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Abstract

This paper utilizes a banking model to analyze sweeping behavior. We find that sweeping responds positively to increases in bank loan rates and reserve ratios and negatively to increases in the interest rate on reserves or to exogenous increases in bank deposits or equity. Sweeping generates greater responsiveness in lending to changes in loan rates or the interest rate on reserves and lower responsiveness to exogenous changes in reserve ratios or equity. Empirical analysis of an explicit condition that we derive relating sweeping to the interest rate on reserves suggests with an unchanged reserve requirement, the Fed could eliminate sweeping by setting the interest rate on reserves to no less than 3.67 percentage points below the market loan rate. The range of interest rates on reserves that lead to zero sweeping increases sharply, however, as the required reserve ratio is reduced.

Interest on Bank Reserves and Optimal Sweeping

1.   Introduction

A key provision of the Financial Services Regulatory Relief Act (FRSSA), passed by Congress in September 2006, authorizes the Federal Reserve to pay interest on reserves that depository institutions hold at Fed banks beginning in October 2011. FRSSA also permits the Federal Reserve to lower reserve ratios on transaction accounts, with the possibility of even ending reserve requirements. As discussed in VanHoose (2008), the Fed has sought passage of such legislation for over thirty years. Indeed, the Federal Reserve has asked Congress to accelerate the date when they can pay interest, to give it better control over interest rates and more leverage to battle the credit crunch [see, for instance, Ip (2008)].

This paper examines effects of the Fed paying interest on reserves on banks' sweeping of funds within retail and commercial demand deposit sweep programs. In so doing, it places sweeping within an explicit optimizing model of the bank's decision. This formal approach yields a number of derived theoretical results and insights regarding the behavior of banks when they have the ability to sweep funds. It also offers a framework for analyzing how the Federal Reserve can induce banks to halt sweeping, given its authority from the FRSSA. Finally, we put forth preliminary estimates of the minimum interest rate on reserves required to eliminate sweeping.

Sweeping occurs when banks move customer funds out of checkable deposits to other outlets in order to avoid statutory reserve requirements. Banks can sweep balances back to transactions deposits if necessary in order to satisfy customer withdrawal needs. Commercial demand deposit sweep programs have been in effect for over twenty years

[for example, see Jones, Dutkowsky, and Elger (2005) for a thorough definition]. However, the onset of retail sweep programs in January 1994 has brought about substantial increases in sweeping, with a sizable amount of funds being swept as a result. As documented by Anderson (2002), cumulative balances from funds swept within retail sweep programs have grown from roughly $5 billion in 1994 to over $760 billion in 2008. Furthermore, estimates from Cynamon and Dutkowsky and Jones (2006) report that over $300 billion of funds have been swept from commercial demand deposit sweep programs in 2006. These actions have generated noticeable decreases in total reserves and required reserves, as discussed in Anderson and Rasche (2001). For example, in 2008, both total reserves and required reserves were approximately 25 percent lower than their peaks in 1994.

A Federal Reserve interest in reducing, if not eliminating, sweeping played a central role in the passage of FRSSA.[1] In welcoming the legislation, Bernanke (2006) states that, "From the perspective of society as a whole, sweep programs have little to no economic value to justify their cost of implementation. … [W]hen the Federal Reserve is able to begin paying interest on required reserve balances, much of the regulatory incentive for depositories to engage in resource-wasting efforts to minimize reserve balances will be eliminated, to the economic benefit of banks, their depositors, and their borrowers." Harsh criticisms of sweep programs along the same lines have been voiced in testimonies of other members of the Board of Governors to Congress, as in Meyer (1998) and Kohn (2004). Bennett and Peristiani (2002) characterize sweeping as an inefficient and costly way to avoid reserve requirements. They argue that this

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[1] See VanHoose (2008) for historical arguments put forth by the Fed for Congressional legislation to allow the payment of interest on reserves. One key issue in the late 1970s was the decline in Fed membership by banks.

underscores the need to decrease if not eliminate reserve requirements in the United

States.[2]

Our study incorporates sweeping behavior within a basic static model of the

representative bank. As described in section 2, the bank maximizes current profits by

choosing the amount of funds to sweep alongside their choices regarding asset holdings.

Comparative static results derived from the resulting first order conditions reveal that

sweeping responds positively to increases in bank loan rates and reserve ratios and

negatively with respect to increases in the interest rate on reserves or exogenous increases

in bank deposits or equity. Sweeping does not qualitatively change other aspects of a

bank's asset allocation decisions, except for introducing an ambiguity with respect to

changes in reserve requirements.

