Retail Sweep Programs and Bank Reserves, 1994-1999

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In January 1994, the Federal Reserve Board permitted a commercial bank to begin using a new type of computer software that dynamically reclassifies balances in its customer accounts from transaction deposits to a type of personal-saving deposit, the money market deposit account (MMDA).[1] This reclassification reduces the bank's statutory required reserves while leaving unchanged its customers' perceived holdings of transaction deposits.

The use of deposit-sweeping software spread slowly between January 1994 and April 1995, but rapidly thereafter. Estimates of the amounts of transaction deposits reclassified as MMDAs at all U.S. depository institutions, prepared by the Board of Governors' staff, are shown in Figure 1.[2] By late 1999, the amount was approximately $372 billion. In contrast, the aggregate amount of transaction deposits (demand plus other checkable deposits) in the published M1 monetary aggregate, as of December 1999, was $599.2 billion.

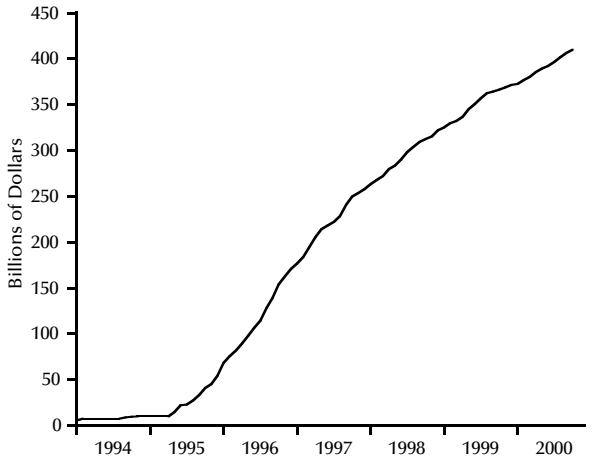
In this analysis, we interpret the effects of deposit-sweeping software on bank balance sheets to be economically equivalent to a reduction in statutory reserve-requirement ratios. We seek to measure the amount by which such deposit-sweeping activity has reduced bank reserves (vault cash and deposits at Federal Reserve Banks). Currently, transaction deposits are subject to a 10 percent statutory reserve-requirement ratio on amounts over the low-reserve tranche ($44.3 million during 2000, $42.8 million during 2001), whereas personal-saving accounts, including MMDAs, are subject to a zero ratio.[3]

To be useful in policy analysis and empirical studies, aggregate quantity data on bank reserves must be adjusted for the effects of changes in statutory reserve requirements on the quantity of reserves held by banks.[4] In the past, such adjustments were straightforward because changes in statutory reserve requirements applied simultaneously and uniformly to groups of depository

Figure 1

Sweeps of Transaction Deposits into MMDAs

Board of Governors Staff Estimates, Jan. 1994 - Oct. 2000



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[1] O'Sullivan (1998, p. 88) identifies this bank as First Union National Bank: "The trend started almost four years ago when First National Bank applied to the Federal Reserve to do something that became known as 'the reserve sweep'." First Union's idea is reminiscent of the automatic-transfer-from-savings (ATS) account of the 1970s. It differs because transaction deposits are reclassified as MMDA deposits, a category first created in 1982 by the Garn–St. Germain Act.

[2] These data are updated monthly, with a one-month lag, and are available on this Bank's Web site at < www.stls.frb.org/research/swdata.html > .

[3] The Monetary Control Act of 1980 imposed Federal reserve requirements on net transaction deposits, which equals the sum of checkable deposits due to individuals, partnerships, corporations (including other depository institutions), the Treasury, state and local governments, and government agencies, minus the sum of cash items in process of collection and demand deposits due from other depository institutions. So far as we are aware, data on net transaction deposits have not been published by the Federal Reserve Board since implementation of the Monetary Control Act. The statutory reserve requirements applicable to transaction deposits are tiered, with a zero rate applied to the *reserve-exemption amount*, a 3 percent rate applied to the *low-reserve tranche*, and since April 1992 a 10 percent rate applied to amounts that exceed the tranche. The reserve-exemption amount and the low-reserve tranche are adjusted each year using a formula set by law. For 1992-99, the reserve-exemption amounts were $3.6, 3.8, 4.0, 4.2, 4.3, 4.4, 4.7, and 4.9 million and the low-reserve tranche amounts were $42.2, 46.8, 51.9, 54.0, 52.0, 49.3, 47.8, and 46.5 million. Prior to April 1992, the marginal ratio applicable to transaction deposits was 12 percent.

[4] A broad cross-country study illustrating the importance of such adjustments is McCallum and Hargraves (1995).

institutions within only a small number of broad classes. The effective date for changes in statutory requirements varied slightly among depositories that report data to the Federal Reserve weekly (larger banks), those that report quarterly (smaller banks), and those that report annually (very small banks). Within each group, however, the effective date was the same for all institutions. During the 1980s, the only changes in statutory requirements were due to the phase-in and indexation provisions of the Monetary Control Act. During the 1990s, the reserve-requirement ratio applicable to nonpersonal savings and time deposits was reduced from 3 percent to zero (December 1990) and the highest marginal ratio applicable to transaction deposits was reduced from 12 percent to 10 percent (April 1992).[5]

The economic effect of deposit-sweeping software is unlike these previous changes. The essence of deposit-sweeping software is that it permits banks to change the share of their transaction deposits that are subject to a non-zero statutory reserve-requirement ratio (see the insert "How Deposit-Sweeping Software Reduces Required Reserves"). Each bank is free to decide when and how to implement the software, subject to constraints discussed below. In this way, in part, banks' effective reserve requirements are "home brewed." As a result, the economic effects of deposit-sweeping software must be analyzed and measured bank-by-bank.

Our analysis suggests that required and total reserves in December 1999, measured by the reserve adjustment magnitude (RAM) developed in this article, were lower by $34.1 billion and $25.8 billion, respectively, as a result of deposit-sweeping activity. In addition, many depository institutions have reduced their required reserves to such an extent that the lower requirement places no constraint on the bank because it is less than the amount of reserves (vault cash and deposits at the Federal Reserve) that the bank requires for its ordinary day-to-day business. For these banks, the economic burden of statutory reserve requirements has been reduced to zero.

DEPOSIT-SWEEPING SOFTWARE, REQUIRED RESERVES, AND RAM

The effectiveness of deposit-sweeping software hinges on the use of the MMDA. This deposit instrument was created in 1982 by a provision in the Garn–St. Germain Act. At that time, many banks perceived extreme competitive pressures from money market mutual funds. The MMDA allowed them to offer a type of deposit that was fully competitive with money market mutual fund shares. The MMDA was not subject to Regulation Q interest rate controls, and, so long as no more than six withdrawals were made by check or preauthorized transfer during a month, it was not subject to the statutory reserve requirements applicable to transactions deposits. (If a bank permitted more than six such withdrawals, the MMDA was reservable as a transaction deposit.) The Monetary Control Act specified three categories of deposits subject to reserve requirements: net transaction deposits, savings deposits (personal and nonpersonal), and time deposits (with a minimum maturity of seven days). The act set the reserve-requirement ratio for personal-saving deposits to zero, and the Board of Governors set the ratio for nonpersonal-saving deposits to zero in December 1990. Because MMDAs are not time deposits and the Garn–St. Germain Act prohibited the Federal Reserve from imposing transaction-deposit reserve requirements, they are classified as savings deposits for reserve-requirement purposes.[6]

At its start, deposit-sweeping software creates a "shadow" MMDA deposit for each customer account. These MMDAs are not visible to the customer, that is, the customer can make neither deposits to nor withdrawals from the MMDA. To depositors, it appears as if their transaction-account deposits are unaltered; to the Federal Reserve, it appears as if the bank's level of reservable transaction deposits has decreased sharply. Although computer software varies, the objective is the same: to minimize a bank's level of reserv-

[5] For banks that reported deposit data weekly to the Federal Reserve, the reserve-requirement ratio applicable to nontransaction deposits was reduced from 3.0 percent to 1.5 percent as of December 13, 1990, and to zero as of December 27, 1990. For banks that reported deposit data quarterly, the ratio was reduced to zero as of January 17, 1991. The latter change applied to all banks as of April 2, 1992.

[6] Banks have attempted other combinations of transaction and saving deposits. In one case, a bank suggested that customers maintain several MMDA accounts and simply shift all funds among the accounts as necessary to avoid making more than six third-party payments (or transfers to other accounts) during any given month (12 CFR 204.133). In another, a bank reclassified transaction deposits as seven-day large-time deposits, staggering the maturity so as to be able to pay, each day, all checks presented (12 CFR 204.134). In these cases, the Board of Governors reclassified the saving and large-time deposits as transaction deposits and imposed transaction-deposit reserve requirements. See the Board of Governors *Regulation D*, 12 CFR Chap. 11.

HOW DEPOSIT-SWEEPING SOFTWARE REDUCES REQUIRED RESERVES

Let us consider a hypothetical $1 billion bank with $200 million in transaction deposits. We focus on two constraints faced by the bank: (i) to satisfy the Federal Reserve's statutory reserve requirements and (ii) to convert deposits into currency and settle interbank debits (related to check clearing and wire transfers) using deposits at the Federal Reserve. Fortunately, the assets involved—vault cash and deposits at the Federal Reserve—do double duty.

The Bank Before Deposit-Sweeping Software. A bank's statutory required reserves are calculated from close-of-business data. Excluding any special adjustments, the bank's required reserves as of late January 1999 would be as follows:

- 0% on the first $4.9 million of transaction deposits (the reserve-exemption amount);
- 3% on the next $41.6 million of transaction deposits (up to the low-reserve tranche of $46.5 million), equal to $1.248 million;
- 10% on the amount in excess of $46.5 million, or $15.350 million.

Banking industry data suggest that such a bank might choose to hold vault cash equal to approximately 5 percent of its transaction deposits, or $10 million. If all vault cash is "applied" to satisfy reserve requirements, the bank would need to maintain at least $6.598 million on deposit at the Federal Reserve to satisfy its statutory reserve requirement. Its balance sheet might look like Table A (see page 55).

Payments Activity and the Reserve-Requirement Tax. Banking-industry data used in our analysis suggest that a typical bank, in the absence of statutory reserve requirements, would tend to maintain deposits at the Federal Reserve equal to approximately 1 percent of its transaction deposits (in the example, $2 million). The data also suggest that deposit-sweeping activity does not affect the amount of vault cash held, relative to the sum of transaction deposits plus the amount of deposits being reclassified as MMDA. For the example bank, the reserve-requirement tax is the interest foregone by maintaining $7 million, rather than $2 million, on deposit at the Federal Reserve.

Overnight Repurchase Agreement–Based Deposit Sweeping. During the 1970s, many banks began "sweeping" customer deposits into overnight repurchase agreements (RPs). Let us suppose that the bank in this example wishes, at the behest of its large business customers, to sweep half its deposits each night. To do so, it maintains an inventory of high-quality liquid securities, such as Treasury bills. Its balance sheet at 3 p.m., prior to sweeping, might look like Table B1. At 6 p.m. after sweeping, it might appear as Table B2.

