

Intraday Management of Bank Reserves: The Effects of Caps and Fees on Daylight Overdrafts

Author(s): Diana Hancock and James A. Wilcox

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DIANA HANCOCK  
JAMES A. WILCOX

# Intraday Management of Bank Reserves: The Effects of Caps and Fees on Daylight Overdrafts

## 1. BACKGROUND AND POLICY ISSUES

EACH BUSINESS DAY, financial institutions in the United States electronically transfer funds to each other via two large-dollar electronic payments systems, CHIPS and Fedwire. CHIPS (Clearing House Interbank Payments System) is a private system operated by the New York Clearing House. Fedwire is operated by the Federal Reserve System and may be accessed directly by financial institutions that have reserve or clearing accounts with Federal Reserve Banks (hereafter referred to as "reserve accounts"). Although nonbank depository financial institutions such as savings and loan associations have direct access to Fedwire, the overwhelming number of direct Fedwire users are commercial banks. For simplicity, we refer to all institutions that use Fedwire as "banks." Fedwire also comprises a book-entry securities system for the electronic delivery of U.S. Treasury and agency securities against (electronic) payment for those securities. The book-entry securities system allows immediate and simultaneous delivery of securities and corresponding payment in immediately available funds.

Large-dollar electronic payments systems are an integral part of payments and clearing mechanisms in the United States. During 1994, for example, the dollar val-

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DIANA HANCOCK is senior economist at the Board of Governors of the Federal Reserve System. JAMES A. WILCOX is professor at the Haas School of Business at the University of California, Berkeley.

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ue of funds transferred over Fedwire and CHIPS was \$506 trillion—about seventy-five times GDP. Thus, on an average business day in 1994, more than \$2 trillion of payments were transmitted via these two systems. In addition, nearly \$145 trillion of government securities transfers were processed over the Fedwire book-entry system during 1994.

In recent decades, even while the banking industry was growing faster than real economic activity, the dollar value of funds transmitted via large-dollar electronic payments systems was growing relative to the size of banks. Panel a of Figure 1 plots the ratio of the annual averages of the daily value of electronic funds transfers to the stock of total bank liabilities.<sup>1</sup> Two decades ago, daily transfers were less than one-tenth as large as total bank liabilities. By the mid-1990s, the ratio had risen to seven times its value in the early 1970s.

Panel b of Figure 1 shows that over the same period, the sum of banks' reserve and clearing balances (hereafter referred to as reserve balances) at Federal Reserve Banks relative to their total liabilities fell markedly: After averaging close to 4 percent in the early 1970s, reserve balances as a proportion of liabilities averaged less than 1 percent by the mid-1990s. As a consequence, the value of banks' electronic payments relative to their reserve balances increased dramatically: By 1994, the ratio of the value of Fedwire transfers to reserve balances was about forty times its 1973 value (Figure 1, panel c).

As their reserve balances at the start of the business day (relative to their liabilities) decreased, banks became more and more likely to overdraw their reserve accounts during the business day by larger and larger amounts. Before 1994, the Federal Reserve System extended the resulting intraday credit to banks at no cost, which fostered various financial market practices that resulted in daylight overdrafts.<sup>2</sup>

By the early 1980s, banks' daylight overdrafts of their reserve accounts had become very large, and regulators recognized that at some point a very large bank might be unable to repay its unsecured, and possibly very large, overdraft. Figure 2 plots the real maximum aggregate daylight overdraft for each month February 1985 through September 1995.<sup>3</sup> During the period, the maximum aggregate value of daylight overdrafts grew as rapidly as the value of transfers, which in turn grew faster than the value of bank liabilities. Figure 2 also shows averages of the daily overdraft maximums and averages of overdrafts for those months. By the early 1990s, daily maximum aggregate overdrafts often exceeded \$150 billion and averaged about \$125 billion.

Since the late 1970s, Federal Reserve Regulation J has explicitly made funds transfers over Fedwire final (irrevocable) at the time a Federal Reserve Bank notifies

1. The solid line in Figure 1 may appreciably underestimate the dollar value of Fedwire funds transfers before 1987. Before 1987, Fedwire transfers were the sum of dollars sent inter-(Federal Reserve) District, dollars received inter-District, and dollars sent intra-District. We divided this sum by two to obtain an estimate of dollars transferred.

2. See Belton et al. (1987) and Humphrey (1989).

3. The aggregate overdraft at any moment is the sum of overdrafts across all institutions of their reserve accounts at the Federal Reserve Banks.