Section 3 compares bank choices under sweeping with those from a

corresponding model with zero sweeping. We show that sweeping implies greater

responsiveness in bank lending to changes in loan rates or the interest rate on reserves. In

contrast, under sweeping banks are less responsive in their lending to changes in reserve

ratios or exogenous changes in equity. The latter result in particular indicates that loan

defaults affect bank lending behavior less when they are able to sweep funds. Sweeping

also makes banks' excess reserve holdings uniformly less responsive to exogenous

changes in interest rates on loans or reserves, the required reserve ratio, bank deposits, or

equity.

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[2] Another adverse effect of sweep programs is that they have distorted the monetary aggregates, particularly
the M1 money stock. For evidence on the magnitude of this distortion and some of its effects, see
Dutkowsky and Cynamon (2003), Jones, Dutkowsky, and Elger (2005), Dutkowsky, Cynamon and Jones
(2006), and Cynamon, Dutkowsky, and Jones (2006).

In section 4 we derive an explicit condition, involving the interest rate on reserves and the required reserve ratio, under which a bank will decide not to engage in sweeping at all. Our analysis, therefore, offers a set of guidelines that the Federal Reserve could use, given their authority under FRSSA, by changing these instruments with an aim to eliminating sweeping. The findings reveal that the incentive for banks to engage in sweeping could be removed with a reserve ratio of zero for any interest rate on reserves.

In the event that the Fed may desire to maintain reserve requirements, we also derive a relationship between the minimum interest rate on reserves and the required reserve ratio such that sweeping would not occur. This condition points to the potential usefulness of keeping a constant spread between the interest rate on reserves and a bank loan rate. Our preliminary empirical results indicate that to eliminate sweeping without changing the reserve requirements, the Fed should set the interest rate on reserves to no less than approximately 3.67 percentage points of market loan rates. The results also show that the Fed's possible range of interest rates on reserves that lead to zero sweeping increases sharply for lower required reserve ratios. Section 5 concludes the paper.

2. Bank Behavior with Sweeping

To begin the analysis, we present a static profit maximizing model of the representative bank, which is essentially a short-run, one-period version of the dynamic model considered by Elyasiani, Kopecky, and VanHoose (1995). At the beginning of the period, the bank has exogenous levels of transactions and non-transactions deposits denoted by D and T and exogenous equity given by E. The transactions deposits carry a reserve requirement with reserve ratio q. Under sweep programs banks sweep a portion

of their total deposits, given by S, from D to T.[3] Consequently, the bank's required

reserves equal $q(D - S)$. The bank pays interest on each type of deposit, based upon

exogenous interest rates r_D and r_T. Note that the rate of interest is applied to the levels of

deposits before sweeping, which is consistent with retail sweep programs. As writings on

the subject, such as Jones, Dutkowsky, and Elger (2005), suggest that customers

perceive swept funds as being a part of transactions deposits and frequently do not know

how much has been swept.

The bank has two assets, loans (L) and reserves. With required reserves defined

above, let X denote the level of excess reserves. The bank earns interest revenue from its

loans, with r_L denoting the exogenous loan rate. It also receives interest on its holdings

of required and excess reserves, based upon the Federal Reserve-determined interest rate

r_Q. The bank derives additional non-pecuniary benefits from its holdings of excess

reserves, such as increased safety against unexpected withdrawals. We model this

behavior as an implicit revenue function given by $G(X)$, with $G' > 0$ and $G'' < 0$. Beyond

interest costs, the bank incurs costs for maintaining and administrating its loans, excess

reserves, and swept funds. This is portrayed by the resource cost function $C(L, X, S)$,

with $C_i > 0$, $C_{ii} > 0$, and $C_{ij} = 0$ when $i \neq j$, for $i, j, = L, X, S$. We assume separability in

the resource cost function to simplify the subsequent analysis.

