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An adverse-selection model of bank asset and liability management with implications for the transmission of monetary policy

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I develop a model in which information problems make it difficult for banks to raise funds with instruments other than insured deposits. The model has a number of implications for bank asset and liability management as well as corporate financing patterns. It also speaks to the question of how monetary policy works: when the Federal Reserve reduces reserves, this tightens banks' financing constraints and leads to both a cutback in the supply of intermediated lending and an increase in bond-market interest rates.

1. Introduction

■ This article develops an adverse-selection-based model of bank asset and liability management. In the model, banks raise funds from individual investors and then turn around and lend these funds out to borrowers, who can be thought of as bank-dependent corporations. The typical bank's job is complicated by the fact that individual investors are not as well informed as bank management is about the value of the bank's existing assets. Depending on the type of liability the bank issues to finance itself, this may or may not create an adverse-selection problem that interferes with the bank's ability to make positive net-present-value loans. In particular, if the bank is able to fund itself completely with insured deposits, no adverse-selection problem arises and lending behavior is undistorted. But if the bank's ability to issue insured deposits is somehow constrained, it will have to turn to noninsured sources of finance, in which case adverse selection does become an issue and lending behavior can be affected.

The article has three primary goals. The first is to provide an empirically plausible microeconomic account of bank portfolio choice. A multiperiod version of the model is especially useful in this regard, as it delivers a number of testable predictions about how banks optimally allocate their assets among loans and securities and about how these allocations respond to shocks in the availability of insured deposit finance.[1]

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[1] In this vein, the article is related to recent work by Lucas and McDonald (1992), who also construct a model of bank portfolio behavior based on asymmetric information. The similarities are discussed in more detail below.

The second goal is to contribute to that branch of the corporate finance literature concerned with how nonfinancial firms choose between bank and nonbank sources of debt finance.[2] To take one example, the model has distinctive implications for how firms' mix of bank versus nonbank debt varies over the business cycle; in contrast to Diamond (1991), the prediction here is that firms will use relatively *less* bank debt and *more* nonbank debt (e.g., commercial paper) when monetary policy is tight and interest rates are high.

The final goal of the article is to address the macroeconomic question of how the monetary transmission mechanism works. The model captures two distinct channels of monetary policy, both of which originate in banks' inability to frictionlessly access uninsured sources of external finance: (1) the Federal Reserve can influence the *spread* between the rates on loans and those on open-market securities (e.g., T-bills); (2) the Fed can also move the *level* of the Treasury rate itself.

The first channel works as follows. When the Fed drains reserves from the system, it forces banks to substitute away from insured deposit financing and toward adverse-selection-prone forms of nondeposit finance. This in turn leads to a cutback in aggregate bank lending and hence to an increase in the relative cost of bank loans. In this sense, the model provides a specific set of microfoundations for the notion of a "bank lending channel" of monetary transmission, which has been the subject of much recent research.[3]

The second effect is more novel. In most theories of monetary transmission—ranging from the textbook IS/LM paradigm to more recent treatments based on limited participation and cash-in-advance constraints[4]—the Fed's ability to influence bond-market rates is predicated on the assumption that households have a demand for non-interest-bearing "money" (e.g., currency) for transactions purposes. In contrast, in my model, household portfolio preferences play no role. Households implicitly face no cash-in-advance constraints and hence can hold all of their wealth in interest-bearing assets. Yet the Fed can still directly affect Treasury rates. This is because banks, unlike households, have a well-defined demand for non-interest-bearing "money," namely reserves. For it is only by holding reserves that banks can issue insured deposits and thereby overcome adverse-selection problems. By exploiting this induced demand for reserves on the part of banks, the Fed can manipulate bond-market rates.

The remainder of the article is organized as follows. In Section 2 I sketch a partial-equilibrium model of a single bank. In this minimalist setup, the bond-market rate is exogenous and the bank faces shocks to its deposit base—shocks it cannot offset by bidding deposits away from other banks. Although this is not very realistic, it introduces the basic intuition about bank portfolio behavior. In Section 3 I extend the model to allow for interbank competition for deposits. As will become clear, this makes it easier to interpret the model as being about the consequences of monetary policy. Moreover, if prices are assumed to be sticky, it is precisely this interbank competition for deposits that will endogenously determine the bond-market rate. Section 4 questions the institutional realism of the model's assumptions and assesses the extent to which the qualitative conclusions carry over to alternative institutional/regulatory environments. Section 5 discusses the article's empirical implications and compares it with related work. Section 6 concludes.

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[2] Recent contributions include Diamond (1991, 1993), Rajan (1992), Hoshi, Kashyap, and Scharfstein (1993), and Houston and James (1996).

[3] For surveys of this literature, see Cecchetti (1995), Kashyap and Stein (1994), Hubbard (1995), and Bernanke and Gertler (1995).

[4] See, e.g., Grossman and Weiss (1983), Rotemberg (1984), and Lucas (1990).

2. A partial-equilibrium model of bank behavior

■ The partial-equilibrium model will be built up in two steps. First I construct an extremely simple one-period version. This version captures the important insight that changes in bank deposits translate into changes in bank loan supply, but it leaves much else out. In particular, in a one-period setting it is hard to capture the notion that banks hold buffer stocks of marketable securities as a means of coping with potential shocks to their deposits. To remedy this deficiency, I next extend the model to a two-period setting.

□ **A one-period version with no securities holdings.** The basic assumptions are as follows. On the asset side of the balance sheet, banks have three items: (1) reserves, denoted by R; (2) new loans, denoted by L; and (3) "old assets," denoted by K. The reserves are non-interest-bearing and are held to satisfy reserve requirements. The volume of new lending L is a choice variable for banks. Finally, the old assets K can be thought of as loans made at an earlier time that are still on the books; the volume of these old assets cannot be adjusted. The old assets will be relevant to the analysis, however, because there is asymmetric information about their value, as will be described momentarily.

On the liability side of the balance sheet, banks have three sources of funding: (1) insured deposits M; (2) previously raised, nondeposit finance P; and (3) incremental nondeposit external finance E, which must be raised when the new loans are made. For simplicity, it is assumed that the old assets are completely supported by the preexisting nondeposit financing, so that $K = P$. Consequently, the bank's balance sheet constraint is

$$L + R + K = M + P + E; \quad \text{or} \quad L \leq M(1 - \varphi) + E, \tag{1}$$

where φ is the fractional reserve requirement on insured deposits.

Banks are assumed to be monopolists in the loan market.[5] They face a loan demand schedule of the form

$$L^D = a - br, \tag{2}$$

where r is the loan rate charged to borrowers. Thus b is a measure of the elasticity of loan demand.[6] The new loans made by the bank are all assumed to be riskless. This is done to abstract away from issues of risk shifting—it removes any incentives for banks to overlend so as to take advantage of government-provided deposit insurance.

The required expected return on all other financial instruments—including the deposits M and the new uninsured external finance E—is exogenously fixed and, for convenience, normalized to zero. Thus in this simple version of the model, r should really be interpreted as the spread between loans and securities; this is all that can be pinned down given the model's current partial-equilibrium nature.

As noted above, there is asymmetric information about the value of the old assets K. In particular, if the bank is a type G ("good") these assets will ultimately be worth

[5] While this is an admittedly extreme simplification, the work of Sharpe (1990), Rajan (1992), Petersen and Rajan (1994), and Slovin, Sushka, and Polonchek (1993) provides theoretical and empirical support for the idea that "informational lock-in" leaves banks with some degree of market power over their customers.