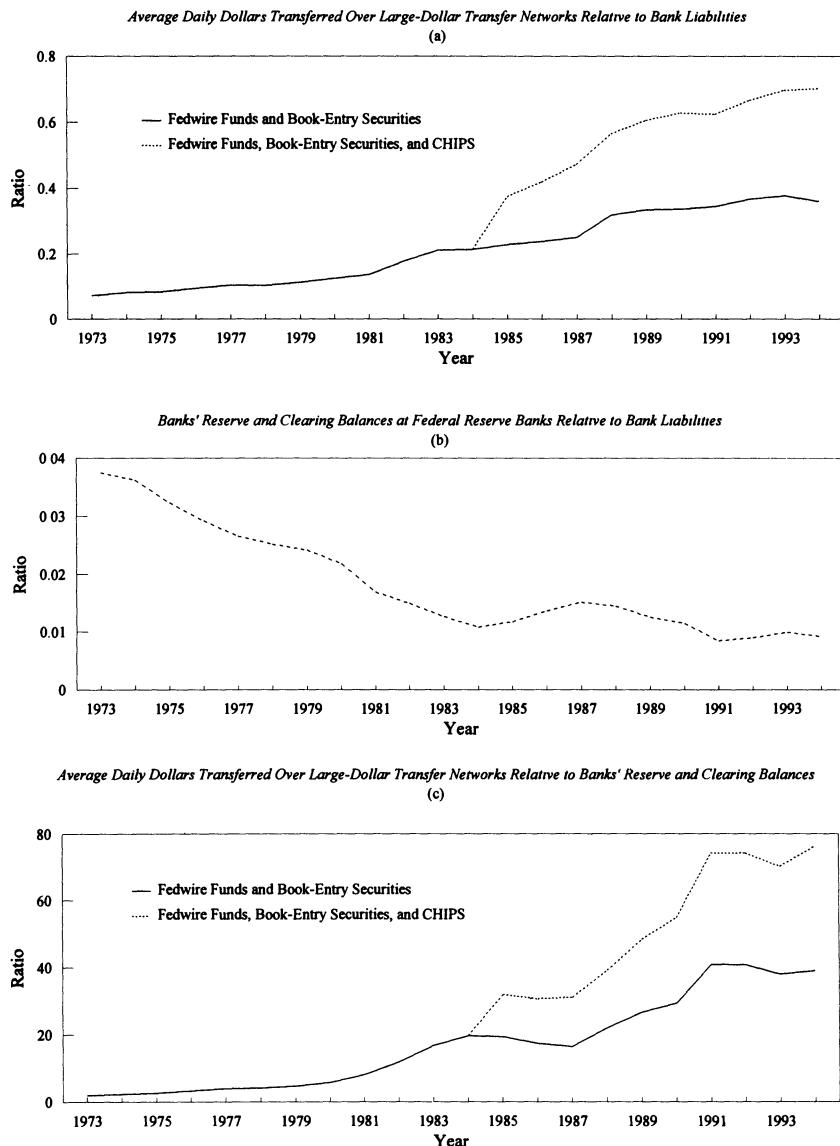


FIG. 1. Trends in Electronic Transfers and Bank Reserves

the receiving bank that a payment has been credited to its reserve account, regardless of whether the sending bank makes good on the payment request.<sup>4</sup> The daylight overdrafts in reserve accounts at the Federal Reserve Banks, particularly the uncollateralized overdrafts generated by Fedwire transfers, create credit risk that is borne by the Federal Reserve System. In addition, because CHIPS permits banks to extend

4. See Board of Governors of the Federal Reserve System (1995).

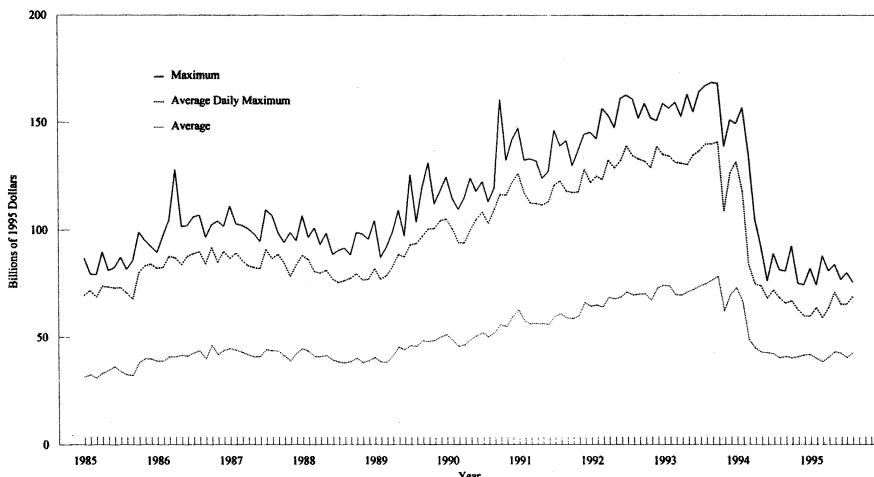


FIG. 2. Maximum, Average Daily Maximum, and Average Overdrafts (Monthly, February 1985–September 1995)

credit to one another, the use of CHIPS can expose participating banks to intraday credit risk.

The credit risks associated with daylight overdrafts led the Federal Reserve to impose limits, or caps, on daylight overdrafts starting in 1986 and to charge fees for daylight overdrafts starting in 1994. The caps put ceilings on banks' maximum daylight overdrafts. The fees, which in effect are interest charges on intraday credit, were intended to discourage overdrafting in general. Because credit via daylight overdrafts had previously been extended at no charge, the imposition of fees reduced a subsidy the Federal Reserve System had been providing to banks.

A goal of this study was to estimate whether, and by how much, the imposition of these caps and fees reduced daylight overdrafts. We begin by describing the evolution of Federal Reserve policies on daylight overdrafts. [For a recent report on daylight overdraft practices and policies, see Richards (1995).] We then model the payment operations of a large commercial bank. We next suggest some empirical implications of caps and fees for daylight overdrafts and assess whether the data for individual banks are consistent with those implications. Finally, we present regression estimates of the effects on aggregate daylight overdrafts of several factors in addition to caps and fees.

## 2. FEDERAL RESERVE POLICIES ON DAYLIGHT OVERDRAFTS

Federal Reserve policies on daylight overdrafts of banks' reserve accounts at Federal Reserve Banks in connection with payment system risk can be separated into three regimes: In Regime A, daylight overdrafts were unfettered by either caps or fees; in Regime B, daylight overdrafts were subject to caps but not to fees; and in Regime C, daylight overdrafts were subject to both caps and fees (see Figure 3).