This example includes the sale (lending) of $5 million in the federal funds market; the bank is assumed to retain $2 million in deposits to service customer accounts and reduce the risk of an overnight overdraft at the Federal Reserve. If the bank's customers routinely desire to engage in overnight RPs, the bank likely will reduce its balance at the Federal Reserve and this lending will vanish.

1990s MMDA-Based Sweeping. Our examination of banking data suggests that MMDA-based sweeping may reduce transaction deposits at a typical bank by two thirds or more. If the bank in

(Continued on p. 54)

able transaction deposits, subject to several constraints. The general parameters of this optimization problem are as follows:

- The Federal Reserve calculates a bank's required reserves based on a 14-day average of the close-of-day level of its transaction deposits.[7]
- Each calendar month, an unlimited number of transfers may be made from a customer's transaction deposit account into the shadow MMDA. However, only six transfers may be made out of the shadow MMDA to the customer's transaction-deposit account.
- Checks presented to the bank for payment are only debited against the customer's transaction-deposit account, not against the MMDA. If the

[7] The computation of statutory required reserves involves two legally defined time periods: the reserve computation period and the reserve maintenance period. The former are 14-day periods that end every other Monday; the latter are 14-day periods that end every other Wednesday. Prior to August 1998, a bank's required reserves, to be maintained during a reserve maintenance period, were based on a bank's deposits during the reserve computation period ending 2 days prior to the end of the reserve maintenance period. As of August 1998, the required reserves have been based on deposits during the reserve computation period ending 30 days before the end of the reserve maintenance period. Required reserves must be satisfied by eligible vault cash and deposits held during the maintenance period at Federal Reserve Banks. Eligible vault cash is vault cash held by a bank during the reserve computation period ending 30 days before the end of the maintenance period.

(Continued from p. 53)
our example does so, its required reserves will decrease by more than 80 percent, to $3.298 million ($1.248 million on the first $46.5 million of deposits, plus $2.050 million on the next $20.5 million). Its vault cash—$10 million—is now more than adequate to fully satisfy its new, lower required reserves. After sweeping, its balance sheet might look like Table C.

Although the bank no longer needs deposits at the Federal Reserve to satisfy reserve requirements, we assume that the bank retains $2 million to service customer accounts and reduce the risk of an overnight overdraft. In a recent banking-industry journal article, a seller of MMDA-based sweep software says that an aggressive deposit-sweeping bank can reduce its holdings of reserves (vault cash and deposits at the Federal Reserve) to less than 1 percent of its total assets.[1] If our example bank reduces slightly its holdings of vault cash, it will attain that target.

In our example, both RP-based and MMDA-based sweeps reduce to zero the "burden" of statutory reserve requirements—the bank holds no more reserves than are necessary for its day-to-day operations. In addition, both types of sweeps reduce the bank's required reserves by enough that they are fully satisfied with vault cash. But, the two types of sweeps differ in other aspects. Note that RP-based sweeps constrain the bank's balance sheet—the bank must hold an inventory of suitable liquid securities, as collateral—but MMDA-based sweeps do not. Also, RP-based sweeps typically are conducted only with large business customers, often in amounts of several million dollars. These customers are economically equivalent to partners with the bank in the RP-based sweeps and hence are likely to receive a significant share of the earnings. In contrast, MMDA-based sweeps may be implemented for most, if not all, transaction-deposit customers and may be invisible to the customers. Finally, MMDA-based sweeps do not directly change the bank's total assets, liabilities, or deposits. Rather, like changes in statutory reserve requirements, they allow the bank to deploy funds from non-interest-bearing deposits at Federal Reserve Banks into loans and other investments.

The Role of Clearing Balance Contracts. The analysis above excludes one additional effect of MMDA-based deposit-sweeping activity: an increase in clearing balance contracts. A clearing balance contract is an agreement between a bank and the Federal Reserve wherein the bank agrees to maintain a certain amount of deposits at the Federal Reserve above and beyond any amount necessary to satisfy statutory reserve requirements. As compensation for (and an incentive to enter into) the contract, the bank receives earnings credits from the Federal Reserve. Earnings credits accrue at a rate slightly less than the federal funds rate and may only be used to defray the cost of financial services, such as check clearing, purchased from the Federal Reserve.

Kohn (1996, p. 48) notes that, through 1996, the aggregate amount of clearing balance contracts had tended to increase by 16 to 17 cents for each dollar that required reserves decreased due to deposit-sweep activity. Let us, therefore, reconsider our example bank. Suppose that this bank incurs an annual cost of $200,000 due to check clearing and wire transfers through the Federal Reserve, on behalf of customers. In our example, MMDA-based deposit-sweeping software reduced required reserves by more than $13 million and freed the bank from using its remaining $2 million at the Fed to satisfy required reserves. If this bank were typical of Kohn's average, it might sign a $2 million clearing-balance contract. This clearing-balance contract does not require the bank to increase its deposit at the Fed beyond the initial $2 million, nor does it infringe in any way on the bank's ability to use its $2 million deposit for routine business activity. If the federal funds rate were to be (say) 5 percent, the bank would receive approximately $100,000 per year in earnings credits. The deposit-sweeping software has done double duty—it eliminated the reserve-requirement tax and, at no cost to the bank, reduced by one-half its payments to the Federal Reserve for purchased services. *(Tables shown on p. 55)*

[1] See O'Sullivan (1998). A bank consultant, quoted in this article, estimates that almost all banks with over $750 million in assets were using deposit-sweeping software at the end of 1997 versus about 100 banks at the end of 1996. He also estimates that eventually bank profits likely will be increased between $1 billion and $3 billion by deposit-sweeping activity. The quoted consultant further suggests that most banks could reduce their vault-cash holdings by 25 to 50 percent after implementing deposit-sweeping software. To us, this seems unlikely because the deposit-sweep activity does not change the amount of deposits that the bank's customers perceive themselves to hold. In fact, we find that the impact of MMDA-based deposit-sweeping activity on vault-cash ratios (when the estimated amount of swept deposits is included in the denominator) at the banks in our sample is near zero.

DEPOSIT-SWEEPING SOFTWARE AND BANK BALANCE SHEETS

Table A: A Bank with No Sweeping Activity

Assets *		Liabilities *	
Vault cash	$10,000	Transaction deposits	$200,000
Deposits at Federal Reserve	7,000	Savings deposits	400,000
Other assets	983,000	Time deposits	300,000
		Other liabilities and capital	100,000
Total assets	1,000,000	Total liabilities	1,000,000
Memo: Required reserves	16,598		
Applied vault cash	10,000		
Surplus vault cash	0		
Applied Federal Reserve deposits	6,598		
Excess reserves (excl. vault cash)	402		

Table B1: A Bank Preparing for RP-Based Sweep

Vault cash	$10,000	Transaction deposits	$200,000
Deposits at Federal Reserve	7,000	Savings deposits	400,000
Treasury bills	100,000	Time deposits	300,000
Other assets	883,000	Other liabilities and capital	100,000
Total assets	1,000,000	Total liabilities	1,000,000
Memo: Required reserves	16,598		
Applied vault cash	10,000		
Surplus vault cash	0		
Excess reserves (excl. vault cash)	402		

Table B2: A Bank After RP-Based Sweep

Vault cash	$10,000	Transaction deposits	$100,000
Deposits at Federal Reserve	2,000	Savings deposits	400,000
Treasury bills	0	Time deposits	300,000
Federal funds sold	5,000	Other liabilities and capital	100,000
Other assets	883,000		
Total assets	900,000	Total liabilities	900,000
Memo: Required reserves	6,598		
Applied vault cash	6,598		
Surplus vault cash	3,402		
Excess reserves (excl. vault cash)	2,000		

Table C: A Bank After MMDA-Based Sweep

Vault cash	$10,000	Transaction deposits	$67,000
Deposits at Federal Reserve	2,000	Savings deposits, including MMDA	533,000
Other assets	988,000	Time deposits	300,000
		Other liabilities and capital	100,000
Total assets	1,000,000	Total liabilities	1,000,00
Memo: Required reserves	3,298		
Applied vault cash	3,298		
Surplus vault cash	6,702		
Excess reserves (excl. vault cash)	2,000		

*As of close of business; dollar amounts are in thousands.

amount of funds in the transaction deposit is inadequate, a transfer must be made from the MMDA.

- On the sixth transfer, all funds remaining in the MMDA are moved to the transaction deposit. (A seventh transfer would cause the MMDA to be subject to the reserve requirements applicable to transaction deposits.)

Because no debits are made to customer transaction deposits between just before the close of business on Friday and just before the opening of business on Monday, some early software simply reclassified transaction deposits as shadow MMDAs prior to the close of business on Friday. This reduced a bank's weekly average level of required reserves by $\frac{3}{7}$: its transaction deposit liabilities for Friday, Saturday, and Sunday, as reported to the Federal Reserve, were zero. About ten times each year, a Monday holiday allowed delaying the return of funds to transaction deposits out of the MMDA until the opening of business on Tuesday. Later software is more sophisticated and analyzes the receipt and payment patterns of customers.[8] Of course, regardless of the efficiency of the software, the bank faces two additional constraints that limit how much it can reduce its reserves. It must keep on hand sufficient vault cash so as to be able to redeem customer deposits into currency, and it must maintain sufficient deposits at Federal Reserve Banks to avoid both excessive daylight overdrafts and overdrawing its account at the end of the day.

To measure the effect of deposit-sweeping software on bank reserves, we need a benchmark, or alternative. RAM furnishes one such measure because it was designed to measure the changes in bank reserves caused by differences in statutory reserve requirements—specifically, the differences between those requirements in effect during the current period and those for a specific benchmark, or base, period.[9] The view that deposit-sweeping activity should be analyzed as a change in statutory reserve requirements, and hence included within the framework of RAM, is not universally held, however. The Board of Governors' staff, for example, does not publish reserve aggregates adjusted for the effects of deposit-sweeping activity, apparently believing that the impact of such activity is not to be interpreted as economically equivalent to a change in statutory requirements.[10]

In its economic aspects, deposit-sweeping software programs of the 1990s differ distinctly from the collateralized overnight-loan sweep programs of the 1970s—to borrow a phrase, they are not "your father's Oldsmobile." The business-oriented sweep programs of the 1970s essentially were overnight collateralized loans to mutual funds and banks, initiated by depositors (see Kohn, 1994, Chap. 9; or Stigum, 1990, Chap. 13). These loans were made with the full participation of depositors, who received directly the lion's share of the investment return; the bank's net earnings arose from being a middleman. Although such sweeps reduced banks' required reserves, their primary purpose was to simulate a legally prohibited interest-bearing demand deposit.[11]

The retail-oriented deposit-sweeping activity of the 1990s differs. First, except for competitive market pressures, it seems unlikely that banks have directly passed along the earnings from deposit-sweeping activity to transaction-account customers.[12] In part, this may be due to few retail depositors understanding the process, despite many banks notifying customers via monthly statement inserts (containing phrases such as "…your deposit may be reclassified for purposes of compliance with Federal Reserve Regulation D…"). Banks' answers to question 12 of the Federal Reserve's May 1998 *Senior Financial Officer Survey* are illustrative. On that question, banks responded

[8] O'Sullivan (1998) includes a description of one learning mechanism in recent software.