[6] In general, loan demand will depend not only on the loan rate, but also on the open-market rate, if borrowers can substitute between bank loans and open-market finance. The simple demand schedule used in the text implicitly assumes that substitution is impossible. (And also that borrowers are price takers who have output that is a quadratic function of the amount invested.)

K^H; if the bank is a type B ("bad") these assets will ultimately be worth $K^L < K^H$. Bank managers are assumed to know their type, but outside investors do not. To streamline the notation, it will be useful to assume that both K^L and K^H are infinitely large relative to L. In this case, a simple measure of the magnitude of the information asymmetry that will come in handy momentarily is $A \equiv (1 - K^L/K^H)$.

Asymmetric information is relevant because of two key features of bank liabilities. The first feature is that uninsured external finance carries with it some degree of exposure to bank type. The simplest way to capture this in the model is to restrict all uninsured bank liabilities to be of the same priority.[7] For example, one might assume that the bank's preexisting financing P is all equity, and that the bank is also restricted to using equity for all incremental nondeposit finance E. So even though the new loans are riskless, any incremental nondeposit liabilities inherit some of the exposure to the old assets.

The restriction that all nondeposit liabilities be of the same priority is clearly unrealistic, but its simplifies the analysis substantially. In principle, one could obtain similar results while allowing for a richer priority structure of uninsured liabilities—e.g., wholesale CDs, subordinated debt, preferred stock, etc.—so long as all these uninsured liabilities were sufficiently junior so as to be somewhat exposed to bank type.[8]

The second key feature is that, unlike with nondeposit external finance, the cost to a bank of using insured deposits does not depend on investors' perceptions of that bank's type. Or, said differently, what is special about deposits in this setup is that they are the only way for a bank to raise "asymmetric-information-proof" external finance. Any attempt to substitute away from deposits brings the potential for adverse-selection problems.[9]

To foreshadow the macroeconomic discussion a bit, what will give monetary policy its potency in the model is the correspondence between reservable forms of bank finance and asymmetric-information-proof forms of bank finance. More specifically, I assume that the only way a bank liability's value can be completely insensitive to perceived bank type is if this liability is subject to reserve requirements.[10] This implies, as we shall see below, that if the Fed can shrink the real supply of bank reserves, it can make it more difficult for banks in the aggregate to raise funding.

For the time being, however, I entertain an even simpler sort of shock than a systemwide contraction in reserves. I simply ask the following: Suppose a given bank is faced with an exogenous outflow of insured deposits—that is, its M falls. How will the bank react? Given the assumptions that have been made, this question is easy to answer. Indeed, the logic exactly parallels that of Myers and Majluf (1984), who demonstrate that a decrease in internal liquidity for a nonfinancial firm decreases its physical investment. For a bank, insured deposits are exactly analogous to internal liquidity, and loans are exactly analogous to physical investment.

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[7] This sort of restriction appears in Myers and Majluf (1984) and in numerous articles that have followed it.

[8] Investors do seem to care about issuer quality, even with senior uninsured liabilities such as wholesale CDs. Bank CDs are evaluated by five rating agencies. Moreover, rates can vary considerably with credit ratings and other measures of credit quality. Keeley (1990) estimates that a one-percentage-point increase in a bank's capital ratio reduces its CD rate by 14 basis points.

[9] For the purposes of this section, it does not matter what the government charges for deposit insurance—banks take deposit flows as exogenous and do not react to a change in insurance premia. However, the pricing of deposit insurance does matter in the analysis of Section 3, where it is examined in more detail.

[10] This assumption does not correspond exactly to the current institutional reality in the United States. Individual time deposits (e.g., small-denomination CDs) are insured but are not subject to reserve requirements. This and related issues are taken up in Section 4.

The details are as follows. There will be a unique separating equilibrium that survives the standard refinements.[11] In this equilibrium, the type B's lend in an undistorted fashion—that is, they simply maximize their interest income. This is accomplished by setting $L^B = a/2$, which implies that the type B's must raise an amount of external finance given by

$$E^B = \max(0, a/2 - M(1 - \varphi)). \tag{3}$$

The type G's, in contrast, raise less external finance and therefore lend less. Let the lending volume of the type G's be given by $L^G \equiv L^B - Z$. Thus Z is the amount by which type G's underlend. Correspondingly, the type G's raise a lesser amount of external finance, $E^G = E^B - Z$. If one denotes the profits of the two types by π^G and π^B respectively, it is easy to show that $\pi^G = \pi^B - Z^2/b$.

The key incentive constraint is that a type B not be tempted to mimic a type G. On the one hand, if a type B does mimic, its profits from lending fall by Z^2/b. On the other hand, it is able to gain by selling overpriced equity. Given our earlier simplifying assumptions, this gain is simply equal to AE^G. The low-cost separating equilibrium (the one that survives the usual refinements) is the one in which the incentive constraint holds with equality. That is, the equilibrium satisfies

$$Z^2/b = AE^G. \tag{4}$$

It is easy to show that the solution to (4) is given by

$$Z = -Ab/2 + (A^2b^2 + 4AbE^B)^{1/2}/2. \tag{5}$$

The solution has an intuitive interpretation. When M exceeds $a/2(1 - \varphi)$, banks have enough deposits available to fund the first-best level of loans without having to turn to any new nondeposit external finance. In this case, both types lend at this first-best level. But as M falls, there is a divergence in the behavior of the two types. The type B's make up the deposit shortfall one-for-one with uninsured external finance, and they leave their lending insulated. The type G's, in contrast, are reluctant to use uninsured sources of finance and make up only a fraction of the shortfall. This reasoning yields the following:

Proposition 1. For $E^B > 0$ (alternatively, for $M < a/2(1 - \varphi)$), the lending of the type G's is sensitive to the availability of insured deposits: $dL^G/dM > 0$. Moreover, the effect of M on type-G lending is stronger when the degree of information asymmetry A is larger in magnitude—i.e., $d^2L^G/dMdA > 0$.

The bottom line is that to the extent that a significant fraction of banks are type G's, a shock to deposits will translate into a noteworthy effect on lending behavior. This is the opposite of the conclusion reached by Romer and Romer (1990), who contend that banks can always insulate their lending decisions from shocks to insured deposits by making use of other forms of finance, such as wholesale CDs. Essentially, the Romer and Romer argument is an application of the Modigliani-Miller proposition to the banking firm. But, if wholesale CDs and other forms of uninsured external finance are subject to adverse-selection problems, this Modigliani-Miller logic is no longer valid.

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[11] For example, the equilibrium I focus on below is the only one that satisfies the intuitive criterion of Cho and Kreps (1987).

□ **A two-period version with buffer stocks of securities.** One obvious objection to the model sketched above is that because it fails to account for banks' holdings of marketable securities, it is both unrealistic and potentially misleading. After all, the typical bank holds somewhere between 30% and 40% of its assets in cash and securities. And even if a bank is unwilling—due to adverse-selection problems—to react to a \$1 deposit outflow by raising an additional \$1 of uninsured external finance, it might be able to draw down on its stock of securities, thereby protecting its lending activity.