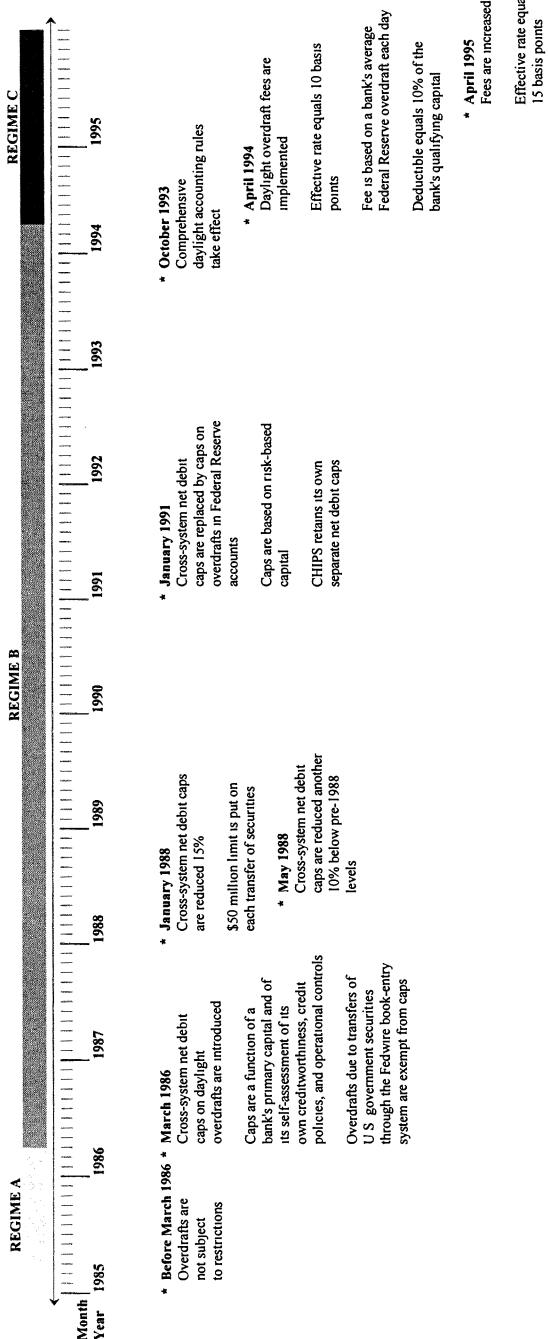


FIG. 3. Timeline for the Federal Reserve's Payment Systems Risk Policies

### *Regime A*

Daylight overdrafts were not normally subject to Federal Reserve restrictions until October 1985, when the Federal Reserve began to require that *private* large-dollar transfer networks establish limits on the dollar amount of daylight credit that each bank could obtain at any moment from any other single bank (bilateral credit limits).<sup>5</sup> However, overdrafts on Fedwire did not come under restriction until March 1986, when the first caps were imposed.

Consistent data for the period before February 1985 were not available. Thus, the portion of Regime A included in our study was the period February 1985 through February 1986.

### *Regime B*

Regime B, which accounted for about 90 percent of our sample period, was in effect from March 1986 until (mid-)April 1994, when the Federal Reserve began to charge fees on daylight overdrafts. Near the end of March 1986, the Federal Reserve began to require that each bank establish for itself a maximum (cap) for the sum of the amounts of daylight credit it could be extended at any moment on Fedwire and private large-dollar payments systems (cross-system net debit caps). The maximum was a function of the bank's primary capital and its self-assessment of its own creditworthiness, credit policies, and operational controls. Overdrafts due to transfers of U.S. government securities via the Fedwire book-entry system were exempt from these cross-system net debit caps.

The formula for setting the cross-system net debit caps changed several times during this regime. In January 1988, the Federal Reserve lowered the caps by 15 percent and imposed a \$50 million limit for each transfer of securities. In May 1988, the caps were lowered another 10 percent below their pre-1988 levels.

In January 1991, cross-system net debit caps were replaced by caps on daylight overdrafts in Federal Reserve accounts. The Federal Reserve account caps limited the sum, at any time, of daylight overdrafts attributable to funds transfers and to transfers of securities via the book-entry system.<sup>6</sup> The caps were set at levels similar to the levels of the earlier cross-system caps. CHIPS retained its own separate net debit caps.

Including the overdrafts attributable to securities transfers in the amount subject to caps effectively reduced the total amount of overdrafting permitted under the caps. On the other hand, applying the caps, which were set at about the same level as the former cross-system caps, only to the overdrafts in Federal Reserve accounts (rather than to cross-system net debits) effectively increased banks' ability to over-draft their reserve accounts. Banks that had overdrafts related to securities transfers probably faced overdraft caps that were effectively lowered, whereas banks that had sizable caps on CHIPS probably faced caps that were effectively raised.

5. See Belton et al. (1987).

6. A depository institution may have two different cap multiples, one for its maximum allowable overdraft on any day ("single-day cap") and one for the maximum allowable average of its peak daily overdrafts over each two-week reserve maintenance period ("two-week average cap").

A bank that incurred an overdraft in excess of its cap was subject to a series of disciplinary administrative actions that depended both on the size and frequency of the violation and on the financial condition of the bank. In addition, a bank that was a “frequent and material” securities-related overdrafter was required to collateralize the entire amount of its overdraft attributable to securities-related transfers.

In October 1993, the debiting of banks’ reserve accounts for check clearing and other non-Fedwire payment activity in effect began to take place earlier in the business day, thereby increasing overdrafts.