[9] For further discussion of RAM, see Anderson and Rasche (1999, 1996a, b) and earlier references therein.

[10] Alternative measures of adjusted reserves currently are published by the Board of Governors of the Federal Reserve System and by the Federal Reserve Bank of St. Louis. The measures differ with respect to both the items included and the adjustment for changes in reserve requirements. See, for example, the annual benchmark release *Reserves of Depository Institutions* (Division of Monetary Affairs, Board of Governors of the Federal Reserve System).

[11] We emphasize the *economic effects* of sweep activity. From the viewpoint of a bank manager, both RP- and MMDA-based sweeps furnish a synthetic interest-bearing demand deposit for its customers; see, for example, Coyle (2000). Note that MMDA-based sweeping may be very profitable for a bank if its customers are unaware of the practice and do not demand a share of the earnings. Some analysts have estimated that profit margins may be as high as 90 percent (O'Sullivan, 1998).

[12] To test this hypothesis, we have examined scatter plots of bank offering rates on other checkable deposits and time deposits, relative to market yields on both short- and long-term Treasury issues. In monthly data, no change is apparent during the last decade.

that even if they were permitted to pay interest on demand deposits and if the Fed paid interest on deposits at Federal Reserve Banks, they most likely would tier rates paid on demand deposits and that the highest rate "would still be considerably below the level of market interest rates." Second, the sweeps of the 1970s required banks to maintain a significant amount of high-quality liquid collateral for use in repurchase agreements with large business customers. The retail sweeps of the 1990s allow a bank to deploy into higher-earning assets, as it sees fit, the funds released by reduced required reserves. In the boxed insert "How Deposit-Sweeping Software Reduces Required Reserves," for example, the bank's earning assets increase with no increase in total deposits or funding costs.

Linkages among retail deposit-sweep programs, the Depression-era prohibition of the payment of (explicit) interest on demand deposits, and the payment by the Fed of interest on deposits at Federal Reserve Banks have been discussed by Federal Reserve Governor Lawrence Meyer in recent Congressional testimony.[13] An important issue is whether banks would reduce or eliminate the use of deposit-sweeping software if the Federal Reserve paid interest on reserve balances. Because the *economic* effects of deposit-sweeping software are similar to reductions in statutory reserve requirements, in our opinion such an outcome is unlikely. First, as noted above, it seems unlikely that banks have passed much of the benefit from 1990s-style deposit-sweeping activity on to their transaction-deposit customers. Second, because newly released funds may be invested as the bank sees fit, including in consumer and business loans, it seems unlikely that deposits at Federal Reserve Banks, earning interest at the federal funds rate, would be an attractive investment. In question 10 of the May 1998 *Senior Financial Officer Survey*, banks were asked whether they would dismantle sweep programs if the Federal Reserve paid interest on deposits. In their summary of the survey, Board staff noted that "several" banks said that they would, or might, dismantle sweep programs. More than half of the respondents, however, said that interest paid at the federal funds rate would be unattractive, relative to the higher returns available on alternative investments. The staff summary also notes, on page 8, that "the results on this question seem qualitatively different from the responses to a similar question on the May 1996 *Senior Financial Officer Survey*. On that survey, two thirds of the respondents indicated that they would dismantle their retail sweep programs either immediately or over time if interest were paid on Fed account balances held to meet reserve requirements." In our opinion, retail deposit-sweeping software is here to stay for the same economic reasons that cause banks to prefer decreases, rather than increases, in statutory reserve requirements.

Reserve-Requirement Ratios and Economically Bound Banks

To measure the effect of deposit-sweeping software on the amount of reserves held by banks, we need to separate banks wherein the quantity of reserves demanded is sensitive to changes in reserve-requirement ratios from those in which it is not.[14] When reserve requirements are "low," a depository institution's demand for reserves may be largely, or even entirely, determined by its business needs (converting customer deposits into currency, originating interbank wire transfers, settling interbank check collection debits) rather than by statutory requirements. In the United States, the level of reserves held in the absence of statutory

[13] See Meyer (1998, 2000). Meyer's 2000 testimony was in regard to House Resolution 4209, a bill that would "require the payment of interest on reserves maintained at Federal reserve [*sic*] banks…" (106th Congress, 2nd Session, as reported with amendments on October 17, 2000). The text of the bill is available on the Library of Congress' "Thomas" legislative Web site. Although the Federal Reserve does not pay explicit interest on deposits at Federal Reserve Banks, banks that enter into clearing balance contracts do currently receive at approximately the federal funds rate "earnings credits" on those deposits that are obligated under clearing balance contracts. A clearing-balance contract is a contractual agreement between a depository institution and a Federal Reserve Bank. In the contract, the depository agrees to maintain a specific amount of deposits at the Federal Reserve Bank above and beyond the amount, if any, necessary to satisfy its statutory reserve requirement. In turn, the depository institution accrues earnings credits which may be used to defray the cost of services purchased from the Federal Reserve such as check clearing and wire transfers. Earnings credits may not be converted to cash and have no cash value except in exchange for Federal Reserves services. Penalties apply for entering into such a contract and subsequently not holding sufficient deposits (Stevens, 1993). A bill now pending in Congress (H.R. 4209) would eliminate earnings credits in favor of cash interest payments.

[14] Note that in this analysis the term "total reserves" includes all vault cash held by depository institutions. In Board of Governors' publications, however, reserves includes only the amount of vault cash that is applied to satisfy statutory reserve requirements—any "surplus" amount is excluded.

reserve requirements might be very small indeed because banks are permitted daylight overdrafts on their deposit accounts at the Federal Reserve Banks (Emmons, 1997; Furfine, 2000). When statutory reserve requirements are "high," the amount of reserves held will be approximately equal to its required reserves. (This statement assumes that all base money held by depository institutions can be used to satisfy reserve requirements. In the United States, member banks could not apply vault cash to satisfy reserve requirements between 1917 and 1959.) Hence, measuring RAM requires a model of banks' demand for reserves that includes an explicit role for statutory requirements.

Let us denote a depository institution's reserve demand function as $TR^D(D,rr)$, where D denotes the institution's deposit liabilities and rr the statutory reserve-requirement ratio. Further, omitting all tiering of reserve requirements, let us denote its required reserves as $RR(D,rr) = rr \times D$. Then, when rr is relatively large,

$$\frac{\partial TR^D(D,rr)}{\partial rr} \cong \frac{\partial RR(D,rr)}{\partial rr} = D > 0$$

such that statutory reserve requirements are, at the margin, the binding constraint that determines the amount of reserves held.[15] When rr is relatively small, we assume that

$$\frac{\partial TR^D(D,rr)}{\partial rr} = 0 \ ,$$

such that the bank's business needs, rather than statutory requirements, are the binding constraint. In Anderson and Rasche (1996b), we introduced the term *economically nonbound* to describe banks where

$$\frac{\partial TR^D(D,rr)}{\partial rr} = 0$$

and *economically bound* to describe banks where

$$\frac{\partial TR^D(D,rr)}{\partial rr} > 0 \ .$$

To measure RAM, we must know (or infer) the sign of the derivative

$$\frac{\partial TR^D(D,rr)}{\partial rr}$$

at all dates and for all banks in our sample. To be specific, for an individual bank, let $RR(D_t,rr_0)$ and $RR(D_t,rr_t)$ and denote the period t levels of required reserves when the statutory requirements of a base period, 0, and of period t, respectively, are in effect. For all cases, assume that sufficient data on reservable liabilities during period t exist so as to permit calculation of the quantity $RR(D_t,rr_0)$. Then, consider four cases:

Case 1: If $rr_0 = rr_t$, that is, reserve requirements have not changed, RAM = 0.

Case 2: If

$$\left.\frac{\partial TR^D(D,rr)}{\partial rr}\right|_{\substack{D=D_0\\rr=rr_0}} = 0 \text{ and } \left.\frac{\partial TR^D(D,rr)}{\partial rr}\right|_{\substack{D=D_t\\rr=rr_t}} = 0 \ ,$$

that is, if the business needs of the bank were the binding constraint in both the base period *0* and period t, then RAM = 0.

Case 3: If both

$$\left.\frac{\partial TR^D(D,rr)}{\partial rr}\right|_{\substack{D=D_0\\rr=rr_0}} > 0 \text{ and } \left.\frac{\partial TR^D(D,rr)}{\partial rr}\right|_{\substack{D=D_t\\rr=rr_t}} > 0 \ ,$$

that is, if the statutory requirements were a binding constraint on the bank in both the base period 0 and period t, then the RAM adjustment for period t (conditional on the choice of period 0 as the base period) is

$$RAM_t = RR(D_t,rr_0) - RR(D_t,rr_t) \ .$$

Case 4: If

$$\left.\frac{\partial TR^D(D,rr)}{\partial rr}\right|_{\substack{D=D_0\\rr=rr_0}} > 0 \text{ but } \left.\frac{\partial TR^D(D,rr)}{\partial rr}\right|_{\substack{D=D_t\\rr=rr_t}} = 0 \ ,$$

that is, if the statutory requirements were binding in the base period but not in period t, then to measure RAM we must find the smallest reserve-requirement ratio, say rr^*, for which

$$\left.\frac{\partial TR^D(D,rr)}{\partial rr}\right|_{\substack{D=D_t\\rr=rr_t^*}} > 0 \ .$$

Then, $RAM_t = RR(D_t,rr_0) - RR(D_t,rr^*)$.

The above analysis is applicable to cases where the only change in statutory reserve requirements between two periods is the reserve-requirement ratio, rr, and data exist to calculate the counterfactual level

[15] Throughout this analysis, we assume that the response of excess reserves at economically bound banks to changes in the statutory reserve-requirement ratio is zero (see Anderson and Rasche, 1996b). Excess reserves at economically nonbound banks typically are positive and an inverse function of the statutory reserve-requirement ratio.

of required reserves, $RR(D_t, rr_0)$. For analysis of other cases, see Anderson and Rasche (1999).

An empirical criterion for measuring RAM in Case 4, for dates beginning November 1980, was developed by Anderson and Rasche (1996b) based on statistical analysis of a large panel dataset. That analysis suggested that a bank was economically bound during a reserve maintenance period if the bank was legally bound and had more than $135 million in net transaction deposits.