To address this issue, I now extend the model to a two-period setting, with banks facing an adverse-selection problem in the market for uninsured external finance in each of the two periods. This extension allows one to derive banks' optimal securities holdings in the first period and to analyze how first-period lending volume, securities holdings, and external finance jointly respond to changes in the availability of deposits.

The notation and assumptions are basically the same as above, with a few generalizations and additions. There are now two time periods, 1 and 2. On the asset side, banks now have an additional option at time 1—they can hold securities. Let L and S denote a bank's holdings of loans and securities respectively at time 1. The key distinction between the two is that any securities held at time 1 can be costlessly liquidated at time 2. In contrast, it is costly to liquidate loans. Specifically, at time 2, a bank can liquidate an amount J (for "jettison") of the loans made at time 1. The net costs of such liquidation are θJ^2.[12]

On the liability side, banks continue to fund themselves with insured deposits and common equity. As before, deposits are exogenous and are given by M_1 and M_2 at times 1 and 2 respectively. It is now important to specify the stochastic structure of deposit shocks, which can be captured simply by assuming that, conditional on the realization of M_1, M_2 is uniformly distributed on

$$[\rho M_1 + (1 - \rho)m - \gamma/2, \rho M_1 + (1 - \rho)m + \gamma/2].$$

In this formulation, m can be thought of as an unconditional mean level of deposits, the parameter ρ is a measure of the persistence of deposit shocks, and the parameter γ is a measure of the variance of these shocks.

With regard to new external finance, E_1 and E_2 now denote the incremental amounts raised at times 1 and 2 respectively. Thus by time 2, a total of $E_1 + E_2$ in new nondeposit financing will have been raised. Loan demand at time 1 continues to be given by (2). Now the interest rate r refers to the return on the loan if it is not liquidated—that is, if it remains outstanding beyond time 2. Other than loans, all other financial instruments have a return that is fixed at zero. This now includes the securities S held by the bank.

The bank's balance sheet constraints at time 1 and time 2 can be written as

$$L + S \leq M_1(1 - \varphi) + E_1 \qquad \text{(time 1)} \tag{6}$$

$$L - J \leq M_2(1 - \varphi) + E_1 + E_2 \quad \text{(time 2).} \tag{7}$$

Finally, as before, there is asymmetric information with respect to the ultimate value of the old assets K. To capture this asymmetric information in a multiperiod setting, I assume that the value of the old assets evolves gradually over time according

[12] The assumption that it is costly to prematurely liquidate loans is a common one—see, e.g., Diamond and Dybvig (1983).

to a binomial process, and that bank management is always "one step ahead" of outside investors in terms of their respective information sets.[13]

Specifically, the unconditional value of the assets (before anyone has any information) is K_0. After time 1, an initial public signal arrives. If the signal is "good," which happens with probability p, the value of the assets rises to uK_0, with $u > 1$. If the signal is "bad," which happens with probability $(1 - p)$, the value of the assets falls to dK_0, with $d < 1$. Although outside investors do not observe the signal until after time 1, bank managers have already observed it when they make their time-1 lending and financing decisions. Similarly, after time 2, a second public signal arrives. If the signal is good, value again increases by a factor of u. If the signal is bad, value again falls by a factor of d. Thus two consecutive good signals lead to a final asset value of u^2K_0, two consecutive bad signals lead to a final value of d^2K_0, and so forth. Bank managers again observe the signal before the rest of the market does, in this case before making their time-2 financing decisions.

A "type G" now refers to any bank whose private information—at either time 1 or 2—leads it to expect an increase in asset values when the next public signal is released. Conversely, a "type B" is any bank whose private information leads it to expect a decrease in asset values. By construction, the ratio of type B value to type G value is always equal to d/u. Thus, by analogy to the above, we can construct a time-invariant measure of the magnitude of the information asymmetry, $A \equiv (1 - d/u)$.

Given the assumptions, it is a straightforward task to solve the model. The details are in Appendix A, but the important conclusions can be simply stated:

Lemma 1. Denote by $S^F(M_1)$ that value of securities holdings sufficient to fully insulate a bank, so that it will not need to either raise new external funds or cut loans at time 2, $S^F(M_1) = (1 - \varphi)[(M_1 - m)(1 - \rho) + \gamma/2]$. A bank that is type B at time 1 will hold $S^B \geq S^F(M_1)$ and will also lend at the first-best level. To do so, a bank that is type B at time 1 will raise an amount of external finance

$$E_1^B = \max\{a/2 - (1 - \varphi)[\rho M_1 + (1 - \rho)m - \gamma/2], 0\}.$$

Lemma 2. Suppose $E_1^B > 0$. Then a bank that is type G at time 1 will have $S^G < S^F(M_1)$—i.e., it will hold less than the full-insulation level of securities. It will also lend at less than the first-best level; $L^G < a/2$.

Proposition 2. Suppose $E_1^B > 0$. As in the simpler model, type G's react to a decrease in M_1 by cutting lending. Also as before, this link between M_1 and L^G is stronger when the information asymmetry A is larger in magnitude—i.e., $d^2L^G/dM_1dA > 0$.

Proposition 3. Suppose $E_1^B > 0$. In general, both type G's and type B's react to a decrease in M_1 by cutting securities holdings. For type G's, the link between M_1 and S can become either stronger or weaker when the information asymmetry A increases in magnitude. When the elasticity of loan demand b is high, it is more likely that $d^2S^G/dM_1dA < 0$—i.e., that securities are more sensitive to M_1 for low-information-asymmetry banks. Conversely, when loan demand is relatively inelastic, it is more likely that $d^2S^G/dM_1dA > 0$.

Lemmas 1 and 2 speak to the precautionary demand for securities at time 1. This demand is driven by the potential for adverse selection in the time-2 market for external finance, which threatens to generate *ex ante* expected loan-liquidation costs. To avoid these liquidation costs, banks will hold securities in their portfolios at time 1, in spite of their lower yield relative to loans. Indeed, a bank that is type B at time 1 will

[13] A similar assumption is used by Lucas and McDonald (1990).

effectively be at a corner solution, holding so much in the way of securities that it never has to worry about going to the market again at time 2—this is Lemma 1.[14]

In contrast, Lemma 2 states that a bank that is a type G at time 1 does not in general fully insulate itself. To the extent that they have to be financed from new nondeposit issues, securities holdings are discouraged by adverse selection in the time-1 market. In light of this observation, Proposition 2 follows directly. Given that it is not fully insulated, further reductions in securities at time 1 are costly for a type G. Hence, when this bank is hit with a shortfall in M_1, the optimal response is to do only some of the adjustment by drawing down on securities, with the rest done by reducing lending.

Proposition 3 is subtler, and is the product of two competing effects. On the one hand, the threat of an adverse-selection problem at time 2 makes it more attractive for high-A banks to hold large buffer stocks of securities at time 1, as it is the high-A banks that most want to avoid being forced to seek external funds at time 2. This suggests that high-A banks will value securities more highly and will be less inclined to cut them as M_1 falls. On the other hand, we have just seen that high-A banks cut their loans by more at time 1. This means that the loan-security spread r rises by more for high-A banks. This latter effect tends to make high-A banks rebalance their portfolios so as to put more weight on loans and less on securities—that is, it tends to make them cut securities by more in response to a deposit outflow. When loan demand is relatively inelastic, the movement in r will be substantial, and the latter effect will dominate.