### *Regime C*

Regime C began in April 1994 and remained in effect at the end of our sample period in September 1995. On April 14, 1994, the Federal Reserve began to charge a fee on daylight overdrafts. For a year the fee was an annual rate of ten basis points; on April 13, 1995, the fee was raised to fifteen basis points. The fee is based on a bank’s *average* Federal Reserve overdraft each day, which is calculated by summing the (absolute value of) negative balances in its Federal Reserve account(s) at the end of each of the 601 minutes of the standard operating day and dividing the total by 601. Because positive balances are, in effect, set to zero in this calculation, larger positive balances do not reduce average overdrafts any more than smaller ones do. The fee is applied to each day’s average overdraft less the bank’s deductible, which is equal to 10 percent of the bank’s qualifying capital.<sup>7</sup>

### 3. INTRADAY MANAGEMENT OF BANK RESERVES

During the day, payment requests and receipts that are exogenous to a bank, such as check clearings, loan takedowns, securities deliveries, and third-party wire transfers, affect the bank’s reserve account.<sup>8</sup> Intraday management of reserves at a large commercial bank is coordinated among employees in the corporate treasury, at the money desk, and in the funds transfer operational areas. For convenience we refer to the actions of a “reserves manager” at a bank. We assume that the reserves manager seeks to minimize the sum of the (expected, discounted) costs of satisfying reserve requirements over two-week reserve maintenance periods and the costs incurred daily that are attributable to making payments on behalf of customers and payments related to the bank’s own accounts, such as its trading accounts. As detailed below, the reserves manager (or a computer program) chooses the times at which to dis-

7. The deductible is intended to provide liquidity to the payment system by allowing for some overdrafting that does not incur fees, and also to compensate for overdrafts caused by computer outages at Reserve Banks. As a result of the deductible, most banks that have daylight overdrafts do not actually incur fees. Fees of less than \$25 incurred during any two-week reserve maintenance period are waived. A bank’s qualifying capital is the sum of its tier 1 capital and its eligible tier 2 capital as defined by the risk-based capital guidelines.

8. Intraday balances are affected by the times that debits and credits are made to a bank’s reserve account. Posting times vary by type of transfer. Fedwire funds and book-entry securities transfers are posted as soon as they occur. Checks, ACH, and other transactions processed by the Federal Reserve are posted at predetermined times during the day.

burse the payments ordered by customers and the bank's other departments and the amounts and times at which to acquire or disburse reserves.

### *Interday and Intraday Management of Reserves*

A bank is required to hold a minimum level of reserves on average over a two-week reserve maintenance period; the level is based on the bank's deposit liabilities. Only the end-of-day balances in the bank's reserve account count toward satisfying reserve requirements. The reserves manager is likely to determine the expected path of end-of-day reserve balances (and thus the next day's opening balance) for the remaining days in the reserve maintenance period before mapping out the day's intraday reserve position. In practice, the sequence of intraday shocks that actually occurs to the reserve account may persuade the manager either to let the end-of-day reserve balance differ from the end-of-day target or to conduct transactions at or near the end of the day to move the reserve balance nearer to that target. If these alternatives are not very costly, the reserves manager may, in conducting intraday operations, be little influenced by the end-of-day target. Although the intraday management of the bank's reserve account may not be completely separable from the management of its end-of-day balances across days, we consider that separation to be a reasonable approximation to how reserves managers act.

A bank's reserve balance changes over the course of the day both because of shocks to the reserve account that are exogenous to the reserves manager and because of actions taken by the reserves manager. We assume that the reserves manager takes as exogenous the purchases and sales of securities by the trading arm of the bank. Thus, the exogenous shocks to the reserve account are the payments made into the accounts of the bank's customers and the payments sent and received as a result of the bank's purchases and sales of financial instruments. Some of these exogenous shocks stem from actions by the bank and its customers, and others from actions by other banks and their customers.

### *Adjusting Intraday Reserve Balances*

The reserves manager can affect the bank's reserve balance during the day in several ways. First, the manager might disburse requested payments less quickly than they could be physically or electronically processed. Delaying payments until later during the same business day, after payments have been received, keeps the bank's reserve balance higher than it otherwise would be. To the extent that payments are queued until they can be made without producing daylight overdrafts, delaying payments implies smaller average overdrafts.

The reserves manager can also purchase and sell federal funds throughout the day. The earlier in the day they are purchased, the sooner the funds are likely to be delivered. Many banks have ongoing relations with their suppliers of federal funds. Because the suppliers typically have reserve balances that are sufficiently positive that daylight overdrafts and caps are not imposing costs on them, they are likely to be willing to deliver funds earlier, when funds demanders request that they do so. To

the extent that funds are transferred over CHIPS, earlier purchases of funds tend to generate earlier delivery because CHIPS procedures require banks to process certain fractions of their daily payments by specified times of day.

Finally, the reserves manager can affect the intraday timing of reserve inflows by timing purchases and sales of securities. Under the delivery-versus-payment system, delivering sold securities via Fedwire triggers a simultaneous transfer of reserves to the bank that sold the securities. Thus, by delivering securities that the bank has sold, the reserves manager can elicit a corresponding inflow of reserves.

#### 4. MINIMIZING INTRADAY COSTS

In managing the bank's intraday reserve balance, the reserves manager attempts to minimize the sum of its costs in up to four categories—transactions costs, postponement costs, cap costs, and daylight overdraft fees. Each daylight overdraft regime is distinguished by the costs that it imposed on banks. In Regime A, banks faced only transactions and postponement costs. Regime B added cap costs, and Regime C added fees for daylight overdrafts. In the following discussion of these costs, we treat the number and value of transactions required by a bank's customers and its trading department as exogenous to the reserves manager.

##### *Transactions Costs*

A bank incurs transactions costs when it adjusts its reserve balance by buying or selling federal funds or securities. Selling securities or buying federal funds raises the reserve balance; buying securities or selling federal funds lowers it.

