

# Off-balance sheet liabilities, deposit insurance and capital regulation

Arnoud W. A. Boot

J L. Kellogg *Graduate School of Management, Northwestern University, Evanston, IL 60208.*  
USA

Anjan V. Thakor\*

School of Business, *Indiana University, Bloomington, IN 47405.* USA

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We examine the **effect** of banks' on-balance sheet activities (particularly loan commitments) on their asset portfolio risk **when** banks as well as borrowers are free to choose asset risk. We formally establish that banks that have loan commitments have lower asset risk than banks that do not. Loan **commitments** may thus reduce the **bank's** portfolio risk and lower the exposure of the federal deposit insurer. We then analyze the **implications** of the interaction between banks' on- **and off-balance** sheet activities **for** the recently adopted **BIS** capital guidelines, maintaining a clear distinction between loan **commitments** and other off-balance sheet activities.

## 1. Introduction

Two striking developments have recently occupied center stage in the financial market. One is the emergence of a dazzling array of new financial instruments, a development that has inspired an emerging literature on optimal security design [e.g., Allen and Gale (1988)]. The other is the S & L crisis which has already revealed losses of staggering proportions to the deposit insurance fund. The voluminous literature on deposit insurance has repeatedly pointed to the **excessive** risk-taking incentives generated by the current deposit insurance scheme, suggesting that the shadow of the present crisis has been around for a while.<sup>1</sup>

As part of the financial innovation process, there has been an increasing tendency for banks<sup>2</sup> to **engage** in off-balance sheet activities. The most

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<sup>1</sup>See, for example, Chan and Mak (1985), Cummins (1988), Edwards and Swett (1979), Kane (1982), Marcus and Shaked (1984), McCulloch (1985), Merton (1977, 1978), Pennachi (1984), Ronn and Verma (1989), and Taggart and Greenbaum (1978).

<sup>2</sup>We will use the term 'banks' to generically describe all depository financial intermediaries, including S&L's.

**prominent** off-balance sheet activity is loan commitments which currently amount to over half a trillion dollars in the U.S.; approximately 80% of all commercial bank lending is done under commitments. This raises an important issue: how do loan commitments affect the liability of the deposit insurer? Despite a burgeoning literature on loan commitments,<sup>1</sup> some of which has provided sufficient conditions for the loan commitment to be an optimal financial contract,<sup>2</sup> this question has received surprisingly little attention.<sup>3</sup> The principal objective of this paper is to take a first step toward a bridge between loan commitment theory and the deposit insurance policy ramifications of the commitment exposure of banks. A second objective is to examine the implications of our analysis for capital requirements on various off-balance sheet liabilities. Although our formal analysis focuses on loan commitments, we explore the capital regulation issue as it pertains to a range of off-balance items, including loan commitments.

At an informal level, the perception seems to be that bank loan commitments escalate the risk exposure of the deposit insurer.<sup>4</sup> The apparent reason for this perception is that a loan commitment imposes a contingent liability on the bank since the borrower's exercise of its commitment option imposes a loss on the bank.<sup>5</sup> Although the fees charged on the commitment are designed to compensate the bank for its exposure,<sup>6</sup> the contingent liability is not quantified and reflected in the deposit insurance premium. This accounting abomination could conceivably induce banks to take on considerable risk by expanding their loan commitment exposure, in pretty much the same fashion that the existing fixed premium structure encourages excessive risk-taking in on-balance sheet spot lending. If this reasoning is correct, then there may be a gross underestimation of the risk exposure of the federal deposit insurance fund.

Our analysis provides conditions under which the outcome is the polar opposite of the above view. Loan commitments are shown to lead to lower bank asset portfolio risk. The lowering of risk comes from two sources. First,

<sup>1</sup>For example, see Boot, Thakor and Udell (1987, forthcoming, 1991b), Campbell (1978), James (1982), Kanatas (1987), Maksimovic (1990), Melnik and Plaut (1986), Solianos, Wachtel and Melnik (forthcoming), Thakor (1982), and Thakor and Udell (1987).

<sup>2</sup>For example, see Berkovitch and Greenbaum (forthcoming) and Thakor (1989).

<sup>3</sup>A notable exception is Avery and Berger (1990). That paper focuses on the effect the loan commitment contract has on the project risk chosen by borrower which takes the commitment. Theoretically they find that the net riskiness of the borrower under the commitment may be more or less than its riskiness with a spot loan. Empirically they discover that commitments tend to lower bank portfolio risk.

<sup>4</sup>See Brewer, Koppenhaver and Wilson (1986) and the discussion in Avery and Berger (1990).

<sup>5</sup>See Thakor, Hong and Greenbaum (1981) where loan commitment pricing exploits the isomorphic correspondence between loan commitments and common stock put options.

<sup>6</sup>The commitment fee appears on the bank's income statement and if it is cash, it also increases the bank's asset.\* However, there is a formula used for determining how much of it appears as a liability. Usually only a fraction of the fee is recognized as a liability at the time the commitment is issued.

we show that the loan commitment contract can be designed to resolve the asset substitution problem between the bank and the borrower. Because a spot loan is a standard debt contract, the borrower is inclined to increase asset risk after **acquiring** a bank loan. With a loan commitment **the** bank can significantly dampen this proclivity. Second, we show **that if** the bank's **existing** spot lending portfolio in a given period is observable to its loan **commitment** customers in that period, then the bank will optimally choose to make spot **loans** to less risky borrowers. The intuition is that **the** bank's current loan **commitment** revenue is an increasing function of the likelihood that the bank will be **solvent** in the future. Hence, an increase in the riskiness of its spot loan portfolio **causes** a reduction in its loan commitment revenue. The **tradeoff** induced by this **causes** the bank's private risk optimum to shift to lower risk. Thus, loan **commitments** may help to resolve the asset substitution problem faced by the **deposit insurer** due to the bank's well-known inclination to exploit the deposit insurance **contract**. This effect on the bank's choice of current asset risk is also present if we **allow** **spot** lending – rather than lending under a commitment – in the future period. To the extent that future **lending** generates rents for the bank, it is induced to **lower** current asset risk to enhance the probability of preserving those rents. We show, however, that if this future lending is done via loan commitments, the bank will choose even lower asset risk in the current period than it would if it could **engage only** in future spot lending. Combined with the previous effect, the deposit insurer finds itself confronted with lower risk in both the **bank's** spot and future **lending** activities **when** **this** future lending is **done** under commitments. An important policy implication of our analysis is that the deposit insurer should insist on all of the bank's outstanding commitments being voided if the bank is unable to pay off its depositors and is **bailed** out by the insurer. This is the only way that the market discipline **created** by the effect of the bank's asset risk on its loan commitment revenue can work.

