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Bank Forward Lending in Alternative Funding Environments

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ABSTRACT

This paper examines the effects of loan commitments on bank lending behavior in both deposit-funding and liability management environments. Assuming that the bank lends exclusively under commitments and that the number of commitments exercised is uncertain, the bank must choose its supply of commitments. Given this choice, the bank becomes a passive lender to commitment holders. Our focus on forward credit markets sheds new light on the private bankers' assertion that they do not directly determine their level of lending, but merely "accommodate" the credit needs of their customers. Similarly, the central banker's claimed inability to control monetary aggregates in the short-run becomes understandable in a new context. It is shown that the advent of liability management will reduce the volume of loan commitments and the expected size of the bank and of the banking system. It is also shown that increased uncertainty regarding borrower takedown behavior diminishes the volume of commitments, expected bank and banking system size.

DESPITE BANKERS' CLAIMS THAT they "accommodate" the credit needs of customers and therefore exercise only limited control over their loans, academic explanations of bank balance sheet behavior focus largely on the bank's direct choice of loans and their simultaneous financing (for example, see Baltensperger [1], Hart and Jaffee [11], and Parkin et al. [17]).[1] In a similar vein, the Federal Reserve's expressions of frustration regarding short-run control of monetary aggregates are often viewed as little more than self-serving rhetoric. Failure to appreciate the bankers' position regarding credit extension and the central bank's regarding control of monetary aggregates is traceable to a failure to distinguish between forward and spot bank lending markets.[2] Consequently, the role of the

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[1] In an earlier form, the banker's alleged passivity is recognizable as the "needs of trade" strand of the Real Bills Doctrine (see Mints [15]).

[2] Crane [7] cites a 1970 speech by Federal Reserve Board Vice Chairman J. L. Robertson as follows: "Our efforts to reduce inflationary pressures by the imposition of monetary restraint were frustrated and delayed by the ingenuity of the banking system in finding ways to get around the restraints of monetary policy and regulation. A large part of this ingenuity was exercised to raise funds with which to honor unwise "commitments to lend," which had been designed to enable big customers to avoid the impact of "tight money" and force others (like small business, housing, state and local governments, etc.) to take the brunt of it."

forward market in determining banks' balance sheet configurations tends to be overlooked in the academic literature.

With the exception of Campbell [6], the recent research on bank loan commitments (see Hawkins [12], James [14], Thakor, Hong, and Greenbaum [21], Thakor [20], and Bartter and Rendleman [2]) is tangential to these issues in that it focuses principally on the valuation problem from the customer's viewpoint. The present paper examines the bank's optimal choice of the volume of rudimentary fixed-rate loan commitments in the context of a two-period model in which commitments made in the first period serve as the basis for loan demand realized in the second period.[3] We assume that banks are primarily in the business of writing put options where the underlying deliverable is the option-owner's debt. The volume of such options sold establishes an upper limit on bank lending, but the realized volume of lending depends on the state of nature in the subsequent period. Consequently, the bank exercises only an indirect control over its loan supply—it controls the maximum and expected quantities, but not the actual quantity supplied—and the above-mentioned banker's allegation is clearly understandable. Similarly, although the central bank presumably influences the bank's choice of optimal commitment volume in the first period as well as the state of nature when commitments are exercised, it has no direct effect on the bank's immediate supply of loans and thus the Federal Reserve's short-run control problem can be understood in a new context. Banks not only write commitments and lend under commitments, they also extend loans in the spot market. In our analysis, however, we shall focus exclusively on the forward market. This has the effect of limiting the generality of our results, but also has the distinct advantage of focusing on the widely ignored impact of the commitment market.[4]

We analyze the bank's choice of the commitment volume in two distinct funding environments. The first, in which the volume of deposit funds is substantial, known, and obtained at a subsidized interest rate, is described as a deposit-funding environment. The second, characterized by a smaller and more uncertain volume of deposits, resulting in a higher and more uncertain cost of funds, is referred to as a liability management environment. This simple characterization of alternative funding environments, based on the mix of deposits and "purchased money," permits us to examine the effects of the growth of liability management on the bank's choice of commitment volume, expected lending, and asset size. In particular, we show that the quantity of loan commitments varies directly with the expected volume of deposits and inversely with the uncertainty in the volume. Thus, the advent of liability management is shown to imply reduced commitments and consequently reduced expected lending as well as diminished expected bank asset size. We also show that reduced uncertainty regarding the commitment exercise rate (loan takedowns) increases the bank's expected lending. Since spot lending can be described as the limiting case of reduced uncertainty in takedowns, this result is interpreted as indicating that banks operating exclusively in a spot

[3] Extension of the analysis of fixed-formula commitments is discussed in Section III.