A bank's cost of adjusting its reserve balance via a Fedwire transaction has both fixed and variable components. Examples of fixed per-transaction costs include Fedwire transfer fees, which are the same regardless of the size of the transfer, and the costs associated with using on-line information screens to ascertain prevailing interest rates on federal funds and with arranging for a federal funds purchase or sale. Examples of variable costs are brokers' commissions on federal funds and securities transactions.<sup>9</sup>

##### *Postponement Costs*

A bank is likely to incur implicit costs to the extent that it postpones until later the same-day payments that its customers have requested. It is likely that customers prefer that payments be made promptly after they have been requested. Moreover, the longer the postponement of payment, the more likely it is that a technical processing problem will prevent the payment's being made the same day that it was requested. Delaying payment overnight, that is, a "fail," would likely entail explicit and implicit costs to the bank: The bank might reimburse the customer for one day's inter-

9. The typical broker's variable fee for federal funds transactions is \$0.50 per million for purchases or sales (see Stigum 1988 and Meulendyke 1989).

est on the amount that was sent one day after it was requested, and if it did not incur that explicit cost, it might suffer the implicit cost of damage to its relationship with the customer. Thus, waiting to send payments until late in the day may entail higher expected costs because of the greater probability that a payment will not get delivered that day. These postponement costs are likely to be related to the dollar value of funds payments delayed and the length of time each was delayed.

### *Cap Costs*

A bank is expected to prevent the daylight overdrafts of its reserve account from exceeding the amount at which it had been capped. In practice, violations of the cap do occur. Over the twelve months following the imposition of fees for daylight overdrafts, for example, an average of approximately 650 banks out of the approximately 10,000 commercial banks in the United States exceeded their overdraft caps in each two-week reserve maintenance period.<sup>10</sup> Similar numbers of banks apparently violated their caps before then. Thus, we regard the cap policy as a penalty function rather than a rigid constraint. The cap can be breached, but only at a cost to the bank. The cost of exceeding the cap is that the bank will incur increasingly severe penalties for violations. In extreme cases, repeated breaches of cap policies may lead to the cap's being lowered or set at zero.

### *Daylight Overdraft Fees*

Since April 1994, a bank has been charged a fee when the *intraday average* of the overdrafts of its reserve account exceeds a prespecified level, or deductible. Each bank's deductible equals 10 percent of its qualifying capital. The Federal Reserve currently charges a fee at an effective annual rate of 0.15 percent (fifteen basis points) on the excess of the bank's intraday average overdraft over its deductible.<sup>11</sup> Thus, the penalty incurred by the bank is proportional to the deviation of its average daily daylight overdraft from its deductible. To calculate the average overdraft, the Federal Reserve measures the bank's reserve balance at the end of each of the 601 minutes each day that the Fedwire funds transfer system is in operation.

## 5. IMPLICATIONS OF DIFFERENT REGIMES FOR DAYLIGHT OVERDRAFTS

Each regime presents different empirical implications for daylight overdrafts. To assess whether the data for individual banks are consistent with those implications, we looked at a sample of "large overdrafters," the 150 banks that on January 12, 1993, had the largest total of funds-related plus securities-related overdrafts. This group of banks is a subset of the group later used to analyze aggregate behavior. Therefore, the following description of data applies to the analyses in both this section and in the later section describing regression results for the aggregate data.

10. See Richards (1995).

11. The effective annual rate is based on a ten-hour Fedwire operating day.

### *Data for Individual Banks*

Since December 1984 the Federal Reserve System has, for each depository institution, collected intraday data for daylight credit extended on all large-dollar payment systems.<sup>12</sup> We used intraday daylight credit data for the period February 1985 through September 1995. Our data set for each bank included the bank's cross-system net debit cap each day from March 1986 through January 1991 and its Fed-wire overdraft cap each day after that. Until October 1993, intraday balances were recorded forty-five times daily, at fifteen-minute intervals from 8:30 A.M. to 6:30 P.M.; since then, these balances have been tallied each minute.

The Federal Reserve disaggregates each bank's reserve account into two components, or subaccounts. Each bank's "securities" balance is arbitrarily set to open each day with a value of zero; debits and credits associated with book-entry-securities transactions accumulate in that subaccount. Each bank's "funds" balance is arbitrarily set to open with a value equal to the bank's entire reserve balance at its Federal Reserve Bank; debits and credits associated with non-book-entry transactions—funds transfers, and check, ACH, and other payment transactions—accumulate in this subaccount. The sum of the funds and securities balances is the bank's reserve balance at its Federal Reserve Bank. The Federal Reserve also receives information on the bank's net debits and net credits on CHIPS.

### *Regime A*

In Regime A, a bank's daylight overdrafts were not subject to caps or fees; therefore, minimizing the sum of transactions costs and the implicit and explicit costs of postponing payments minimized total costs during this regime. Banks not concerned with daylight overdraft caps or fees would not incur the transactions costs associated with acquiring reserves for the purpose of reducing their daylight overdrafts. Thus, banks minimized total costs by sending payments as soon as they were requested, allowing overdrafts to evolve unfettered. Data from Regime A provide a benchmark against which to measure the effects of the policies instituted during Regimes B and C.

### *Regime B*

During Regime B, a bank was subject to the costs associated with the cap on its daylight overdrafts in addition to transactions and postponement costs. In this case, were it not for the costs associated with postponing payments, a bank could minimize its costs by waiting until the end of the day to send funds. Because a bank generally opened the day with a positive reserve balance, postponing payments would avoid violation of the daylight overdraft cap and would eliminate all cap-related costs to the bank. We assumed that either the (expected) costs associated with the postponement of payments or the marginal transactions costs were large enough to preclude this "last-minute" strategy from being optimal.<sup>13</sup>

12. See Belton et al. (1987).

13. It may also be the case that risk aversion on the part of the reserves manager would preclude waiting until the end of the day to make the transactions that would move the reserve balance to its target.