Empirical Analysis

Because the design, implementation, and operation of sweep software is idiosyncratic, our analysis focuses on a longitudinal panel of 1231 depository institutions between January 1991 and December 1999. A depository institution is included in the panel if, during at least one reserve-maintenance period, it was either economically or legally bound.[16] Our panel is a subset of a larger dataset containing more than 7500 depository institutions, which, in turn, is an updated version of the dataset used in Anderson and Rasche (1996b). For some banks, data begin after January 1991 because the bank opened for business at that point, was created by the merger of existing banks, or only then began reporting data to the Federal Reserve. For others, the data stop before December 1999 because the bank failed, merged with another bank, or was dropped from the reporting panel. For each such bank, we use the Federal Reserve's bank structure database to trace predecessors and successors. When a bank with deposit-sweeping activity is acquired by another bank, we add the amount of activity at the acquired bank to the amount at the acquiring bank. In all cases, we focus special attention on those institutions where deposit-sweeping software has reduced the level of transaction deposits to such an extent that the level of the depository's required reserves is less than the amount of reserves (vault cash and deposits at the Federal Reserve) that the bank requires for its ordinary day-to-day business.

RAM 1991-93

We begin by re-examining RAM from January 1991 through December 1993. Our previous measure of RAM was based on the statistical models of Anderson and Rasche (1996b). Those results suggested that economically bound banks (the only ones included in that measure of RAM) were characterized by two features: (i) a level of required reserves that exceeded their vault cash and (ii) having more than $135 million in net transaction deposits. This framework allowed us to classify banks into broad groups without tedious examination of time-series data for individual banks.

In this analysis, we revise our measure for 1991-93 for two reasons. First, because deposit-sweeping software allows banks to home-brew reserve requirements, our analysis for 1994-99 must necessarily be based on the examination of data for individual banks. It is important to assess whether this change in procedure—from using aggregated data for groups of banks to using individual-bank data—has any effect on measured RAM. The 1991-93 period provides an experimental control for this change in procedure. Second, we seek to reduce the number of occurrences when a bank, as well as its deposits, moves from being included in RAM to being excluded. It seems unlikely that a bank's responsiveness to possible changes in a statutory reserve-requirement ratio fluctuates very much from period to period. Absent changes in statutory reserve requirements (or a merger), we assume that a typical bank switches infrequently between economically nonbound and bound.

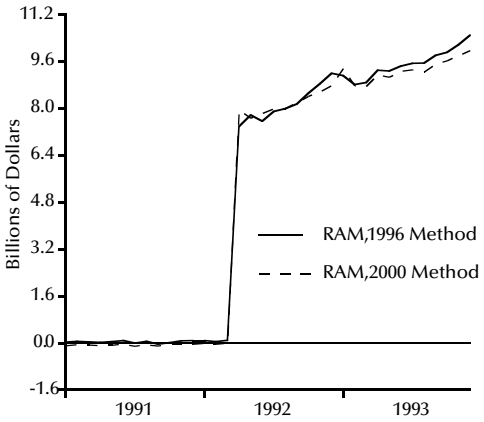
The most reliable indicator of a bank's economically bound or nonbound status is its response to a change in statutory reserve requirements. An economically bound bank will reduce its holdings of reserves, following a reduction in reserve requirements, by approximately the same amount as the decrease in its required reserves. An economically nonbound bank will not, although it might reduce its holdings by a smaller amount. Between January 1991 and December 1993, there were only two ways that the statutory reserve-requirement ratio for a bank could change:

- In April 1992, the Federal Reserve reduced the statutory reserve-requirement ratio on transaction deposits above the low-reserve tranche from 12 percent to 10 percent. If a bank reduced its deposits at Federal Reserve Banks (relative to transaction deposits) following the April 1992 reduction in reserve requirements and did not begin or increase the size of a clearing-balance contract, we classified the

[16] A bank is said to be legally bound if the amount of its required reserves exceeds the amount of vault cash that is legally permitted to apply to satisfy its reserve requirement.

Figure 2

RAM, 1991-93



bank as economically bound from January 1991 to December 1993. If the bank began or increased the amount of a clearing balance contract, we classified the bank as economically nonbound from the date of that increase through the end of December 1993. An increase in the bank's clearing balance contract at the time of the reduction indicated that payments activity, not statutory reserve requirements, had been determining the level of reserves held by the bank.

- The second change affected only banks that acquired another bank. Federal Reserve regulations permit an acquiring bank to "amortize" over eight quarters the reserve exemption amount and low-reserve tranche of the acquired bank.[17] For an acquirer with transaction deposits greater than the low-reserve tranche, the amortization reduces the acquirer's required reserves. If an acquirer did not reduce its holdings of reserves so as to match the reduced required reserves, we classified the bank as nonbound beginning in that maintenance period.

Finally, we also classified a bank as economically nonbound in a reserve-maintenance period if it is legally nonbound (that is, if its eligible vault cash exceeds its required reserves). Because some banks alternate between legally bound and nonbound, we modify this presumption by judgmentally smoothing changes in status.

Figure 2 compares two measures of RAM for 1991-93. One is based on our 1996 method, and the other on the method outlined above. The two measures, for all practical purposes, are the same.

RAM 1994-99

Deposit-sweeping activity by banks substantially complicates measuring RAM for 1994-99. To cope, we follow a three-step procedure. First, we identify the dates (reserve-maintenance periods) affected by new or expanded deposit-sweeping activity and estimate the amounts of transaction deposits relabeled as MMDA. Second, we classify each bank, for each reserve-maintenance period between January 1994 and December 1999, as economically bound or nonbound. This procedure is similar to our revised measure for RAM during 1991-93 and relies heavily on the observed response of the bank to changes in reserve-requirement ratios and the effects of implementing its deposit-sweeping software. Finally, we calculate RAM based on the framework of Cases 1, 2, 3, and 4 introduced above.

Sweep Dates and Amounts

Our first task is to identify the dates on which banks either began or changed their deposit-sweeping activity. Although the date of the first such deposit-sweep program is known (January 1994), banks are not required to notify the Federal Reserve when a program is implemented, expanded, or discontinued; nor are they required to report the amount of deposits affected.[18] To identify those dates when deposit-sweeping activity either began or was expanded, we visually analyzed time-series data for each bank. The variables examined were changes in the levels of transaction and savings deposits, changes in the size of a clearing-balance contract, and the ratios of vault cash and deposits at Federal Reserve Banks to transaction deposits.[19] For a typical bank, the data

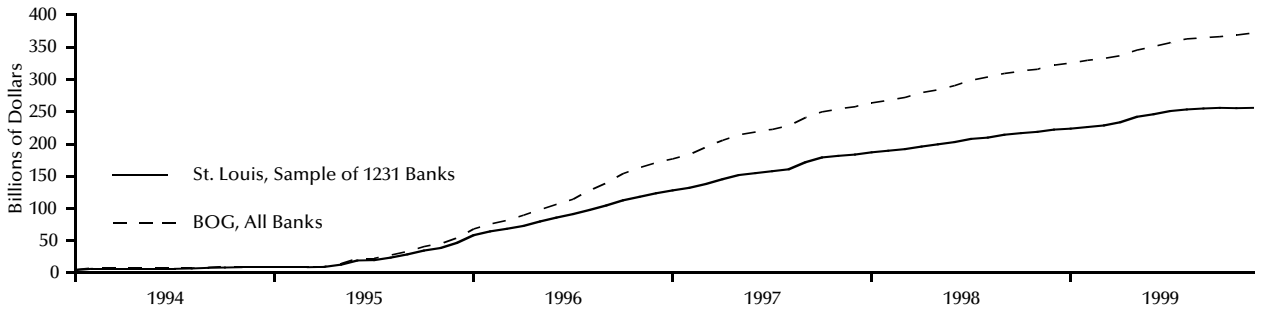
[17] Under Federal Reserve Regulation D, when a bank acquires another, the required reserves of the survivor are reduced by a *tranche loss adjustment*. The initial value of the adjustment equals the difference, during the reserve maintenance period immediately preceding the merger, between the required reserves of the survivor bank (computed as if the merger had been completed) and the required reserves of the acquired bank(s). The reduction is phased out over eight quarters: During the first quarter, the survivor's required reserves are reduced by seven eigths of the adjustment, during the next quarter by three quarters of the adjustment, etc.

[18] The staff of the Board of Governors maintains a database of sweep dates and amounts at individual banks, gleaned from deposit-report data and interviews with staff of individual banks. This database was not available for our research.

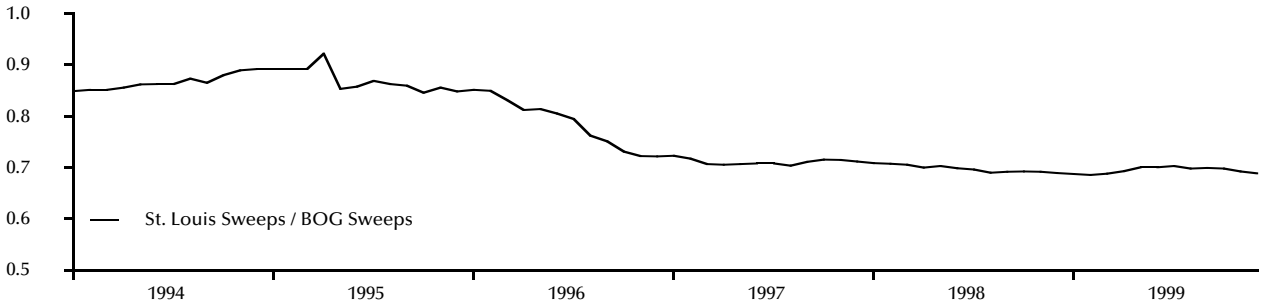
[19] We also experimented with statistical methods, including vector autoregressions containing transactions and savings deposits. The identification error rates from these methods, in our opinion, were unacceptably high.

Figure 3

A. Sweeps of Transaction Deposits into MMDAs



B. Ratio of St. Louis to Board of Governors (BOG) Staff Sweeps Estimates



signature of deposit-sweeping activity consists of two simultaneous changes:

- The level of transaction deposits decreases and the level of savings deposits increases, during the same reserve-maintenance period and by approximately the same dollar amount, while the bank's level of total deposits is approximately unchanged. It is important to condition the analysis on the level of total deposits because, in some cases, mergers of banks with different mixtures of deposits otherwise create false signals.
- The ratio of vault cash to reported transaction deposits (that is, transaction deposits not reclassified as MMDAs) increases sharply. This most likely occurs because the amount of vault cash held by a bank depends on its customers' *perceived* amount of transaction deposits, not the amount of reservable transaction deposits reported by the bank to the Federal Reserve.

For each so-identified maintenance period, our estimate of the amount of deposits affected is the smaller of the increase in savings deposits and (the absolute value of) the decrease in transaction deposits. For some identified periods, however, transaction deposits *increased*, savings deposits decreased, and the ratio of vault cash to transaction deposits fell. We interpret these changes to indicate that deposit sweeping was discontinued or reduced in amount. The amount of the change in deposit-sweeping activity is calculated as the negative of the above calculations, but is capped at the maximum amount that we estimate the bank previously had been sweeping.

