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Core Deposits and Securitization[#]

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Abstract

Securitization is a strategic choice variable that affects the liquidation efficiency of both retained and sold loans. After granting loans and learning about their quality, a depository institution can use securitization to increase its core deposits ratio and to optimally adjust the overall quality of its portfolio. This increases the incentive to efficiently liquidate loans in the future, which results in a socially optimal equilibrium in which the value of the depository institution is maximized. Efficient liquidation of securitized loans can be induced by properly structuring a recourse provision. The implication is that a portfolio of loans that would otherwise be inefficiently liquidated may be efficiently liquidated if some of the loans are sold. Consistent with casual observations of securtization contracts, the model predicts that the lower is the quality of the securitized loan package, the more recourse will be offered.

Introduction

In recent years, core deposits have become increasingly scarce¹. Mutual funds and other non-bank entities have become increasingly competitive by promising higher returns with similar services. An implication of this is that depository institutions (DIs) have been forced to either reduce the size of their balance sheets or accept a lower ratio of core deposits to total deposits. There are drawbacks to both of these alternatives. Berlin and Mester (1996), for instance, show that DIs have a unique contracting advantage when they hold a sufficient amount of core deposits. Because these deposits are rate inelastic in nature, the higher is the ratio of core deposits to total deposits, the more efficient is the liquidation policy. Intuitively, the efficiency gain arises because the DI is able to provide intertemporal cross-subsidization of loans.² The implication is that if DIs accept a lower core deposits ratio, then they also accept less efficient liquidation policies. Reducing the balance sheet size may also be unattractive. If DIs choose to grant fewer loans, then they may pass up profitable loans. If DIs instead choose to grant the same number of loans but then sell more of them, then the sold loans may not receive some of the benefits of DI financing. I argue, however, that securitization allows DIs to maintain efficient liquidation policies. By selling off loans and using the proceeds to retire non-core deposits, DIs can effectively maintain a high core deposits ratio and consequently induce more efficient liquidation of retained loans. Furthermore, efficient liquidation of sold loans can be maintained by structuring an appropriate recourse provision.

I find that the value of a DI is greatest when an efficient liquidation equilibrium is credible, but that the DI cannot necessarily credibly commit to an efficient liquidation policy. If the ratio of core deposits to total deposits is low, then the aggregate interest rate faced by the depository institution is heavily dependent on the rate demanded by non-core depositors. Since non-core deposits are relatively rate-elastic, any liquidation announcement may consequently have a large impact on the deposit interest rate paid by the DI. This disincentive to liquidate may overcome the benefits of efficient liquidation and result in an inefficient liquidation policy. The point of this paper is to show that the DI can use securitization to alter its portfolio structure and core deposits ratio, thus inducing efficient liquidation. By

selling loans and using the proceeds to retire non-core deposits, the institution can effectively increase its core deposits ratio to the point where it becomes optimal to efficiently liquidate loans in the future. This increases the expected loan proceeds and consequently increases the value of the DI. Furthermore, I find that when loan liquidation values are high (low), the DI will prefer to sell its best (worst) loans. This is consistent with the observation that DIs tend to sell their best, most collateralized loans. For instance, DIs tend to sell performing mortgages rather than non-performing mortgages. My work suggests that the high liquidation value makes it optimal for the DI to sell their best mortgages rather than their worst ones. When liquidation value is high, the opportunity cost incurred by a DI that chooses to not liquidate bad loans is high. To induce efficient liquidation in the future, the institution can sell off its best loans and consequently increase the fraction of bad loans in its portfolio. This increases the total opportunity cost (as a fraction of portfolio size) for not liquidating bad loans and consequently induces efficient liquidation of the bad loans in the future. If liquidation values are low, the opportunity cost is low and efficient liquidation cannot be induced by increasing the fraction of bad loans in the portfolio. Instead, a DI can sell off some of its best loans and consequently increase the fraction of good loans in the portfolio. This reduces the opportunity cost, but also reduces (at a greater rate) the impact of the revision in the non-core interest rate. The result is that there is little disincentive to liquidate loans, and liquidation policies become more efficient.

I also find that a recourse provision can be structured so that the sold loans will be efficiently liquidated. If the DI guarantees a minimum cash flow from the security, then the DI is essentially providing a put option on the security. If the DI continues to service the loans after they are sold, then the DI has incentives to minimize the value of that put option. Because efficient liquidation reduces the volatility of security payoffs, it reduces the value of the put option. I show that if the recourse guarantee is set equal to the worst case security payoff given efficient liquidation, then the DI will subsequently adopt an efficient liquidation policy for the security.

To be clear, I am not arguing that my work explains why we have securitization. Rather, I argue that there is a strategic relationship between core deposits and securitization. That relationship may impact the quantity of loans sold, the type of loans sold, and the nature of securitization contracts.

My work adds to the literature concerning the benefits of securitization and the special nature of banks. Greenbaum and Thakor (1987) argue that securitization allows banks to credibly signal to quality of loans to investors, which results in more accurate pricing of loans. They also argue that the level of recourse will be increasing in the quality of the loans being sold. My work differs from Greenbaum and Thakor in that my focus is on the role of securitization in improving liquidation efficiency. Theirs, in contrast, is on the role of securitization in increasing the efficiency of loan pricing. My findings differ from theirs in several ways, most notably in that I find that the level of recourse will be decreasing in the quality of the loans being sold. This is consistent with the casual observation that more recourse seems to be offered on poorer securities. Benveniste and Berger (1987) also address the benefits of securitization and show that it allows the DI to form securities that better match the risk preferences of its investors. Pennacchi (1988) shows that securitization provides an optimal restructuring of loan obligations in which risk sharing is optimized. He also suggests that the incentive to efficiently monitor loans limits the potential extent of securitization. My work differs in that I focus on the internal management of loans while their papers are on investor-driven aspects of loan pricing.

The paper is organized as follows. Section I presents the basic model. In section II, equilibrium interest rates are developed in a world without securitization and the liquidation decision is explained. Securitization and its impacts are introduced and discussed in Section III. Section IV concludes. Proofs may be found in the Appendix.

