u'=-S$. On the other hand, if it reneges on only one commitment, then $N_rN^{-1}=N^{-1}$, and thus $\lim_{N\to\infty}\xi_1=0$. Once again. $u'=-S$. This means that, when there is a finite number of reneged commitments, there is a nonzero probability that the bank will escape legal punishment. But, the per capita gains from reneging vanish with increasing bank size. Although for any finite N, there will generally be an optimal N„ we assume that, if the bank reneges, it will renege on all its commitments. This does not sacrifice much since we focus on an infinitely large bank for which the optimal N, is shown later to be zero (see Theorem 3). Note. however, that an infinitely large bank is unnecessary to establish credibility; generally $u'<0$ for a finite N.

Table 3

**Payoffs of depositors,** (infinitely large) bank **and** borrower in **different** states and **strategies (payoffs** discounted to $t=0$ lor each spot rate **realization,** $R_f \in \{R_l, R_h\}$, with **expectation** taken **across** success and failure states at $t=2$, borrower **chooses** $a_1$).

| Stale | **Depositors'** per capita **expected payoff** | | **Bank's** per capita expected **payoff** | |
|---|---|---|---|---|
| At $t=1$ | Bank honors LC | Bank reneges | Bank honon LC | Bank reneges |
| $R=R_l$ | $[R_f]^{-1}+g$ | $[R_f]^{-1}+g$ | $S[R_f R_l]^{-1}$ | $S[R_f R_l]^{-1}$ |
| $R=R_h$ | $g+p(a_1)\Psi\delta \times [R_f R_h]^{-1} + [1-\Psi][R_f]^{-1}$ | $g+p(a_1)\Psi\delta \times [R_f R_h]^{-1} + [1-\Psi][R_f]^{-1}$ | $S[R_f R_h]^{-1}$ | 0 |

| Stare | **Borrower's** expected payoff | | |
|---|---|---|---|
| | $k=G$ | | k−B |
| **At $t=1$** | Bank honors LC | Bank **reneges** | |
| R−R, | $U_1^1$ | $U_1^1$ | $U_3^1$ |
| $R=R_h$ | $U_c^1 + \Psi[R_h - p(a_1)\delta]\}$ | $U_2^1 + (S \times [R_f R_h]^{-1}$ | $U_4^1$ |

Now suppose $R=R_h$ at $t=l$ and the bank refuses to honor any of the commitments taken down. Consequently, it will lose all of its equity, including the commitment fee revenue, if any commitment holder **successfully** sues. As in the non-bank case, we want depositors to obtain the same (expected) payoff as in the case in which the bank honors its commitments. Thus, the deposit contract stipulates that depositors get a **per** capita payoff of $gR_f R_h + p(a_1)\Psi\delta + \{1-\Psi\}R_h$ when there is no lending under commitments and $R=R_h$. If a commitment holder successfully sues, this amount must first be paid to depositors with the rest going to the commitment holders.

**Thus,** the deposit contracts in the bank and the non-bank cases are similar. Table 3 lists the depositors' and the bank's payoffs in different states for alternative bank strategies.

*Theorem 3. There exists o **CPSELC** involving banks, each dealing with* a ***countable*** *infinity of borrowers, such that each borrower* ***purchases*** *o loan commitment at $t=0$* ***and*** *chooses $a$, and each bank honors* ***every commitment at*** ***$t=1$.***

This theorem implies two key points. First, a (large) bank can resolve the contract **enforceability** problem that plagues the bilateral credit transactions.

This is despite the fact that a borrower has the *same* legal recourse when dealing with a bank as it docs when dealing with an individual lender. In both cases, the maximum penalty imposed on the lender is the loss of all of its terminal equity. The difference between the two *cases* lies in the *effectiveness* of the legal punishment mechanism. The effectiveness increases with the size of the c.s. and attains its maximum for an infinitely large bank.