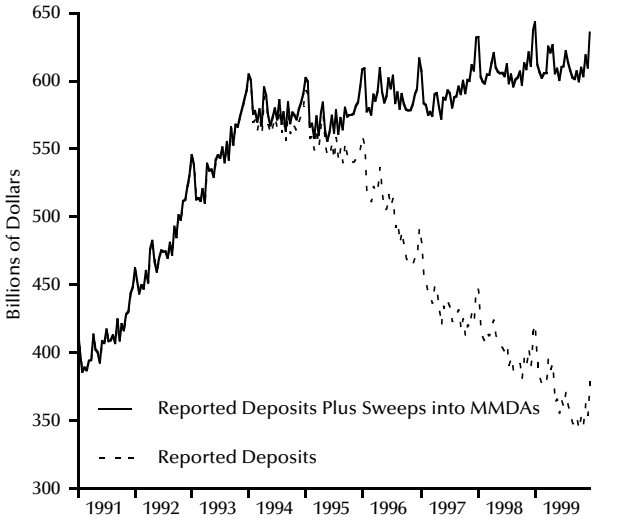
Results

Overall, we observed deposit-sweeping activity at 680 of the 1231 banks in our panel dataset.[20] Due to mergers, acquisitions, and liquidations, as of

[20] For 671 banks, we have identified specific reserve-maintenance periods in which we believe deposit-sweeping activity began or was expanded. For 9 banks, deposit-sweeping activity is inferred because they acquired other banks with deposit-sweeping activity. Among the 671 banks, there were 425 acquisitions of banks by others between January 1994 and December 1999. (This number includes acquired banks that later were acquired by others among the 671.) Bank mergers and acquisitions are handled by assuming that the acquirer continues to sweep the same amount of deposits as was being swept by the acquired bank.

Figure 4

Transaction Deposits



December 1999 our panel includes only 649 active banks. Of these, we estimate that 463 banks were operating deposit-sweeping software, affecting $255.9 billion of transaction deposits. Figure 3A shows estimates of the amount of deposit-sweeping activity at our panel of banks during 1994-99. For comparison, the figure also shows the Board of Governors staff's estimate of the amount of deposit-sweeping activity at all depository institutions. As of December 1999, the Board staff estimate is $371.8 billion. Figure 3B shows the ratio of the two estimates. Prior to mid-1995, the aggregate amount measured in our panel of banks is approximately 85 to 90 percent that of the Board staff's; since mid-1997, our measure has been approximately 65 to 70 percent of their total. The difference between the amounts may be due to one or more of three factors:

1. Deposit-Sweeping Programs at Smaller Banks. Our panel includes only 1231 banks, those which are relevant to measuring RAM; the Board staff's estimate seeks to include all banks. For our purpose—measuring the reduction in total and required reserves due to deposit-sweeping activity—the difference is unlikely to be important. Our previous analysis (Anderson and Rasche, 1996b) suggests that the smaller banks omitted from our panel are unlikely to change their holdings of reserves in response to a change in statutory reserve-requirement ratios.

2. Overlooked Deposit-Sweeping Programs. Repeated re-examinations of our data suggest that we have overlooked few, if any, banks within our sample that are operating deposit-sweeping programs. We have searched not only for the implementation of deposit-sweeping software but also for subsequent changes in the level of sweep activity.

3. Inaccurate Estimates of the Amount of Reclassified Deposits. Our estimated amounts are the smaller of the absolute values of the change in transaction and savings deposits, subject to caveats explained above. As a further check, we visually examined two ratios for each bank: vault cash (VC) divided by reported (reservable) transaction deposits (NT), VC/NT, and vault cash divided by the sum of net transaction deposits plus the estimated amounts of deposits reclassified as MMDA (SWP), VC/(NT + SWP). These data suggest that our estimates of the amounts being reclassified are quite accurate. The ratio VC/NT almost always increases sharply when deposit-sweeping activity begins or expands. On these same dates, the ratio VC/(NT + SWP) shows no such jumps.

Figure 4 displays total transaction deposits at the banks in our panel. The smaller series is the amount of transaction deposits reported by our panel of banks to the Federal Reserve, NT, and hence subject to statutory reserve requirements. The larger series is the sum of NT plus SWP. The difference, of course, is deposit-sweeping activity.

E-Bound Status

We emphasize that our purpose in this analysis is not to estimate either the total number of banks using deposit-sweep software or the total amount of deposits involved. Rather, we wish to identify how deposit-sweeping activity at economically bound banks has reduced the quantity of reserves held during each reserve maintenance period during 1994-99. The concept and calculation of RAM focuses on deposits, not on banks. It is the derived demand for reserves, arising from the level of deposits and the characteristics of the banks, that is of primary interest to us. Our next step, therefore, is to classify, for each biweekly reserve-maintenance period, a bank (and its

deposits) as either economically nonbound or economically bound. To do so, we visually analyzed time-series data, for individual banks, on a period-by-period basis from 1994-99. Similar to 1991-93, we believe that banks should not (and do not) alternate often between bound and nonbound status.

The most important indicator of the bank's bound and nonbound status is the change in its holdings of reserves, relative to the change in its required reserves.

- If a bank acquired another bank, did it make use of the reduction in required reserves as provided for by Federal Reserve regulations? If not, then the acquiring bank is revealed to be economically nonbound during those periods. In most cases, such a bank is classified as economically nonbound in all subsequent periods.
- If a bank implemented a sweep program, did its ratio of reserves to reported transaction deposits (after subtracting required reserves against the low-reserve tranche from the numerator and the deposit-amount of the low-reserve tranche from the denominator) increase above 10 percent? If so, the bank is revealed to be economically nonbound because it holds more reserves than is necessary to satisfy statutory reserve requirements. In most cases, such a bank is classified as economically nonbound for all subsequent periods.
- If a bank implemented a sweep program, did it increase its required clearing-balance contract? If so, the bank is revealed to be economically nonbound because it voluntarily increased its reserves above the amount necessary to satisfy legal requirements. In most cases, the bank is classified as economically nonbound for all subsequent periods unless it reduces or eliminates its clearing balance contract.
- If a bank implemented a sweep program, did its required reserves decrease below its vault cash (that is, did the bank become legally nonbound)? If so, the bank is revealed to be economically nonbound because the amount of vault cash necessary for its ordinary business exceeds its required reserves. The bank is classified as economically nonbound for all periods in which it is legally nonbound.

In general, if a bank is reclassified to economically nonbound from economically bound, it remains nonbound through to the end of the sample. We observed, however, that a few banks subsequently sharply reduced their excess reserves and began responding to changes in reserve requirements. Although the reasons for such changes in behavior are unknown to us, we reclassified these banks as economically bound beginning at the date of the change.

Banks that neither implemented a deposit-sweep program nor acquired another bank during 1994-99 experienced no change in their statutory required-reserve ratio. Hence, we use different criteria to classify these as economically bound or nonbound. For most banks, their status as of December 1993 is extended forward through December 1999. A bank's status might be changed if it significantly changes its level of excess reserves, enters into a clearing-balance contract, or experiences a major change in its level or mixture of deposits. In our sample, there are 551 such banks; 88 of these had their classification changed between January 1994 and December 1999.

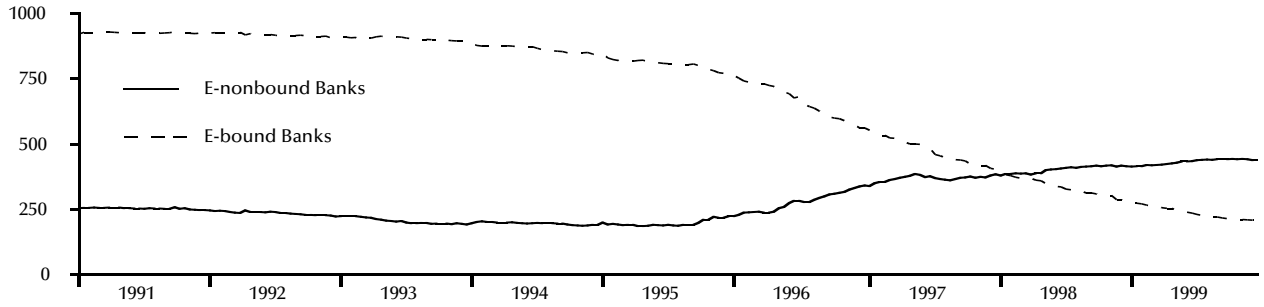
Figure 5 shows the numbers of banks in our panel classified as economically bound and nonbound and the amounts of their reservable transaction deposits. Changes in the numbers of banks should not be over-interpreted because of the large number of bank mergers and acquisitions since 1995. Regardless, the figure shows clearly that a major shift has occurred since deposit-sweeping computer software began to spread rapidly through the U.S. banking industry. In late 1994, for example, deposits in our panel's economically bound banks totaled approximately $500 billion, whereas deposits in economically nonbound banks were less than $100 billion. By late 1999, reported transaction deposits (subject to statutory reserve requirements) in economically bound banks totaled less than $100 billion, and reported transaction deposits in economically nonbound banks were approximately $250 billion.

Estimate *rr**

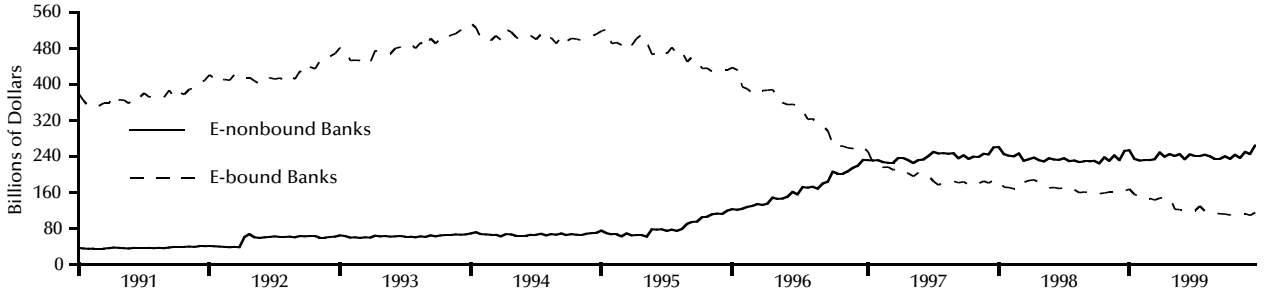
The above analysis allows us to classify each bank in our dataset, during each reserve-maintenance period, as being in Case 1, 2, 3, or 4. For those banks in Cases 1 and 2, RAM = 0. For those in Case 3, calculation of RAM is straightforward, as shown above. For banks in Case 4, it remains to estimate *rr**.