Because there may be no appreciable actual or opportunity costs associated with holding positive reserve balances or with overdrawing amounts less than the cap amount during the day, a one-sided policy for the bank's intraday reserve balance may be optimal (see Scarf 1960). This policy specifies a floor ( $u$ ) on the bank's reserve balance and a return point ( $U$ ), the level to which the balance rises after falling to or through the floor. If the balance is at the floor, the difference between the return point and the floor is the amount of the reserves purchase. Eppen and Fama (1968, 1969) demonstrate that the lower the fixed cost per transaction, the smaller the difference between the return point and the floor and the more frequent the transactions. Penttinen (1991) demonstrates, not surprisingly, that the optimal floor on the intraday reserve balance falls as the volatility of exogenous payment flows falls, rises as the marginal cost of exceeding the daylight overdraft cap rises, and falls as per-transaction fees rise.

To the extent that a bank followed a  $(u, U)$  policy during Regime B, the distribution of readings of its reserve balance over the course of a day would be expected to be more skewed during Regime B than during Regime A, when no cap was in place. Panel a of Figure 4 shows how a bank's reserve balances measured each fifteen minutes over the course of a day might have been distributed during Regime A and panel b shows how they might have been distributed during Regime B if the bank had followed a  $(u, U)$  policy. Imposition of an internally determined floor ( $u$ ) and a return point ( $U$ ) by the bank on its reserve balance effectively changes the observed distribution of reserve balances, moving some of the area in the tail of the original distribution that was left of the floor ( $u$ ) rightward to the region around the return point ( $U$ ). Qualitatively similar results would be expected for readings taken at the same time of day on different days.

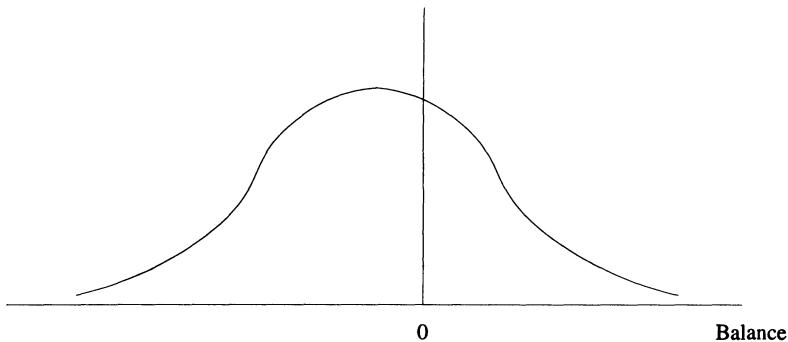
Imposition of or lowering of a cap on daylight overdrafts, which operates like an externally imposed floor on reserve balances, also seems likely to extend the period of time during which the bank is near its maximum daylight overdraft value for the day. When the bank is near its daylight overdraft cap, it is likely to have a queue of postponed payments. Additional payment requests are also likely to be postponed in order to keep overdrafts from becoming larger. Once overdrafts are near the cap (or some other internally determined level), reserve inflows are likely to engender similar-sized payments. As a consequence, overdrafts may hover near their regulatory or internally determined cap levels for extended periods. Thus, the lower the daylight overdraft cap, the longer the time that daylight overdrafts are likely to remain in the vicinity of their maximum value. This reinforces the likelihood that a binding overdraft cap would increase the skewness of reserve balances. As a result, the left tail of the distribution of reserve balances would be more like that in panel b than that in panel a of Figure 4.<sup>14</sup>

We looked at the distributions of individual banks' intraday reserve balances to see if they changed when the caps that applied to banks' overdrafts changed. Figure 5 plots the distributions of the intraday reserve balances for the three banks (in our

14. Cap policy may have been designed so that caps had little immediate effect but would become binding if overdrafts continued to grow. The data in Figure 4 focus only on the immediate effects of the changes in cap policies.

(a)

Hypothesized Distribution of a Bank's Intraday Reserve Balance Before Overdraft Cap Implementation



(b)

Hypothesized Distribution of a Bank's Intraday Reserve Balance After Overdraft Cap Implementation

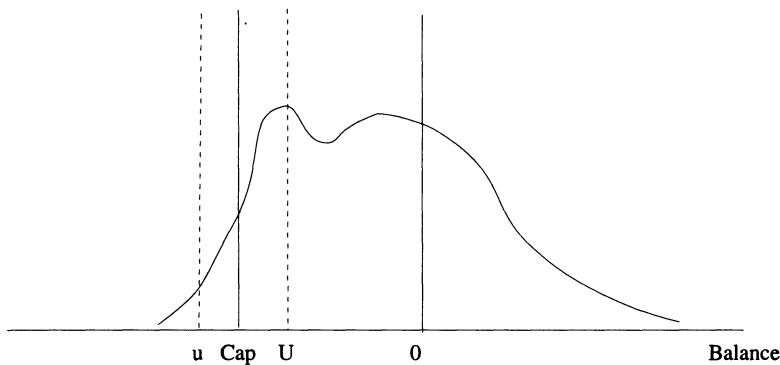


FIG. 4. The Effects of an Overdraft Cap on a Bank's Reserve Balance. The bank's floor on the reserve balance is denoted by  $u$ , and the return point, or level to which the balance rises upon falling to or through the floor, is denoted by  $U$ .

sample of 150 banks) whose average maximum overdrafts in the month before each change in overdraft cap policy were largest relative to the overdraft caps that applied to them in the month after the change.<sup>15</sup> The data are for the months just before and after the 1986 change and the two 1988 changes in overdraft caps. For each month, the data include readings of each bank's balance forty-five times each business day. Each bank's balances were standardized by subtracting the average balance in the month prior to the cap policy change and dividing by the standard deviation of the

15. This sample size was the smallest that ensures the confidentiality of each individual bank's data. The data used in Figure 5 were not merger-adjusted because none of the three banks merged during any of these three-month periods.

banks' balances. Until 1991, overdraft caps were applied to the sum of the bank's net debit position on CHIPS and its overdraft in its Fedwire funds transfer sub-account. Therefore, Figure 5 shows the distributions of the sums of these two balances.