[4] Boltz and Campbell [3] indicate that in excess of 50 percent of short-term business loans at "money center" banks were made under loan commitments during 1977 and over 60 percent at "major regional banks."

market will lend more, in an expected sense, than banks operating exclusively in forward markets. Models which ignore forward lending therefore will tend to overestimate bank lending, irrespective of the extant funding environment. Finally, commitment volume is shown to vary directly with commitment fees and commitment loan interest rates, and inversely with deposit and purchased money interest rates.

The paper is organized in four sections. Section I describes the demand and supply for loan commitments, the funding environments and uncertainties in the deposit volume and commitment takedowns. Section II presents the main results on the effects of changes in the funding environment and commitment takedown behavior on the optimal volume of commitments and loans. Section III discusses implications for bank lending behavior, monetary policy, and liability management, and concludes by indicating possible extensions.

I. The Model

In order to simplify the analysis and to focus on loan commitments, we assume that all bank lending is effected through the exercise of loan commitments.[5] A lender faces a deterministic and imperfectly elastic demand for fixed-rate loan commitments in Period 1. After choosing the volume of commitments in Period 1, the lender faces an uncertain loan demand in Period 2 when a random number of commitments is exercised. Given the loans demanded, lenders fund them partly with low-cost deposits and partly with high-cost purchased money. The deposit volume available in Period 2 may or may not be known in Period 1, depending on the extant funding environment. Thus, banks face uncertainty in the loan demand irrespective of the funding environment. However, liability management complicates the bank's decision problem by introducing uncertain (and higher) funding costs as well.

A. Demand for Loan Commitments and Loans

Define a loan commitment as an option to borrow a unit of funds in Period 2 at a fixed interest rate r. The loan, if taken, will have a one period term-to-maturity and no default risk. Let Q be the quantity of loan commitments, and $p = p(Q)$ be the fee per unit charged by the lender. Throughout we shall assume that the marginal revenue from the sale of commitments is declining. Thus, we have

$$p = p(Q), p'(Q) \leq 0, [2p'(Q) + Qp''(Q)] \leq 0, \quad \text{for all} \quad Q \geq 0 \tag{1}$$

While Q is the maximum amount of loans the lender will extend in Period 2, loan commitments are not expected to be exercised *in toto*. If we let Θ denote the exogenously determined fraction of commitments exercised, then the loans made will be

$$L = \Theta Q, 0 \leq \Theta \leq 1 \tag{2}$$

[5] As discussed in Section III.*D*., a more general formulation would allow for both spot lending and for repudiation of commitments.

We interpret Θ as a random variable in Period 1 when commitments are sold. Thus, in Period 1, the bank faces a deterministic demand for loan commitments, but the derived demand for loans in Period 2 is random. We shall now consider the lender's borrowing cost function and show how it can be used to distinguish alternative funding environments.

B. Supply of Loan Commitments and Loans

In deciding on the amount of loan commitments to sell in Period 1, the lender must consider the cost of funding the loans in Period 2. We assume that the lender can borrow up to an exogenously determined amount in the form of deposits, D, at a constant marginal cost, c_1, where $c_1 < r$. Additional funds are obtainable at a rising marginal cost which we take to be linear in the funds borrowed, $(L - D)$. Thus, the lender's marginal borrowing cost is given by

$$MC(L) = \begin{cases} c_1 & \text{if } \; L \le D \\ c_1 + c_2(L - D) & \text{if } \; L \ge D \end{cases} \tag{3}$$

The lender's total borrowing cost can then be expressed in terms of Q as

$$C(\Theta, D, Q) = c_1 \Theta Q + \phi(\Theta, D, Q) \tag{4}$$

where

$$\phi(\Theta, D, Q) = \begin{cases} 0 & \text{if } \; \Theta Q \le D \\ \dfrac{c_2}{2}(\Theta Q - D)^2 & \text{if } \; \Theta Q \ge D \end{cases} \tag{5}$$

is the premium, over and above the subsidized interest rate c_1, paid for borrowing in excess of D. The funding cost function (4) implies that the bank may borrow less than D at a unit cost c_1. If the bank were obliged to passively accept D, then $c_1 D$ would be a fixed cost. Thus any bank receiving deposits in excess of loans is assumed to costlessly broker surplus funds at the subsidized interest rate c_1. However, our results are compatible with a variety of alternative cost structures, provided the marginal cost function $MC(\cdot)$ is continuously nondecreasing.[6]

C. Funding Environments

A pure deposit funding environment can be interpreted as one in which the lender can borrow a known quantity of funds (deposits), at a known, subsidized interest rate. In this setting, the size of the bank is determined entirely by the deposit market (for convenience, we ignore the funding implications of bank capital). In the context of our model, this is equivalent to having $c_2 = \infty$, with D known and fixed. All funds, up to an exogenously determined D, are obtained at the constant marginal cost, c_1, and additional funds are unavailable.