Before moving on, it is worthwhile to note one weakness in the formal analysis. As emphasized above, Propositions 2 and 3 are derived under the assumption that E_1^B is strictly positive. That is, it is assumed that banks must seek new external finance at time 1 if they wish to hold a level of securities $S^F(M_1)$ sufficient to insulate them fully from future deposit shocks. But is this assumption reasonable? One might argue that with many time periods, banks would have an incentive to gradually accumulate huge buffer stocks of securities financed by permanent capital. They might do so even in the presence of adverse-selection problems, perhaps by financing the securities holdings with retained earnings. In the language of the model, this would imply that the preexisting stock of finance P would ultimately become very large relative to the preexisting loans K, so that at time 1, S could be well above $S^F(M_1)$ even without recourse to any external new finance E_1. In this case, incremental shocks to M_1 could be met by drawing down S (but still keeping it above $S^F(M_1)$) and not touching L.[15]

This reasoning suggests that the model as currently formulated is missing something; another friction must be added to explain why banks do not gravitate toward holding arbitrarily large buffer stocks of securities financed with permanent capital (i.e., equity). A natural candidate for such a friction is taxes. In particular, the tax cost of holding equity-financed money-market securities is just the mirror image of the tax advantage of debt finance. It is straightforward to show that if one adds tax considerations into the model, banks will opt not to build up too much financial slack *ex ante,* so that all the above results continue to apply.[16]

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[14] Note that the greater the variance of the time-2 deposit shock, the larger the required buffer stock for a type B at time 1. Also, securities holdings react more to time-1 deposit shocks when these shocks are relatively transitory in nature.

[15] Effectively, there are two distinct questions: Why, in the long run, don't banks hold arbitrarily large levels of S? And given that S starts out being not so large, why don't banks cut S one-for-one with a deposit shock and not touch L? While the model in the text answers the latter question, it is not a complete answer to the former.

[16] Froot and Stein (1998) develop a model of banks along these lines, in which there are both flow costs of raising new external finance (corresponding to adverse selection) and stock costs of holding equity-financed slack on the balance sheet (corresponding to taxes).

3. Interbank competition for deposits and interest rate determination

■ Thus far, the partial-equilibrium nature of the analysis has meant that (1) the potential for interbank competition for deposits has been ignored and (2) the model has been silent as to the rate of return on securities. In an effort to remedy these deficiencies, I begin with the one-period version of the model developed in Section 2 and add several new features. First, the market for deposits is now perfectly competitive, so individual banks perceive themselves as price takers. Second, households are totally indifferent between holding deposits and any other security; this implies that there is a common interest rate on deposits and bonds. This interest rate is denoted by i and, as will be seen shortly, will be determined endogenously.[17]

The overall level of real reserves available to the banking system is R. If monetary policy is to have any real effects, I must assume that the Fed can control R. This amounts to assuming that prices are at least partially sticky. In other words, like any other model of monetary transmission, this model requires some imperfect price adjustment in addition to the other frictions that have been assumed thus far. Since I have nothing to add in terms of the primitive sources of this price stickiness, I simply assume its existence.

The final key assumptions have to do with the noninterest costs to banks of financing themselves with insured deposits. First, I have to be more specific about the terms on which banks obtain deposit insurance. These terms clearly matter here; if, for example, banks can avail themselves of underpriced deposit insurance, they will compete more aggressively to raise deposits, all else equal. Perhaps the cleanest assumption to make is that any bank that raises deposits obtains deposit insurance on "fair" terms—i.e., there is no potential for subsidy to any type of bank from the government insurance fund. This no-subsidy feature could arise in one of two ways. One possibility is that banks could issue the same otherwise risky liabilities they ordinarily do, and the government insurer could charge risk-based premiums for guaranteeing these liabilities. To implement this, the government insurer would have to be able to observe bank types, so as to be able to charge the type B's more for insurance. Alternatively, the government could simply allow deposits to be made senior to all other bank liabilities.[18] In this case, the deposits are riskless without the need for any explicit guarantee, thanks to the assumption that all the new loans are riskless. In effect, financing the new loans with senior deposits is equivalent to doing perfectly secured project finance. Hence a premium of zero results in no subsidy to banks of either type. Under this latter interpretation, there is no need for an insurer that can observe bank types.

Although I focus on the no-subsidy case in the analysis below, the qualitative conclusions that emerge are not critically dependent on this assumption. For example, I have also explored a variant of the model in which the government cannot observe bank types and follows the simple policy of offering deposit insurance to all banks on terms that are appropriate for the type G's, up to some fixed coverage limit. In this

[17] The assumption that households are indifferent between deposits and securities is made just to render the results of the model starker. It is worth emphasizing that the only distinction between deposits and securities comes from banks' preferences, not those of households. Type-G banks will have a preference for deposits over uninsured security market finance because the former do not involve an adverse-selection problem. This imperfection at the level of the banks is the Fed's only lever over the economy.

[18] This formulation can be loosely rationalized by observing that short-maturity debt is, in economic terms, effectively senior to longer-maturity debt (see, e.g., Gertner and Scharfstein, 1991, and Diamond, 1993). Thus the demandable nature of deposits naturally makes them less sensitive to bank type.

case, there is clearly a subsidy to type-B banks. Yet I obtain results very similar to those discussed below.[19]

The second key assumption about deposit finance is that it entails holding reserves that do not pay interest. This implies that although deposits have the advantage of being insured (on fair terms), they are subject to an offsetting cost in the form of a reserve tax that is not borne by uninsured sources of finance. The simplest way to generate this feature is to just assume, as I have been doing throughout, that *all* insured deposits are subject to legal reserve requirements. However, in Section 4, I shall discuss the applicability of the model in the alternative cases where (1) there exist some bank liabilities that are insured but are not subject to reserve requirements or (2) there are no legal reserve requirements whatsoever.

Before diving into the algebra, it may be useful to give some intuition for how the monetary mechanism works in this setup. Essentially, if the Fed can control real reserves, it controls the aggregate real supply of "permits" for issuing insured liabilities. So when the Fed tightens, it contracts the supply of such permits. This means that the relative price of these permits will have to rise. This relative price is given by φi, which is the reserve tax on deposits. Therefore, when the Fed tightens, the bond-market rate i must rise. The shortage of permits also means that type-G banks will raise less financing in the aggregate, and will do less lending. So the loan rate r faced by their customers will also rise.

To formalize these ideas, I begin by describing the timing of the game. First, the Fed moves and sets the level of real reserves R. Next, individual banks choose their level of uninsured external finance, and the market draws inferences about bank type accordingly. Finally, with their uninsured finance in place, the banks choose their optimal levels of insured deposits and loans, taking the market-clearing interest rate i as given.

In this setting one can, as before, construct a separating equilibrium—i.e., an equilibrium in which the quantity of external finance chosen by a bank reveals its type. In such an equilibrium, the type B's will do the first-best level of lending, which is now given by

$$L^B = (a - bi)/2. \tag{8}$$

The only difference from before is the presence of a nonzero cost of funds for type-B banks.

On the financing side, the type B's will completely shun the use of deposit financing and use only uninsured external finance—that is, $E^B = L^B$. This represents the most cost-effective form of financing for the type B's, since they completely avoid the reserve tax.