I. The Model

A. General Assumptions

Consider an economy with universal risk-neutrality and a risk-free rate of zero. A depository institution (DI) acts as an intermediary between borrowers and investors, and may also trade assets

strategically with a non-depository institution (NDI). The DI raises funds from core and non-core depositors and supplies funds to firms. The deposit and loan agreements are simple debt contracts. After granting loans, the DI receives noisy but valuable information about the quality of each loan in its portfolio and has the opportunity to sell loans to the NDI. Subsequently, the DI learns the true quality of each loan and has the opportunity to liquidate loans. The state of the economy ($s \in \{high, low\}$) impacts the probability that borrowers repay their loans. The state is initially unknown to all, but common beliefs are that the state is high with probability q and low with probability $1-q$.

Several interpretations of the state of the economy are reasonable. First, it may be loosely interpreted as elements of the quality of the DI. Since even the DI does not know the state initially, it must represent elements that are likely to change over time or that are uncertain. The model is consequently most applicable to situations in which a DI changes its lending policies or brings in new managers, but is generally applicable to any situation in which the DI is likely to obtain private information about its ability. A second interpretation of the state of the economy is that it represents uncertainty in portfolio value due to potential future changes in the economy. For example, if a large company announces a significant number of layoffs, the portfolios of local DIs are affected, but the extent of the effect is likely to be known only by the DIs. The critical element, here, is that the DI obtains private information during the course of the game. Within the model, this creates an asymmetric information problem in which the DI has incentives to hide the true quality of the portfolio from outsiders.

B. Market Participants

Participants in the economy include borrowers, depositors (both core and non-core), the DI, and the NDI. The role of each is as follows.

i) *Borrowers* receive funds from the DI in exchange for a contract requiring a repayment of ρ per dollar loaned.³ The probability that a given borrower repays its loan depends on both borrower quality ($\tau \in \{\text{good}, \text{bad}\}$) and the state of the economy. Each loan that is not liquidated is repaid in full with probability $\theta_{\tau s} \in [0, 1]$ and repays nothing with probability $1 - \theta_{\tau s}$. For simplicity, I assume that $\theta_{gh} = 1$, $\theta_{gl} > \theta_{bl}$ and $\theta_{bh} > \theta_{bl}$ so that good loans dominate bad ones, and the high state of the economy dominates the low state. Loan default is triggered by systematic factors and loan payoffs are consequently correlated. If one good (bad) loan is repaid, all good (bad) loans will be repaid. Similarly, if one good (bad) loan defaults, all good (bad) loans will default. I also assume that if the bad loans are repaid, the good loans will be repaid. Thus, with probability θ_{bi} all loans will be repaid. With probability $\theta_{gi} - \theta_{bi}$, only the good loans will be repaid. With probability $1 - \theta_{gi}$, no loans will be repaid. Each loan initially has a net liquidation value of L ,⁴ where $L > \theta_{bl} \rho$, $L < \theta_{bh} \rho$, and $L < \theta_{gl} \rho$. The implication is that expected revenues are maximized by liquidating bad loans when the state of the economy is low, and maintaining loans otherwise. A given borrower is good with probability f and is bad with probability $1-f$. All borrowers appear to be identical when loans are granted, so the DI's portfolio consists of a fraction f of good loans and a fraction $1-f$ of bad loans.

ii) *Depositors* provide funds to the DI in exchange for simple debt contracts. Depositors compete for the right to provide funds and thus earn zero profits in expectation.⁵ There are two types of depositors. There is a fixed supply of core depositors who enter into a contract with the DI, but then ignore any subsequent information about the quality of the DI's portfolio. The interest rate they demand, r_c , is consequently fixed at the time of investment, and does not change as information is revealed. In contrast, *non-core depositors* carefully observe events related to the DI and revise the interest rate they require, r_{nc} , as information is revealed. If, for instance, the DI announces the liquidation of loans, non-core depositors may infer that the state of the economy is

low and consequently revise the interest rate they require. The implication is that at each point in time, the interest rate demanded by non-core depositors is set so that they earn zero profits in expectation (conditional on their information set at that time). The distinction between core depositors (typically fully-insured deposit accounts⁶ with balances less than \$100,000) and non-core depositors is motivated by the observation that core depositors invest primarily for transactions purposes and not for investment purposes. The interest rate they receive consequently does not vary greatly with changes in the economy. Non-core depositors, on the other hand, provide funds for investment purposes and consequently change their reservation interest rate when information is revealed.

- iii) The *depository institution* collects funds from core depositors and non-core depositors, and grants loans to borrowers. The DI possesses a special ability to originate loans,⁷ so all borrowers initially obtain financing from the DI. The DI is characterized by the variables $\{f, \phi\}$, where $f \in (0, 1)$ is the fraction of good loans in the DI's portfolio and $\phi \in (0, 1)$ is the DI's ratio of core deposits to total deposits. Core deposits are scarce, so the DI does not have the ability to raise an unlimited amount of core funds. Since the DI prefers to grant all positive NPV loans, the level of ϕ is initially exogenous.⁸ In the remainder of the paper, subscripts on f refer to the date. For instance, f_2 is the fraction of goods loans in the DI's portfolio at date 2. At each point in time, the DI acts to maximize its expected profits.

- iv) The *non-depository institution* collects funds from investors and invests those funds by purchasing loan packages from the DI. Although not critical to the analysis, I assume that the DI has full bargaining power in the sale of securities. The result is that the sale price of a securitized package will be equal to its expected future cash flow.

C. *The Sequence of Events*

At date 0, borrowers approach the DI and request funds. The type of each borrower is initially unknown to all, so borrowers appear to be identical. Each potential loan is a positive NPV investment for the DI, so each borrower is granted a loan. To finance the loans, the DI raises core and non-core funds from depositors, with interest rates being set so that each depositor receives zero expected profits. Depositors can solve the DI's maximization problem and thus can infer the DI's optimal liquidation policy.

At date 1, noisy signals ($\gamma \in \{g, b\}$) of borrower quality are revealed to all. There is one signal per loan and the signals are independent.⁹ The signals are accurate with probability p and allow the DI to update beliefs concerning the quality of loans. Using Bayes' Rule,

$$p_g = \Pr(\tau = g | \gamma = g) = \frac{p f}{p f + (1-p)(1-f)} \quad (1)$$

and

$$p_b = \Pr(\tau = b | \gamma = b) = \frac{p(1-f)}{p(1-f) + (1-p)f}. \quad (2)$$

Here, p_g is the probability that a borrower is good given the signal $\gamma = g$. Similarly, p_b is the probability that a borrower is good given the signal $\gamma = b$. I assume that $p > 0.5$ so that the signals are informative. The important aspect of this development is that the DI learns about the quality of its portfolio and is able to separate loans into two groups. In one group, the loans are good with probability $p_g > f$. In the other, the loans are good with probability $1-p_b < f$.