Pure liability management is often described in terms of the lender being able to borrow unlimited funds at a constant but uncertain interest rate (see Humphrey [13], Kane [15], and Silber [19]). This description is captured in our model either

[6] For a treatment of deposits as a quasi-fixed input, see Flannery [8].

with $D = 0$ and with the marginal borrowing cost, c_2L, equal to a randomly determined constant, or with $D = \infty$ and c_1 random. However, a perfectly elastic supply of funds is incompatible with any input fixity or adjustment cost; the marginal cost of funds to the banking firm must rise after some point (see Budzeika [4], [5]). Moreover, a perfectly elastic funds supply and an imperfectly competitive loan commitment market implies that the expected marginal revenue from the sale of loan commitments and the loan commitment fee may be negative at the optimum. Furthermore, if the loan market is perfectly competitive, pure liability management leads to an indeterminate lending firm size. Equally dubious is the view of deposit funding as implying $c_2 = \infty$. Given a lender of last resort, the bank is almost always able to borrow beyond its deposits, if at an increasing marginal cost.

We, therefore, adopt a cost structure describing mixed and presumably more descriptive environments. We assume that all lenders, irrespective of their funding environments, can obtain some deposits, D, at the subsidized interest rate, c_1, and that the marginal cost of borrowing beyond D increases linearly at rate c_2 in the level of nondeposit borrowing $(L - D)$. We distinguish between the two funding environments in terms of the magnitude and uncertainty of D. Hence, in a deposit funding environment, D is known and consequently the bank's cost of funds schedule is known as well. In a liability management setting, D is random with an expected value lower than the known D prevailing in deposit funding. The shift from deposit funding to liability management means that an uncertain quantity of deposits are transformed into purchased money, often with the introduction of an added layer of intermediation. Hence, the advent of liability management confronts the lender with both a higher and more uncertain cost of funding its unknown loan demand. This formulation portrays deposit funding as a special case of liability management.

Let $h(\theta, d)$ denote the joint probability density function of (Θ, D) from which we derive the marginal density of D, denoted as $g(d) = \int_0^1 h(\theta, d)\, d\theta$, and the conditional density of Θ given $D = d$, as $f(\theta | d) = h(\theta, d)/g(d)$. Let $H(\theta, d)$, $F(\theta | d)$ and $G(d)$ denote the corresponding cumulative distribution functions. This formulation with (Θ, D) jointly distributed subsumes various interesting cases. As already indicated, a degenerate distribution of D corresponds to the deposit funding environment. Another special case takes Θ and D as independent [i.e., $h(\theta, d) = f(\theta) g(d)$], so that the commitment takedown behavior of borrowers is independent of the funds supply behavior of depositors. In a deposit funding environment, the independence assumption is obviously satisfied since D is deterministic and we obtain a trivial kind of separability. However, as the environment evolves toward liability management, the independence assumption and separability become increasingly questionable. Dependence in this context is nothing more than recognition that those factors influencing demand for loans also influence the supply of funds to the bank. Thus, when the demand for loans facing the bank is high, as reflected in a high value for Θ, it is plausible, even compelling, to expect the supply of deposits, D, to the bank to be low. This latter situation describes a third case which can be stylized by viewing both Θ and D as deterministic functions of the spot interest rate, S, expected to prevail in Period 2. Then it is reasonable to assume Θ is increasing and concave in S, and D is decreasing and convex in S, i.e., a higher spot interest rate in Period 2 results in both higher commitment takedowns (greater demand for loans at the fixed commitment interest rate) and reduced funds availability to the bank (reduced supply of loanable funds at the subsidized interest rate). In what follows, we generalize this reasoning with a stochastic analog and assume

$$\frac{\partial F(\theta \mid d)}{\partial d} \geq 0, \quad \frac{\partial^2 F(\theta \mid d)}{\partial d^2} \leq 0, \quad \text{for all} \quad d \geq 0, \qquad \theta \in [0, 1] \tag{6}$$

Condition (6) says that greater deposit availability results in stochastically smaller commitment takedowns, but the marginal effect diminishes with higher deposit levels.