On the capital regulation issue, the policy implication of our analysis is that an explicit capital requirement against (**unexercised**) loan commitments is counterproductive if the objective of capital regulation is to limit risk taking by banks. Capital requirements against other types of off-balance sheet liabilities which take **the** form of financial guarantees (such as standby letters of credit) may well serve a purpose. The essential difference is that the latter type of **off-balance** sheet liabilities impose credit risk on the bank because of its role as third-party guarantor, while loan commitments generally do not.

The rest of the paper is organized as follows. Section 2 outlines the basic model and discusses the asset substitution problem between the bank and the borrower and between the bank and the deposit insurer. We also derive the optimal asset risk choices in a static **environment** in **which** banks can only

make loans in the current period. In Section 3 we allow the bank to lend in a future period and compare the outcome in which the bank can only lend in the spot market in the future with the outcome in which ~~this future lending~~ may be done under a loan commitment sold now. Section 4 takes up ~~issues~~ related to robustness and model extensions. Section 5 examines the policy implications of our analysis for capital regulation and the relative competitiveness of U.S. Banks. Section 6 concludes the paper.

## 2. The basic model and the asset substitution problem

### 2.1. The model

We consider a two-period model with three points in time,  $t=0, 1, 2$ . The first period spans  $t=0$  to  $t=1$  and the second period spans  $t=1$  to  $t=2$ . There are four parties: the bank (and its stockholders), the borrowers, the depositors, and the federal deposit insurer. All parties are risk neutral. Each borrower can invest in either a safe project, say 's', or a risky project say 'r'. Each project has a random payoff that is realized one period hence. The probability distribution of this payoff has a ~~two-point~~ support. We indicate a borrower's type as  $\theta$  and let  $\delta_i(\theta)$  be the probability with which a return  $X(\delta_i(\theta))$  is obtained; with probability  $1-\delta_i(\theta)$  the return is zero. The subscript  $i \in \{s, r\}$  denotes the type of project chosen. Let  $\Delta \equiv \{\delta_s(\theta), \delta_r(\theta)\}$  denote the feasible set of success probabilities. We assume  $\delta_s(\theta) > \delta_r(\theta) \forall \theta$  and that the safe project is socially optimal. That is,

$$\delta_s(\theta)X(\delta_s(\theta)) > \delta_r(\theta)X(\delta_r(\theta)). \quad (1)$$

Each project requires a \$1 investment. Cross-sectionally the borrower's  $\theta$  takes values in a continuum with  $\theta \in [\underline{\theta}, \bar{\theta}]$ , and the bank can choose any  $\hat{\theta}$  in this interval. While the bank can observe the borrower's risk parameter  $\theta$ , it cannot control the borrower's project choice,  $i \in \{s, r\}$ . We recognize that the borrower's asset substitution problem may be partially resolved through contract covenants. But since this resolution will generally be only partial, the borrower will have some project choice latitude. Success probabilities of all projects are continuously differentiable and strictly increasing in  $\theta$ , i.e.,  $\forall \hat{\theta}, \bar{\theta} \in [\underline{\theta}, \bar{\theta}]$

$$\delta_s(\hat{\theta}) > \delta_s(\bar{\theta}) \quad \text{and} \quad \delta_r(\hat{\theta}) > \delta_r(\bar{\theta}) \quad \text{for } \hat{\theta} > \bar{\theta}. \quad (2)$$

At  $t=0$ , the bank can make spot loans and also sell loan commitments. Spot loans have a single period maturity and are due to be repaid at  $t=1$ . A loan commitment entitles the commitment buyer to borrow for a single period from the bank at  $t=1$ . This loan will be due to be repaid at  $t=2$ . For

a borrower of type  $\theta$ , the commitment interest factor (one plus the interest rate) is  $i_c(\theta)$  which **may** be more or less than the spot interest factor (one **plus** the interest rate at which the customer can borrow) at  $t = 1$ . The **term** structure of interest rates is stochastic. The single period **riskless** interest factor at  $t = 0$  is  $R_f$ . At  $t = 1$ , the single period **riskless** interest factor will be  $R_H (> R_f)$  with probability (**w.p.**)  $l$  and  $R_L (< R_f)$  **w.p.**  $1 - l$ .

For simplicity we assume that the bank lends to a single borrower at  $t = 0$  and sells at most one loan commitment at  $t = 0$ . At  $t = 1$ , it lends again to single borrower, either to a commitment buyer if it decides to borrow, or else to a borrower in the spot market. The bank finances its \$1 loan with \$D in deposits, with the rest coming from equity; D is **exogenous**. Deposit insurance is complete. Thus, if the borrower defaults on its loan, the deposit insurer steps in and pays off the depositors. As under the prevailing system, the deposit insurance premium is a **risk-insensitive** amount P that the bank must pay at the beginning of each period. If the bank is unable to meet its repayment obligation to the depositors, it is technically insolvent and any claims against its assets are null and void?

We assume that the bank charter has positive **value**.<sup>10</sup> To achieve this positive value, we assume that the bank's loan interest factor is  $\alpha X(\delta(\theta))$  above the zero expected profit interest factor, where  $\alpha \in (0, 1)$  and  $\delta(\theta)$  is the borrower's success probability given its **equilibrium** project choice.<sup>11</sup> That is, the loan factor  $i(\theta)$  satisfies

$$i(\theta) = R_f[\delta(\theta)]^{-1} + \alpha X(\delta(\theta)). \quad (3)$$

The specification in (3) implies that the total surplus on a project is shared by the bank and the borrower. All that is needed for our results is that the share of the surplus captured by the bank is non-decreasing in the total surplus of the project. The specific functional form in (3) merely eases the algebra; at the expense of adding more cumbersome details to the analysis, we can **replace** (3) with a more general specification consistent with the surplus sharing rule mentioned above. Such surplus sharing will arise in equilibrium in some types of oligopolistic banking industry structures. For example, if banks are differentiated spatially or in **product/service attributes**

This appears to signify a rather draconian bank closure policy since the present value of **future** rents that the bank **could** earn may still **be** positive **at**  $t = 1$ . However, our assumption even applies to instances in which the bank is merged **with another** solvent bank rather than **being** closed. All that we need is that the bank is not obliged to cover its contingent liability under outstanding commitments **if** it is closed or merged with another bank.

<sup>10</sup>Chan, Greenbaum and Thakor (1990) have shown that deposit Insurance problems are not interesting if bank charters are **worthless**. They show that this result holds for both private information and **moral** hazard scenarios.

<sup>11</sup>We assume throughout that  $\alpha$  is small enough to guarantee satisfaction of the **borrower's** participation constraint.

and each borrower's cost (benefit) of approaching different banks is weakly increasing (decreasing) in the total surplus of the borrower's project that needs to be funded, the bank with the greatest relative advantage with respect to the borrower will capture project surplus in equilibrium in the stipulated manner [see, for example, Besanko and Thakor (1990) for a spatial banking model]. In such an imperfectly competitive environment then, we can view (3) as the highest interest factor the bank can charge the borrower on a spot loan before the latter switches to another bank.