The bank chooses holdings of loans, excess reserves, and the amount of swept

funds to maximize current period profits (π), given by:

$$\pi = r_L L + r_Q q(D - S) + r_Q X + G(X) - r_D D - r_T T - C(L, X, S), \qquad (1)$$

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[3] Since D and T denote beginning-of-period deposits, they do not correspond to the measures found in the data. Since swept funds are recorded as part of non-transactions deposits (see e.g. Anderson 2002), the recorded measures of deposits are $D - S$ and $T + S$.

subject to the balance sheet identity:

$$L + X + q(D - S) = D + T + E .$$ (2)

Forming the Lagrangian (Λ) and optimizing yields the following set of first order conditions:

$$r_L - C_L - \lambda \leq 0, \qquad\qquad L\frac{\partial \Lambda}{\partial L} = 0,$$ (3)

$$r_Q + (G' - C_X) - \lambda \leq 0, \qquad\qquad X\frac{\partial \Lambda}{\partial X} = 0,$$ (4)

$$-r_Q q - C_S + q\lambda \leq 0, \qquad\qquad S\frac{\partial \Lambda}{\partial S} = 0,$$ (5)

$$D + T + E - L - X - q(D - S) \geq 0, \qquad\qquad \lambda\frac{\partial \Lambda}{\partial \lambda} = 0,$$ (6)

where λ is the Lagrange multiplier. The variable can be interpreted as the shadow marginal profit due to an increase in the deposit base or equity capital.

Equation (5) describes how a bank determines optimal sweeping. By reducing required reserves, sweeping expands the bank's capabilities to increase its explicit or implicit revenues by means of greater lending or holdings of excess reserves. This is equivalent to an increase in the deposit base of qS. At the same time, banks forgo interest on the decreased required reserves and incur resource costs based upon the amount they

sweep. The remaining first order conditions are standard in the context of static profit-maximization models of banking.

We begin by assuming interior solutions for all the choice variables, including sweeping, so that (3)-(6) hold with equality. Table 1 reports comparative static results from this model. It highlights findings based upon changes in the interest rate on loans, the interest rate on reserves, the reserve ratio, or equity. The expressions for exogenous changes in either type of deposit are as follows: for endogenous variable Y, $\partial Y/\partial T = \partial Y/\partial E$ and $\partial Y/\partial D = (1 - q)(\partial Y/\partial E)$. In obtaining the solutions for changes in the reserve ratio, we make the substitution $q(\lambda - r_Q) = C_S$ from (5).

The last column in Table 1 reveals how the bank's sweeping decision responds to exogenous changes. Swept funds unambiguously increase in response to a rise in either the loan rate or the required reserve ratio. Either change gives the bank a greater incentive to free up required reserves. Sweeping decreases as a result of increases in the interest rate on reserves, bank equity, or deposits. The negative relationship between the interest rate on reserves and swept funds corresponds to Federal Reserve arguments in favor of paying interest on reserves. Exogenous increases in the bank's deposit base or equity reduce the need for sweeping. The latter result also implies that increased loan defaults will lead to greater amounts of swept funds.

The signs of the comparative statics terms for loans and excess reserves largely correspond to those in an environment without sweeping. An increase in the interest rate on either asset leads to substitution behavior. A rise in the deposit base or equity enables the bank to allocate more funds to either asset. Incorporating sweeping, however, brings about ambiguous responses in holdings of loans and excess reserves to changes in the

reserve ratio. An increase in the required reserve ratio leads to greater holdings of swept funds, which reverses to some extent the effect of reducing the bank's available funds for asset allocation. Indeed, highly active sweeping theoretically may lead to positive relationships between the required reserve ratio and either loans or excess reserve holdings.

3.   What Has Sweeping Done to Bank Behavior?

By and large, the above results reveal that sweeping does not change the qualitative findings of how banks react to exogenous influences. We now compare the absolute magnitudes of bank response to exogenous changes under sweeping versus zero sweeping. The exercise is conducted as follows. Suppose that conditions prevail so that the bank chooses not to sweep at all but wishes to hold loans and excess reserves. Then in the context of our model, the inequality in (5) becomes operative and the remaining first order conditions hold with equality. Substituting $S = 0$ into the conditions, the resulting equations (3), (4), and (6) are the same as those from a standard model of bank behavior without sweeping. This model yields comparative static results for holdings of loans and excess reserves, which appear in the Appendix.

Table 2 reports the differences in responsiveness to exogenous changes in the model with sweeping versus the model without sweeping. Expressions in the table equal the difference in absolute values of the partial derivatives between the models with positive sweeping and with zero sweeping. A positive value implies greater magnitude of response under sweeping.

The findings in Table 2 all show unambiguous differences in responsiveness. Under sweeping, banks exhibit greater response in their extensions of loans to changes in either the interest rate on loans or reserves. Sweeping accelerates the bank's ability to respond to such changes. For example, an increase in the interest rate on loans results in the bank acquiring more available funds through sweeping.