Second, we have a novel economic rationale for a bank. Because bilateral contracts are not credible and the legal system is ineffective in restoring appropriate incentives, a *non-organizational*, market-mediated equilibrium fails to exist. This market failure creates an impetus for the emergence of organizations (banks) to intermediate between individual borrowers and lenders (depositors) in a manner that assures credibility.

## 5. Concluding thoughts

We have taken a close look at c.s. incentives to honor its loan commitments. Although contract enforceability hazard has been acknowledged in the loan commitments literature, ours is the first paper to analyze its implications. Our principal findings arc listed below.

(i) Loan commitments serve an economic function in an environment characterized by linear preferences and takedown uncertainty; in addition they dominate inside equity in resolving moral hazard.
(ii) A loan commitment can be economically valuable even when its seller's incentive to renege is explicitly allowed for.
(iii) A new economic rationale is provided for the existence of a bank; an organization like a bank can make credible promises to honor its loan commitments, while an individual lender cannot.

A callous observer might question the centrality of contract enforceability because banks renege infrequently. This misses the point, however. Perhaps loan commitments are generally honored *because* they are issued by *banks*.

Since the loan commitment is a put option, an interesting question is whether the borrower could buy a put option directly from a securities exchange.[11] Since we could assume that the exchange would never decline to honor its obligation to buy the customer's debt when the latter chose to exercise its option, is it possible to do better with this approach?

Although we have formally analyzed this case and shown that a loan commitment solution dominates that attainable with an exchange-based put

[11] We thank a referee lor suggesting this comparison. The referee also suggested that we could explicitly model the credit quality insurance aspect of a bank loan commitment. Indeed, if the bank is a monitoring specialist whose monitoring affects the probability distribution of $k$, then $\Pr(k=B)$ would be lower with a bank than with an exchange, strengthening the case lor a bank loan commitment.

option, we will only outline the intuition here. We can assume that the exchange-based put option permits the buyer of the option to sell its debt (a promise to repay the exchange at $t=2$) to the exchange at a fixed price of \$1. The face value of this debt can be set to ensure that the option buyer chooses the first best action as with the bank loan commitment contract. Now, the intuition is that the willingness of the exchange to always honor its contract with the option buyer allows the buyer to put its debt to the exchange even in the state in which the buyer's project has negative NPV, given the high interest rate realization. In this state the bank is able to renege with impunity by invoking the MAC clause in its contract. Since the exchange is compensated ex ante by the option buyer for the dissipation involved in investing in the negative NPV state, it is the option buyer who is worse off.

The basic point is that an exchange-based solution can dominate a bank solution if the credibility of the bank in honoring its contract is suspect. However, when the credibility problem is resolved, the greater flexibility of a bank loan commitment (provided by the MAC clause) means that the bank solution dominates the exchange-based solution.

Banks in our model lend through loan commitments and also directly in the spot market. Moreover, they borrow long and lend both long and short, suggesting that an augmented version of the model could potentially address maturity mismatching and asset-liability mix issues. Hence, these 'conventional' issues could be analyzed in a framework in which contracts may not be honored and there is an endogenous reason for the bank to exist.[18]

## Appendix A. Derivation of no-arbitrage term structure relationship

Consider two different investment strategies that yield identical payoffs with identical risk. The first strategy involves investing \$1 at $t=0$ in a two-year pure discount bond with price $P_0^2$. The payoff at $t=2$ will be $(R'_f)^2$. The second strategy involves buying two securities at $t=0$. One is a one-year pure discount bond that pays \$1 at $t=1$; we buy $(R'_f)^2/R_h$ units of this bond. This purchase will cost $((R'_f)^2/R_h)R_f^{-1}$ at $t=0$. The other security we buy is a call option. This option entitles us to buy $(R'_f)^2$ units of a one-year pure discount bond at $t=1$ with each unit of this bond paying \$1 at $t=2$; the exercise price of this option is $(R'_f)^2/R_h$. Because investors arc risk neutral and the option will be exercised at $t=1$ only if $R=R_l$, the pria of this call option at $t=0$ should be

$$P_0^c=(\theta/R_f)((R'_f)^2R_l^{-1}-(R'_f)^2R_h^{-1}).$$

[18] We could also model seller reputation in contract enforcement, in which case banks may be shown to value reputation more than an individual c.s.