After observing the signals, the DI may choose to sell part of its portfolio to the NDI. In packaging and selling the loans, the DI incurs a cost of $C(m)$, where m is the fraction of the portfolio that is being sold. I assume only that C is positive and monotonically increasing in m . As part of the sale, the DI may offer recourse that takes the form of a guaranteed minimum cash flow, G , from the security. If the future cash flow from securitized loans is less than G , then the DI must pay the NDI the difference

between the cash flow from loans and the guaranteed amount. As part of the securitization agreement, the DI continues to service the loans that are sold and establishes a liquidation policy for those loans.

At date 2, both the state of the economy and the type of each loan is perfectly and privately revealed to the DI. The DI must then decide whether or not to liquidate any loans. Any liquidations are publicly revealed to all market participants and, in response to the liquidation decision, non-core depositors may revise the interest rate they demand.

At date 3, loan cash flows are realized and depositors (both core and non-core) are repaid according to the contracts.

D. Definition of Equilibrium

Each DI is potentially faced with two decisions. The first decision involves whether or not to sell loans and, if so, what sort of securitization contract to offer. The second decision involves whether or not to liquidate loans. In equilibrium, the interest rates demanded by depositors must be consistent with these decisions. Formally, I define a subgame perfect Nash equilibrium as an equilibrium that meets the following conditions:

- C1:** At each point in time, the DI acts to maximize expected profits, conditional on the optimal behavior of all other participants.
- C2:** At each point in time, non-core depositors act to ensure zero expected profits conditional on the optimal future behavior of the DI.
- C3:** At date 0, core depositors act to ensure zero expected profits conditional on the optimal future behavior of the DI.
- C4:** At no point in time do the DI and/or depositors have incentives to deviate from the equilibrium.

With these conditions in mind, any equilibrium will be one in which the DI's recourse and liquidation policies are known to all participants at date 0, and the DI has no incentive to unilaterally deviate from these policies at subsequent times.

For simplicity, all analysis is conducted on a per dollar of face value basis. It is also useful to assume that the DI's portfolio is infinitely divisible in that the DI can choose to sell any fraction of the portfolio in the interval (0,1). This allows the use of derivatives to demonstrate several results. For ease of exposition, I define an "efficient liquidation policy" to be a policy under which all bad loans are liquidated when the state of the economy is low, and no loans are liquidated under any other circumstances. Said differently, an efficient liquidation policy is one that maximizes expected loan payoffs. A liquidation policy is said to be "credible" if it is part of a subgame perfect Nash equilibrium.

Since the focus of this paper is on the tradeoff between efficient liquidation of loans and deposit interest rate revisions resulting from liquidation announcements, the following assumptions are useful.

- A1:** If all the good loans within a lender's portfolio are repaid, the proceeds are sufficient to repay core and non-core depositors in full.
- A2:** If all the bad loans within a lender's portfolio are liquidated and no good loans are repaid, the proceeds are insufficient to repay the core and non-core depositors in full. In that case, each depositor receives a pro rata share of the proceeds¹⁰ and the lender receives nothing.

Assumption A1 ensures that the DI earns positive profits whenever its good loans are repaid.¹¹ Assumption A2 ensures that the non-core depositors will revise their interest rate after a liquidation announcement. Without A2, a liquidation announcement would guarantee full repayment to depositors and result in an equilibrium in which DIs always adopt an efficient liquidation policy. A2 consequently restricts the parameter space to the region where the DI might choose an inefficient liquidation policy.

II. Equilibrium Interest Rates and the Liquidation Decision with No Securitization

Consider first a setting in which securitization is not permitted. In this setting, the only decision faced by the DI is the liquidation decision. Since a DI will never liquidate good loans and will only consider liquidating bad loans when the state of the economy is low, the only potential subgame perfect Nash equilibria are ones in which the DI chooses to liquidate bad loans (in the low state) with some probability $p_L \in [0,1]$. When $p_L \in (0,1)$, then the liquidation policy is part of a mixed strategy equilibrium. If $p_L = 1$, then the liquidation policy is efficient.

The state of the economy is unknown at date 0, so the value of the DI at that date is simply the difference between expected revenues and expected interest payments to depositors. Although later results require the explicit calculation of the interest rates demanded by depositors, the date 0 value of the DI given a liquidation policy can be calculated without knowledge of the deposit rates. Since depositors earn zero profits in expectation, the expected future payment to depositors is simply one dollar for every dollar of deposits. Consider, then, the mixed strategy equilibrium in which the DI's liquidation policy is to liquidate bad loans with probability p_L if the state of the economy is low. The date zero value of the DI can be written

$$V_0(p_L) = q(\theta_{bh}\rho + (1-\theta_{bh})f\rho) + (1-q)\left[p_L((1-f)L + \theta_{gl}f\rho) + (1-p_L)(\theta_{bl}\rho + (\theta_{gl} - \theta_{bl})f\rho)\right] - 1 \quad (3)$$

The first term of the right hand side of the above expression is the probability that the state of the economy will be high multiplied by the expected revenues given the high state and given no liquidation. The second term on the right hand side of the equation is the probability that the state of the economy will be low multiplied by the expected revenues given the low state and given liquidation of bad loans with probability p_L . The first term in the brackets is the probability of liquidation multiplied by the expected loan proceeds given liquidation of bad loans. The second term in the brackets is the probability of no liquidation multiplied by the expected loan proceeds given no liquidation. The third term (one) is simply the expected payment to depositors.

It is clear that $V_0(p_L)$ is increasing in p_L , which leads to the following result.

Lemma: *The value of a DI is maximized when the DI adopts a credible efficient liquidation policy.*

The lemma follows from the observation that expected loan proceeds are maximized if the DI liquidates all bad loans whenever the state of the economy is low. Although deposit rates are different for different liquidation policies, the rates are always set so that depositors receive their money back in expectation. Thus, the expected (at date 0) payment to depositors is independent of liquidation policy. The implication is that an ex ante marginal increase in expected revenues accrues entirely to the DI.