Figure 5

Number of Active Banks in Panel



Deposits



We remind the reader that rr^* does not equal the marginal reserve-requirement ratio against transaction deposits but, rather, is the smallest (counterfactual) reserve-requirement ratio for which

$$\left.\frac{\partial TR^D(D,rr)}{\partial rr}\right|_{\substack{D=D_t \\ rr=rr_t^*}} > 0 ,$$

when

$$\left.\frac{\partial TR^D(D,rr)}{\partial rr}\right|_{\substack{D=D_0 \\ rr=rr_0}} > 0 , \quad \left.\frac{\partial TR^D(D,rr)}{\partial rr}\right|_{\substack{D=D_t \\ rr=rr_t}} = 0 ,$$

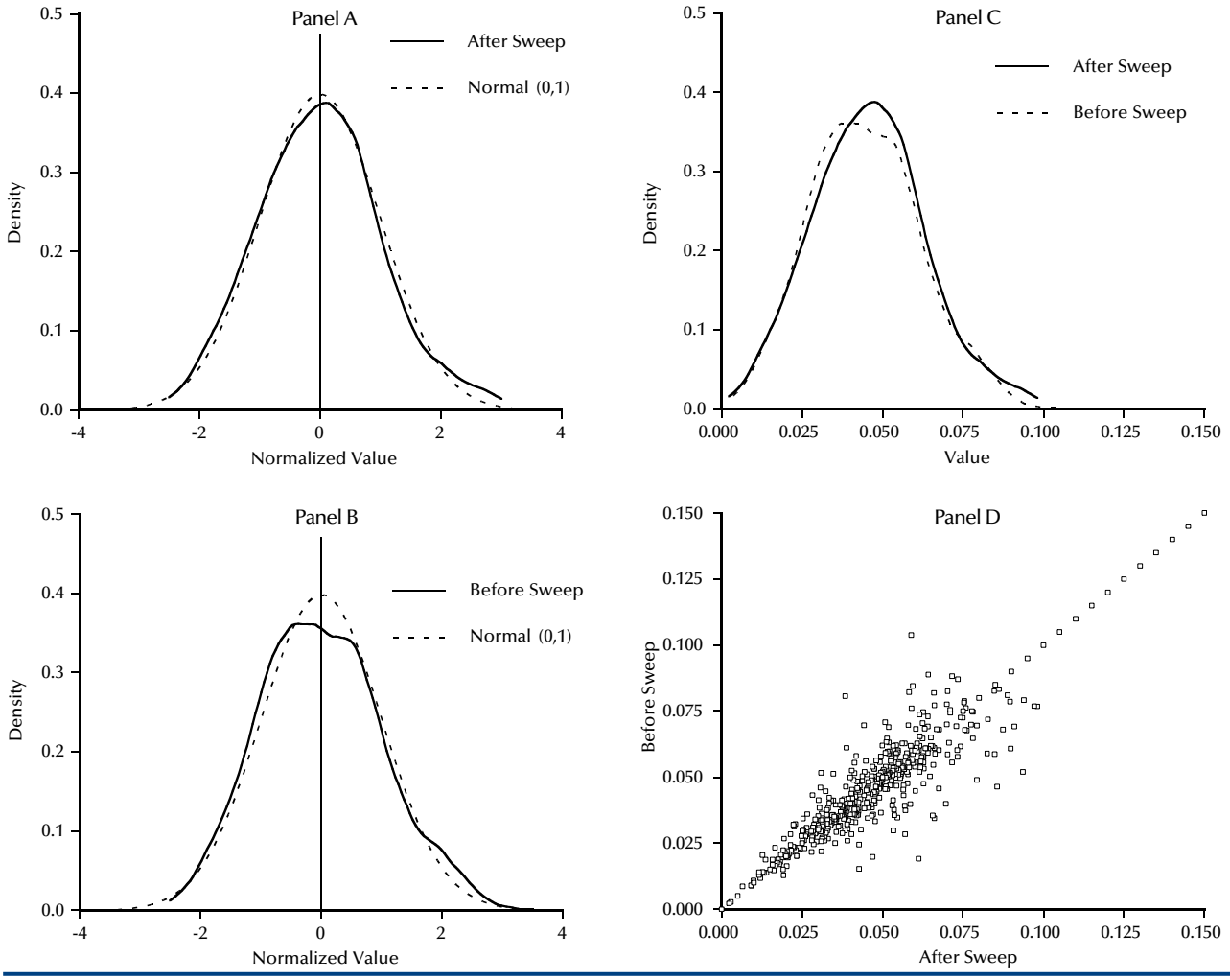
$rr_0 > rr_t$, and rr_0 and rr_t are, respectively, the base period and period t reserve-requirement ratios. In this case, $RAM_t = RR(D_t, rr_0) - RR(D_t, rr^*)$. An estimate of rr^* is calculated only once, for the maintenance period before the sweep activity that allows the bank to become economically nonbound. This mimics in spirit the pre-1994 Federal Reserve statutory regime in which reserve-requirement ratios changed by specific amounts at specific dates and then remained fixed at the new values until the next change. RAM is calculated for all subsequent periods in the dataset as if the calculated value for rr^* were the applicable statutory ratio.

In what follows, we treat rr_t and rr^* as ratios of reserves (vault cash, VC, plus deposits at Federal Reserve Banks, RB) divided by the sum (NT + SWP).[21] Complications regarding tiering (the reserve-exemption amount and low-reserve tranche) are omitted because all aspects of the statutory reserve requirement system, including tiering, are irrelevant to Case 4 banks. To estimate rr^*, recall that the amount of reserves held by an economically nonbound Case 4 bank is determined by its day-to-day business needs, not by statutory reserve requirements. Hence, the amount is less than the product of rr^* times the sum

[21] In this analysis, "RB" refers to total deposits held by banks at Federal Reserve Banks, including amounts held to satisfy clearing-balance contracts (line 25, Table 1.18, *Federal Reserve Bulletin,* August 2000). Note that this differs from the concept of reserve balances published by the Board of Governors staff, which equals deposits at Federal Reserve Banks minus the amount of clearing-balance contracts (line 1, Table 1.12, *Federal Reserve Bulletin,* August 2000). Also, "VC" includes all vault cash held by depository institutions. In Board of Governors' publications, total reserves includes only the amount of vault cash that is applied to satisfy statutory reserve requirements—any "surplus" amount is excluded.

Figure 6

Vault Cash/(Reported Net Transaction Deposits + Sweeps)
Banks E-bound Before to E-nonbound After Sweep, Obs=458



(NT + SWP):

$$VC + RB < (rr^*) \times (NT + SWP) \ .$$

Note that the opposite is true for an economically bound Case 3 bank where, at the margin, the amount of reserves is determined by the statutory reserve-requirement ratio rr_t: [22]

$$VC + RB \geq (rr_t) \times (NT + SWP) \ .$$

These two relationships are not sufficient, however, to provide an estimator for rr^*. To do so, we impose one additional condition: We assume that the amount of a bank's vault cash is determined by its day-to-day retail business needs and is not affected by statutory reserve requirements or deposit-sweeping activity. Conditional on this assumption, we examine separately the ratios VC/(NT + SWP) and RB/(NT + SWP). From these ratios, we infer upper and lower boundaries for rr^* and, thereafter, a value for rr^* itself.

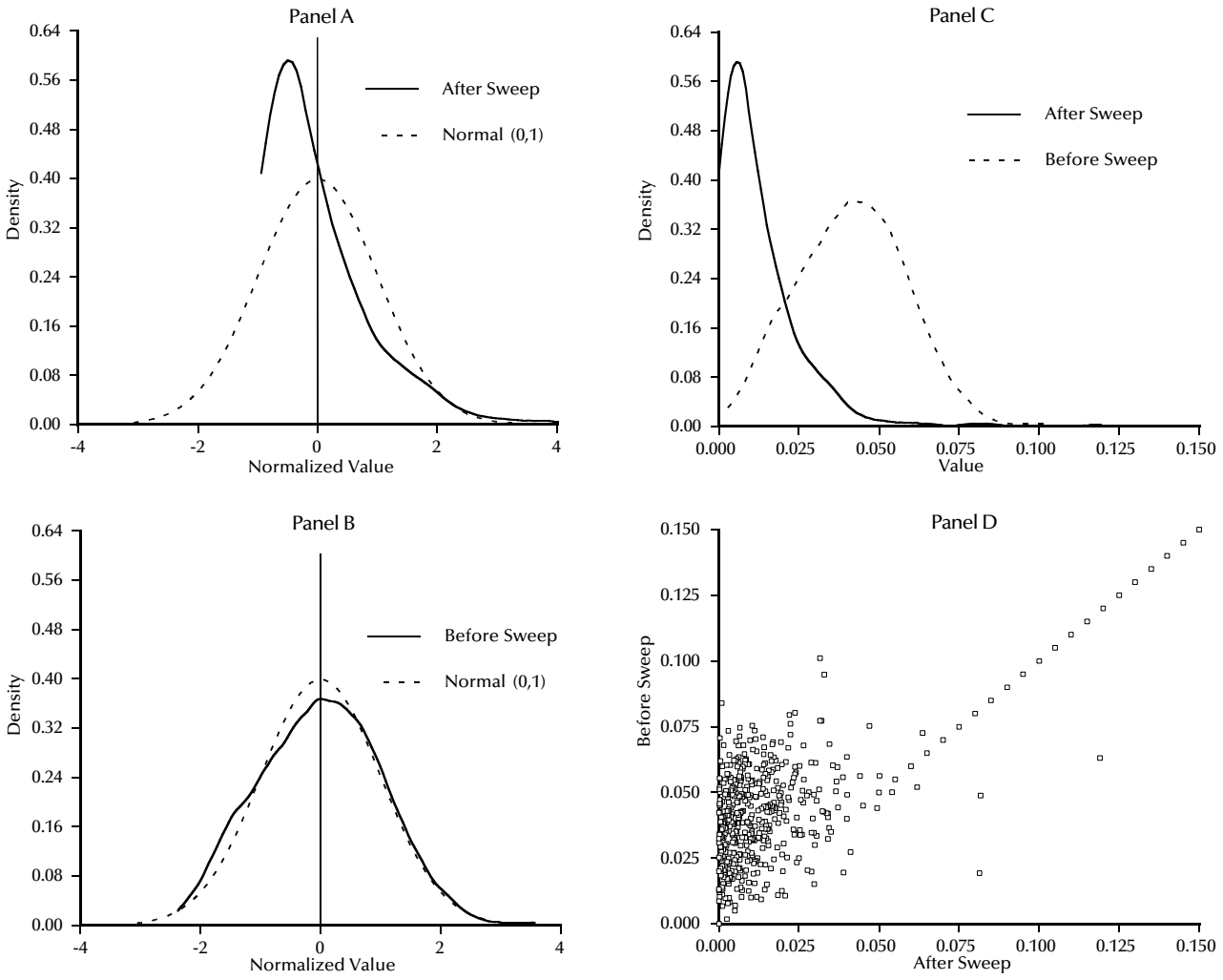
We begin by comparing the reserves held by banks before and after they implemented deposit-sweeping software. Selection of the appropriate "before" and "after" reserve-maintenance periods requires some judgement. Our data suggest that at many banks deposit-sweeping activity was phased-in during a number of reserve-

[22] This analysis ignores the carryover provision of Federal Reserve accounting. That provision allows a bank's required reserves during a reserve maintenance period to exceed the sum of its eligible vault cash and deposits at Federal Reserve Banks so long as the deficiency is offset (made up) during the following period.