It can be seen that *both* investment strategies yield sure payoffs of $(R'_f)^2$ at $t=2$ and hence, to prevent arbitrage, they should cost the same at $t=0$. Equating the investment in the first strategy ($1) to that in the second strategy $(P^c_0+(R'_f)^2(R_h R_f)^{-1})$ gives us the desired term structure relationship.

Modified version of (PR-1)

$$\begin{aligned} &p(a_1)\{\theta\Psi(X(a_1,G)-r(a_1|R_l))(R_f R_l)^{-1}+\theta(1-\Psi) \\ &\quad\times(X(a_1|B)-r(a_1|R_l))(R_f R_l)^{-1} \\ &\quad+(1-\theta)\Psi(X(a_1,G)-r(a_1|R_h))(R_f R_h)^{-1}\}-V(a_1) \\ &>p(a_2)\{\theta\Psi(X(a_2,G)-r(a_2|R_l))+\theta(1-\Psi) \\ &\qquad\times(X(a_2|B)-r(a_2|R_l)\}(R_f R_l)^{-1}-V(a_2). \end{aligned} \tag{PR-1'}$$

## Appendix B. Proofs of the results

Proof of Lemma 1. We will first prove that the allocation described in the lemma is indeed a N.E. A necessary condition for a N.E. is

$$\begin{aligned} &p(a_2)\sum_{\xi_i\in\Xi}\Pr(\xi=\xi_i)(X(a_2,k(\xi_i))-r(a_2|R(\xi_i)))-V(a_2) \\ &\geqq p(a_1)\sum_{\xi_i\in\Xi}\Pr(\xi=\xi_i)(X(a_1,k(\xi_i))-r(a_2|R(\xi_i)))-V(a_1) \end{aligned} \tag{B.1}$$

where $k(\xi_i)$ is the realization of k corresponding to the realization $\xi_i$ and $R(\xi_i)$ is the realization of R corresponding to the realization $\xi_i$; $r(a_1|R_j)$ is defined in (4). Comparing (B.1) with (PR-2) now reveals (B.1) to be weaker. Thus, this equilibrium is supported by the bank believing the borrower has chosen a, and the borrower believing that the bank will extend credit at $r(a_2|R_l)$ if $R=R_l$ and at $r(a_2|R_h)$ if $R=R_h$. Both beliefs are rationalized in equilibrium. Moreover, the bank earns zero expected profit and, with these beliefs, no other contract makes the borrower strictly better off. All that remains to be shown is that the borrower's expected utility is non-negative. Using (PR-3), the borrower's expected utility is

$$\begin{aligned} &p(a_2)\{\theta\Psi(X(a_2,G)-r(a_2|R_l))+\theta(1-\Psi)(X(a_2,B)-r(a_2|R_l)\} \\ &\quad\times(R_f R_l)^{-1}-V(a_2). \end{aligned} \tag{B.2}$$

From (**PR-5**). (**B.2**) is strictly positive. Thus, this is a N.E. From (**PR-1′**) it follows that this is a lower expected utility than first best.