Using standardized data makes it possible to see changes in the mean and in the skewness of the banks' overdrafts over time.<sup>16</sup> If the balance data were distributed symmetrically around some point, the coefficient of skewness would equal zero. If overdraft caps reduced the likelihood of large overdrafts at a bank (without a simple additive shift of the distribution to the right), the left tail of the distribution of reserves would be attenuated. The resulting tendency of the banks' balances to be skewed to the right would produce larger positive (or smaller negative) values for the coefficient of skewness. Figure 5 shows that the balances at the three banks that were most likely to be affected by changes in cap policy exhibited only a weak tendency to be more skewed after changes in cap policies. In panels b and c, skewness increased, but by only small amounts, and in panel a it decreased by a similar amount. The data in Figure 5 also suggest that the frequency of large negative balances fell only slightly after the March 1986 and January 1988 cap policy changes. Somewhat surprisingly, the largest shifts in balances around the time of cap policy change seem to have been rightward shifts of positive balances toward even larger positive balances, where caps were presumably irrelevant.

Table 1 shows the average coefficients of skewness for two groups of domestically chartered commercial banks for the months just before and just after changes in overdraft cap policies. Because until 1991 overdraft cap regulations applied to the sum of a bank's net debits on CHIPS and its overdraft in its Fedwire funds subaccount, we used that measure of overdrafts for rows 1, 2, and 3 of Table 1. (For simplicity, we refer to this sum as an "overdraft.") Beginning in 1991, overdraft caps applied to the total of overdrafts in the Fedwire funds and book-entry subaccounts; we used that measure of overdrafts for row 4 of Table 1.

The first group of banks in Table 1 is made up of the ten banks in our sample whose average maximum overdrafts in the month before each of the four changes in overdraft cap policies were the largest relative to the overdraft caps that applied to them in the month after each change. The second group is made up of the ten banks in our sample whose average maximum overdrafts in the month before each of the four changes in overdraft cap policies relative to the overdraft caps that applied to them in the month after each change were closest to the median of that ratio in our sample of 150 banks.

Before March 1986, overdrafts were almost completely unfettered by Federal Reserve policy. If changes in cap policy reduced the size and frequency of large daylight overdrafts, that is, if they reduced the mass in the far left tail of the distribution of observed intraday reserve balances, the skewness of intraday reserve balances

16. The standardized distributions of overdrafts differed little across these three banks. The overdraft caps shown in Figure 5 are the average of the similarly standardized values of the caps for the three banks.

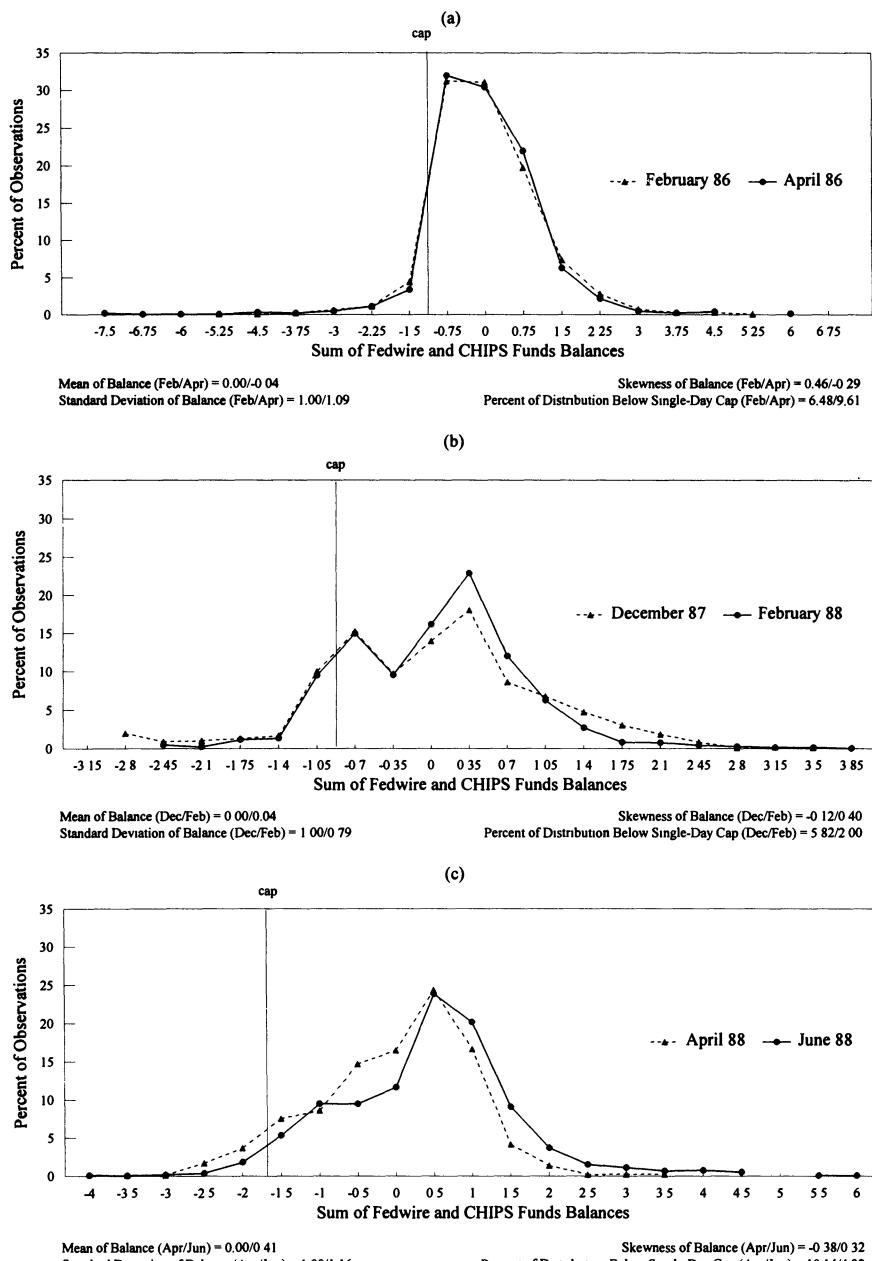


FIG. 5. Distributions of Selected Banks' Intraday Balances before and after Overdraft Cap Policy Changes

would rise (or become less negative). The increase in skewness ought to be particularly noticeable for the group of banks with large overdrafts (relative to their cap). In Table 1 we compare the skewness of reserve balances before and after changes in overdraft cap policy at banks with relatively large overdrafts with the skewness of reserve balances at banks less likely to be constrained by their overdraft caps. This latter group of banks consisted of those with about the median amount of overdrafts (relative to their caps).