The lemma demonstrates the importance of establishing a credible efficient liquidation policy. Such a policy is socially optimal in the sense that productivity (measured by expected loan proceeds) is maximized. It is also optimal in the sense that the value of the DI is greatest (all else equal) when an efficient liquidation policy can be adopted. It is natural, then, to examine the conditions under which such an equilibrium is credible.

Recall that the core deposits rate is set at date 0 and that the non-core rate is essentially set at date 2 (after observing the liquidation decision).¹² Now, consider a candidate equilibrium in which $p_L = 1$ (an efficient liquidation equilibrium). The DI's date 2 optimization problem is to maximize its expected profit by choosing to liquidate or to not liquidate loans. Let $a \in \{\text{Liquidate, Not liquidate}\}$ represent the liquidation decision of a DI given that the state of the economy is low. Any equilibrium, of course, must satisfy an incentive compatibility condition in which the lender does not prefer to unilaterally deviate from the equilibrium. Recall that a DI will never liquidate loans when the state of the economy is high, so the focus here will be on the decision of a DI when the state of the economy is low. Let π_l be the date-3 profits obtained by a DI in the low state of the economy given the candidate equilibrium. Incentive compatibility says that the efficient liquidation equilibrium is credible if and only if

$$E(\pi_l | a = L) \geq E(\pi_l | a = N). \quad (4)$$

That is, the DI must not prefer to defect from the candidate equilibrium by failing to liquidate bad loans when the state of the economy is low. If (4) does not hold, then the equilibrium is not credible and some other equilibrium (with $p_L < 1$) must hold.

In an efficient liquidation equilibrium, the core deposit rate (which is fixed at date 0) satisfies

$$q r_c + (1-q) \left[\theta_{gl} r_c + (1-\theta_{gl})(1-f_2) L \right] = 1, \quad (5)$$

where f_2 is the fraction of the DI's date 2 portfolio that is good. The first term of the expression is the probability that the state of the economy will be high multiplied by the contractual core deposits rate (since depositors will be repaid in full whenever $s = h$). The second term of the expression is the probability that the state of the economy will be low multiplied by the expected payment to depositors in that state. With probability θ_{gl} , the good loans will be repaid and depositors will receive the contractual interest rate. With probability $1 - \theta_{gl}$, the good loans will default and depositors will receive all of the proceeds from the liquidation of bad loans. The expected payoff is set equal to one so that the core depositors receive zero profits in expectation. Rearranging (5) gives

$$r_c = \frac{1 - (1-q)(1-\theta_{gl})(1-f_2) L}{q + (1-q)\theta_{gl}}, \quad (6)$$

which is the efficient liquidation equilibrium rate demanded by core depositors.

Non-core depositors, on the other hand, revise their interest rate at date 2 after observing the liquidation decision. Let r_{nc}^L be the non-core rate given that loans are liquidated and r_{nc}^N be the non-core rate given that loans are not liquidated. In an efficient liquidation equilibrium, the liquidation of loans provides a perfect signal to depositors that the state of the economy is low. Under that scenario, the non-core rate must satisfy

$$\theta_{gl} r_{nc}^L + (1-\theta_{gl})(1-f_2) L = 1. \quad (7)$$

The first term of the expression is the probability that the good loans are repaid multiplied by the contractual interest rate (again recall that depositors are repaid in full whenever the good loans are repaid). The second term of the expression is then the probability that the good loans default multiplied by the proceeds from the liquidation of bad loans. The expected payoff is set equal to one so that non-core depositors receive zero profits in expectation. Rearranging (7) gives

$$r_{nc}^L = \frac{1 - (1 - \theta_{gl})(1 - f_2)L}{\theta_{gl}}, \quad (8)$$

which is the efficient liquidation equilibrium rate charged by non-core depositors who observe loan liquidation. Notice that r_{nc}^L is strictly greater than one. To see this, recall that by assumption, the DI defaults on its deposit obligations unless its good loans are repaid. An implication of this is that $(1 - f_2)L < 1$, which in turn implies $r_{nc}^L > 1$.¹³ If loans are not liquidated, non-core depositors infer that the state of the economy is high. Since they will be repaid in full with certainty under that scenario, $r_{nc}^N = 1$. Because $r_{nc}^L > r_{nc}^N$, the DI has a disincentive to liquidate loans. When liquidations are announced, non-core depositors increase the interest rate they demand, resulting in a higher cost of funds for the DI.

The aggregate interest rate faced by the DI given an efficient liquidation equilibrium is equal to

$$r^L = \phi \frac{1 - (1 - q)(1 - \theta_{gl})(1 - f_2)L}{q + (1 - q)\theta_{gl}} + (1 - \phi) \frac{1 - (1 - \theta_{gl})(1 - f_2)L}{\theta_{gl}} \quad (9)$$

if the state of the economy is low and liquidations are announced, and is equal to

$$r^N = \phi \frac{1 - (1 - q)(1 - \theta_{gl})(1 - f_2)L}{q + (1 - q)\theta_{gl}} + (1 - \phi) \times 1 \quad (10)$$

if the state is low and no liquidations are announced. Both rates are calculated as the weighted average of the core and non-core interest rates. For an efficient liquidation equilibrium to be credible, a DI in the low state of the economy must not prefer to unilaterally deviate from the equilibrium by refusing to liquidate its bad loans. If the DI chooses to liquidate bad loans, its expected profits will be

$$\begin{aligned}
E(\pi_l | a = L) &= \theta_{gl} [f_2 \rho + (1-f_2)L - r_L] \\
&= \theta_{gl} \left[f_2 \rho + (1-f_2)L - \phi \frac{1-(1-q)(1-\theta_{gl})(1-f_2)L}{q+(1-q)\theta_{gl}} - (1-\phi) \frac{1-(1-\theta_{gl})(1-f_2)L}{\theta_{gl}} \right]. \quad (11)
\end{aligned}$$

Recall that the loan proceeds are sufficient to repay depositors in full only if the good loans are repaid. Thus, the DI earns positive profits only if the good loans are repaid. In this case, the bad loans pay L with certainty and the good loans pay ρ with probability θ_{gl} . The expected profits to the DI are then the probability that the good loans are repaid multiplied by the difference between the loan proceeds and the aggregate interest rate faced by the DI.