Deposits are in elastic supply at the **riskless** rate, i.e., the depositors must be promised an expected return equal to the **riskless** rate. Our focus is on problems of asset substitution rooted in the perverse incentives created both by the standard debt contract and by deposit insurance. We thus **abstract** from pre-contract private information issues by allowing all parties to be equally informed at the outset. This simplification is particularly welcome in our model since we have two layers of asset substitution problems; the **bank** chooses its borrower, and then the borrower chooses its project.

## 2.2. The static solution

In this subsection we **discuss** the basic asset substitution problem between the bank and the borrower and between the bank and the deposit insurer. In order to provide **intuition** for our results, we focus initially on the static case, i.e., the bank lends only at  $t=0$ . Future lending is introduced later.

(1) **The first best.** The first best solution is attained when the borrower self-finances its project. A type-8 borrower solves the following maximization problem

$$\underset{\delta(\theta) \in \Delta}{\text{maximize}} \{ [R_f]^{-1} \delta(\theta) X(\delta(\theta)) - 1 \}. \quad (4)$$

Given (1), the solution to this problem is  $\delta(\theta) = \delta_s(\theta)$ .

(2) **The second best.** We define the second best outcome as one that obtains when the borrower finances its project entirely with a bank loan, and the bank funds the loan entirely with its own equity, i.e., it uses no deposits. Thus, we do not as yet have deposit insurance in the picture.

It is convenient to assume a functional form for  $X(\cdot)$ , namely  $X(\delta(\theta)) = K - \delta(\theta)$ . Although this can be generalized, making this specific assumption buys us considerable algebraic simplicity. An **implication** of this payoff stipulation is that the borrower can avail of higher safety (a higher  $\delta(\theta)$ ) only by sacrificing its return in the successful state.<sup>12</sup>

<sup>12</sup>This functional form implies that the expected output  $\delta(\theta)X(\delta(\theta))$  is concave in  $\theta$ , and has an interior maximum. As long as this general property holds, all of our results go through. The specific functional form for  $X(\cdot)$  merely simplifies the algebra.

We can now determine the bank's choice of borrower type and that borrower's choice of project. The bank solves the following maximization program to choose its  $\theta$ :

$$\underset{\theta}{\text{maximize}} \{[R_r]^{-1}\alpha[K\delta^*(\theta) - \{\delta^*(\theta)\}^2]\}, \quad (5)$$

$$\text{subject to } \delta^*(\theta) \in \underset{\delta(\theta) \in A}{\text{argmax}} \{\delta(\theta)[K - \delta(\theta) - i(\theta)]\}, \quad (6)$$

$$i(\theta) = R_f[\delta^*(\theta)]^{-1} + \alpha[K - \delta^*(\theta)]. \quad (7)$$

Note that in the objective function (5), the portion  $R_f[\delta^*(\theta)]^{-1}$  of the interest factor received by the bank cancels out against the bank's cost of funds (i.e., the bank's equity cost of capital is equal to the riskless rate). In the **proposition** below we present the solution to this problem.

**Proposition 1.** *There exists a critical riskless interest  $\bar{R}_f$  such that, if  $R_f > R_r$ , then in a Nash equilibrium the borrower chooses the risky project regardless of its type.<sup>13</sup> Moreover, the bank's Nash equilibrium choice of borrower type is  $\theta^* = \delta_r^{-1}(K/2)$ .*

For the proof of Proposition 1, see Appendix A.

The importance of this proposition for our later analysis is that it shows that the bank cannot resolve the asset substitution problem in our setting if the spot riskless rate is too high.<sup>14</sup>

(3) *The third best.* We now introduce deposit insurance. That is, we take the setting of the second best case and assume that the bank finances the borrower's loan partly with (completely) insured deposits. We will assume henceforth that  $R_f$  is sufficiently high, so that the spot borrower at  $r=0$  always prefers the risky project. This permits us to drop (6) and (7) from the maximization program and write the bank's objective function as

$$\begin{aligned} \underset{\theta}{\text{maximize}} & \{[R_f]^{-1}\alpha[K\delta_r(\theta) - \{\delta_r(\theta)\}^2] + [R_f]^{-1}\delta_r(\theta)\{R_f[\delta_r(\theta)]^{-1}\} \\ & - [R_f]^{-1}\delta_r(\theta)R_fD - P - [1 - D]\}. \end{aligned} \quad (8)$$

<sup>13</sup>It is straightforward to verify that  $\bar{R}_f > 0$  for a sufficiently small.

<sup>14</sup>Qualitatively, this proposition is unaffected by our functional form assumptions. For example, the result that  $i_r(\theta) > i_s(\theta)$  is true in general. It should be noted, though, that we have ignored the role of collateral in resolving moral hazard. Chan and Thakor (1987) as well as Boot, Thakor and Udell (forthcoming, 1991a) have analyzed that problem. However, to the extent that collateral has dissipative control transfer costs as in Boot, Thakor and Udell (forthcoming, 1991a), using collateral to combat moral hazard will be distortionary as well.

Here the deposit interest factor is  $R_f$  (because deposits are completely insured), the insurance premium is  $P$ , and the bank's equity input is  $1 - D$ . Our next proposition compares the bank's asset choice in this third best case with that in the second best case.

**Proposition 2.** *The bank chooses a strictly riskier borrower in the third best Nash equilibrium when it finances with insured deposits than in the second best Nash equilibrium when it finances with equity.*

**Proof.** From (8) we get the following FOC:

$$[R_f]^{-1}\alpha[K - 2\delta_r(\theta)] - D = 0,$$

which yields  $\hat{\theta} = \delta_r^{-1}([K/2] - [R_f D / 2\alpha])$  as the bank's privately optimal asset choice.  $\hat{\theta}$  is unique since the SOC is clearly satisfied. Clearly,  $\hat{\theta} < \theta^*$  (the second best in Proposition 1). It is easy to verify that this is a Nash equilibrium.  $\square$

This proposition highlights the distortion caused by the bank substituting to riskier assets when it has access to insured deposits.<sup>15</sup> Thus, we now have augmented risk-taking at two levels: the borrower takes more risk with a bank loan than when it self-finances, and the bank, lends to an intrinsically riskier borrower when it has insured deposits available instead of only equity. Note also that  $P$  can be set here to ensure that deposit insurance is fairly priced.