Type G's will raise an amount of uninsured finance $E^G < E^B$. The type G's balance sheet constraint is

$$E^G = L^B - Z - M^G(1 - \varphi). \tag{9}$$

Thus, for a given shortfall of uninsured funds relative to the type B's, the type G's can adjust in one of two ways: they can raise insured deposits in an amount M^G, or

[19] The primary effect of changing the assumptions in this way is to raise the equilibrium interest rate i relative to that given by equation (13) below. When they can take advantage of underpriced insurance, type-B banks will be more tempted to issue deposits. Hence their induced demand for reserves will be greater. For the reserves market to clear, the opportunity cost of holding reserves—which is given by the interest rate i—must therefore rise.

they can cut lending by an amount Z. The total cost of these two distortions relative to the first-best strategy of the type B's is given by $Z^2/b + \varphi i M^G$. Therefore, for a fixed E^G, the optimal tradeoff between these two choices involves setting Z as follows:

$$Z = \varphi ib/2(1 - \varphi). \tag{10}$$

As before, the key incentive constraint is that a type B not mimic a type G. This incentive constraint is given by

$$Z^2/b + \varphi i M^G = AE^G, \tag{11}$$

where the left-hand side represents the loss that a type B would incur if it switched to the type-G strategy and had to cut loans by Z and raise deposits of M^G, and the right-hand side represents the gains from issuing overpriced securities.

Combining the four equations (8)–(11) yields

$$M^G = (Aa/2 - Abi/2(1 - \varphi) - i^2\varphi^2 b/4(1 - \varphi)^2)/(\varphi i + A(1 - \varphi)). \tag{12}$$

Equation (12) gives the demand for deposits by a representative type-G bank as a function of the interest rate i. The total supply of deposits is determined by the amount of reserves available and is equal to R/φ. If there are n banks in total, and we denote the fraction of type G's in the population by α, then the equilibrium interest rate is the solution to

$$R/\alpha n\varphi = (Aa/2 - Abi/2(1 - \varphi) - i^2\varphi^2 b/4(1 - \varphi)^2)/(\varphi i + A(1 - \varphi)). \tag{13}$$

It is easy to see from (13) that the interest rate i is a decreasing function of the amount of real reserves R. Again, the intuition is as follows. All else equal, type-G banks would prefer using insured deposits to using uninsured external finance. Since deposit financing requires banks to hold reserves, there is an induced demand for reserves on the part of the type G's. Given that reserves are non-interest-bearing, the total demand for reserves is a decreasing function of the interest rate i. Thus, to the extent that prices are sticky and the Fed can control the supply of real reserves, it can also control the interest rate.

Once the interest rate has been determined, it is a simple matter to solve for type-G lending volume and to show that it is negatively affected by a contraction in reserves. Correspondingly, the loan rate r increases, with the magnitude of the increase depending on the elasticity of loan demand b. The more inelastic is loan demand, the greater will be the rise in r. Thus this version of the model can be thought of as pinning down both the bond-market interest rate and the loan-bond spread.

4. Alternative institutional/regulatory environments

■ A key feature of the model to this point is that all insured bank liabilities are subject to reserve requirements. In practice, this feature does not always hold true. For example, in the United States, reserve requirements on personal time deposits were phased out gradually beginning with the passage of the Monetary Control Act of 1980. Thus some types of accounts, such as small-denomination (less than $100,000) CDs, are currently insured but not subject to reserve requirements. Moreover, in some countries—e.g., Switzerland and Canada—there are currently no legal reserve requirements whatsoever. A natural set of questions to ask is: Do the qualitative conclusions of the model carry over in such environments? If so, what additional assumptions must one make for this to be true?

□ **Legal reserve requirements are not a binding constraint.** Given the other assumptions of the model, legal reserve requirements are binding—i.e., banks choose not to hold excess reserves. In reality, this does not seem to be too far off the mark for the U.S. case: in recent years, excess reserves of the banking system have been on the order of only 1–2% of total reserves (Economic Report of the President, 1995). However, the basic story I am telling does not hinge on legal reserve requirements being binding. All that really matters is that *for some reason*—be it legal or economic considerations—banks view noninterest-bearing reserves as necessary for issuing insured liabilities.

To see this point most simply, suppose for the moment that the government only insures demand deposits. Because of their demandable nature, banks will have to hold some level of reserves against these deposits, whether or not the law requires them to, simply so they can accommodate unpredictable withdrawals.[20] In this case, one might think of φ as representing not legal requirements, but rather the (fixed-coefficient) "deposit production technology" that relates a bank's use of reserves to its level of deposits.

□ **Individual time deposits are insured, but do not require reserves.** A subtler issue arises when there are bank liabilities that are eligible for government insurance but do not require reserves, either in the legal sense or in the "technological" sense described just above. Small-denomination CDs are a good example of this, as they are not only currently exempt from legal requirements, but also unlikely to impose any significant technological need for reserves, in light of the penalties for early withdrawal.

Given the structure of the model, introducing a perfect market for insured, nonreservable small-denomination CDs would have a radical effect. First of all, this instrument would be the dominant form of financing for banks—it would be strictly preferred to *both* uninsured, nonreservable liabilities such as wholesale CDs as well as insured, reservable liabilities such as demand deposits. Second, if banks financed themselves exclusively with nonreservable instruments, monetary policy would be rendered completely impotent.

Since in reality small-denomination CDs and other insured, nonreservable liabilities are not the single dominant form of bank financing, it must be that the model as currently cast is missing something. In particular, there must be some countervailing cost to using such instruments. There are a number of possibilities in this regard, but one simple story goes as follows. Because they are not negotiable (in contrast to wholesale CDs), small-denomination CDs are a less attractive investment vehicle than either demand deposits, T-bills, or wholesale CDs. Thus, households will purchase small-denomination CDs only if they are offered a return greater than the bond-market/demand-deposit rate of i.

To see what this implies for the determination of interest rates, denote the return on small-denomination CDs as $i + c$, and assume that household demand for these CDs is given by $h(c)$, where $h()$ is an increasing function. In other words, the larger the illiquidity premium c, the more households will invest in small-denomination CDs. Now observe that in an interior equilibrium, it must be the case that the all-in cost to a bank of obtaining a dollar of insured funding—inclusive of the opportunity cost of

[20] As an illustration, consider the fact that some small banks apparently now hold substantial excess reserves simply because the amount of cash they must keep in their ATMs exceeds required reserves (Kohn, 1994).

holding idle reserves—is the same for small-denomination CDs and demand deposits. This implies that $i + c = i/(1 - \varphi)$, or, equivalently, that $c = \varphi i/(1 - \varphi)$. With this in mind, it is straightforward to show that the appropriate modification of equation (13) is given by

$$R/\alpha n\varphi = (Aa/2 - Abi/2(1 - \varphi) - i^2\varphi^2 b/4(1 - \varphi)^2)/(\varphi i + A(1 - \varphi)) - h(c)/\alpha n(1 - \varphi). \quad (14)$$

Thus the only change in the equation is that the quantity $h(c)/\alpha n(1 - \varphi)$ has been subtracted from the right-hand side. In other words, the aggregate demand for reserves on the part of banks is now lower, and therefore the interest rate is lower too, all else equal. The intuition is straightforward. Suppose that we were initially at an equilibrium in the world of Section 3, where there is no possibility of issuing small-denomination CDs. When small-denomination CDs become available, banks will compete to attract them and offer a rate premium of $c = \varphi i/(1 - \varphi)$, since these CDs economize on reserve holdings. This will call forth a supply of CDs $h(c)$ from the household sector, thereby reducing the overall banking sector demand for reserves and hence the interest rate i.