With sweeping, banks are less responsive in their lending to changes in the reserve ratio, bank deposits, or equity. In these cases, sweeping plays an offsetting role. Given an increase in the required reserve ratio, for example, banks will sweep in order to restore some of their funds available to lend. This leads to a smaller decrease in loans than what would occur under zero sweeping. As another example, under sweeping a drop in equity due to a loan default leads to a smaller decrease in loans. In all cases, banks show less responsiveness in their holdings of excess reserves to exogenous changes as a result of sweeping.

4.   How to Eliminate Sweeping

Suppose that the Federal Reserve wants to create conditions such that banks will choose not to sweep. Under FRSSA, the Fed will have at least two tools to accomplish this task—the interest rate on reserves and the required reserve ratio. We can use our model to derive possible operational combinations that lead to the end of sweeping.

The obvious point of departure here is the first order condition for sweeping when $S = 0$. Given that the corner solution holds, we express the condition as a strict inequality:

$$-r_Q q - C_S + q\lambda < 0. \tag{7}$$

Equation (7) reveals an immediate way for the Fed to get banks to stop sweeping: Set the reserve ratio equal to zero. This proposal matches up directly with Bennett and Peristiani (2002), who note that many industrialized nations operate without reserve requirements. Since banks sweep funds exclusively to reduce required reserves, there would no longer be any incentive to sweep without this regulation, since sweeping of any amount increases the resource cost. This result holds for any interest rate on reserves, including $r_Q = 0$.

Suppose instead that the Federal Reserve wishes to maintain reserve requirements, although possibly with lower reserve ratios. Then it can eliminate sweeping by paying a sufficiently high interest rate on reserves. We now derive an operational relationship that the Fed can use to decide an appropriate interest rate, for any given reserve ratio.

A bank will continue to have positive loans, so (3) holds with equality. Substituting this equation into (7) for λ yields:

$$-r_Q q - C_S + q(r_L - C_L) < 0. \tag{8}$$

The marginal resource cost function C_S is evaluated at $S = 0$.

To more closely examine the zero sweeping condition, we specify functions for the marginal resource costs of loans and swept funds. For simplicity, we use linear forms, given by $C_L = \alpha_L + \beta_L L$, and $C_S = \alpha_S + \beta_S S$. Positive and increasing marginal resource

costs imply that each of the parameters α_L, α_S, β_L, and β_S are greater than zero.
Substituting the marginal resource cost functions into (8) and performing some
rearrangement yields the zero-sweeping condition:

$$(r_L - r_Q) < \alpha_L + \alpha_S / q + \beta_L L. \tag{9}$$

This condition points to the utility of having the interest rate of reserves tied to a loan
rate. Equation (9) also suggests a means of determining the magnitude of the spread
between the loan rate and the interest rate on reserves that would be necessary to
eliminate sweeping. Before proceeding further with the analysis, though, two initial
points emerge.

First, the permissible spread varies negatively with the reserve ratio. With a
smaller reserve ratio the Fed can operate with a larger difference between the interest
rates on loans and reserves. The hyperbolic relationship implies that reducing reserve
requirements for low reserve ratios could bring about a sharp increase in the acceptable
spread. This property implies that if the Fed wishes to maintain a small but positive
reserve ratio, it may be able to offer an interest rate on reserves well below loan rates and
still achieve an objective of zero sweeping.

Second under increasing marginal resource costs for loans, greater holdings of
bank loans raise the permissible spread. Higher marginal costs would be a deterrent to
further lending. Furthermore, because the main advantage of sweeping lies in freeing up
funds for loans, banks would have less incentive to sweep. Consequently, under more

holdings of loans the Fed can offer a lower interest rate on reserves relative to loan rates and still provide an incentive for banks to halt sweeping.

To perform a first-pass investigation on the minimum spread required to halt banks' sweeping activities, we obtain preliminary estimates of the marginal resource cost parameters. This is accomplished by specifying the aggregate resource cost function, given by:

$$C_t = \theta_0 + \alpha_L L_t + (\beta_L/2)L_t^2 + \alpha_S S_t + (\beta_S/2)S_t^2 + \mu_t, \tag{10}$$

where C is total resource cost, θ_0 is an intercept, and μ is a stationary residual.