Figure 7

Deposits at the Federal Reserve/(Reported Net Transaction Deposits + Sweeps)

Banks E-bound Before to E-nonbound After Sweep, Obs=458



maintenance periods. Also, we observed some banks increasing their sweep activity at later dates, often a year or more after the initial implementation.[23] For each deposit-sweeping bank, we visually searched the data to select the first ("before") reserve-maintenance and last ("after") reserve-maintenance periods affected by changes in the intensity of deposit-sweeping activity—that is, the period before sweep activity began and the period during which the bank's transaction and savings deposits later settled down to new levels or trends. We inferred from the ratios VC/(NT + SWP) and RB/(NT + SWP) whether the economically bound status of the bank was changed by implementation of deposit-sweeping software. We classified 458 banks that were economically bound before implementing deposit-sweeping software as economically nonbound after (Case 4); 155 banks that were economically bound before as remaining bound after (Case 3); 53 banks that were economically nonbound before as remaining nonbound after; and 2 banks that were economically nonbound before as bound after.[24]

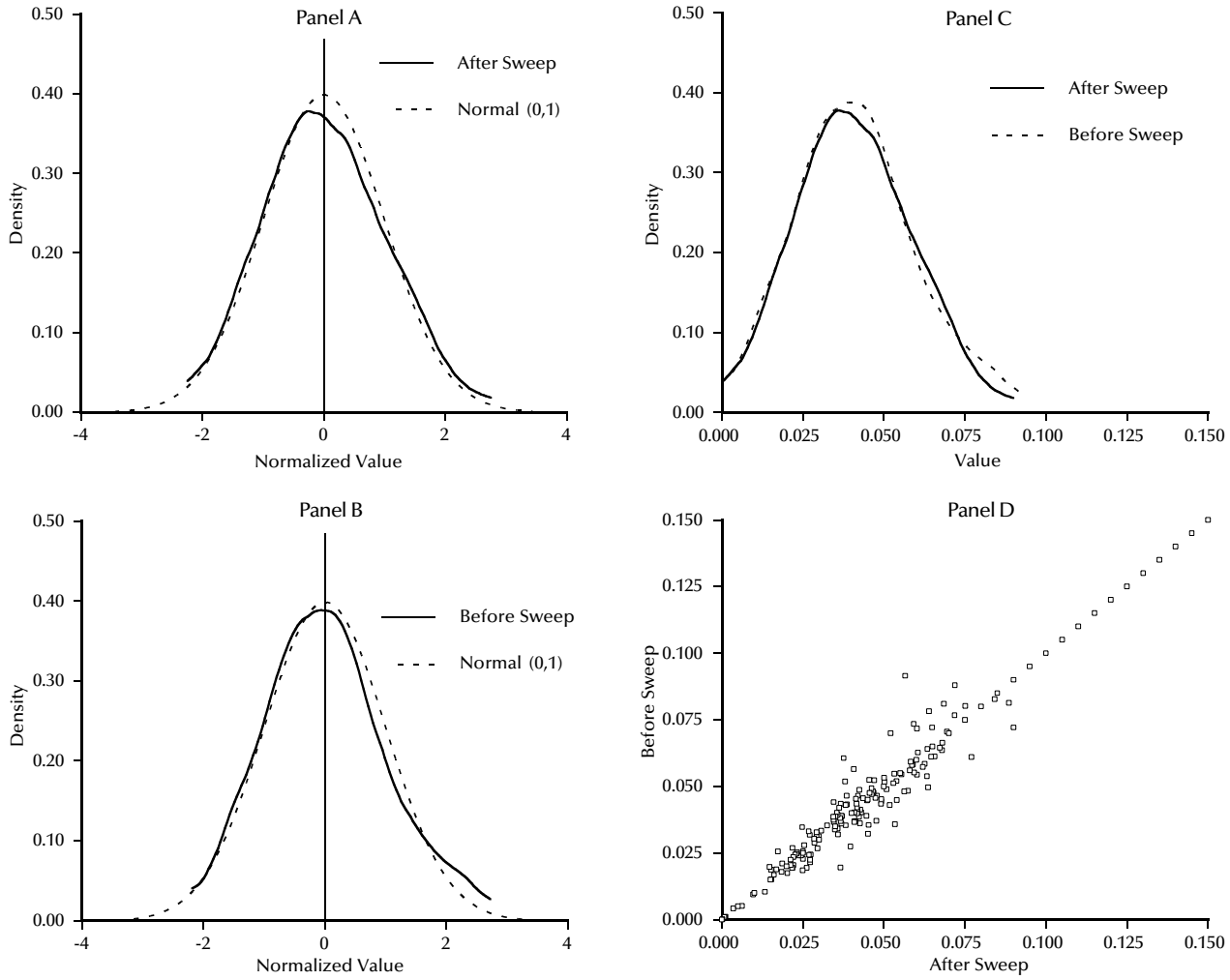
Data for the 458 banks that changed status

[23] The ongoing tuning and expansion of deposit-sweep programs is discussed in O'Sullivan (1998).

[24] Note that these banks differ with respect to the number of periods between the "before" and "after" dates, and the first and last periods in which data were reported. Twelve of the 680 identified sweeping banks are omitted (the figures in the text sum to 668) because data were not available for periods before and after the implementation of their sweep programs.

Figure 8

Vault Cash/(Reported Net Transaction Deposits + Sweeps)
Banks E-bound Before and After Sweep, Obs=155



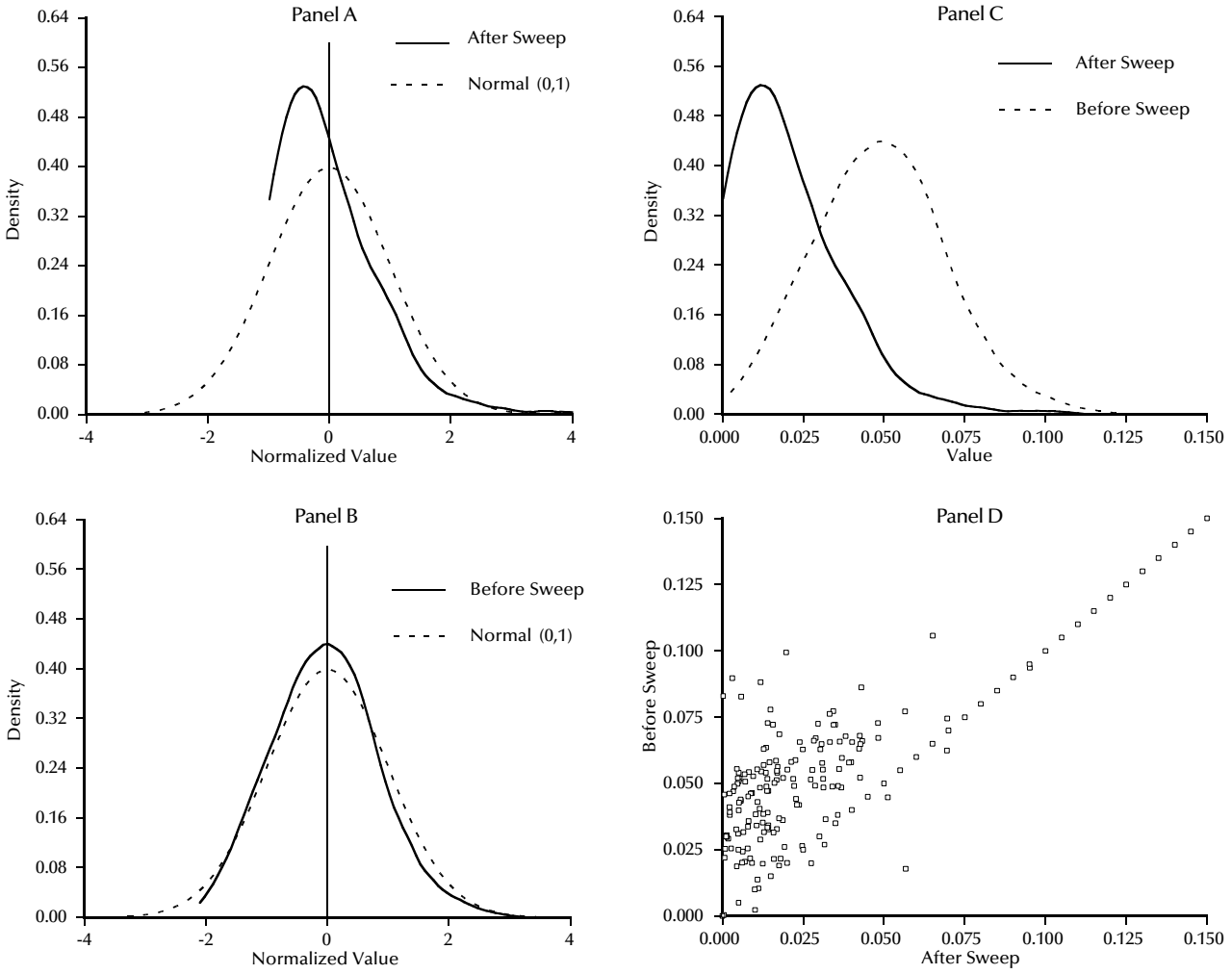
from economically bound to economically non-bound provide evidence for a lower boundary for *rr**. Scatter plots and smoothed density functions of the ratios VC/(NT + SWP) and RB/(NT + SWP) are shown in Figures 6 and 7, respectively, for the reserve-maintenance periods immediately before and after implementation of deposit-sweeping activity (the normal density is included for reference).[25]

- For vault cash, Figure 6, the *similarity* of the "before" and "after" distributions is striking. The means are approximately the same in both cases—4.5 percent for the "before" distribution and 4.6 percent for the "after" distribution—and the densities have similar dispersion. The Kolmogorov-Smirnov statistic fails to reject both the normality of the two distributions and their equality. For normality, the values of the test statistics are $(458)^{1/2} \times 0.0446 = 0.954$ for the "before" distribution and $(458)^{1/2} \times 0.0241 = 0.516$ for the "after" distribution. For equality, the value of the statistic is $[(458 \times 458)/(458 + 458)]^{1/2} \times 0.0611 = 0.925$. In all cases, the 5 percent critical value is 1.36.

[25] The densities are calculated by the RATS program KERNEL.SRC, which computes a nonparametric estimate of the unconditional distribution using the Epanechnikov kernel. We also have examined these ratios during the 5th, 10th, 15th, 20th, and 25th periods after the intensity of sweep activity stabilized. Those densities and scatter plots are nearly identical to the ones shown.

Figure 9

Deposits at the Federal Reserve/(Reported Net Transaction Deposits + Sweeps)
Banks E-bound Before and After Sweep, Obs=155



The Jarque-Bera test also suggests normality. Values of the statistic for the "before" and "after" distributions, respectively, are 5.54 (p-value 0.0628) and 4.89 (p-value 0.0866).