### 3. Analysis with loan commitments and future spot lending

We will now permit the bank to lend in a future period, in addition to its current spot lending. What simplifies the ensuing analysis is the observation that the bank's choice of  $\theta$  on its first period spot loan does not affect either

<sup>15</sup>Note that we have not analyzed the intermediate case in which the bank finances with uninsured deposits. We can show, somewhat surprisingly, that in this case the bank takes even more risk than when deposits are insured. The intuition is as follows. With uninsured deposits, the cost of deposits will reflect the (rational) expectations of the depositors with respect to the bank's inclination to take risk. Since the bank's incentive to take risk is increasing in the deposit interest rate, the higher deposit funding cost with uninsured deposits than with insured deposits leads to more risk taking when deposit insurance is absent. Emmons (1990) provides some qualifications to this argument. In particular, he shows that if each bank's deposit insurance is fairly priced and the insurance premium is deposit financed, the presence of deposit insurance does not affect the bank's choice of asset portfolio risk.

its choice of  $\theta$  on its loan commitment customer or its choice of  $\theta$  on its second period spot loan.

### 3.1. The solution with future spot lending

Consider first the case in which the bank makes a sequence of spot loans. In this case the bank first chooses the first period borrower's type and makes its first period spot loan. If this borrower repays its loan, then the bank chooses the type of its second period borrower (which will generally depend on the spot riskless rate prevailing at  $t=1$ ) and makes its second period spot loan. If the first period borrower defaults, the bank has no opportunity to make its second period loan. Consider the second period first. The spot riskless interest factor at  $t=1$  is either  $R_H$  or  $R_L$  with  $R_H > R_L$ . We will assume henceforth that  $R_H > \bar{R}_f$  and  $R_L < \bar{R}_f$ . From Proposition 1 we know that the borrower chooses the risky project if  $R_r$  is realized. Let  $\hat{\theta}_H$  be the bank's optimal choice of borrower type for this case. From Proposition 2 we know that

$$\hat{\theta}_H = \delta_r^{-1}([K/2] - [R_H D/2\alpha]). \quad (9)$$

Similarly, if the spot riskless interest factor at  $t=1$  is  $R_L$ , we know that the borrower invests in the safe project. Once again, from Proposition 2 we know that the bank's optimal choice of borrower type,  $\hat{\theta}_L$ , satisfies

$$\hat{\theta}_L = \delta_s^{-1}([K/2] - [R_L D/2\alpha]). \quad (10)$$

It is apparent that  $\delta_s(\hat{\theta}_L) > \delta_r(\hat{\theta}_H)$ .

Having chosen  $\hat{\theta}_H$  and  $\hat{\theta}_L$ , the bank now chooses  $\hat{\theta}$  (its borrower type for the spot loan at  $t=0$ ) by solving

$$\begin{aligned} \underset{\theta}{\text{maximize}} \quad & \{[R_f]^{-1}\alpha[K\delta_r(\theta) - \{\delta_r(\theta)\}^2] + [R_f]^{-1}\delta_r(\theta)\{R_f[\delta_r(\theta)]^{-1}\} \\ & - [R_f]^{-1}\delta_r(\theta)R_f D - P - [1-D] + \delta_r(\theta)\Omega_2(\hat{\theta}_H, \hat{\theta}_L)\}, \end{aligned} \quad (11)$$

where we recognize the fact that the first period spot borrower will choose the risky project (given  $R_f > \bar{R}_f$ ) and we have defined

$$\begin{aligned} \Omega_2(\hat{\theta}_H, \hat{\theta}_L) \equiv & l(R_H R_f)^{-1}\{\alpha[K\delta_r(\hat{\theta}_H) - \{\delta_r(\hat{\theta}_H)\}^2] + \delta_r(\hat{\theta}_H)[R_f\{\delta_r(\hat{\theta}_H)\}^{-1}]\} \\ & - l[R_H R_f]^{-1}\delta_r(\hat{\theta}_H)R_f D - [P + \{1-D\}][R_f]^{-1} \\ & + [1-l][R_L R_f]^{-1}\{\alpha[K\delta_s(\hat{\theta}_L) - \{\delta_s(\hat{\theta}_L)\}^2]\} \end{aligned}$$

$$+ \delta_s(\hat{\theta}_L) \{ R_L [\delta_s(\hat{\theta}_L)]^{-1} \} \\ - [1 - l] [R_L R_f]^{-1} \delta_s(\hat{\theta}_L) R_L D. \quad (12)$$

The first two lines in the objective function (11) represent the bank's first period revenue (similar to (8)). The term  $\Omega_2(\hat{\theta}_H, \hat{\theta}_L)$  gives the bank's expected second period revenue, with the expectation being taken across the high and low interest rate states. Note that this term is multiplied by  $\delta_r(\theta)$ . This is because the bank will continue to exist and make its second period loan only if its first period spot **borrower** does not default. The next proposition describes the solution to this problem.

*Proposition 3.* Suppose that the bank has access to insured deposits to make a spot loan at  $t=0$  as well as at  $t=1$ . Then in a Nash equilibrium, the bank chooses a strictly less risky **borrower** at  $t=0$  than it does in the (third best) static case of Proposition 2. The first period spot borrower invests in the risky project at  $t=0$ . The second period spot borrower invests in the risky project at  $t=1$  if  $R_H$  is realized and in the safe project at  $t=1$  if  $R_L$  is realized.

*Proof:* Let  $\theta^*$  denote the optimal solution to this problem. Now  $\theta^*$  can be obtained through the appropriate FOC (see (11)) and is

$$\theta^* = \delta_r^{-1} ([K/2] - [DR_f/2\alpha] + [\Omega_2(\hat{\theta}_H, \hat{\theta}_L)/2\alpha]). \quad (13)$$

Comparing (13) to the expression for  $\hat{\theta}$  given in the proof of Proposition 2, we see that  $\theta^* > \hat{\theta}$ . This proves that the bank chooses less risk than in the static case. The project choices of the spot borrower at  $t=0$  and at  $t=1$  follow from  $R_f > \bar{R}_f$  and  $R_L < \bar{R}_f < R_H$ .  $\square$

This proposition highlights the importance of considering the bank's future opportunities. The amount of asset risk the bank desires to take in the current period is a decreasing function of the rents it expects to earn on future loans. The intuition is that greater future profitability increases the cost of current risk taking since this risk jeopardizes the realization of future profits.<sup>16</sup> We now turn to **lending** under **loan** commitments.

### 3.2. The loan commitment solution

Now suppose that, in addition to making a spot loan at  $t=0$ , the bank is selling a loan commitment at that time. This is a fixed rate loan

<sup>16</sup>Keeley (1990) provides empirical evidence that decline in banks' access to future rents has increased incentives to take risk.

commitment that requires the commitment buyer to pay a fee of  $\Psi$  to the bank at  $t=0$ . The commitment gives the buyer the option to borrow from the bank at a fixed interest factor of  $i_c(\theta)$ . If the spot borrowing rate for the commitment buyer at  $t=1$  is lower than  $i_c(\theta) - 1$ , then it is free to let the commitment expire **unexercised** and borrow from the bank at the lower spot borrowing rate. Although this is a fixed rate commitment, our analysis generalizes to variable rate loan commitments as long as there is some rigidity in the fixed add-on (in a prime-plus commitment) or multiple (in a prime-times commitment) **used** to compute the variable rate.