In the polar case where households' willingness to supply small-denomination CDs is inelastic—i.e., where $h(c)$ is roughly constant over the relevant range of interest rates—we obtain the same basic result as in Section 3: the impact of monetary policy on both the bond-market rate i and the loan rate r is shaped by banking-sector imperfections rather than by any frictions at the household level. This illustrates that the key idea of Section 3 is not necessarily sensitive to the introduction of insured, nonreservable bank liabilities, so long as there is some other imperfection that prevents them from becoming the single dominant form of bank financing.[21]

5. Discussion: related work and empirical implications

■ **Bank asset and liability management.** This article is related to several distinct strands of research. First, in terms of providing a microeconomic account of bank portfolio behavior based on costs of uninsured external finance, the two-period partial-equilibrium model in Section 2 resembles that in Lucas and McDonald (1992). Like I do, they consider a multiperiod setup in which banks face exogenous deposit outflows. And like I do, they are able to derive banks' "precautionary" demands for marketable securities. However, their approach differs quite a bit from mine in its details and, more importantly, in its empirical implications.[22]

Propositions 2 and 3 above can be used to generate both aggregate and cross-sectional predictions about the behavior of bank balance sheets. At the aggregate level, one would expect the banking sector's total lending volume and securities holdings to both drop after a contractionary shock to monetary policy. This is clearly borne out in the data, as demonstrated by Bernanke and Blinder (1992) and a number of subsequent researchers. Moreover, it has been documented that the spread on uninsured bank CDs relative to T-bills rises sharply when monetary policy tightens (Fama, 1985; Stigum,

[21] Of course, one can think of other frictions that would also prevent personal time deposits from becoming the dominant form of bank financing. For example, it may be that because small depositors cannot continuously monitor the rates paid by all banks, banks face increasing marginal search/advertising costs in attracting such depositors.

[22] In the Lucas-McDonald model, unlike mine, there is the potential for exploiting deposit insurance via a risk-shifting strategy. Thus, holding riskless securities tends to be unattractive and is done only as a signalling mechanism. This leads to their principal empirical conclusion, which is that higher-asset-quality banks will hold more securities.

1990). This fits with the notion that banks are forced to shrink their assets because the supply of uninsured liabilities is not perfectly elastic.

Cross-sectional predictions can be generated to the extent that one can come up with a reasonable proxy for the magnitude of the information asymmetry A.[23] In Kashyap and Stein (1995) we take this approach, using bank size as our proxy for A—large banks are taken to face less severe problems in raising uninsured finance. The results are as follows: First, as implied by Proposition 2, we find strong evidence that small (i.e., high-A) banks cut loans by more in response to monetary-policy-induced deposit outflows. Second, we find weaker evidence that small banks also cut securities holdings by more in response to the same deposit outflows. According to Proposition 3, the latter finding suggests the joint presence of adverse-selection problems in external finance and relatively inelastic loan demand.

While the results of Bernanke and Blinder (1992) and Kashyap and Stein (1995) for lending volume are consistent with the theory here, they also admit alternative interpretations, based on movements in loan demand, rather than supply. Aggregate lending volume may decline in the wake of a monetary tightening simply because this induces a recession through the usual IS/LM channel, which in turn depresses loan demand. Similarly, the lending of small banks may fall more than the lending of large banks to the extent that small banks tend to lend to smaller customers, and these customers have relatively more cyclical loan demand.

In an effort to provide a sharper test of the theory, in Kashyap and Stein (1997) we examine its implications at the level of individual banks. Using a panel dataset that includes quarterly observations of every insured commercial bank in the United States over the period 1976–1993, we find that among the smaller banks in the sample—i.e., those *a priori* most likely to have high values of A—the impact of monetary policy on lending behavior is significantly stronger for those with lower ratios of cash and securities to assets. As we argue in detail in that article, such a finding is much harder to explain away based on movements in loan demand and thus would seem to constitute strong evidence in favor of the sort of theory developed above.

In addition to these focused tests of the theory, we also document in Kashyap and Stein (1995, 1997) a number of more basic facts about banks that fit closely with the spirit of the model. First, smaller banks make almost no use of nondeposit debt liabilities such as unsecured federal funds borrowing or subordinated debt. In contrast, these are very important sources of funds for the largest banks. This accords with the view that information asymmetries essentially preclude the use of certain types of risky debt by small banks. Second, small banks hold substantially more in the way of cash and marketable securities than do large banks. This is precisely what the two-period version of the model would lead one to expect.

□ **Corporate finance.** As noted above, there is a growing literature that studies how firms choose between bank and nonbank sources of debt. For the most part, this work takes a "demand-side" approach; i.e., it focuses on the costs and benefits to borrowers of using either type of finance. For example, bank debt has the advantage of generating more monitoring (Diamond, 1991) but the disadvantage that there may be excessive *ex post* liquidation (Diamond, 1993) or *ex post* holdup problems due to the bank's informational monopoly over its clients (Rajan, 1992). Depending on a borrower's characteristics, bank debt may or may not on net be an attractive instrument.

[23] In general, it is difficult to directly test predictions having to do with bank type—e.g., the prediction that type G's cut loans by more after a monetary contraction—because bank type is private information and hence unobservable (at least *ex ante*) to the econometrician. Instead, it makes more sense just to assume that type G's make up a nontrivial fraction of the population and focus on the model's cross-sectional predictions with respect to the publicly observable variable A, which measures the degree of information asymmetry.

In contrast, this article offers a "supply-side" angle on the same set of questions, focusing on the attributes of the banks rather than their customers. This can lead to very different empirical implications. In particular, Diamond (1991) predicts that the ratio of bank to nonbank (e.g., commercial paper) financing volume should increase during times of high interest rates, since this is when the need for monitoring by banks is greatest. The model here makes the reverse prediction, since it emphasizes the fact that the banks themselves will be most constrained during periods of tight monetary policy. Existing evidence seems to favor the latter view. Kashyap, Stein, and Wilcox (1993) find that while bank loans fall after a monetary contraction, commercial paper issuance surges sharply.[24]

In a similar demand-versus-supply vein, this article suggests a novel rationale for the widespread use of bank loan commitments. Existing theories of commitments are again demand-based, emphasizing the need to insure against various shocks to borrowers.[25] However, an alternative possibility is that commitments are used to insure against shocks to lenders. Simply put, borrowers know that if there is a contraction in monetary policy, their bank will have to cut back on overall lending, and some may be willing to pay a commitment fee to guarantee that they get preferential treatment. Evidence in Morgan (1998) suggests that this is at least a plausible story; he finds that when the Fed tightens, banks' loans to borrowers *without* commitments fall much more sharply than do loans to borrowers *with* commitments.

Finally, one can use the same basic logic to explain why borrowers might prefer to borrow from several banks simultaneously. Rather than a fear of being held up by a single banker with an informational monopoly (as in Rajan, 1992), it may be that the primary benefit of multiple banking relationships is insurance against a scenario in which any one bank becomes very liquidity constrained and unable to satisfy its customers' loan demand.