Now, for any given commitment volume, Q, the expected total cost of funds is

$$E[C(\Theta, D, Q)] = c_1 E(\Theta) Q + E[\phi(\Theta, D, Q)] \tag{7}$$

where $E[\phi(\Theta, D, Q)] = E\{E[\phi(\Theta, D, Q) \mid D]\}$ yields

$$E[\phi(\Theta, D, Q)] = \frac{c_2}{2} \int_0^Q \int_{\frac{d}{Q}}^1 (\theta Q - d)^2 f(\theta \mid d) g(d) \, d\theta \, dd \tag{8}$$

Differentiating (8) yields

$$\frac{\partial E[\phi(\Theta, D, Q)]}{\partial Q} = c_2 \int_0^Q \int_{\frac{d}{Q}}^1 \theta(\theta Q - d) f(\theta \mid d) g(d) \, d\theta \, dd \tag{9}$$

which is nonnegative and nondecreasing in Q, so that the expected cost of funds (7) is convex increasing in Q. For future reference, we integrate by parts and rewrite (9) as

$$\frac{\partial E[\phi(\Theta, D, Q)]}{\partial Q} = c_2 E[\nu(D, Q)] \tag{10}$$

where $\nu(\cdot, \cdot)$ is defined by

$$\nu(d, Q) = \begin{cases} (Q - d) - \displaystyle\int_{\frac{d}{Q}}^1 (2\theta Q - d) F(\theta \mid d) \, d\theta, & \text{if} \quad d \leq Q \\ 0 & \text{if} \quad d \geq Q \end{cases} \tag{11}$$

Equivalently, we may write (9) as

$$\frac{\partial E[\phi(\Theta, D, Q)]}{\partial Q} = c_2 \int_0^Q E[\psi(\Theta) \mid D = d] g(d) \, dd \tag{12}$$

where $\psi(\cdot)$ is given by

$$\psi(\theta) = \begin{cases} 0 & \text{if} \quad \theta \leq \dfrac{d}{Q} \\ \theta(\theta Q - d) & \text{if} \quad \theta \geq \dfrac{d}{Q} \end{cases} \tag{13}$$

We shall need the following properties of ν and ψ:

Lemma (a) For any given Q, the function $d \to \nu(d, Q)$ is convex nonincreasing; and

(b) $\psi(\theta)$ is convex, nonnegative, and nondecreasing in θ.

Proof: Part (b) follows directly from expression (13). To see Part (a), note that for $d \leq Q$, we have

$$\frac{\partial \nu(d, Q)}{\partial d} = -\frac{d}{Q}\left[1 - F\left(\frac{d}{Q} \,\middle|\, d\right)\right] - \int_{\frac{d}{Q}}^{1} \left\{[2\theta Q - d]\frac{\partial F(\theta \mid d)}{\partial d} + [1 - F(\theta \mid d)]\right\} d\theta \leq 0$$

and

$$\frac{\partial^2 \nu(d, Q)}{\partial d^2} = \frac{2d}{Q}\frac{\partial F\left(\frac{d}{Q} \,\middle|\, d\right)}{\partial d} - \int_{\frac{d}{Q}}^{1}\left[(2\theta Q - d)\frac{\partial^2 F(\theta \mid d)}{\partial d^2} - 2\frac{\partial F(\theta \mid d)}{\partial d}\right] d\theta$$
$$\geq 0,$$

where both inequalities follow from assumption (6) and properties of the distribution functions.

We now examine the optimal commitment volume and its dependence on interest rates, funding environment, and commitment takedown behavior.

II. Optimal Loan Commitments

The lender's problem is to determine the number of loan commitments Q to sell in the first period at price $p(Q)$, given by Equation (1), while facing uncertainty regarding the next period's loan demand L as expressed by Equation (2) and the cost of funds function given by Equation (4). Ignoring discounting, we can express the lender's expected profit as

$$\pi(Q) = p(Q)Q + (r - c_1)E(\Theta)Q - E[\phi(\Theta, D, Q)] \tag{14}$$

where $E[\phi(\Theta, D, Q)]$, given by (8), is convex increasing in Q. The first-order condition for an optimal commitment volume, say Q^*, involves equating the expected marginal revenue from the sale of commitments and from lending under commitments to the lender's expected marginal cost of funding loans. Thus, Q^* is characterized by

$$[p(Q^*) + p'(Q^*)Q^*] + (r - c_1)E(\Theta) = \frac{\partial E[\phi(\Theta, D, Q^*)]}{\partial Q^*} \tag{15}$$

where the right-hand side, given by (9), is nondecreasing in Q^*. This expected marginal borrowing cost in excess of the subsidized deposit rate, c_1, can be interpreted as the bank's Fed Funds borrowing rate less the unit cost of servicing demand deposits. The first term on the left-hand side of (15) is the known marginal revenue from the sale of commitments [which is nonincreasing in Q^* by assumption (1)], whereas the second term is the marginal expected profit from lending under commitments, so long as the loans can be funded with deposits. Inspection of (15) yields our first result on the price dependence of Q^*.