Note that any N.E. involving the bank lending at $r(a_2|R_j)$ if $R=R_j$ for $j\in\{h,l\}$ and rationing otherwise is strictly Pareto dominated by the N.E. above. Thus, we need not consider those N.E. Also, 'mixed action' contracts, involving $r(a_i|R_l)$ if $R=R_l$ and $r(a_j|R_h)$ if $R=R_h$, with $a_i\neq a_j$, can never be N.E. Thus, the only candidates for N.E. that we **need** to examine are those involving (i) the bank charging $r(a_1|R_l)$ if $R=R_l$ and rationing otherwise and **(ii)** the bank charging $r(a_1|R_h)$ if $R=R_h$ and rationing otherwise. The reason why these are the only two remaining candidates is twofold. First, (**PR-2**) precludes a N.E. in which the bank charges $r(a_1|R_l)$ if $R=R_l$ and $r(a_1|R_h)$ if $R=R_h$. And second, an allocation involving the bank charging $r(a_i|R_l)$ if $R=R_h$ or $r(a_i|R_h)$ if $R=R_l$ can never **be** a N.E. in the spot credit market because it would entail the bank making either a positive expected profit or a negative expected profit. Now suppose the bank charges $r(a_1|R_l)$ if $R=R_l$ and rations otherwise. **Since** the borrower correctly anticipates this in equilibrium, it will assess its expected utility from choosing $a_1$ as

$$p(a_1)\{\theta\Psi(X(a_1,G)-r(a_1|R_l))+\theta(1-\Psi)(X(a_1,B)-r(a_1|R_l))\}$$
$$\times(R_fR_l)^{-1}-V(a_1), \tag{B.3}$$

and its expected utility from choosing $a_2$ as

$$p(a_2\{\theta\Psi(X(a_2,G)-r(a_1|R_l))+\theta(1-\Psi)(X(a_2),B)-r(a_1|R_l)\}$$
$$\times(R_fR_l)^{-1}-V(a_2). \tag{B.4}$$

Note now that (**PR-3**) implies that $X(a_2,G)-r(a_1|R_h)<0$, whereas $X(a_1,G)-r(a_1|R_h)>0$. Moreover,

$$X(a_1,B)-r(a_1|R_h)>X(a_2,B)-r(a_1|R_h).$$

Using these observations with (PR-2) implies that (B.4) strictly **exceeds** (B.3). **Thus,** the bank's belief about the borrower's action choice is not **rationalized** and this is not a N.E. Next suppose the bank charges $r(a_1|R_h)$ if $R=R_h$ and rations **otherwise.** The borrower's **expected** utility from **choosing** $a_1$ is

$$p(a_1)\{(1-\theta)\Psi(X(a_1,G)-r(a_1|R_h))+(1-\theta)(1-\Psi)(X(a_1,B)-r(a_1|R_h))\}$$
$$\times[R_fR_h]^{-1}-V(a_1). \tag{B.5}$$

But from (PR-3), $X(a_1, B) - r(a_1|R_h) < 0$. Now from (PR-4), it follows that the expression in (B.5) is strictly negative. Hence, this is not a **N.E.** either. □

Proof of Theorem 2. We first define $\bar{S} \equiv (1-p(a_1))(r(a_1|R_h) - \delta)$, where $\delta$ follows from (PR-3) if substituted for $r(a_1|R_h)$ and solved as an equality (see the proof of Theorem 1),

$$\delta \equiv \{\lambda_2 - [V(a_1) - V(a_2)]R_f\}[\Psi\{1-\theta\}\{p(a_1) - p(a_2)\}[R_h]^{-1}]^{-1}$$

and

$$\begin{aligned}\lambda_2 \equiv\ & p(a_1)\{\Psi\theta X(a_1, G)[R_l]^{-1} + \Psi[1-\theta]X(a_1, G)[R_h]^{-1} \\ & + \theta[1-\Psi]X(a_1, B)[R_l]^{-1}\} \\ & - [p(a_1) - p(a_2)]\theta r(a_1|R_l)[R_l]^{-1} \\ & - p(a_2)\{\Psi\theta X(a_2, G)[R_l]^{-1} + \Psi[1-\theta]X(a_2, G)[R_h]^{-1} \\ & + \theta[1-\Psi]X(a_2, B)[R_l]^{-1}\}.\end{aligned}$$

In this and subsequent proofs, we utilize the extensive form of the commitment game (see figs. B.1 and B.2). We now analyze the depositors. Because the CD contract makes their payoff independent of the bank's strategy, they do not care about the bank's strategy. The only important factor is the depositor's belief about the borrower's action choice. Suppose $\Pr(a = a_1) = \mu_d$, $\Pr(a = a_2) = 1 - \mu_d$. That is, $\mu_d$ is the probability depositors attach to a choice of a, and $1 - \mu_d$ is the probability attached to a,. We will return to these beliefs later on in the proof.