Our initial focus is on the ability of the loan commitment to resolve the asset substitution problem between the bank and the borrower more efficiently than is possible with just future spot lending. The intuition is as follows. From our analysis in section 2 we know that the borrower's assessment of the **difference** between the net expected payoff from the risky project and that from the safe project is increasing in the loan interest factor. When  $R_f$  is sufficiently high, the bank is unable to make the borrower's loan interest factor low enough to deter a choice of the risky project. A dynamic setting, however, provides the bank with the ability to insure the borrower against the realization of the high interest rate state at  $t=1$ . That is, the bank can issue a loan commitment at  $t=0$  and set  $i_c(\theta)$  to induce the socially **preferred** project choice by the borrower at  $t=1$ . If  $i_c(\theta)$  is lower than the commitment customer's realized spot borrowing rate at  $t=1$ , then the bank will suffer a loss relative to spot lending at  $t=1$ . However, the commitment fee,  $\Psi$ , can be set ex ante to compensate the bank for its expected future loss. Let  $\theta_c$  be the  $\theta$  of the commitment customer. Then the bank needs to set  $i_c(\theta_c)$  to satisfy the following condition if it wishes the commitment buyer to choose the safe project at  $t=1$ .

$$\delta_r(\theta_c)[K - \delta_r(\theta_c) - i_c(\theta_c)] \leq \delta_s(\theta)[K - \delta_s(\theta_c) - i_c(\theta_c)].$$

The **maximum**  $i_c(\theta_c)$  is the one at which the above is **an** equality. Without loss of generality, we take this as the commitment rate and write

$$i_c(\theta_c) = K - [\{\delta_s(\theta_c)\}^2 - \{\delta_r(\theta_c)\}^2][\delta_s(\theta_c) - \delta_r(\theta_c)]^{-1}. \quad (14)$$

Note that it is optimal to induce the customer to choose the safe project; it maximizes social surplus which is shared **by** the bank and the customer. As in our previous analysis, we assume that  $R_f > \bar{R}_f$ ,  $R_H > \bar{R}_f$  and  $R_L < \bar{R}_f$ . Thus, the customer would invest in the risky project if it were to borrow at spot credit terms at  $t=0$  or at  $t=1$  in the high interest rate state. We also assume that at  $t=0$  the bank chooses its spot loan first and then sells its loan **c**mmitment.

We assume that **this** loan commitment customer can determine the

riskiness of the bank's spot loan at  $t=0$ .<sup>17</sup> Now let  $\hat{\theta}_c$  be the bank's optimal choice of loan commitment customer. Note that this customer will borrow under the commitment only if  $R_H$  is realized. Thus, we know from Proposition 2 that

$$\hat{\theta}_c = \delta_s^{-1}([K/2] - [R_H D/2\alpha]). \quad (15)$$

In the low interest rate state at  $t=1$ , the bank lends in the spot market. As in our previous analysis, its optimal choice of borrower is then

$$\hat{\theta}_L = \delta_r^{-1}([K/2] - [R_L D/2\alpha]). \quad (16)$$

The bank now solves the following maximization program to determine its choice of  $\theta$  on the spot loan at  $t=0$ . In the maximum program we have already substituted the result  $\delta^*(\theta) = \delta_r(\theta)$ , which holds for  $R_f > \bar{R}_f$ .

$$\begin{aligned} \underset{\theta}{\text{Maximize}} \{ & \Psi(\hat{\theta}_c, \delta_r(\theta)) + [R_f]^{-1} \alpha \delta_r(\theta) [K - \delta_r(\theta)] \\ & + [R_f]^{-1} \delta_r(\theta) \{ R_f [\delta_r(\theta)]^{-1} \} - [R_f]^{-1} \delta_r(\theta) R_f D \\ & - P - [1 - D] + \delta_r(\theta) \Omega_2(\hat{\theta}_c, \hat{\theta}_L) \}, \end{aligned} \quad (17)$$

where

$$\begin{aligned} \Omega_2(\hat{\theta}_c, \hat{\theta}_L) \equiv & l[R_H R_f]^{-1} \delta_s(\hat{\theta}_c) i_c(\hat{\theta}_c) - l[R_H R_f]^{-1} \delta_s(\hat{\theta}_c) R_H D \\ & - [P + \{1 - D\}] [R_f]^{-1} \\ & + [1 - l][R_L R_f]^{-1} \{ \alpha \delta_s(\hat{\theta}_L) [K - \delta_s(\hat{\theta}_L)] \\ & + \delta_s(\hat{\theta}_L) R_L [\delta_s(\hat{\theta}_L)]^{-1} \} - [1 - l][R_L R_f]^{-1} \delta_s(\hat{\theta}_L) R_L D, \\ \Psi(\hat{\theta}_c, \delta_r(\theta)) = & \delta_r(\theta) l[R_H R_f]^{-1} \delta_s(\hat{\theta}_c) \{ \alpha [K - \delta_s(\hat{\theta}_c)] + R_H [\delta_s(\hat{\theta}_c)]^{-1} - i_c(\hat{\theta}_c) \}. \end{aligned}$$

This program is similar to the one in (11), except for the commitment fee  $\Psi(\hat{\theta}_c, \delta_r(\theta))$ . The computation of the commitment fee is as follows. Since the commitment is only taken down if the spot **riskless** interest factor is  $R_H$ , the quantity  $\alpha[K - \delta_s(\hat{\theta}_c)] + R_H [\delta_s(\hat{\theta}_c)]^{-1} - i_c(\hat{\theta}_c)$  represents the bank's loss under the commitment relative to funding the loan in the spot market. This is

<sup>17</sup>We assume that the asset risk is known to the loan commitment customer, but this information is not verifiable in court. This rules out forcing contracts to influence the bank's asset choice.

multiplied with  $\delta_s(\hat{\theta}_c)$  to obtain the expected loss (the Nash equilibrium assumption is that the borrower will select the safe project). Since the loss is realized at  $t=2$ , we discount back to  $t=0$  at  $[(R_H R_f)]^{-1}$  which is the arbitrage-free two-period discount factor, given the assumed term structure and optimal **takedown** behavior of the commitment **customer** in the high interest rate state. Finally, this discounted present value is multiplied with  $\delta_r(\theta)$ , the **repayment** probability on the spot loan made by the bank at  $t=0$ .