Suppose, then, that a DI in a low state of the economy considers defecting from the efficient liquidation equilibrium by announcing that it will not liquidate loans. Non-core depositors infer (incorrectly) that the state of the economy is high and demand an interest rate in accordance with that inference. The expected profits to the DI given defection from the candidate equilibrium can be written

$$\begin{aligned}
E(\pi_l | a = N) &= \theta_{bl} [\rho - r_N] + (\theta_{gl} - \theta_{bl})(f_2 \rho - r_N) \\
&= (\theta_{gl} - \theta_{bl}) f_2 \rho + \theta_{bl} \rho - \theta_{gl} r_N \\
&= [\theta_{gl} f_2 + \theta_{bl} (1-f_2)] \rho - \theta_{gl} \left[\phi \frac{1-(1-q)(1-\theta_{gl})(1-f_2)L}{q+(1-q)\theta_{gl}} + (1-\phi) \right]
\end{aligned} \quad (12)$$

If the DI chooses to not liquidate bad loans, it will earn profits if both the bad and good loans in the portfolio are repaid, or if only the good loans are repaid. The first term of the first line of the above expression is the product of the probability that both good and bad loans are repaid, and the profits earned by the DI in that case. The second term is the product of the probability that only the good loans are repaid, and the profits earned by the DI in that case.

Substituting (11) and (12) into (4) gives a sufficient condition for a credible efficient liquidation equilibrium,

$$\begin{aligned} & \theta_{gl} \left[f_2 \rho + (1-f_2)L - \phi \frac{1-(1-q)(1-\theta_{gl})(1-f_2)L}{q+(1-q)\theta_{gl}} - (1-\phi) \frac{1-(1-\theta_{gl})(1-f_2)L}{\theta_{gl}} \right] \\ & \geq [\theta_{gl} f_2 + \theta_{bl}(1-f_2)] \rho - \theta_{gl} \left[\phi \frac{1-(1-q)(1-\theta_{gl})(1-f_2)L}{q+(1-q)\theta_{gl}} + (1-\phi) \right] \end{aligned} \quad (13)$$

Rearranging (13) and simplifying gives

$$\phi \geq \frac{(1-\theta_{gl}) - (1-f_2)(L - \theta_{bl} \rho)}{(1-\theta_{gl}) - (1-f_2)(1-\theta_{gl})L}, \quad (14)$$

which is a necessary and sufficient condition for an efficient liquidation equilibrium to be credible.

Defining

$$\phi^* = \frac{(1-\theta_{gl}) - (1-f_2)(L - \theta_{bl} \rho)}{(1-\theta_{gl}) - (1-f_2)(1-\theta_{gl})L} \quad (15)$$

then leads to the following result.

Proposition 1: *An efficient liquidation equilibrium is credible if and only if $\phi \geq \phi^*$.*

If $\phi < \phi^*$, then the level of non-core deposits is sufficiently large so that the DI prefers to not liquidate bad loans when the state of the economy is low. The intuition is as follows. The benefit of liquidating bad loans is that there are higher expected loan proceeds. The drawback is that the act of liquidation signals to investors that the state of the economy is low. This also informs investors that the loans remaining on DI's books have a significant probability of default. Non-core depositors consequently revise the interest rate they demand, resulting in a higher cost of funds to the DI. If the core deposits ratio is low, the impact of the non-core rate revision is high and the DI faces a large penalty when it liquidates loans. The resulting equilibrium must then be one in which the DI liquidates bad loans in the low state of the economy with some probability less than one ($p_L < 1$). If the core deposits ratio is high, then the

disincentive of announcing liquidations is low, and the DI optimally and credibly chooses an efficient liquidation policy.

Recall now that the lemma showed that the value of the DI is maximized when an efficient liquidation equilibrium is credible. It is reasonable to conclude, therefore, that a DI may optimally act to increase its core deposits ratio to the point where $\phi \geq \phi^*$, thus credibly committing to efficiently liquidate loans in the future. Since ϕ^* is a function of f_2 , it also suggests that a DI may optimally act to change the fraction of good loans in its portfolio, thus reducing ϕ^* and again credibly committing to efficiently liquidate loans in the future.

An obvious question, here, is why doesn't the DI simply select a high core deposits ratio at date 0, thus ensuring $\phi \geq \phi^*$? If core deposits are scarce, however, the DI can only increase its core deposits ratio by decreasing its level of non-core deposits. This would specifically force the DI to grant fewer loans (i.e., pass up positive net present value projects). An alternative is to raise enough non-core funds to grant each loan and then subsequently use securitization to adjust its core deposits ratio and the fraction of good loans on its books. Properly done, these adjustments may induce an efficient liquidation policy. Since depositors anticipate what decisions will be made by the DI, interest rates (at each date) would be set in accordance with those decisions, resulting in a higher valuation of the DI.

III. The Impact of Securitization

A. Loan Sales

The sale of loans is a critical choice variable in establishing liquidation policy because it allows the DI to change the nature of its portfolio after acquiring information about the loans in the portfolio. Suppose, for instance, that the DI's core deposits ratio is lower than the critical core deposits ratio calculated in the previous section. By selling loans and retiring non-core debt, the DI can effectively increase its core deposits ratio to the point where it is at least as great as the critical core deposits ratio. If

so, it becomes optimal to efficiently liquidate loans in the future. This argument is the basis for the following result.

Proposition 2: *If the cost of loan sales is sufficiently low, a depository institution may use loans sales to improve future liquidation efficiency and hence increase the value of the institution.*

The sale of loans allows the DI to raise funds and retire non-core debt. In doing so, the DI increases its core deposits ratio and thus decreases the impact of non-core rate revisions. This decreases the penalty (a higher cost of funds) faced by a DI that announces loan liquidations and thus makes loan liquidation more attractive.

Proposition 2 shows only that loan sales may be used to improve liquidation efficiency, and shows nothing about the optimal use of loan sales. In fact, the sale of loans provides the DI with an additional opportunity. Because the DI may choose which loans to sell, the fraction of good loans in the retained portfolio may be controlled, which in turn affects the critical core deposits ratio. It is consequently important to examine the types of loan that will optimally be sold by the DI. There are two primary effects when the fraction of good loans within the DI's portfolio is changed. First, notice that the non-core interest rate given liquidation (r_{nc}^L) changes. Any change in the fraction of good loans in the DI's portfolio consequently impacts the DI's cost of funds. Second, notice that the difference between the expected revenues given liquidation and the expected revenues given no liquidation is also a function of f_2 . The result is ϕ^* can be changed by simply changing the fraction of good loans in the DI's portfolio. By carefully selecting which loans to sell, the DI may be able to reduce ϕ^* to the point where an efficient liquidation equilibrium is credible.