### C.S.'s metastrategy (conditional on borrower buying loan commitment)

This is relevant only when a borrower comes for a loan commitment The probability that the borrower will accept the loan commitment is irrelevant for the commitment seller. The commitment seller's beliefs about the borrower's action are $\Pr(a = a_1) = \mu_c$, $\Pr(a = a_2) = 1 - \mu_c$. Since the commitment seller is the last to move, its perfect metastrategy, $m$, is

$$m = \begin{cases} h & \text{if } \mu_c > D_3, \\ n \text{ or } h & \text{if } \mu_c = D_3, \\ n & \text{if } \mu_c < D_3, \end{cases} \qquad \text{(B.6)}$$

when

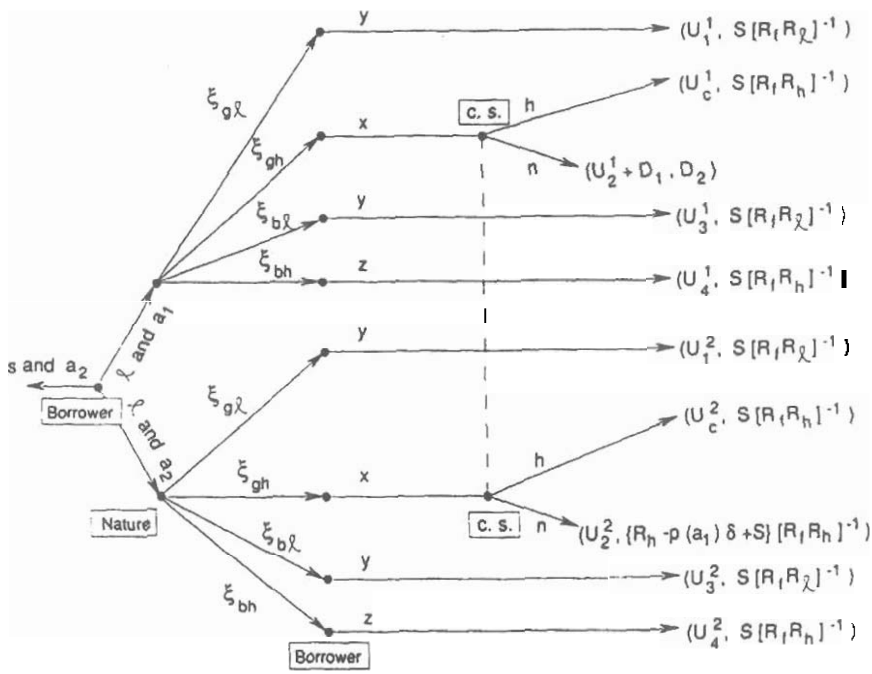


Fig B.1. Extensive form lor commitment game.