We can now compare the riskiness of the bank's **spot lending** portfolio at  $t=0$  under **two** regimes: (i) when its future lending is exclusively in the (future) spot market and (ii) when its future spot lending is potentially under a loan commitment sold at  $t=0$ .

*Proposition 4.* *The bank's portfolio risk in a Nash equilibrium in which it makes a spot loan at  $t=0$  and sells a loan commitment than which expires at  $t=1$  is strictly lower than in a Nash equilibrium in which the bank lends exclusively in the spot market at  $t=0$  and  $t=1$ . Furthermore, the overall risk exposure of the deposit insurer is lower in the former case as well.*

*Proof.* Let  $\tilde{\theta}$  denote the optimal choice of spot loan at  $r=0$  for the bank that sells a loan commitment. Now  $\tilde{\theta}$  can be obtained from the appropriate first-order condition (see (17)) and is

$$\tilde{\theta} = \delta_r^{-1}([K/2] - [DR_f/2\alpha] + \Omega_2^*(\hat{\theta}_c, \hat{\theta}_L)/2\alpha) \quad (18)$$

where  $\Omega_2^*(\hat{\theta}_c, \hat{\theta}_L) = \Omega_2(\hat{\theta}_c, \hat{\theta}_L) + \Psi(\hat{\theta}_c, \delta_r(\theta))[\delta_r(\theta)]^{-1}$ .

Since  $\Omega_2^*(\hat{\theta}_c, \hat{\theta}_L) > \Omega_2(\hat{\theta}_H, \hat{\theta}_L)$ , the expressions in (18) and (13) imply that  $\tilde{\theta} > \theta^*$ . Hence, the bank's portfolio risk with a loan commitment is strictly lower than without. The deposit insurer's exposure is lower for this reason and because the loan commitment **customer** is less risky than a spot borrower in the high interest rate state. Verification that these equilibria are Nash is routine.  $\square$

A loan commitment helps to lower risk in two ways. First, the commitment customer is a less risky borrower under a loan commitment than in a spot lending regime. This happens because the commitment borrower can be induced to choose a less risky project than a spot borrower,<sup>18</sup> and also because the bank itself chooses an intrinsically less risky borrower to lend to under the commitment than it would in the second period spot market. Second, the presence of a loan commitment induces the bank to optimally lower the riskiness of its first period spot loan.

The reason why a bank's overall portfolio risk is lower when it sells a loan

<sup>18</sup>The ability of the loan commitment to resolve agency problems has been previously noted in Boot, Thakor and Udell (1987). That paper shows that a loan commitment can improve effort supply incentives.

commitment than when it lends exclusively in the spot market is as follows. With a loan commitment, the bank induces the commitment customer to make the **socially** optimal project choice in a future period for any realization of the customer's spot borrowing rate. Since social wealth gains are shared between the bank and the customer, the bank's rents (including the commitment fee) are higher when it sells a loan commitment. This increase in rents causes the bank to optimally choose lower risk now.

#### 4. Robustness and extensions

We have shown the powerful risk attenuation role that bank loan commitments can play. We assumed in our analysis that the loan commitment customer can observe the bank's asset risk at  $t=0$ . If this risk was unobservable, then our model would become more complicated. To capture our intuition, we would need to craft a reputation model in which the bank's ability or willingness to take asset risk was a **priori** unknown. Its loan commitment revenue would then depend on its reputation whose evolution would be determined by the realized payoffs on its loan portfolio. We would also need a longer time horizon and either a richer distribution of loan payoffs or the assumption that even after a first period loan default, the bank can continue to exist. We believe this more elaborate structure will yield results similar to those we have obtained. Our model seems to be the most direct way to capture the intuition.

Another assumption we have made is that the cost of equity is the **riskless** rate. However, recent work [see, for example, Myers and Majluf (1984)] has shown that external financing is generally more costly than retained earnings. This means that the equity cost of external capital will exceed the **riskless** rate and bank capital will be costly **relative** to deposits. Such a stipulation will strengthen our results. Since the loan commitment provides a commitment fee at  $t=0$ , it augments the bank's equity base and lessens its dependence on external equity. This improves the bank's profit from future lending and induces it to invest in safer loans in the current period. This is consistent with the intuition that, when capital is costly, incentives to build up capital will arrest the bank's risk-taking propensity.

It is also quite straightforward – albeit algebraically more cumbersome – to model more general payoff distributions on bank loans and to allow the bank to hold multiple loans in its spot loans and commitment portfolios.

#### 5. Implications for capital regulation

##### *5.i. The new capital guidelines and off-balance sheet items*

We have thus far analyzed the bank's risk choices without addressing the

role of capital. However, capital plays an important role in determining the riskiness of a bank, both as a 'first line of defense' against asset portfolio losses and as an incentive device to lessen the bank's preference for risk. We begin our discussion of the link between bank capital and risk with an overview of the recently adopted capital guidelines.

In 1987, the **Basel** Committee on Banking Regulation and Supervisory Practices, under the umbrella of the Bank for International Settlements (**BIS**), developed risk-based capital guidelines. The final guidelines were officially adopted in December 1988 by twelve leading industrial nations, including the U.S. The proposal includes a phase-in period, and only in January 1993 (March 1993 for Japanese banks), will the guidelines be fully in force.<sup>19</sup> The BIS capital requirements distinguish between on-balance sheet and off-balance sheet items.<sup>20</sup> Moreover, these requirements are risk-based in that, even among on-balance sheet assets, the requirements are different for assets of different risks. For example, the capital requirement against on-balance sheet claims on private entities (e.g., commercial loans) and individuals is 8%, whereas the capital requirement against some types of government debt is lower. The feature that most distinguishes the BIS guidelines, however, is that explicit capital requirements are stipulated against off-balance sheet items. Direct credit substitutes, such as financial guarantees and standby letters of credit, have a capital requirement of 8%, whereas loan commitments and close substitutes, such as credit lines, underwriting commitments and note issuance facilities, have a capital requirement of 4%.<sup>21</sup> Prior to the adoption of these guidelines, U.S. banks were subject to capital requirements only against assets on the balance sheet, although proposals to impose capital requirements against off-balance sheet items had been previously discussed.

We now examine the implications of our analysis for the effectiveness of these capital guidelines in controlling bank risk. Consider first the effect of capital requirements on the portfolio risk of the bank's on-balance sheet items, ignoring for the moment off-balance sheet items. From the proof of Proposition 2, we know that the bank's asset risk choice  $\hat{\theta}$  depends on D, the amount of deposits. A higher capital requirement lowers D and thereby increases  $\hat{\theta}$ . Thus, a higher capital requirement induces the bank to choose lower risk on its spot loans or on-balance sheet assets.

While the ability of capital to restrain risk-taking is well known in an agency context, it is in contrast to Kahane (1977) and Koehn and Santomero (1980). They argued that a risk averse bank may react to a higher capital requirement by choosing a portfolio with a higher standard deviation and a

<sup>19</sup>These guidelines stipulate minimum capital levels. Individual countries are free to adopt higher levels.