We estimate (10) with annual data during 1994-2006, the period during which sweeping substantially increased due to the emergence of retail sweep programs. The use of annual observations arises because of the difficulty in finding data on total bank resource costs. The C variable is measured by Total Noninterest Expense of FDIC-Insured Commercial Banks in the United States and Other Areas, taken from Table CB07 of FDIC Historical Statistics on Banking (http://www4.fdic.gov/hsob/hsobRpt.asp). Data for loans also come from the FDIC Historical Statistics on Banking (see the same Web site), as reported in Table CB09. We use three measures for the L variable: Total Loans and Leases + Investment Securities, Total Loans and Leases, and Net Loans and Leases.

Data for swept funds come from the website http://www.sweepmeasures.com. As described in Cynamon, Dutkowsky, and Jones (2006), the website provides measures of monetary aggregates adjusted for retail and commercial demand deposit sweep programs. We form observations for the S variable by subtracting the not seasonally adjusted M1S

measure from the corresponding M1 aggregate. The empirical findings of Jones, Dutkowsky, and Elger (2005) and Dutkowsky, Cynamon, and Jones (2006) point to the importance of adjusting for swept funds based upon commercial demand deposit sweep programs as well as for retail sweeps. Because the cost and loan variables are year-end balances, we use the December observations for swept funds. All aggregates are in billions of dollars.

Table 3 reports OLS estimates of the resource cost function. The results are very uniform across the different measures of bank loans. We obtain estimated coefficients for α_L that are positive and significantly different from zero at the 5% level. Estimates for α_S and β_S have positive sign in all cases but are imprecisely estimated. Estimated coefficients for β_S are much smaller in magnitude compared to α_S.

A somewhat surprising result occurs for the estimates of β_L. We find them to be negative in sign and in some cases, significantly different from zero at the 10 percent level. This finding appears to reflect a distinct downward trend over the sample in average resource cost of loans, which holds true for all loan measures. The estimates are smaller in absolute magnitude relative to the estimated coefficients for α_L—sufficiently smaller to indicate positive estimated marginal resource costs of lending. On the other hand, the property of decreasing marginal resource costs of lending changes somewhat the interpretation of the zero sweeping condition in (9). Under a negative value for β_L, increased holdings of bank loans reduce the permissible spread. Larger quantities of loans reduce the marginal resource cost of lending, implying an increased desire to sweep

funds. The Fed would need to pay an interest rate on reserves closer to bank loan rates to stop this behavior from occurring.[4]

We now turn to using the estimates to compute the minimum spread to eliminate sweeping from (9). Here the estimated coefficients from the models with Total Loans and Leases or Total Net Loans and Leases produce much more plausible results as compared with the model with Total Loans and Leases + Investments. The problem seems to center on the estimated α_S coefficient. The latter model generates an estimate much larger in magnitude than the others. Dividing this estimate by a reasonable value of the reserve ratio leads to highly inflated values of the permissible spread.[5]

Note also that the zero sweeping condition suggests a positive value for α_S. Although Table 3 includes findings from estimated models with the parameter restricted to be zero—primarily to examine possible multicollinearity—a zero value implies that the reserve ratio has no influence in eliminating sweeping. Therefore, we focus on the estimated models for Total Loans and Leases and Net Loans and Leases without the restriction. The models generate very similar estimates for all parameters, with values of α_S in a range from 0.004 to 0.006.

Figure 1 contains plots of the minimum spread to eliminate sweeping for the model with Net Loans and Leases and various reserve ratios. It consists of the right-hand-side of (9) given the parameter estimates and data for loans. The solid line depicts the minimum spread for $q = 0.100$, a value used by Elyasiani, Kopecky, and VanHoose (1995). The graph shows that the minimum spread has been steadily declining over the

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[4] This finding also changes several comparative statics results from Tables 1 and 2. A negative value for C_{LL} suggests sign switches in several cases, most notably the effects of changes in the reserve ratio or equity on holdings of excess reserves and swept funds.
[5] We obtain very similar parameter estimates and results for the estimated model with Net Loans and Leases + Investments.

period due to the increase in loans. This finding indicates that while in the beginning of retail sweeping the Fed could have managed to maintain a low rate of interest on reserves to have eliminated sweeping, it now would have to keep the interest rate on reserves closer to market loan rates.

As of 2007, the estimated minimum spread was approximately 0.0367, implying that eliminating sweeping would require the Fed to set the interest rate on reserves within 3.67 percentage points of the market loan rate. The model utilizing Total Loans and Leases as a loan measure generates slightly higher estimates. For example, with $q = 0.10$, the minimum spread for 2007 equals approximately 4.99 percentage points.