It is important to note, here, that when loans are sold, the DI does not have perfect information about the type of each loan. Hence, any securitization package will include some good and some bad

loans. In the context of this model, a DI that prefers to sell good loans will create a security consisting of loans which had date 1 signals of $\gamma = g$. The security would consequently consist of a fraction p_g of good loans and a fraction $1-p_g$ of bad loans. Similarly, a DI that prefers to sell bad loans will create a security of loans with $\gamma = b$. Such a security would consist of a fraction p_b of bad loans and a fraction $1-p_b$ of good loans. The implication is that the DI cannot simply sell off all its good loans (or all its bad loans) to achieve efficient liquidation.

Notice, then, that

$$\frac{\partial \phi^*}{\partial f_2} = \frac{(1-\theta_{gl})(\theta_{gl}L - \theta_{bl}\rho)}{[(1-\theta_{gl}) - (1-f_2)(1-\theta_{gl})L]^2}. \quad (16)$$

The sign of $\frac{\partial \phi^*}{\partial f_2}$ is determined by the sign of the expression in the brackets of the numerator. This suggests the following result.

Proposition 3: *If the liquidation value of loans is sufficiently large, then a DI will prefer to sell its best loans. Otherwise, the DI will prefer to sell its worst loans.*

The intuition is as follows. If

$$L > \frac{\theta_{bl}}{\theta_{gl}} \rho \quad (17)$$

then $\frac{\partial \phi^*}{\partial f_2} > 0$. If the liquidation value of a loan is sufficiently high, then the DI is better off selling good

loans (to increase the fraction of bad loans in its portfolio). This increases the opportunity cost (measured as a fraction of the face value of the portfolio) to a DI that considers defecting from the equilibrium, and thus reduces the core deposits ratio necessary to induce efficient liquidation. If, on the other hand,

$$L < \frac{\theta_{bl}}{\theta_{gl}} \rho, \quad (18)$$

then an *increase* in the fraction of good loans in the DIs portfolio will decrease ϕ^* . By selling its worst loans (to increase the fraction of good loans in its portfolio), the DI is able to reduce the subsequent change in non-core rates when liquidations are announced. Although the opportunity cost associated with not liquidating bad loans is reduced, the interest rate effect is more than offsetting and ϕ^* decreases.

Proposition 3 is consistent with the observation that DIs tend to sell performing mortgages. Because mortgages are highly collateralized, their liquidation value is high. The proposition then predicts that DIs will prefer to sell performing (good) mortgages rather than non-performing (bad) ones.

B. Loan Sales

In the previous section, the relationship between loan sales and liquidation efficiency is demonstrated. In this section, I examine the optimal contract associated with securitization (defined as the sale of loans with some credit enhancement). The key issue is whether or not the DI can structure a securitization package so that the loans being sold will be efficiently liquidated. If a recourse provision can be designed to improve the liquidation efficiency of sold loans, then the provision will be socially beneficial in that it increases the total productivity of the loans. This in turn increases both the sale price of the security and the value of the DI.

Although many recourse structures are possible, I consider recourse provisions in which the DI guarantees a level of future cash flows. Specifically, the recourse provision is a guarantee that the security being sold will produce a future cash flow of G . In the event that the sold loans produce a total cash flow less than G , the DI must make up the difference. The recourse provision is then essentially a put option on the loan proceeds. As part of the securitization agreement, the DI continues to service the loans and thus established the liquidation policy for the sold loans.

In the previous section, L is defined as the net liquidation value of a loan. In this section, it is important to differentiate between the liquidation value of loans and the cost of liquidating those assets. Let $L = A - k$, where A is the liquidation value of borrower assets and k is the cost of liquidating those

assets. Since the DI retains the responsibility to service loans, the cost of liquidation is borne by the DI. The liquidation value of assets, however, is passed on to the NDI. Suppose then that a security is sold (at date 1) that contains a fraction f_s of good loans and a fraction $1 - f_s$ of bad loans. At date 2, the DI has the opportunity to pay a cost k to liquidate a loan. Let m_b be the "measure" of bad loans that are liquidated at date 2 and let m_g be the measure of good loans that are liquidated at date 2. The term "measure" refers to the fraction of loans in the portfolio that are liquidated. For example, suppose that a security consists of 60% good loans and 40% bad loans. If $m_b = 0.4$, then all of the bad loans are liquidated. If $m_b = 0.1$, then one-fourth of the bad loans are liquidated. The decision to liquidate is one in which the costs of liquidation are compared to the expected future recourse payment. Assuming that $G < f_s \rho$, the DI will never liquidate loans when the economic state is high. The DI consequently only faces a liquidation decision when the economic state is low. In that case, the date 2 optimization problem of the DI can be written

$$\begin{aligned}
\min_{m_b, m_g} E(CF) &= k(m_b + m_g) + (1 - \theta_{gl}) \max[G - (m_b + m_g)A, 0] \\
&\quad + (\theta_{gl} - \theta_{bl}) \max[G - (m_b + m_g)A - (f - m_g)\rho] \\
&\quad + \theta_{bl} \max[G - (m_b + m_g)A - (f - m_g)\rho - (1 - f - m_b)\rho] \\
\text{subject to} \quad m_b &\in [0, 1 - f_s] \\
m_g &\in [0, f_s]
\end{aligned}$$

The first term of the expected cash flow expression is the total cost of liquidating $m_b + m_g$ loans. The second term is the expected recourse payment given that no loans are repaid. The third term is the expected recourse payment given that only the good loans are repaid. The fourth term is the expected recourse payment given that all loans are repaid. Assuming for the time being that the max operators are not binding and differentiating with respect to m_b and m_g yields

$$\frac{\partial E(CF)}{\partial m_b} = k - A + \theta_{bl} \rho = \theta_{bl} \rho - L \tag{19}$$

and

$$\frac{\partial E(CF)}{\partial m_g} = k - A + \theta_{gl} \rho = \theta_{gl} \rho - L. \quad (20)$$

By assumption, $\theta_{bl} \rho < L$ and $\theta_{gl} \rho > L$, so $\frac{\partial E(CF)}{\partial m_b} < 0$ and $\frac{\partial E(CF)}{\partial m_g} > 0$. Thus, the DI will choose to liquidate no good loans and will choose to liquidate as many bad loans as possible, subject to the constraint $m_b \leq 1 - f_s$ and subject to the effects of the **max** operators. It is clear from examination of the minimization problem that there is no benefit to liquidating more loans than is necessary to collect G in liquidation proceeds, so the solution to the minimization problem is

$$m_b^* = \min[(1 - f_s), G / A] \quad ; \quad m_g^* = 0, \quad (21)$$

which establishes the optimal date 2 behavior of the DI given the recourse level G .