<sup>20</sup>For a recent comprehensive perspective on risk-based capital standards, see Alfriend (1988).

<sup>21</sup>For further details, see Graddy and Spencer (1990).

higher expected return, so that its default risk is increased.<sup>22</sup> The asset substitution problem in our model is different. Banks expropriate wealth from uninsured depositors or the deposit insurer by choosing projects with **higher risks and lower expected returns.** This is consistent with the standard option effect in levered firms, namely that the value-maximizing bank's **privately optimal** choice is the **portfolio with the highest** expected return on **equity.** As the level of deposit funding increases this privately optimal choice shifts to assets with successively **higher** expected returns and higher risks because these assets result in **greater expropriation** of wealth from uninsured depositors or from the deposit insurer if deposits are insured.<sup>23</sup>

Even when loan **commitments** and future lending opportunities are introduced, capital requirements are effective in inducing banks to take lower risk in their on-balance sheet **assets.**<sup>24</sup> Of greater interest to us, however, is the desirability of capital requirements against off-balance sheet items, an issue that has recently been the subject of some discussion.

Our analysis asserts that loan commitments reduce the bank's incentive to take risk. Avery and Berger (1990) provide empirical support for this finding. Thus, if the purpose of capital requirements is to depress risk taking by banks, it is not worthwhile **imposing** a capital requirement at all on loan commitments; doing so reduces the attractiveness of loan commitments to banks, assuming that capital is costly relative to deposits. Of course, there should still be a capital requirement against the loan made under the commitment if the latter is exercised. Under the BIS capital guidelines, however, this capital requirement (8%) is in place, so an **additional** requirement against the commitment per se is not called for.<sup>25</sup>

The prescription does not necessarily extend to other off-balance sheet liabilities. For example, many financial guarantees and standby letters of credit transfer additional credit risk to the bank because of its role as a third party guarantor. It is of **secondary** importance that these contracts do not involve funding; the bank still assumes **contingent** credit risk. For these contracts, capital **requirements** serve the same risk-curtailment purpose as

<sup>22</sup>This conclusion has recently been criticized by Keeley and Furlong (1990) who argue that Koehn and Santomero (1980) deal erroneously with the put-option effect of deposit insurance. This biases their results in the direction of a perverse effect of capital requirements.

<sup>23</sup>For a further comparison of utility-maximizing and value-maximizing banks, see Keeley and Furlong (1990).

<sup>24</sup>This argument holds even if the capital requirement against on-balance sheet assets is not risk-based. If the regulator could observe (even noisily) the bank's risk choice, then risk-based capital requirements, as in the BIS guidelines, would be even more effective in controlling the bank's risk-taking incentives.

<sup>25</sup>It is possible that loan commitments could increase the bank's credit risk exposure if they forced the bank to **extend** loans that it would not extend in the spot market. However, the 'general nervous clause' ubiquitous in loan commitment contracts empowers the bank to decline to lend under the commitment if the customer's credit standing declines to '**unacceptable**' levels. Our policy prescription about loan commitment capital requirements relies on this clause being appropriately deployed.

they do for on-balance sheet claims and thus should be imposed. Of course, our model does not permit us to assess the magnitude of optimal capital requirements, so we cannot comment on the specific percentages stipulated in the BIS guidelines.<sup>26</sup>

### *5.2. Capital requirements and international competitiveness*

While the BIS capital requirements are intended to put banks from different countries on an equal footing, they are likely to have differing effects across banks. Our main result that capital requirements on loan commitments are undesirable implies that the BIS guidelines will have the most severe constraining effect on banks that have relatively low pre-adoption capital levels. To the extent that an explicit capital requirement on loan commitments discourages the growth of that contingent liability, this discouragement will be greater for banks that are initially more capital-constrained. Our analysis highlights two important consequences of loan commitments: the borrowers who purchase loan commitments are safer than the bank's spot market borrowers, and the bank lends to safer spot borrowers when it has loan commitments outstanding. Hence, the reduced loan commitment volume induced by capital constraints is predicted to result in greater asset risk for banks. Of course, as we mentioned earlier, our Proposition 2 implies that the banks with poorer capital levels have a greater incentive to take more on-balance sheet risk in the first place. Thus, we face the disturbing irony that the depressing effect of the new capital requirements on loan commitment volume will be felt the most by those (marginally capitalized) banks for which the 'need' for the risk-mitigating effect of loan commitments is the greatest.

As an example of cross-sectional differences that may be generated by the BIS capital guidelines, consider the relative competitiveness of U.S. and foreign banks. Evidence suggests that the new capital requirements are likely to prove more binding on U.S. banks than on their European competitors, although this may be debatable.<sup>27</sup> If U.S. banks are constrained to a greater degree, then they will also experience a greater decline in their loan

<sup>26</sup> However, since the BIS guidelines stipulate a smaller minimum capital requirement on loan commitments than on other off-balance items, the direction of the difference in capital requirements is consistent with our prescription.

<sup>27</sup> For example, Bove (1990) cites evidence which suggests that the BIS capital requirements would not be binding on over half of all U.S. banks. The general perception, however, is that the major U.S. banks are far more capital-constrained than their European competitors. This seems borne out by the retrenchment of U.S. banks cited in table I and the growth of European banks. One of the reasons why U.S. banks may be more capital constrained is that they have a larger LDC exposure.

Table I  
Specific instance of international retrenchment by selected U.S. banks.

Bank name	Nature of retrenchment
Security Pacific Corporation	Announced in December 1990 that it plans to disband its merchant bank, which is <b>responsible for its</b> international and <b>investment banking</b> activities
Chase Manhattan Corporation	Announced plans to sell or close its European retail banking network
Citicorp	Announced that it would cut back its corporate <b>and</b> wholesale business overseas
First Chicago Corporation	<b>Announced</b> plans to close its representative <b>offices</b> in Mexico and Brazil and shut down its Manila branch early next year
- <b>Fleet/Norstar</b> Financial Group, Inc. Providence, RI	All announced plans to shut down remaining overseas <b>offices</b>
- First Bank System, Inc., Minneapolis	
- PNC Financial Corporation, Pittsburgh	

commitment volume. In a relative sense, therefore, U.S. banks will be faced with a deterioration in their fee income on loan commitments. In addition to this direct **competitive jeopardy**, our **analysis** implies that the on-balance sheet asset risk of U.S. banks could increase too. The combined effect of lower fee income and riskier assets on the balance sheet will be to tighten the capital constraints on U.S. banks.