Figure 1 also includes estimated minimum spreads for reserve ratios of 0.075 and 0.050 for the model utilizing the Net Loans and Leases measure. These curves represent shifts upward from the benchmark case of $q = 0.100$. If the Fed chooses to reduce but not eliminate reserve ratios, sweeping can be halted with a higher minimum spread. In 2007, the estimated minimum spreads to eliminate sweeping equal approximately 5.11 percentage points for $q = 0.075$ and 8.00 percentage points for $q = 0.050$. The latter case in particular indicates that by cutting the reserve ratio in half, the Fed can offer a minimal interest rate on reserves and still eliminate sweeping. Finally, as (9) implies, removing reserve ratios would lead to the end of sweeping regardless of the interest rate on reserves.

5. Conclusion

This study examines sweep programs within basic banking theory. It thereby provides model-based results regarding the determinants of sweeping and how they affect

levels of swept funds chosen by banks. Our framework also enables us to derive how sweeping influences other aspects of bank decision-making in comparison with bank choices without sweeping. Although sweep programs have repeatedly been singled out as sufficiently costly to society to warrant elimination, surprisingly little formal research has taken place on sweeping and bank behavior.

Our analysis additionally suggests an operational method that the Federal Reserve could adopt to effectively remove the incentive for banks to engage in sweeping as well as some preliminary estimates. Statements made by Fed officials in arguing for the payment of interest on reserves indicate that this is an important goal. While the Fed certainly takes into account additional factors in deciding the appropriate interest rate on reserves, including increasing total reserves and excess reserves to specified levels, this study puts forth the minimum rate required to halt sweeping. Our findings indicate that if the Fed wishes to maintain the existing reserve ratio and yet end sweeping, they should set the interest rate on reserves to no less than 3.67 percentage points less than a market loan rate. Reducing required reserve ratios would enable the Fed to offer a sharply lower interest rate on reserves and still achieve its goal.

This being said, our overall findings do not provide a clear rationale for eliminating sweeping. The noticeable decline in reserves and required reserves under retail sweep programs certainly might present an argument for reducing swept funds under a monetary policy operating procedure that relies on reserve levels as a policy indicator or objective. However, some previous research suggests that sweeping has not seriously affected the conduct of monetary policy. Wrase (1998) contends that particularly with lagged reserve accounting, sweep programs have not seriously affected

the Federal Reserve's ability to hit its federal funds rate target. VanHoose and Humphrey (2001) provide empirical evidence that the lower reserve balances under retail sweep programs have not had a significant effect on federal funds rate volatility or the volatility of market interest rates.

Our results indicate that sweeping does not qualitatively alter other aspects of the bank's decision. In addition, although sweeping requires banks to expend resources, it also expands bank profits. Furthermore, our findings also suggest that sweeping prompts greater bank lending in response to increases in loan rates and may lead to decreased volatility in excess reserves. Moreover, sweeping could play an important role in cushioning bank lending activity in response to increased defaults. These arguments do not in any way close the case against eliminating sweeping. Rather, they move these important issues of sweeping and bank behavior into a more formal context. Our work calls for further examination on the effects of sweeping within banking and monetary policy to gather more scientific evidence, especially in preparation for the payment of interest on bank reserves.

Table 1
Comparative Statics Results: Sweeping Model

Exogenous/Endogenous	L	X	S
r_L	$\dfrac{-q^2(G''-C_{XX})+C_{SS}}{H}$ $(+)$	$-\dfrac{C_{SS}}{H}$ $(-)$	$-\dfrac{q(G''-C_{XX})}{H}$ $(+)$
r_Q	$\dfrac{q^2(G''-C_{XX})-C_{SS}}{H}$ $(-)$	$\dfrac{C_{SS}}{H}$ $(+)$	$\dfrac{q(G''-C_{XX})}{H}$ $(-)$
q	$\dfrac{-(G''-C_{XX})[C_S-(D-S)C_{SS}]}{H}$ $(-)*$	$\dfrac{C_{LL}[C_S-(D-S)C_{SS}]}{H}$ $(-)*$	$\dfrac{C_{LL}[C_S-q(D-S)(G''-C_{XX})]-C_S(G''-C_{XX})}{H}$ $(+)$
E	$-\dfrac{(G''-C_{XX})C_{SS}}{H}$ $(+)$	$\dfrac{C_{LL}C_{SS}}{H}$ $(+)$	$\dfrac{qC_{LL}(G''-C_{XX})}{H}$ $(-)$

Notes: The variable $H = C_{LL}[C_{SS}-q^2(G''-C_{XX})]-C_{SS}(G''-C_{XX})$, with $H > 0$. The * indicates that the sign holds if $C_S < (D-S)C_{SS}$. The expressions for changes in D and T are as follows: for endogenous variable Y, $\partial Y/\partial T = \partial Y/\partial E$ and $\partial Y/\partial D = (1-q)(\partial Y/\partial E)$.