Proposition 1: Optimal commitment volume Q^* is increasing in $(r - c_1)$ and decreasing in c_2. If the commitment market is competitive with $p(Q) \equiv \bar{p}$, then Q^* is increasing in $\bar{p}$.

Thus, an increase in the markup of the loan rate over the subsidized cost of funds or a rise in the commitment fee will increase the number of commitments sold. If Θ is independent of these parameters, expected loans made also will rise. An increase in c_2 is an increase in the marginal cost of nondeposit funds and, provided Θ is independent of c_2, this results in a fall in commitments and in expected loans.

We next examine the effect of changes in the funding environment on the supply of loan commitments.

A. Effect of Altered Funding Environments

As discussed in Subsection I*C*, a shift from deposit funding to liability management may be viewed as involving higher and more uncertain borrowing costs for the lender. We model such a shift by assuming that the deposit level D decreases and also becomes uncertain. In particular, we shall examine the effect of a probabilistic decrease in the random variable D, in the sense of first-order stochastic dominance (see, for example, Hadar and Russell [10]), and an increase in the uncertainty in D, in the sense of a mean-preserving spread of its distribution (as in Rothschild and Stiglitz [18]). We shall show that the effect of these changes is to reduce the optimal commitment volume.

First, suppose that the random deposit level D decreases stochastically to D_1, so that

$$P\{D_1 \leq d\} \geq P\{D \leq d\}, \; d \geq 0$$

This is equivalent to

$$E[u(D_1)] \geq E[u(D)]$$

for any nonincreasing function $u(\cdot)$. In particular, by taking $-u(\cdot)$ as the identity mapping, we have $E(D_1) \leq E(D)$. As another special case, we may take $u(d) = \nu(d, Q)$, given by (11), which is nonincreasing by Lemma (a). It now follows from (10) that, for any Q,

$$\frac{\partial E[\phi(\Theta, D_1, Q)]}{\partial Q} \geq \frac{\partial E[\phi(\Theta, D, Q)]}{\partial Q}$$

As a result, the optimality condition (15) now implies that the new commitment volume Q_1^* is lower than Q^*. Thus, (stochastically) reduced availability of subsidized funds results in a reduced supply of loan commitments Q^* and hence of expected loans.

Next, suppose that D_1 changes to D_2 where D_1 and D_2 have the same mean but that the distribution of D_2 is more "dispersed" than that of D_1. Rothschild and Stiglitz [18] have shown that this is equivalent to

$$E(D_2) = E(D_1)$$

and

$$E[u(D_2)] \geq E[u(D_1)]$$

for any convex function $u(\cdot)$. By Lemma (a), $\nu(d, Q)$ is convex in d; hence, we may take $u(d) = \nu(d, Q)$ and again conclude from (10) that

$$\frac{\partial \mathrm{E}[\phi(\Theta, \mathrm{D}_2, \mathrm{Q})]}{\partial \mathrm{Q}} \geq \frac{\partial \mathrm{E}[\phi(\Theta, \mathrm{D}_1, \mathrm{Q})]}{\partial \mathrm{Q}}$$

Thus, from the optimality condition (15) we have new optimal $Q_2^* \leq Q_1^* \leq Q^*$. This result has an intuitive interpretation. For a given Q, and a given distribution of Θ, if an exceptionally high D is realized, the lender will be able to finance a greater volume of loans with funds at below-market *constant* unit cost, c_1. However, if an exceptionally low D is realized, the lender must finance a greater portion of loans at an increasing marginal cost. This asymmetry in the effects of large deviations in D from its expected value induce the lender to reduce the optimal quantity of loan commitments in the face of an increased probability of incurring such deviations. Thus, the model predicts that an increase in the uncertainty regarding the market cost of funds will lead lenders to reduce the supply of loan commitments. Expected lending will decrease as well.

Combining the two results, we have the following:

Proposition 2: As the funding environment shifts from deposit-funding to liability management, the optimal commitment volume, Q^*, and the corresponding expected loan volume, $E(\Theta)Q^*$, decrease.

Thus, (stochastically) reduced availability of subsidized funds and a greater uncertainty in the cost of purchased money, the two hallmarks of liability management, result in a reduction in the volume of loan commitments and expected lending by individual banks. Barring other changes, the advent of liability management should reduce the expected size of banks and the banking system.

We conclude the analysis by examining the effects on the bank's optimal commitment volume of changes in the demand for loans, as reflected in the customer's commitment takedown behavior.