**Notes for fig. B.1**

- Nature is a passive player.
- The borrower's decision at $t=0$: '$\ell$' (purchase loan commitment) and '$s$' (plan to borrow in spot market at $t=1$).
- The borrower's decisions at $t=1$: '$x$' (take down loan commitment), '$y$' (don't take down loan commitment but borrow in spot market), and '$z$' (avoid both commitment takedown and spot borrowing i.e., don't invest).
- Terminal nodes have payoffs (discounted to $t=0$ values): first term in payoff pair is borrower's expected utility over terminal ($t=2$) wealth and the second term is the c.s. expected (terminal) wealth. Both expectations are assessed at $t=1$, after $\xi$ has been realised but prior to the realization of the borrower's project cash flow. $U^i_j$ = borrower's expected utility with anion $a_i$ and state realization $\xi_j$, assuming commitment is not taken down: $U^i_c$ = borrower's expected utility if commitment is taken down.
- Pnny whose turn it is to move is indicated in each rectangular box
- *Definition of terms:*

$$D_1 \equiv \{p(a_1)R_h + p(a_1)S' - p(a_1)^2\delta)\}(R_f R_h)^{-1}$$

$$D_2 \equiv \{(1-p(a_1))(R_h - p(a_1)\delta + S)\}(R_f R_h)^{-1}$$

For $i \in (1, 2)$:

$$U^i_1 = \{p(a_i)X(a_i, G) - R_l p(a_i)(p(a_1))^{-1}\}(R_f R_l)^{-1} - V(a_i) - g,$$

$$U^i_c = \{p(a_i)X(a_i, G) - p(a_i)\delta\}(R_f R_h)^{-1} - V(a_i) - g,$$

$$U^i_3 = \{p(a_i)X(a_i, B) - p(a_i)R_l(p(a_1))^{-1}\}(R_f R_l)^{-1} - V(a_i) - g,$$

$$U^i_4 = -V(a_i) - g,$$

$$U^1_2 = \{p(a_1)X(a_1, G) - R_h\}(R_f R_h)^{-1} - V(a_1) - g,$$

$$U^2_2 = -V(a_2) - g.$$

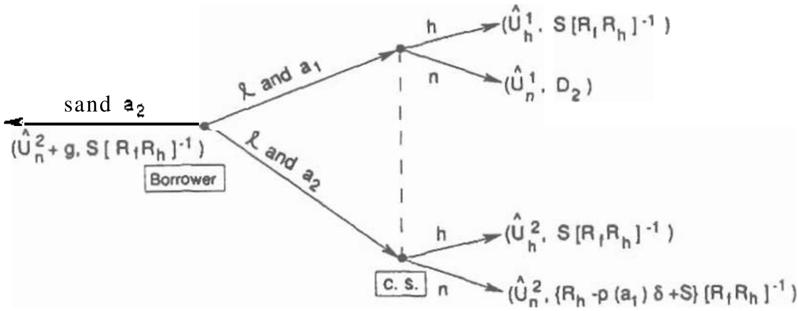


Fig. B.2. 'Condensed' extensive form lor commitment game.

**Notes for fig. B.2**

- **Extensive form drawn** lor state $\xi_{gh}$ (only state in which **c.s. metastrategy** relevant).
- **Payoff** pain in terminal **nodes** have borrower's **expected** utility first and **c.s. expected payoff second. Expectations** of **borrower's** utility arc **assessed** at $t=0$ and arc **across** $\xi$ **realizations,** i.e., prior io **borrower's** action choice. **Expectations** of the c.s. **payoff** arc **assessed** at $t=1$, conditional on $\xi_{\mu h}$, **since** c.s. knows $\xi$ when deciding whether to honor **commitment.**
- *Definitions of terms:*

$$\hat{U}_h^1 = \theta\Psi U_1^1 + \Psi(1-\theta)U_c^1 + (1-\Psi)\theta U_3^1 + (1-\Psi)(1-\theta)U_4^1$$
$$= \theta(\Psi p(a_1)X(a_1,G) + (1-\Psi)p(a_1)X(a_1,B) - R_l\}(R_f R_l)^{-1},$$
$$+ (1-\theta)\{\Psi p(a_1)X(a_1,G) - \Psi p(a_1)\delta\}(R_f R_h)^{-1} - V(a_1) - g,$$