Table 2
Difference in Absolute Effects: Sweeping versus Zero Sweeping

Exogenous/Endogenous	L	X
r_L	$\dfrac{q^2(G''-C_{XX})^2}{(H)(\widetilde{H})}$ $(+)$	$\dfrac{q^2C_{LL}(G''-C_{XX})}{(H)(\widetilde{H})}$ $(-)$
r_Q	$\dfrac{q^2(G''-C_{XX})^2}{(H)(\widetilde{H})}$ $(+)$	$\dfrac{q^2C_{LL}(G''-C_{XX})}{(H)(\widetilde{H})}$ $(-)$
q	$\dfrac{(G''-C_{XX})(C_S+SC_{SS})}{H}-\dfrac{q^2(D)C_{LL}(G''-C_{XX})^2}{(H)(\widetilde{H})}$ $(-)$	$\dfrac{-C_{LL}(C_S+SC_{SS})}{H}+\dfrac{q^2(D)C_{LL}^2(G''-C_{XX})}{(H)(\widetilde{H})}$ $(-)$
E	$\dfrac{-q^2C_{LL}(G''-C_{XX})^2}{(H)(\widetilde{H})}$ $(-)$	$\dfrac{q^2C_{LL}^2(G''-C_{XX})}{(H)(\widetilde{H})}$ $(-)$

Notes: The variable $\widetilde{H}=C_{LL}-(G''-C_{XX})$, with $\widetilde{H}>0$. Entries equal $|\partial Endogenous/\partial Exogenous|$ for the model with positive sweeping minus the corresponding expression under zero sweeping. For the definition of H, see Notes to Table 1.

Table 3
Parameter Estimates: Resource Cost Function

Model/Parameter	α_L	β_L	α_S	β_S	R^2	SE	DW
Total Loans and Leases + Investment Securities	0.0504 (0.0188)	-5.09E-6 (3.32E-6)	0.0294 (0.0309)	1.60E-5 (6.22E-5)	0.996	3.50	1.93
Total Loans and Leases + Investment Securities	0.0668 (0.0073)	-7.98E-6 (1.32E-6)	0.0000	5.36E-5 (4.78E-5)	0.996	3.48	1.68
Total Loans and Leases	0.0773 (0.0295)	-1.25E-5 (0.60E-5)	0.0055 (0.0384)	6.93E-5 (6.18E-5)	0.996	3.87	1.87
Total Loans and Leases	0.0813 (0.0099)	-1.33E-5 (0.20E-5)	0.0000	7.47E-5 (4.64E-5)	0.996	3.66	1.86
Net Loans and Leases	0.0783 (0.0294)	-1.30E-5 (0.61E-5)	0.0043 (0.0382)	7.37E-5 (6.02E-5)	0.996	3.86	1.88
Net Loans and Leases	0.0814 (0.0099)	-1.37E-5 (0.19E-5)	0.0000	7.79E-5 (4.47E-5)	0.996	3.64	1.87