C. Effect of Altered Loan Demand

In the last section, we related funding environments to a change in the lender's uncertainty regarding borrowing costs. Here, we interpret changes in the uncertainty regarding the demand for loans. Given the commitment volume Q, the derived loan demand L, given by Equation (2), depends upon the customers' uncertain takedown fraction Θ. Without uncertainty in Θ, the bank in effect behaves as a spot lender. That is, if Θ is known by the bank, it can be viewed as contracting in the present period to make loans of known amount for delivery in the next period (possibly at a currently unknown cost). The essential characteristic of forward lending, the uncertain derived loan demand, disappears. We shall show that decreased uncertainty in Θ results in increased loan commitments and hence in expected loans. Therefore, we interpret a reduction in the uncertainty concerning the derived demand for loans as equivalent to a movement towards spot lending.

First, suppose Θ changes to a more certain Θ_1, in the sense of a mean-preserving decrease in the spread of its distribution. Thus, as in the previous section, suppose that for any deposit level d, we have

$$E(\Theta_1 \mid D = d) = E(\Theta \mid D = d)$$

and

$$E(v(\Theta_1) \mid D = d) \leq E[v(\Theta) \mid D = d]$$

for any convex function v. In particular, by Lemma (b), we may take $v = \psi$, where ψ is defined in (13), and conclude that

$$E[\psi(\Theta_1) \mid D = d] \leq E[\psi(\Theta) \mid D = d]$$

It now follows from (12) that, for any Q,

$$\frac{\partial E[\phi(\Theta_1, D, Q)]}{\partial Q} \leq \frac{\partial E[\phi(\Theta, D, Q)]}{\partial Q}$$

Since the left-hand side of the optimality condition (15) remains unchanged, we conclude that the new optimal Q_1 is higher than Q^*. Thus, we have the following result.[7]

Proposition 3: Reduced uncertainty in the commitment takedown fraction (in the sense of a mean-preserving spread) results in an increase in the optimal volume of commitments and of expected loans.

The intuitive explanation for the increase in Q^* lies in the asymmetry of the costs and benefits of large deviations of Θ from its expected value. For a given choice of Q, the cost of realizing a low value of Θ is a *constant* per unit loss, $r - c_1$. However, the realization of a large value of Θ results in increasing per unit losses $[r - MC(L)]$ because loans must be made with increasing amounts of purchased money. Thus, as the probability of incurring very large or very small values of Θ decreases, the optimal Q increases. This result holds in both the liability management and deposit-funding environments; a decrease in loan demand uncertainty will prompt lenders to increase the amount of commitments. Furthermore, this reduction in uncertainty can be interpreted in terms of a shift from forward to spot lending. Hence, a bank engaged in forward lending will extend less credit, in an expected sense, than an otherwise similar bank engaged in spot lending.

III. Interpretation and Conclusion

By modeling the banking firm as a seller of loan commitments in alternative funding environments, we are able to address several issues. These include: (1)

[7] The effect on optimal Q of stochastic increases in Θ is ambiguous (see Appendix).

the bankers' claim that they passively accommodate their customers' demand for loans and therefore do not directly control their loans; (2) the Federal Reserve's similar claim that they cannot accurately control short-run oscillations in monetary aggregates; and (3) the effects of liability management on the lending behavior of banks. In this section we comment on each of these and indicate possible extensions of our analysis.

A. The Bank

Modeling the bank as a supplier of loan commitments focuses on a traditional role of banks, but one that tends to be ignored in formal discussion. We view the bank as a producer of contingent claims, a provider of hedging instruments, and a participant in forward rather than spot lending markets. As a consequence, the bank exercises only limited control over its lending. The bank ensures the availability of a certain volume of credit to customers at a pre-established interest rate in exchange for a commitment fee. In subsequent periods, the customers determine the bank's volume of lending, consonant of course with the bank's previously chosen volume of commitments. Following the customer's takedown decision, the bank's problem is to finance the volume of loans determined by the customers. The compression of this inherently two-stage problem into a simultaneous lending-financing problem, wherein the bank operates exclusively in spot markets, overstates the optimal volume of bank lending and makes the banker's traditional interpretation of his own lending behavior incomprehensible. By recognizing the central role of the forward market, we add an important institutional detail to our modeling of bank behavior and illuminate the banker's short-run passivity in the determination of bank lending volume. We also find that a bank engaged in forward lending will restrict its (expected) volume of lending in comparison with an otherwise similar bank engaged in spot lending.