The recourse level is set by the DI at date 1 so that the net value of the securitization is maximized. Since the noisy signals (γ) of borrower quality are revealed to all, there is no asymmetric information (at date 1) between the DI and the NDI. By assumption, the DI has full negotiating power, so the price of the security will simply be the expected cash flow to the NDI. The net value of the securitization (to the DI) will be the price less expected future cash outflows. Again assuming that¹⁴ $G < f_s \rho$ and given the DI's optimal date 2 strategy, the date 1 price of the security can be written

$$P = q(\theta_{bh} \rho + (1 - \theta_{bh}) f_s \rho) + (1 - q) \left[\theta_{bl} (f_s \rho + (1 - f_s - m_b^*) \rho + m_b^* A) + (\theta_{gl} - \theta_{bl}) (f_s \rho + m_b^* A) + (1 - \theta_{gl}) G \right]. \quad (22)$$

The first term of the right hand side is the probability that the economic state will be high multiplied by the expected payoff on the loans given the high state and no liquidations. The second term is the probability that the state will be low multiplied by the expected loan repayment, including liquidations, plus the expected recourse payment. With probability θ_{bl} , all good loans and all bad loans that are not liquidated are repaid. The NDI also receives the proceeds from the liquidation of m_b^* bad loans. This gives the first term in the brackets. The second term in the brackets is the probability that only the good

loans will be repaid $(\theta_{gl} - \theta_{bl})$ multiplied by the payoff on the good loans plus the liquidation proceeds. The last term in the brackets is the probability that no loans will be repaid multiplied by the total repayment to NDI in that case. Recall from the discussion of the previous section that the liquidation proceeds will optimally be no more than G , so the liquidation proceeds are either equal to G or are some amount less than G . If they are less than G and no loans are repaid, then the DI must pay an amount to bring the total payment to the NDI up to G . Thus, the cash flow to the NDI in the event that no loans are repaid is always G .

The DI's date 1 optimization problem can then be written

$$\max_G P - (1-q) \left[m_b^* k + (1 - \theta_{gl}) \max[G - m_b^* A, 0] \right]$$

The first term in the expression is the sale price of the security. The second term is the probability that the economic state will be low multiplied by the expected cash flow from the DI. When the state is low, the DI will liquidate m_b^* bad loans and pay a cost $m_b^* k$ to do so. With probability $1 - \theta_{gl}$, no loans will be repaid and the DI must pay the difference between the recourse level and the liquidation proceeds.

The solution to the maximization problem suggests the following result.

Proposition 4: *The optimal recourse level is equal to the worst case security payoff given an efficient liquidation policy. Furthermore, that recourse level induces efficient liquidation of the loans being sold..*

Specifically, the solution to the maximization problem is $G^* = (1-f_s) A$. That is, the optimal recourse level is set equal to the total liquidation value of assets that would be liquidated (in the low economic state) under an efficient liquidation policy. Given this recourse level, the DI will optimally respond by liquidating all bad loans (and no good loans) whenever the economic state is low. This is a socially optimal outcome in that the expected loan proceeds are maximized.

Recall now that when liquidation value is high, the DI will prefer to sell its best loans. When liquidation value is low, the DI will prefer to sell its worst loans. Although the model does not predict that G^* will be higher in one case or the other,¹⁵ it does predict that more loans will be liquidated when liquidation value is low. Thus, securitized packages of highly-collateralized loans will tend to have fewer loan liquidations (all else equal) than securitized packages of poorly-collateralized loans.

Two further points are worthy of discussion. First, notice that G^* is increasing in the number of bad loans in the security. Thus, the model predicts that the level of recourse offered on a security will be *decreasing* in the quality of that security. This is consistent with casual observations of real-world securitizations and provides an empirically testable contrast with the results of Greenbaum and Thakor (who argue that the level of recourse will be increasing in the quality of the security). Second, notice that the liquidation of loans decreases the volatility of security payoffs. This decreases the value of the recourse provision, which is a put option on the security. The increase in liquidation efficiency occurs because the DI, having sold a put option on the security, has increased incentives to reduce the volatility of security payoffs and hence reduce the value of the put option.

V. Conclusion

This paper documents an important relationship between a depository institution's liquidation efficiency and its strategic decision to sell loans. The decision to liquidate loans provides a signal to investors that the depository institution's portfolio is of low quality. Depositors might then increase the interest rate they demand from the institution. Because core deposits are relatively rate-inelastic, however, depository institutions with high core deposits ratios have some degree of insulation against potential interest rate increases. The higher is the core deposits ratio, the less is the impact on aggregate deposit interest rates when liquidations are announced. The primary result of the paper is that a depository institution may use securitization to improve liquidation efficiency. By selling loans and using the proceeds to retire non-core deposits, the depository institution can effectively raise its core deposits ratio, thus reducing the disincentive of announcing liquidations. The paper also shows that if the

liquidation value of loans is high, the depository institution will prefer to sell its best loans. By increasing the fraction of bad loans in its portfolio, the depository institution effectively increases the opportunity cost of not liquidating bad loans in the future, thus increasing the incentive to efficiently liquidate loans. This suggests that highly-collateralized, securitized loans will tend to be of high quality and will consequently seldom be liquidated. If the liquidation value of loans is low, the depository institution will prefer to sell its worst loans. This increases the fraction of good loans in its portfolio and consequently reduces the impact of interest rate revisions when liquidations are announced. This suggests that securitized packages of poorly-collateralized loans will tend to be of low quality and will consequently be liquidated more often than highly-collateralized offerings.

I also investigate the optimal recourse provision and find that a provision can be structured so that securitized loans will be efficiently liquidated. If the depository institution maintains the responsibility to service loans after they are sold, then efficient liquidation of sold loans can be induced by offering an appropriate recourse provision. This increases the expected payoff on the security and consequently increases the security price and the value of the depository institution. Intuitively, the recourse provision is a put option on the security. The depository institution consequently has incentives to decrease the volatility of security pays. This provides the necessary incentive to induce efficient liquidation of sold loans.