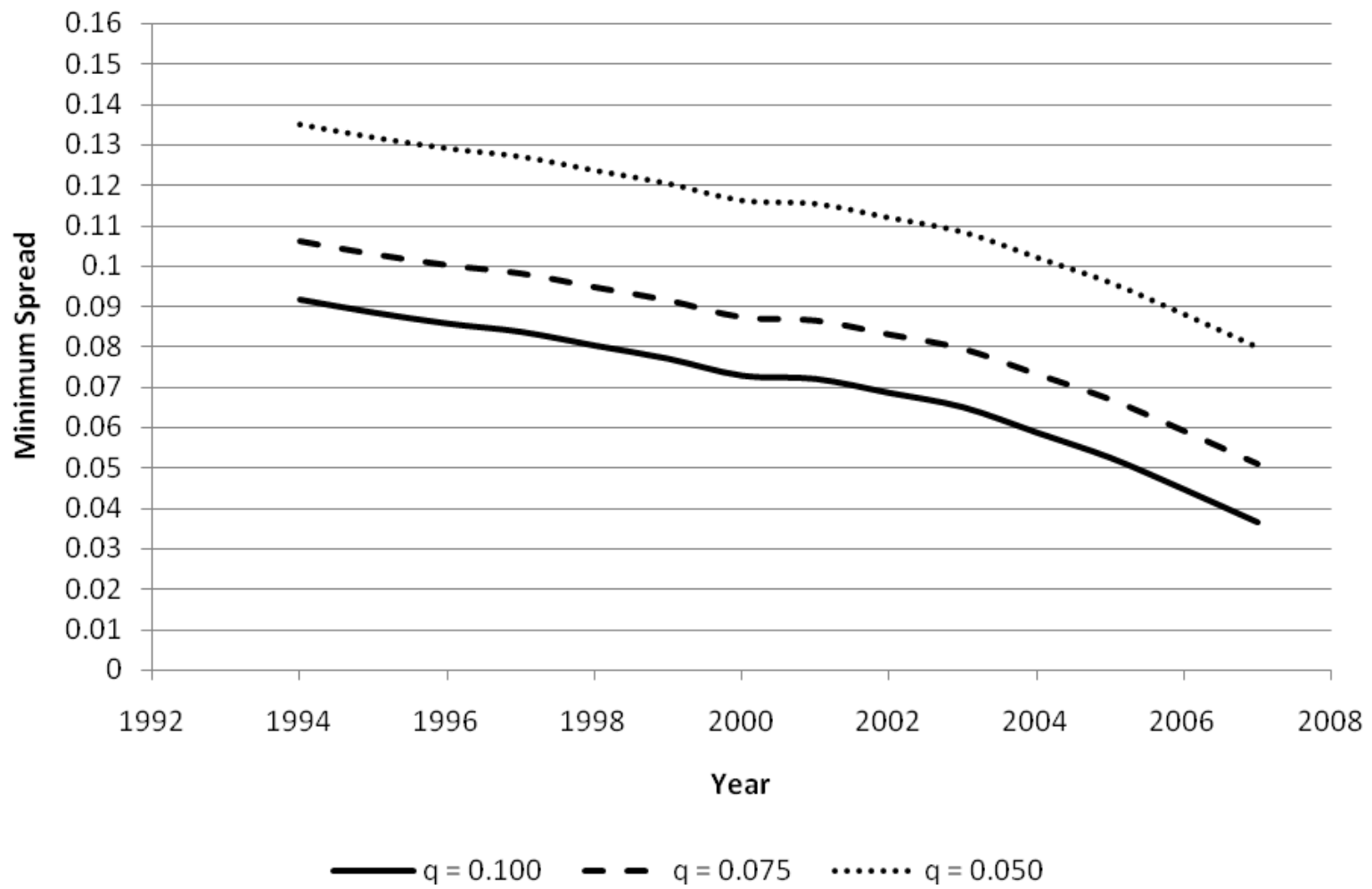Notes: Standard errors appear in parentheses. All models include an intercept.

Figure 1

Appendix
Comparative Statics Results: Model with Zero Sweeping

Exogenous/Endogenous	L	X
r_L	$\dfrac{1}{\widetilde{H}}$ $(+)$	$-\dfrac{1}{\widetilde{H}}$ $(-)$
r_Q	$-\dfrac{1}{\widetilde{H}}$ $(-)$	$\dfrac{1}{\widetilde{H}}$ $(+)$
q	$\dfrac{D(G''-C_{XX})}{\widetilde{H}}$ $(-)$	$\dfrac{-C_{LL}D}{\widetilde{H}}$ $(-)$
E	$-\dfrac{(G''-C_{XX})}{\widetilde{H}}$ $(+)$	$\dfrac{C_{LL}}{\widetilde{H}}$ $(+)$

Notes: The variable $\widetilde{H} = C_{LL} - (G''-C_{XX})$, with $\widetilde{H} > 0$. For endogenous variable Y, $\partial Y/\partial T = \partial Y/\partial E$ and $\partial Y/\partial D = (1 - q)(\partial Y/\partial E)$.

Figure Caption

Figure 1. The minimum spreads between the interest rates on loans and bank reserves
needed to eliminate sweeping for various reserve ratios, based upon estimates from the
model with Net Loans and Leases.

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