□ **Macroeconomics: monetary policy, interest rates, investment, and output.** While the model above is capable of endogenizing both bond-market and bank-loan rates, it stops short of being a complete macroeconomic framework. However, it is a straightforward task to embed it into a richer structure, thereby capturing the effects of monetary policy on aggregate investment and output. Indeed, this final step can be accomplished using a number of "off-the-shelf" macro models, depending on the tastes of the user. As one concrete example, I have embedded the model of Section 3 directly into the two-period monopolistic competition apparatus of Kiyotaki (1988). Appendix B provides an overview of how this works.

There is a good deal of evidence that is consistent with the theory's implications for investment. At the aggregate level, Kashyap, Stein, and Wilcox (1993) find that proxies for the spread between the bank lending rate and the commercial paper rate are significant determinants of economywide investment and inventory movements, even after controlling for the level of real interest rates. And in disaggregated data,

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[24] Oliner and Rudebusch (1996) argue that this finding is due to a compositional effect—they claim that recessions have less of an impact on the credit demand of the largest borrowers, who are the primary users of commercial paper. However, Kashyap, Stein, and Wilcox (1996) rebut this claim by showing that the relative movements in bank loans and commercial paper are the same for large firms. Moreover, they suggest that tight-money-induced surges in commercial paper volume reflect the fact that large firms are taking over the intermediation function from banks by extending more trade credit, and hence need more financing. This interpretation fits squarely with the model above.

[25] See, e.g., Holmström and Tirole (1998), who suggest that loan commitments are a device for ensuring that projects that are *ex ante* attractive do not get prematurely terminated *ex post* when the borrower experiences a liquidity shock.

several studies have found that, subsequent to monetary contractions, liquidity constraints become much more pronounced in the investment and inventory decisions of small (and presumably relatively bank-dependent) firms.[26]

From a macroeconomic perspective, however, it is natural to ask whether one can go beyond qualitative statements and say something about the aggregate quantitative importance of the specific mechanism described in this article. This is a difficult question to answer satisfactorily. There is an inherent tension: To measure aggregate impacts, it is useful to work with aggregate data. Yet in doing so it is hard to be sure that one is identifying an effect that comes from the precise channel articulated here. Conversely, if one wants to have more confidence on the identification front, it helps to rely on micro data. But then it can be tricky to "aggregate up" the results to make statements about economywide magnitudes.

For example, the macro-data results of Kashyap, Stein, and Wilcox (1993) suggest fairly large effects: the coefficient on their proxy for the relative cost of bank versus nonbank financing implies that a shock similar to the one following the Fed's October 1979 shift in policy results in declines in corporate investment and inventories that alone account for about 1% of GNP. But this sort of experiment is open to the general criticism that the explanatory variable may be picking up other effects besides the one pinpointed in the model above.[27]

Taking an alternative, more micro tack, the cross-sectional results in Kashyap and Stein (1997) imply that four quarters after a 100-basis point hike in the funds rate, an "illiquid" (10th percentile of cash and securities to assets) bank will have cut its C&I loans outstanding by as much as 2% relative to a "liquid" (90th percentile of cash and securities to assets) bank. This cross-sectional differential sounds big, given that the total decline in lending following such an event is also around 2%. But even if it can be concluded that banks cut their loans sharply as a result of the mechanism modelled above, one still needs to know how readily their customers can switch to nonbank forms of finance. Absent a measure of this elasticity of substitution, the micro data on banks cannot speak to the ultimate investment or output consequences of monetary policy. Clearly, this remains a challenging topic for future work.

□ **Asset pricing.** Although the model is not directly concerned with asset pricing, it may help to put a bit more structure on one particular asset-pricing puzzle, the small-firm effect. It is well known that the stocks of firms with low market capitalizations tend to earn high excess returns. One hypothesis to explain this, emphasized by Fama and French (1993), is that firm size is a proxy for a loading on some risk factor. But this leaves open the questions of exactly what the underlying fundamental risk factor is, and why small firms are more exposed to it. The theory here offers one possible set of answers: the risk factor is associated with shocks to monetary policy, and a firm's loading reflects the extent to which it is bank dependent and, hence, relatively more vulnerable to monetary contractions.

In order to test this story directly, one needs to identify a measure of bank dependence at the firm level that is sufficiently uncorrelated with size. In principle this should be possible, since not all small firms are bank dependent; some are largely financed with retained earnings, etc. A simple proxy in this spirit might be the ratio of bank debt to total capital, and one could ask to what extent this variable subsumes size as a predictor of excess returns.[28]

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[26] See, e.g., Gertler and Hubbard (1988), Gertler and Gilchrist (1994), Kashyap, Stein, and Lamont (1994), and Carpenter, Fazzari, and Petersen (1994).

[27] For a more detailed discussion of this and related calibration exercises using aggregate and quasi-aggregate data, see Kashyap and Stein (1994).

[28] See Lamont, Polk, and Saa-Requejo (1997) for recent empirical work along these lines.

□ **Other related work.** There are a couple of recent articles that share with this one the broad theme that money can be a device for reducing adverse-selection problems. In Williamson and Wright (1994), adverse selection makes a nonmonetary barter equilibrium inefficient—consumers are reluctant to directly exchange goods with each other, for fear of receiving low-quality goods. A universally recognized fiat money ameliorates this problem and improves efficiency. In a similar spirit is Gorton and Pennacchi (1990). They observe that adverse selection may also be a problem if consumers settle up with each other using, say, uninsured corporate securities such as equity or risky debt. They then suggest that insured claims such as bank deposits can help resolve the adverse-selection problem and facilitate exchange.

What both these articles have in common, and what distinguishes them from this one, is that they focus on adverse-selection problems in exchange between consumers. Indeed, both can be thought of as providing the microfoundations for something like a cash-in-advance constraint at the consumer level. In contrast, I focus on an adverse-selection problem between banks and purchasers of bank liabilities. To see the import of this distinction, note that adverse-selection problems between consumers can be solved in a number of ways other than with insured bank liabilities: Williamson and Wright suggest precious metals, and Gorton and Pennacchi point to Treasury securities. But neither of these alternative mechanisms will help banks to finance their lending operations more effectively.

In terms of the general notion that capital market frictions can constrain bank lending, this article is related to another recent and fast-growing strand of the literature that stresses the importance of bank equity capital.[29] However, though it is built on the same costly-external-finance foundations, this work is concerned less with the direct effects of monetary policy than with the consequences of adverse shocks to banks' net worth, such as falling profits, declines in real estate prices, rising interest rates, etc.

By drawing an explicit link between monetary policy and bank lending behavior, the model here is perhaps closest to that of Bernanke and Blinder (1988), who use a simple IS/LM-style model to illustrate the "bank lending view" of monetary transmission. Indeed, my work can be thought of as an attempt to provide some of the microfoundations for theirs, using adverse selection to endogenously deliver several key features that theirs simply assumes, e.g., (1) on the asset side, banks have well-defined portfolio preferences across loans and securities, and (2) a contraction in reserves leads banks to shrink their assets.[30]

There is one key distinction between the model here and that of Bernanke and Blinder, which is seen most clearly in the polar case where households are indifferent between deposits and securities. In Bernanke and Blinder, as in most models of monetary transmission, this household-level indifference leads the bond-market interest rate to be insensitive to monetary policy. Here, however, monetary policy can still affect the bond-market rate in this scenario. This is because of the adverse-selection friction in the banking sector and the demand for non-interest-bearing reserves that this friction induces.