This documents an important benefit of the securitization process. By dividing a portfolio into two parts and selling one with recourse, a depository institution can increase the liquidation efficiency of both retained and sold loans, thus creating a socially optimal equilibrium in which the expected payoff on loans is maximized and the value of the depository institution is maximized. The paper also provides a rationale for the recent increases in securitization activity. Faced with increased competition for deposits (from mutual funds with check-writing privileges, for instance), a depository institution may optimally respond by increasing the level of securitization. This allows the institution to avoid the negative effects of reducing the core deposit ratios or reducing the size of the balance sheet.

Appendix

proof of Lemma: Notice that

$$\begin{aligned}\frac{\partial V_0(p_L)}{\partial p_L} &= (1-q)\left[\left((1-f)L + \theta_{gl} f \rho\right) - \left(\theta_{bl} \rho + (\theta_{gl} - \theta_{bl}) f \rho\right)\right], \\ &= (1-q)(1-f)(L - \theta_{bl} \rho)\end{aligned}\tag{A1}$$

which is strictly positive since $L > \theta_{bl} \rho$ by assumption. Thus, the value of the DI is maximized when $p_L =$

1. **QED**

proof of Proposition 1: Given in text.

proof of Proposition 2: Suppose that a DI has characteristics such that an efficient liquidation equilibrium is not credible and that the DI sells a portion m of its portfolio, using the proceeds to retire non-core deposits. Suppose further that the fraction of good loans in the portfolio is f . By assumption, loans are positive NPV projects, so even if the sold loans will not be efficiently liquidated after being sold, they can be sold for at least \$1. Thus, the DI can retire non-core deposits with face value of (at least) m . The core deposits ratio after the loan sales (denoted ϕ_s) is then

$$\phi_s = \frac{\phi}{1-m}.\tag{A2}$$

Setting (A2) equal to the right hand side of (15) and solving for m gives

$$m = 1 - \frac{\phi\left[(1-\theta_{gl}) - (1-f_2)(1-\theta_{gl})L\right]}{(1-\theta_{gl}) - (1-f_2)(L-\theta_{bl}\rho)},\tag{A3}$$

which is a sufficient level of loans to induce efficient liquidation of retained loans. If $C(m)$ is sufficiently low, then the benefit of inducing an efficient liquidation equilibrium exceeds its costs and it is profitable for the DI to sell loans. **QED**

proof of Proposition 3: Given in text.

proof of Proposition 4: Let V_s be the net value of the securitization, which is the expression given in the maximization problem. Notice then that although the expected recourse payment is an expected cash outflow to the DI, it is also an expected cash inflow to the NDI. The recourse payment is consequently priced, so the expected recourse payment is exactly offset by an increase in the security price. The maximization problem can consequently be reduced to a tradeoff between the marginal cost of liquidation and the marginal increase in expected loan proceeds. Equation (19) shows that the marginal benefit exceeds the marginal cost, so it is optimal to set the level of recourse so that all bad loans are liquidated in the low state of the economy. Thus, $G = (1 - f_s)A$ (implying $m_b^* = (1 - f_s)$) is the solution to the maximization problem. **QED**

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Endnotes

¹ See Boyd and Gertler (1994) and Berlin and Mester (1996) for discussions and evidence in this regard.

² Petersen and Rajan (1994) provide empirical support for this idea. They show that for every one percentage point change in the prime rate, interest rates on bank loans to small businesses change by only 28 basis points.

³ Since my focus is on the optimal behavior of DIs after granting loans, I do not endogenize the provisions of the loan contracts.

⁴ I assume a fixed liquidation value (type- and state-independent) for simplicity. Relaxing that assumption changes none of the qualitative results of the paper.

⁵ The idea that core deposits are scarce may appear to be inconsistent with the idea that core depositors compete to provide funds. Because core depositors do not provide funds for investment purposes, however, it is reasonable to assume that they earn zero profits in expectation.

⁶ Since my focus is on liquidation efficiency, I do not explicitly model deposit insurance. If deposit insurance is fairly priced, then the results of this paper are not adversely affected.

⁷ Since my focus is on DI behavior after loans are granted, I do not endogenize this ability. If the borrowing decision were endogenous, however, borrowers would still approach the DI because of the greater liquidation efficiency that is associated with core deposit funding. See Leland and Pyle (1977), Campbell and Kracaw (1980), and Diamond (1984, 1991) for other theoretical models of the special nature of DIs. For empirical evidence, see Fama (1985) and James (1987).

⁸ Under these assumptions, the core deposits ratio is determined by the supply of loans and is therefore not initially a choice variable.

⁹ The idea that signals are independent is not inconsistent with the idea that loan payoffs are correlated. For example, abnormal returns associated with, say, earnings surprises may be correlated conditional on the surprise being positive. That does not mean, however, that signals about which firms will have positive earnings surprises are correlated.

¹⁰ An alternative assumption is to assume that core depositors have a senior claim on DI assets. One justification for such an assumption is that core deposits are fully insured and that core depositors are consequently not affected by potential DI default. Consider, however, that when a DI goes into default, core depositors lose access to their funds for a period of time. Although the funds earn interest during that time, the FDIC has the right to lower the interest rate. The result is that even though core deposits are fully insured, DI default is costly to core depositors.

I consequently model DIs as if there is no deposit insurance and avoid the complexity of endogenizing deposit insurance.

¹¹ The alternative is to consider each of the various cases separately, which would greatly increase the length and complexity of the paper without creating additional, meaningful results.

¹² Solving for the equilibrium liquidation policy is then one of backward induction. The policy is set based on the expected future reaction (by non-core depositors) to potential liquidations.

¹³ If that were not the case, then loan proceeds would always be greater than one in an efficient liquidation equilibrium (i.e., the DI would never default), which is contrary to the assumptions of the model.

¹⁴ This is a relatively innocuous assumption in that it seems to be the most reasonable case. In the event that it is greater, then no recourse provision will result in perfectly efficient liquidation. Instead, the DI would either liquidate some loans in the high state of the economy or would not liquidate some bad loans in the low state of the economy.

¹⁵ Notice that when A is high, the DI will sell its best loans. The result is that $(1-f_s)$ will be low.