$$\hat{U}_n^1 = \hat{U}_h^1 - \{\Psi(1-\theta)p(a_1)(\{1-p(a_1)\}(r(a_1|R_h) - \delta) - S')\}(R_f R_h)^{-1},$$
$$\hat{U}_h^2 = \theta\Psi U_1^2 + \Psi(1-\theta)U_c^2 + (1-\Psi)\theta U_3^2 + (1-\Psi)(1-\theta)U_4^2$$
$$= \theta\{\Psi p(a_2)X(a_2,G) + (1-\Psi)p(a_2)X(a_2,B) - R_l p(a_2)(p(a_1))^{-1}\}(R_f R_l)^{-1}$$
$$+ (1-\theta)\{\Psi p(a_2)X(a_2,G) - \Psi p(a_2)\delta\}(R_f R_h)^{-1} - V(a_2) - g,$$
$$\hat{U}_n^1 = \hat{U}_h^1 - \Psi(1-\theta)p(a_2)(r(a_1|R_h) - \delta).$$

$$D_3 \equiv (R_h - p(a_1)\delta)(p(a_1)\{R_h - p(a_1)\delta + S\})^{-1}.$$

Now. because $S \in (S', \bar{S})$, it is easy to verify that $D_3 > 1$. *Thus,* m=n is the optimal strategy of the **c.s.**

## Borrower's **metastrategy**

We **consider** the metastrategy of the borrower when it has the choice of accepting or rejecting the loan commitment contract. **Since** $n$ is a dominant strategy for the **c.s.,** the borrower's only consistent belief is $\mu_b \equiv \Pr(m=n) = 1$ and $1-\mu_b = 0$. Now, $\hat{U}_n^2 + g > \hat{U}_n^2$ and $\hat{U}_n^2 > \hat{U}_n^1$ [follows from **(PR-2)]**. Thus, the borrower's metastrategy is to choose $s$ given p. Finally, since the **c.s.** does not borrow at $t=0$, depositors' metastrategy is irrelevant □

***Proof*** of Theorem 3. We will consider a bank with $N=\infty$. Because the CD **contract** makes the depositors' payoff **independent** of the bank's strategy, their beliefs about the strategy are irrelevant. Only their beliefs about each borrower's action choice matter. As in the previous proof, we designate their beliefs about that action choice by the probability $\mu_d$. We will argue later on that the only consistent belief for depositors is to assign $\mu_d = 1$.

**Bank's metastrategy**

This is relevant only when the borrower comes for a loan commitment. The probability that the borrower will accept the loan commitment is irrelevant for the bank. Since the bank is the last to move, its perfect metastrategy is given by

$$m = \begin{cases} h & \text{if } \mu_b > D_4\{D_4 + S\}^{-1}, \\ n \text{ or } h & \text{if } \mu_b = D_4\{D_4 + S\}^{-1}, \\ n & \text{if } \mu_b < D_4\{D_4 + S\}^{-1}, \end{cases} \tag{B.7}$$

where $\mu_b$ is the probability the bank assigns to the borrower having chosen $a_1$, and $D_4 \equiv \Psi\{R_h - p(a_1)\delta\}$. We now discuss the bank's consistent belief at its information set. It is useful to begin by noting that $a = a_1$ is a *dominant* strategy for the borrower which accepts a loan commitment, since $\hat{U}_h^1 > \hat{U}_h^2$. Thus, there is no consistent belief of the bank (or the depositors) that puts positive weight on $a = a_2$. On the other hand, if the bank believes that the borrower chose $a = a_1$, then according to its metastrategy it must decide to honor the commitment, and this decision indeed makes it optimal for the borrower to have chosen $a = a_1$. This implies that the only consistent belief at the bank's information set is $\mu_b = 1$. Thus, the bank's optimal choice is h. The borrower – who is the informed player in this game – has a metastrategy which is reduced to a usual strategy, given the fact that the borrower has already accepted the loan commitment. This is because if the borrower does not accept the loan commitment, the bank has no metastrategy. Now, since $D_4\{D_4 + S\}^{-1} < 1$, we need $\mu_b$ to exceed a number less than *1* in order for $m = h$. This is certainly true since the only consistent belief of the bank is $\mu_b = 1$.