B. Monetary Policy

Monetary policy initiatives are transmitted through bank lending behavior, either by the direct availability of loanable funds or via interest rates. Focusing on banks' direct lending behavior leads to skepticism regarding the central bank's alleged inability to effect shortrun monetary control. By emphasizing the role of bank loan commitments, however, we see that the monetary authorities exert only indirect control over bank lending and therefore over the various monetary aggregates.[8]

[8] Wojnilower [23] observes that:

> The crunch (of 1969) also spurred a widespread move toward formalizing in a legally obligating manner the hitherto largely informal credit-line arrangements prevailing between banks and their business customers. Both parties wanted to be protected from future "antilending" injunctions such as that contained in the Federal Reserve's letter of September 1966. Corporations wanted and were willing to pay for legally binding credit lines. Bankers believed that the authorities could not in the future place them in a position in which they would have to dishonor such agreements. In effect, they were trying to create still more private instruments with monetary properties. Ever since, the growth of this invisible money supply has rendered suspect policy as well as scholarly conclusions based on monetary aggregate data. Unused bank-credit commitments currently slightly exceed the total quantity of demand deposits included in measures of the money stock (288–9).

The availability of deposits, D, can be viewed as varying directly with the level of unborrowed reserves supplied to the banking system. Furthermore, the rising portion of the bank's marginal borrowing cost function can be interpreted as describing the availability of funds to the bank from either the central bank's discount window or from other high cost sources such as the Fed Funds market, for example. An unexpected contractionary monetary policy shock, employing any of the central bank's three major policy instruments, would reduce D—deterministically in the case of deposit-funding or stochastically in the case of liability management—and/or increase c_2 and hence the slope of the rising portion of the marginal borrowing cost function. The immediate effect of this contractionary policy would be to force banks to honor their currently exercised loan commitments at an unexpectedly high cost of funds.[9] Also, the number of loan commitments exercised would increase, because of the reduced availability of alternative sources of funds, and due to the higher level of market interest rates (relative to the fixed commitment interest rate). The bank therefore sustains unexpectedly high costs in supplying loanable funds for an unexpectedly high number of exercised commitments. The immediate effects are unexpected bank losses together with an *increase* in loans made under commitments. Thus a contractionary monetary policy leads to an immediate expansionary growth in lending.[10]

However, the reduction in deposit funds, D, and the increased cost of obtaining funds beyond D, leads the bank to decrease its optimal quantity of loan commitments, Q^*. Thus, if the distribution of Θ does not change, the expected volume of loans, $E(\Theta)Q^*$, made in the subsequent period, would also be reduced. However, as explained above, the reduced availability of alternative sources of funds for commitment holders should result in a higher expected takedown fraction, $E(\Theta)$; therefore the effect of monetary policy on the expected loan volume in the subsequent period will depend on the relative magnitude of these two opposing adjustments.

Focusing on loan commitments provides further insight into the effects of monetary policy; defensive open market operations also can be shown to have unexpected results. These transactions allegedly seek to reduce interest rate variability. If interest rate variability leads to variability in D or in Θ, then the interest rate smoothing by the Fed would induce banks to increase their loan commitments and expected loans, provided the expected values of D and Θ

[9] This may help explain why bank profits tend to diminish as interest rates approach peak levels (see Flannery [9]).

[10] With some qualification, the same point can be made in a more general setting with fixed-formula (as in the case of prime-plus) commitments. Spot interest rate changes may or may not be accompanied by real interest rate changes. If, for example, spot rates increase due to expectations of increased inflation, the demand for funds should remain unchanged, but holders of prime-plus commitments will be permitted to borrow at below their appropriate spot market rate owing to the fixed add-on. (We expect the add-on to increase, probably at an increasing rate, with the spot-rate in the absence of a commitment.) Hence, in this case, takedowns should increase with spot rates. If, however, spot rate increases are due to real interest rate increases, the tendency to borrow under commitments deriving from the fixed add-on will be offset by a reduced demand for borrowings. Thus when spot rate changes are accompanied by real rate changes, the relation between takedowns and spot rates will depend on the net effect of two opposing tendencies.

remain unaffected. Hence, defensive operations in themselves may be expansionary.

C. Funding Environments

Liability management is an incompletely understood syndrome rooted in inflation and in advances in transactions technology. It is widely acknowledged to have elevated banks' funding costs and to have reduced the duration of bank liabilities. However, it also is asserted that liability management provides banks with greater flexibility in funding and therefore in adjusting their asset volume. By supplanting a demographic constraint on bank size with a money market discipline, banks presumably can increase their lending more readily. More extreme descriptions of this new-found flexibility suggest that banks can borrow essentially unlimited quantities of funds at the prevailing money market interest rate, i.e., at a constant albeit uncertain marginal cost. This extreme view ignores all constraints on bank size, implies optimal bank size is indeterminate if asset markets are competitive, and also can yield negative prices for loan commitments. Putting aside this more extreme view, we are left with the unanswered question of how liability management affects the optimal size of the bank. Our analysis provides a clear and plausible answer; if liability management means higher and more uncertain funding costs, then the advent of liability management will lead the bank to choose a reduced quantity of loan commitments and expected loans, and therefore, a reduced expected bank size.