Our conjecture is that a consequence of this will be a further retrenchment of U.S. banks from international lending while these banks refurbish their capital levels. This retrenchment already seems underway; specific instances are provided in table 1.<sup>28</sup> Moreover, to the extent that U.S. banks cut back on their domestic lending activities, the better-capitalized European banks can be expected to grow in the U.S. market. Indeed, for the 12 months ended June 1990, European banks have increased their U.S. **assets** 12.3% to \$160 billion. Bankers and regulators have viewed the deteriorating competitiveness of U.S. banks with alarm.<sup>29</sup>

Our analysis provides a possible warning about the effect of the **BIS** capital guidelines on the future competitiveness of U.S. banks. While uniform capital requirements on loans and off-balance sheet items across banks in different countries may, in the long run, prove to be a panacea for banks, at least in the short run their effect on the relatively poorly capitalized U.S.

<sup>28</sup>These facts and some of the statistics given below were taken from Kraus and Evans (1990). U.S. banks' international lending has decreased in nominal dollars by about 20% between 1982 and 1990. Foreign banks' U.S. assets have grown by about 135% during this period.

<sup>29</sup>A report to Congress by a Congressional task force warned, 'U.S. banks could play an increasingly less influential role in global markets and continue to lose market share to foreign competition in the domestic market' [see Kraus and Evans (1990)].

banks is likely to be **perversely** manifested in higher asset risk and lower charter values.

## 6. Concluding remarks

The contemporaneous growth in bank off-balance sheet activities and escalation in the number of depository institutions failures has raised questions about the possible relationship between the two developments. In the case of the largest off-balance sheet item, namely loan commitments, we have shown that the correlation is most likely spurious. Rather than increasing the exposure of the deposit insurer, loan commitments generate interactive incentives for banks to retard risk taking. Not only are commitment customers safer than spot borrowers, but the spot borrowers chosen by the bank ~~are~~ themselves safer than those the bank would choose in the absence of loan **commitments**.

A significant policy implication of our analysis is that it is important for the deposit insurer to require, by law, that the bank's outstanding **loan** commitments be voided if the deposit insurance fund has to bail out the bank. This rule should apply whether the bank is liquidated or merged with a solvent institution. The reason is that the prices at which the bank can sell loan commitments will be affected by its asset portfolio risk only if potential commitment buyers perceive that the likelihood of the commitments being honored **depends** on the bank's asset portfolio risk. If the **federal** deposit insurance fund bails ~~out~~ commitment customers, then a valuable source of market discipline will have been lost. Current practice conveys a somewhat fuzzy picture. If a bank is liquidated and ceases to exist, then its outstanding commitments are voided. However, if it **is** merely merged with **another** solvent institution or if the deposit insurer pays off depositors and allows the bank to continue, then the extent to which the bank is bound to honor its previous commitments is unclear. Presumably, **in** these cases the bank's obligation depends at least partly on the formality of its commitment contracts and their specific contractual covenants.

Another policy implication of our analysis pertains to the recently adopted BIS capital guidelines. Our analysis suggests that capital requirements may be worthwhile against on-balance sheet items and off-balance sheet items (such as financial guarantees) that transfer additional credit risk to the bank. However, capital requirements on loan commitments are counterproductive if their purpose is to reduce risk taking by banks. Since the BIS guidelines impose capital requirements against on-balance sheet items as well as loan commitments, they are **not** internally consistent in serving the objective of lowering the riskiness of banks. Capital requirements against on-balance sheet items encourage **banks** to take less risk, whereas those against loan commitments encourage more risk. In addition, imposing capital **require-**

ments on loan commitments could impede efforts to improve the competitive position of U.S. banks relative to foreign competitors.

We believe we have only opened the door a crack. The loan commitment is an exciting financial innovation that deserves further study. We need more complete models that endogenize the simultaneous demand for spot and commitment loans without excluding the asset substitution issues that have been the dominant theme of this paper. Perhaps pre-contract private information will be an important feature of such models. Moreover, models that deal specifically with other off-balance sheet claims may prove useful. On the empirical front, the Avery and Berger (1990) paper is a useful start, but much remains to be attended to. Further research using disaggregated data from individual banks, if available, seems to hold promise.

## Appendix A

*Proof of Proposition I.* Let  $i_s(\theta)$  be the loan interest factor the bank would charge a borrower of type  $\theta$  if it believes this borrower will choose a safe project. From (6) we know then that the borrower will choose a risky project if

$$\delta_r(\theta)[K - \delta_r(\theta) - i_s(\theta)] > \delta_s(\theta)[K - \delta_s(\theta) - i_s(\theta)], \quad (\text{A.1})$$

with  $i_s(\theta) = R_f[\delta_s(\theta)]^{-1} + \alpha[K - \delta_s(\theta)]$ . From this expression, we see that  $\partial i_s(\theta)/\partial R_f > 0$ . Moreover, the left-hand side (LHS) of (A.1) declines less rapidly than the right hand side (RHS) of (A.1) as  $i_s(\theta)$  increases. Thus,  $|\partial \text{LHS}/\partial R_f| < |\partial \text{RHS}/\partial R_f|$ . This means that if  $\bar{R}_f$  is the value of  $R_f$  satisfying

$$\delta_r(\theta)[K - \delta_r(\theta) - \bar{i}_s(\theta)] = \delta_s(\theta)[K - \delta_s(\theta) - \bar{i}_s(\theta)]$$

with

$$\bar{i}_s(\theta) = \bar{R}_f[\delta_s(\theta)]^{-1} + \alpha[K - \delta_s(\theta)],$$

then (A.1) will hold for all  $R_f > \bar{R}_f$  and the inequality in (A.1) will be reversed for  $R_f < \bar{R}_f$ . Since  $i_r(\theta) > i_s(\theta)$  for any  $R_f$ , the borrower will choose the risky project when  $R_f > \bar{R}_f$ , even if the bank correctly anticipates this choice.

The bank's privately optimal choice of  $\theta$  is given by the first-order condition (FOC)  $K - 2\delta^*(\theta^*) = 0$ . In a Nash equilibrium, given  $R_f > \bar{R}_f$ , the bank must correctly anticipate that  $\delta^*(\cdot) = \delta_r(\cdot)$ . This yields  $\theta^* = \delta_r^{-1}(K/2)$ . This inverse exists because  $\delta_r(\cdot)$  is continuous and strictly increasing on  $[0, 1]$ . Note that the second order condition (SOC)  $-2\delta'(\theta^*) < 0$  is also satisfied since  $\delta_r(\cdot)$  is increasing in  $\theta$ . Hence,  $\theta^*$  is a unique optimum. It is apparent that this is a Nash equilibrium. The bank chooses  $\theta^*$ , taking as given the type- $\theta^*$  borrower's equilibrium strategy of choosing the risky

project, and the **type- $\theta^*$**  borrower indeed chooses the risky project when confronted with an interest factor  $i_r(\theta^*)$ .  $\square$

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