Note that the depositors' only consistent belief is $\mu_d = 1$, using arguments similar to those for the bank. Thus, they will supply deposits.

**Generalized borrower metastrategy**

This is the borrower's metastrategy when it can accept or reject the loan commitment contract. Let the probability $\eta$ be the borrower's belief that the bank will honor the loan commitment. A necessary condition for the borrower to purchase the loan commitment is

$$\eta \geqq (\hat{U}_n^2 + g - \hat{U}_n^1)(\hat{U}_h^1 - \hat{U}_n^1)^{-1}. \tag{B.8}$$

We also need to preclude the possibility that the borrower will accept the loan commitment at t=0 and then choose $a_2$. (Our earlier incentive compatibility conditions do not help here since they assume $\eta = 1$.) Thus, we need

$$\eta \geqq (\hat{U}_n^2 - \hat{U}_n^1)(\hat{U}_h^1 - \hat{U}_h^2 - \hat{U}_n^1 + \hat{U}_n^2)^{-1}. \tag{B.9}$$

Now, if (B.8) holds and (B.9) does not, then the borrower will accept the loan commitment and choose $a_2$. So, we want (B.9) to hold automatically when (B.8) holds. In that case, a borrower that chooses a loan commitment will always choose $a_1$. That is, we need

$$(\hat{U}_n^2 - \hat{U}_n^1)(\hat{U}_h^1 - \hat{U}_h^2 - \hat{U}_n^1 + \hat{U}_n^2)^{-1} < (\hat{U}_n^2 + g - \hat{U}_n^1)(\hat{U}_h^1 - \hat{U}_n^1)^{-1}. \tag{B.10}$$

It is easy to see that, if (B.10) holds, then $\eta$ can be a probability. This is because $\hat{U}_h^1 > \hat{U}_n^2 + g$, implying that

$$(\hat{U}_n^2 + g - \hat{U}_n^1)(\hat{U}_h^1 - \hat{U}_n^1)^{-1} < 1.$$

As long as (B.10) holds, it is possible to have $\eta \in (0, 1]$ such that the borrower buys a loan commitment at t=0 and chooses $a_1$. However, we have argued that once the bank issues a commitment, its dominant strategy, in conjunction with its own consistent belief about $a_i$, is to honor the commitment. Thus, the only consistent belief is for the borrower to set $\eta = 1$. Rearrange (B.10) as

$$\{\hat{U}_h^1 - \hat{U}_h^2 + [\hat{U}_n^2 - \hat{U}_n^1]\}\{\hat{U}_h^2 - \hat{U}_n^2\}^{-1} > \{\hat{U}_n^2 - \hat{U}_n^1\}\{g\}^{-1}. \tag{B.10'}$$

Now, since $\hat{U}_h^1 > \hat{U}_h^2$ and $\hat{U}_n^2 > \hat{U}_n^1$ (see the proof of Theorem 2), (B.10) holds if $\hat{U}_h^2 - \hat{U}_n^2 < g$. But this is certainly true since

$$g = \{\Psi(1-\theta)p(a_1)(r(a_1 | R_h) - \delta)(R_f R_h)^{-1}$$

[see (6)] and

$$\hat{U}_h^2 - \hat{U}_n^2 = \{\Psi(1-\theta)p(a_2)(r(a_1 | R_h) - \delta\}(R_f R_h)^{-1}.$$

Finally, a comment on strategies off the equilibrium path. A borrower with $a = a_1$ will find it ex post efficient to sue a bank that reneges. Moreover, the courts will prematurely liquidate the bank's projects since the borrower collects $\varepsilon > 0$ per project, i.e., it is in the borrower's best interest to force liquidation of the bank's equityholdets' projects. □

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