6. Conclusions

■ Many articles in the literature on financial intermediation have the feature that intermediaries are able to completely resolve information or agency problems with their

[29] See, e.g., Holmström and Tirole (1997) for a model, Houston, James, and Marcus (1997) and Peek and Rosengren (1997) for recent empirical evidence, and Sharpe (1995) for a survey.

[30] Another article that can be thought of as rationalizing the lending view is Greenwald, Levinson, and Stiglitz (1991). However, their mechanism is quite different: they consider a regulated setting where deposits pay below-market rates of interest. Thus, expansionary policy that increases deposits acts as a direct subsidy to the banking sector.

investors and therefore are not subject to liquidity constraints.[31] In contrast, this article has stressed two points. First, banks may, in equilibrium, be subject to adverse-selection problems that constrain their lending. Second, insured deposits can represent a unique financing instrument for banks that allows them to circumvent such problems and thus lend more freely.

These simple observations have been shown to have a variety of implications for the asset and liability management behavior of banks themselves; the financing arrangements of corporate borrowers who rely on banks; and monetary policy and the determination of interest rates. With regard to monetary policy, the novel conclusion is that one can develop a quite rich model of the transmission mechanism by taking a "bank-centric" approach—i.e., by focusing solely on frictions at the level of banks and completely ignoring the frictions at the household level that are at the center of most theories of monetary transmission. Even if money plays no special role for households, the model here shows that the Federal Reserve can still influence both bond rates and loan-bond spreads and thereby have a direct impact on both firms that finance themselves in the open market and those that rely on banks.

In closing, it is worth highlighting one important set of issues that is not addressed within the context of the model. Throughout, the institutional structure of commercial banking has been exogenously imposed, in the sense that the taking of insured deposits and the making of loans to corporations has simply been assumed to occur under the roof of a single entity. But why do banks engage in both of these activities simultaneously? Is it a result of distortionary current or past regulation (e.g., mispriced deposit insurance), or are there deeper economic synergies that cause deposit taking to be complementary with certain types of lending activity? A complete and satisfying answer to these questions awaits future research.

Appendix A

■ **Solution of the two-period partial equilibrium version of the model.** The model can be solved backwards, starting with time 2. As before, the focus is on the low-cost separating equilibrium at this time. The nature of such an equilibrium is almost exactly identical to that in the one-period model. Type B's will raise an amount $E_2^B = \max(0, L - E_1 - M_2(1 - \varphi))$. According to the time-2 balance sheet constraint (7), this means that type B's raise enough so as to not have to liquidate any loans, given their time-1 financing choice E_1 and their time-1 lending choice L.

The type G's raise a lesser amount $E_2^G = E_2^B - J$ and therefore have to liquidate an amount of loans J. The incentive constraint is now of the form

$$\theta J^2 = AE_2^G. \tag{A1}$$

The solution to (A1) is given by

$$J = -A/2\theta + (A^2 + 4\theta AE_2^B)^{1/2}/2\theta. \tag{A2}$$

Given (A2), the next step is to compute the *ex ante* expected costs of liquidation as of time 1, which will be denoted by X. These costs can be shown to have the following form:

$$X = pC(L - E_1 - (1 - \varphi)(\rho M_1 + (1 - \rho)m - \gamma/2)), \tag{A3}$$

where recall that p is the time-1 probability that the bank will be a type G at time 2—i.e., p is the probability of an "up" move on the binomial tree—and where $C()$ is an increasing convex function, with $C(0) = 0$.

Now fold back the analysis to time 1. Again, the focus is on the low-cost separating equilibrium at this time. In this equilibrium, type B's lend in an undistorted fashion, setting $L^B = a/2$. Type B's also raise enough external finance at time 1, and thereby also hold sufficient securities, so that they never have to raise further external funds at time 2. As stated in Lemma 1, this amount is given by

[31] See Diamond (1984) for an explicit theory of how intermediaries resolve agency problems and relax their own credit constraints.

$$E_1^B = \max\{a/2 - (1 - \varphi)(\rho M_1 + (1 - \rho)m - \gamma/2), 0\}.$$

This policy ensures that $X^B = 0$.

Consider the case where E_1^B is strictly positive. Type G's raise a lesser amount E_1^G at time 1. In doing so, they invest less in both loans and securities than do the type B's (this is Lemma 2) and thereby suffer a net cost $W(E_1^G)$, where $W()$ is defined as follows:

$$W(E_1^G) = a^2/4b - \max\{(aL - L^2)/b - pC(L - E_1^G - (1 - \varphi)(\rho M_1 + (1 - \rho)m - \gamma 2))\}. \quad (A4)$$

Thus $W()$ is a decreasing function, with $W(a/2 - (1 - \varphi)(\rho M_1 + (1 - \rho)m - \gamma/2)) = 0$. Analogous to before, the low-cost separating equilibrium then satisfies

$$W(E_1^G) = AE_1^G. \quad (A5)$$

Propositions 2 and 3 follow from the comparative-statics properties of this solution.

Appendix B

■ **Embedding the model of Section 3 in a monopolistic competition macro framework.** I will omit the mathematical details and give only a brief sketch of the setup. As in Kiyotaki (1988), there are households and monopolistically competitive firms. These firms produce a differentiated set of goods in both periods, have a constant returns to scale technology, and can borrow directly in the bond market at the rate i. They can be interpreted as large, non-bank-dependent firms. Their desired investment depends both on the rate i that prevails in the first period and on the anticipated level of output in the second period.

In addition, there are banks as well as a set of competitive firms that produce an undifferentiated good and can only borrow from the banks. These two sets of agents are exactly as described in the model of Section 3; thus the competitive firms can be thought of as smaller, bank-dependent firms. Unlike the large monopolistic competitors, the small competitive firms produce output only in the second period; in the first period they just borrow and invest.

The investment input of both the large and small firms is, in equilibrium, an equally weighted mix of the first-period goods produced by the large, monopolistically competitive firms. Thus its composition is the same as that of first-period consumption. This simplifying assumption also follows Kiyotaki (1988).

If one assumes that first-period prices are rigid, the analysis goes as follows. The stance of monetary policy—as measured by the level of real reserves R—determines both the real interest rate i and the level of investment by the small competitive firms, as in the model of Section 3. Once the real interest rate i is fixed, one can solve jointly both for the second-period output by the large monopolistic competitors and for their investment demand, exactly as is done by Kiyotaki (1988). Given constant returns to scale, there is a unique solution for a given rate i.

Having done this, we will have the aggregate first-period investment demand, which is just the sum of the investment by the two types of firms. Given the assumption that first-period prices are rigid, total first-period output will be demand determined, as the sum of desired consumption plus desired total investment at the prevailing interest rate i. The bottom line is that a contraction in reserves that raises the real interest rate on loans and securities also reduces both types of investment, as well as aggregate first-period and second-period output.

Incidentally, if one assumes instead that first-period prices are fully flexible, the model of Section 3 can now be used to pin down the price level, instead of the real interest rate. In the flexible-price setting, first-period output will be completely determined by household labor supply considerations. Equating this level of output to aggregate demand will in turn pin down an interest rate i. Now the price level has to adjust so that real reserves satisfy the equilibrium condition in equation (13) above, given the interest rate i.

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