- For deposits at Federal Reserve Banks, Figure 7, the *difference* between the "before" and "after" distributions is striking.[26] The means differ: 4.2 percent for the "before" distribution and 1.2 percent for the "after" distribution (the median for the "after" distribution is 0.8 percent). The Kolmogorov-Smirnov statistic fails to reject normality of the "before" distribution, with a value of $(458)^{1/2} \times 0.031 = 0.663$. Normality of the "after" distribution is easily rejected, with a value of $(458)^{1/2} \times 0.173 = 3.70$. (In all cases, the 5 percent critical value is 1.36.) The Jarque-Bera statistic yields similar results for normality, with values of 2.03 (p-value 0.363) and 5059.7 (p-value of 0).

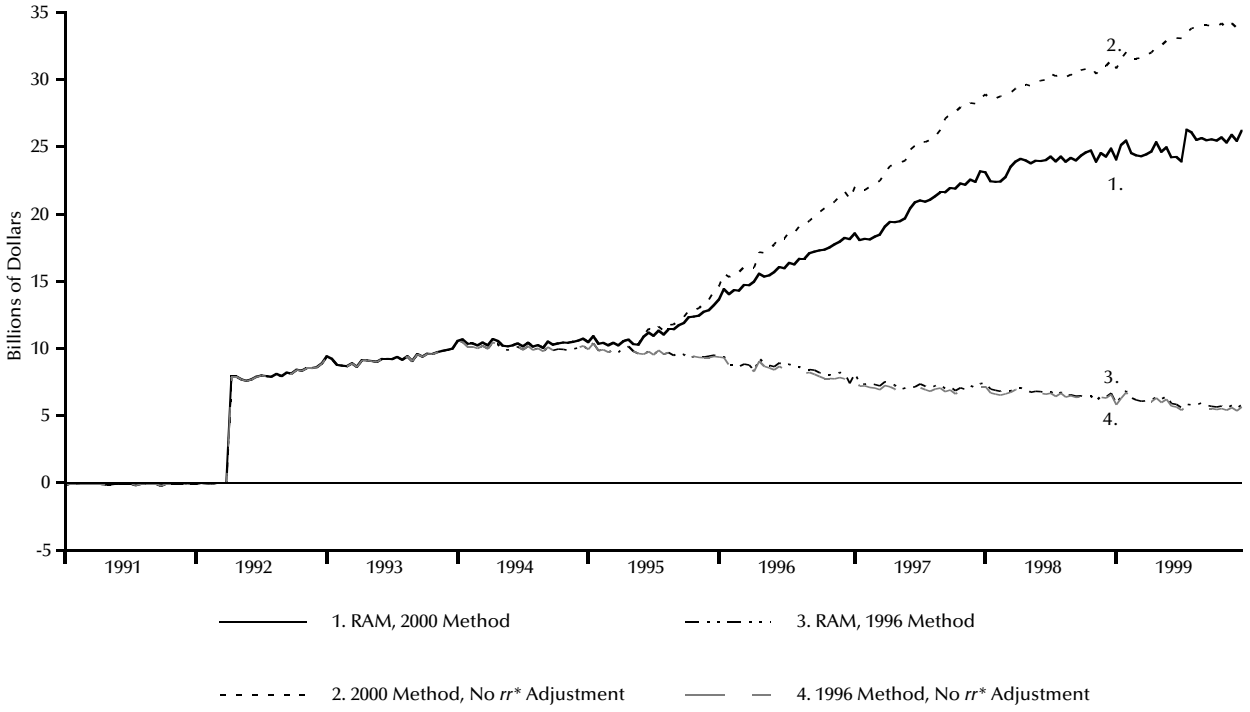
These distributions suggest that the mean of *rr** likely is not less than 5.8 (= 4.6 + 1.2) percent.

Data for the 155 economically bound banks that remained bound after implementing sweep programs provide evidence in favor of an upper boundary for *rr**. Scatter plots and smoothed density functions of the ratios VC/(NT + SWP) and

[26] Note that the inclusion of deposits at the Federal Reserve used to satisfy required clearing balance contracts gives the distributions thick right tails.

Figure 10

RAM, 1991-99



RB/(NT + SWP) are shown in Figures 8 and 9, respectively, for the reserve-maintenance periods immediately before and after implementation of deposit-sweeping activity.

- For the vault-cash ratio, the means of the "before" and "after" distributions are equal, at 4.1 percent. Normality of the distributions is not rejected, with Kolmogorov-Smirnov test statistics equal to 1.03 and 0.980, respectively, and equality is not rejected with a value of 0.040. (In all cases, the 5 percent critical value is 1.36.) The Jarque-Bera statistic also does not reject normality, with values of 2.04 (p-value 0.361) and 0.719 (p-value 0.698).
- For deposits at Federal Reserve Banks, the means of the "before" and "after" distributions are 5.0 and 2.1 percent, respectively. Normality of the "before" distribution is not rejected with a statistic of 1.11, but normality of the "after" distribution is rejected with a value of 1.74. Normality of both distributions is rejected by the Jarque-Bera statistic, however, with values of 1752.4 (p-value 0) and 4187.2 (p-value 0).

These data suggest that the mean of *rr** likely is not more than 6.2 (= 4.1 + 2.1) percent.

These statistics suggest that, in the absence of statutory reserve requirements, a typical bank in our sample likely would maintain approximately a 1 percent ratio of deposits at Federal Reserve Banks (including deposits used to satisfy clearing-balance contracts) to total net transaction deposits (including any amounts reclassified as MMDA). Hence, we conclude that a reasonable estimator for *rr** for a Case 4 bank is the sum of 1 percent plus the bank's vault-cash ratio during the reserve-maintenance period immediately before the period (or sequence of periods) during which the bank began (or changed the intensity of) its deposit-sweeping activity. Applying this rule to our sample of 680 identified sweeping banks, we estimate *rr** for 454 banks where, during the reserve-maintenance period immediately prior to beginning sweep activity, (i) the bank is classified as economically bound and (ii) the level of required reserves is less than the sum of vault cash plus 1 percent of transaction deposits plus sweeps:

$$\left.\frac{RR}{NT+SWP}\right|_{\tau} < \left.\frac{VC}{NT+SWP}\right|_{\tau} + 0.01 \ ,$$

where RR denotes the bank's required reserves, VC its vault cash, and SWP the estimated amount swept. The mean of these *rr** estimates is 5.79

FEDERAL RESERVE PUBLICATIONS AND DEPOSIT-SWEEP PROGRAMS

During the 1990s, Federal Reserve publications have documented the spread of deposit-sweeping software through the U.S. banking industry. The July 1994 Humphrey-Hawkins Act monetary-policy report introduced deposit-sweep programs in a single sentence. The July 1995 report noted that approximately $12 billion of deposits were involved in sweep activity and, as a result, that deposits at Federal Reserve Banks had decreased by about $1.2 billion. It also raised concern regarding an increase in federal funds rate volatility if deposits decreased further. The July 1996 report included a special appendix on the operation of sweep programs. The February 1997 report noted that the aggregate amount of deposits affected by sweep programs had increased to approximately $116 billion, compared with $45 billion in 1995. The July 1997 report noted the introduction of deposit-sweep programs for household demand deposits and noted that some banks were increasing the size of their clearing balance contracts when sweep programs reduced their required reserves. Subsequent reports have repeated these themes, along with an appeal that the Congress allow the Federal Reserve to pay interest on reserve balances (Meyer, 1998, 2000). In addition, deposit-sweep activity also has been highlighted in the annual reports of the Open Market Desk (see, for example, Hilton 1999, and Bennett and Hilton, 1997) and in the *Federal Reserve Bulletin* (Edwards, 1997).

percent, exactly the lower boundary discussed above, with a standard deviation of 1.96.

As of December 1999, after numerous mergers, our panel contained 649 active banks. Of these, 269 were classified as Case 4, 199 as Case 3, 60 as Case 2, and 121 as Case 1. The mean of the estimated *rr** for the 269 banks classified as Case 4 is 5.62 percent.

RAM

To illustrate the importance of our adjustments for deposit-sweeping activity and for banks falling below frictional levels of reserve demand (the *rr** correction, in Case 4), four alternative RAM series are shown in Figure 10.[27]

- Our preferred measure, which includes the effects of deposit-sweeping activity and *rr**, is labeled "1. RAM, 2000 method." This measure suggests that bank reserves in December 1999 were lower by $25.8 billion, relative to what might be expected in the absence of deposit-sweeping software.
- The series labeled "2." is the same calculation as "1." except that it ignores the *rr** adjustment. That is, it assumes for each bank that the amount of reserves freed by deposit-sweeping activity equals the reduction in required reserves. Our analysis shows, however, that deposit-sweeping software often is able to reduce a bank's required reserves to a level below the reserves necessary for the bank's day-to-day business. This measure suggests that banks' required reserves in December 1999 were lower by $34.1 billion, relative to what might be expected in the absence of such software.
- The series labeled "3." is RAM according to the method of Anderson and Rasche (1996b). This series ignores deposit-sweeping activity.
- The series labeled "4." is the same as "3." except that it adjusts for *rr**-type behavior. The very small difference between series "3." and "4." ($1.9 billion in December 1999) emphasizes that a correct RAM adjustment must include the effects of *interaction* between reductions in reserve requirements and banks realizing that their required reserves have fallen below the amount necessary for day-to-day business.

SUMMARY AND CONCLUSIONS

This analysis has examined the extraordinary

[27] These estimates differ from reserve measures published by the Federal Reserve Board. In that data, total and required reserves (adjusted for changes in reserve requirements and seasonal variation) both decreased from January 1994 to December 1999 by $19 billion. Note that the Board's measure does not include "surplus" vault cash, that is, vault cash held by depositories but not used to satisfy reserve requirements. The Board's measures also include an adjustment for the effect of changes in the low-reserve tranche between January 1995 and December 1999 of approximately $700 million (during this period, decreases in the size of the tranche increased required reserves).

unwinding of statutory reserve requirements in the United States since January 1994. Based on the statistical results in Anderson and Rasche (1996b), we selected a panel of 1231 banks whose demand for reserves likely is responsive to changes in statutory reserve requirements. For these banks, we estimate that deposit-sweeping activity has reduced required reserves in December 1999 by $34.1 billion. Adjusting for banks where the new lower level of required reserves is less than the bank's necessary day-to-day operating balances, we estimate that deposit-sweeping activity has reduced total bank reserves, as of December 1999, by $25.8 billion relative to the amount that would have been held in the absence of such activity.

Our analysis suggests that the willingness of bank regulators to permit use of deposit-sweeping software has made statutory reserve requirements a "voluntary constraint" for most banks. That is, with adequately intelligent software, many banks seem easily to be able to reduce their transaction deposits by a large enough amount that the level of their required reserves is less than the amount of reserves that they require for day-to-day operation of the bank. For these banks at least, the economic burden of statutory reserve requirements is zero.

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