Observations to the contrary may reflect distributional effects of liability management which we have not modeled. In particular, the replacement of demographic constraints on bank size with money market constraints may have redistributed funds away from smaller banks toward the larger ones. This would follow if prevailing bank size serves as a positive signal to the money market of the bank's creditworthiness. To the extent that such distributional effects offset the tendency to reduced size among larger banks, they will, of course, magnify the effects on smaller banks. Hence, liability management may doubly impact smaller institutions, explaining their acute reluctance to sacrifice the protection provided by demographic constraints.

D. Extensions

By modeling the bank as a seller of loan commitments, rather than a purchaser of spot loans, we have obtained a variety of results which shed new light on bank lending behavior, monetary policy, and the effects of liability management. Most assuredly, however, these results are obtained from an exceedingly simple model and one that therefore immediately suggests further research.

The most obvious extension would permit the bank to participate in the spot loan market as well as in the forward market. One might visualize the bank selling commitments in Period 1, followed by customer takedowns in Period 2. The bank might then purchase (perhaps even sell) additional loans at the prevailing spot interest rate in Period 2. The ability to purchase (sell) spot loans in Period 2 would, of course, affect the volume of loan commitments sold in Period 1. In addition, the introduction of the spot loan market would assign a central role to the Period 2 spot interest rate. It would then seem natural to express the deposit level, D, and the takedown ratio, Θ, as deterministic functions of the Period 2 spot interest rate and thereby reduce the number of random variables from two to one. This suggested modification of the model adds considerable descriptive detail and might be expected to illuminate the commitment pricing issue.[11] However, it probably would not qualitatively alter our results on optimal loan commitments, especially if banks could purchase (sell), but not sell (purchase) spot loans. This would give rise to an asymmetry wherein banks could offset a loan demand shortfall (surplus), but not adjust to a surplus (shortfall).

Another extension would substitute a fixed formula for the fixed rate commitment. Again we would not expect this generalization to reverse our results on optimal commitment choice as long as there remains an element of inflexibility in the commitment loan rate without counterpart among bank borrowing costs. For example, assume prime-plus commitments and an increase in spot interest rates that increases banks' borrowing costs by causing the loss of deposits. Banks will reduce commitments provided the increase in marginal revenue (owing to the increase in the prime rate) is smaller than the increase in marginal borrowing costs. This decrease in the marginal lending-borrowing spread seems plausible since the bank will be borrowing at the market rate but lending at below the market rate (due to the fixed add-on).

Still other extensions might allow banks to default on their commitments when such behavior is dictated by an explicit optimization. Banks also may influence takedown behavior of commitment owners by adjusting subsequent commitment prices in light of past takedown behavior, in much the same way that insurance companies influence the submission of claims (see Venezia and Levy [22]). Not all of these extensions promise striking results, nor are they even all relevant for the questions addressed in this paper. However, they do suggest the range of issues raised by explicitly recognizing banks' important role in the forward as well as spot credit markets.

APPENDIX

In this appendix, we examine the effect on optimal Q of a stochastic increase in Θ. Suppose that the takedown fraction Θ increases stochastically to Θ_2 so that

$$P\{\Theta_2 \leq \theta \mid D = d\} \leq P\{\Theta \leq \theta \mid D = d\}, \qquad \theta \in [0, 1], \quad d \geq 0$$

Since, by Lemma (b), $\psi(\cdot)$ is nondecreasing, we have

$$E[\psi(\Theta_2) \mid D = d] \geq E[\psi(\Theta) \mid D = d]$$

and hence, by (13),

$$\frac{\partial E[\phi(\Theta_2, D, Q)]}{\partial Q} \geq \frac{\partial E[\phi(\Theta, D, Q)]}{\partial Q}$$

[11] The present stochastic structure subsumes as a special case the model with the spot rate as the sole source of random variation.

Although the marginal expected cost of purchased money increases, we also have $E(\Theta_2) \geq E(\Theta)$, and hence the expected marginal profit from lending deposit funds, $(r - c_1)E(\Theta_2)$, is higher than before. The effect on Q^* determined by (15) depends upon which of these two effects dominates. Thus, a stochastically higher takedown fraction may imply higher or lower volumes of commitment and expected loans. One might expect Q^* to decrease as a result of the greater takedown fraction. This would follow if the lender seeks to maintain the loan volume, L, at a constant level. However, the lender's expected profit maximization problem (14), is only indirectly related to the expected loan volume and hence there is no reason to expect the lender to optimally choose the earlier expected loan volume. As a result, the effect of a stochastic increase in the distribution of Θ leads to an ambiguous change in Q^*. However, for small spreads between r and c_1, or at high levels of Q where the marginal expected borrowing costs are high, stochastically dominating shifts in Θ can be expected to reduce Q^*.

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