Row 1 of Table 1 shows that for the banks that had the largest overdrafts in February 1986 the average skewness of reserve balances rose considerably, from -0.328 to 0.816, after the March 1986 introduction of overdraft caps. At the same time, the average skewness of reserve balances at the median-overdrafting banks, which had average maximum overdrafts in February 1986 that were well below their April caps, also rose, from -0.050 to 0.397, though not as much as did the average skewness at banks with large overdrafts. Thus, the results in row 1 are consistent with the March 1986 introduction of overdraft caps having reduced overdrafts at banks that had large overdrafts.

In contrast, the data offer little evidence that the two 1988 changes in cap policy immediately reduced overdrafts by large amounts. Row 2 of Table 1 shows that skewness at banks with large overdrafts rose no more than that at banks with median-sized overdrafts: Skewness at both groups of banks rose about 0.4. Around May 1988, the average skewness of reserve balances rose slightly at large-overdrafting banks and fell slightly at banks with median-sized overdrafts. This finding suggests that the May 1988 change in overdraft cap policy may have reduced overdrafts more than did the January 1988 change, though neither change affected the absolute or relative skewness of balances very much.

Row 4 of Table 1 shows that around January 1991 skewness declined slightly for the large-overdrafting banks and rose noticeably for the median-overdrafting banks. These results suggest that overdrafts were little affected by the changes in cap policy around January 1991. Such a finding might have been anticipated given that net debits on CHIPS were removed and balances in the book-entry securities subaccount were added to the total that was subject to the cap. In Table 1, for each instance when the skewness of overdrafts declined more at large-overdrafting banks, there was an instance when skewness declined less at large-overdrafting banks. Thus, the

TABLE 1  
THE EFFECTS OF CHANGES IN OVERDRAFT CAP POLICY ON RESERVE BALANCES

Month Overdraft Cap Changed	Average Coefficient of Skewness			
	Ten Banks with Largest Overdrafts Relative to Their Overdraft Caps		Ten Banks with Median Overdrafts Relative to Their Overdraft Caps	
	Month Before	Month After	Month Before	Month After
1. March 1986	-0.328	0.816	-0.050	0.397
2. January 1988	-0.230	0.179	0.071	0.485
3. May 1988	-0.060	0.062	0.319	0.096
4. January 1991	0.430	0.152	0.866	1.637

NOTE: Data are not merger adjusted. None of the banks merged during the three-month period centered on the month that overdraft cap policy changed.

skewness data in Table 1 offer at best mild support for the notion that the caps were effective at constraining overdrafts in the short run.<sup>17</sup>

### *Regime C*

Vickson (1985) derived optimal cash management policies for the case in which costs are a function of a bank's *average* overdraft (relative to its deductible). He demonstrated that, just as in the case in which a bank incurs costs when its overdrafts at any moment exceed its caps, a reserves management policy that is stated in terms of a floor on the bank's reserve balance (a limit on overdrafts different from the regulatorily imposed cap) and return point ( $u$ ,  $U$ ) is optimal.<sup>18</sup> The optimal limit and return point are stated not in terms of the *actual* overdrafts at any time, as in the case of an overdraft cap, but rather in terms of a state variable that is related to expected cumulative overdrafts over the day.<sup>19</sup> Under the optimal policy, the imposition of fees based on average overdrafts tends to push banks to adjust their reserves earlier in the day, because reserves acquired earlier in the day reduce the overdraft for more minutes than those acquired later in the day. That banks acquired reserves earlier during Regime C than they had before the Federal Reserve began charging fees for average overdrafts is documented by Richards (1995).

Vickson (1985) extended his own empirical results to a setting in which banks faced an overdraft cap as well as average overdraft costs. He suggested that the optimal policy contain a "manual override," which would put a limit, or ceiling, on overdrafts at any time and thus would require the reserves manager to acquire reserves when the level of the overdraft exceeded that limit. This modified policy, then, had two limits on overdrafts: one for the expected cumulative overdrafts and one for the actual overdrafts (negative reserve balances) at any time. The modification required the reserves manager to make larger and more frequent acquisitions of reserves (and smaller and less frequent disbursements of reserves) than in the absence of a daylight overdraft cap. Vickson showed how the manual override could be selected so that the daylight overdraft cap would be violated no more than a percentage of the day chosen by the reserves manager. He used simulations based on actual data to show that the optimal policy coupled with this manual override would be simple, cheap, and effective for the bank.

## 6. STATISTICAL RELATIONS IN AGGREGATE DATA

In the preceding section, we related individual banks' daylight overdrafts to a number of bank-specific variables. Unfortunately, the lack of data precluded our

17. We also calculated the changes in the skewness of overdrafts, rather than of reserve balances, for these banks. The changes in the skewness of overdrafts around these dates produced similarly weak evidence that changes in overdraft cap policy affected overdrafts.

18. The absence of costs associated with having reserve balances above the deductible means that the optimal policy places no ceiling or associated upper return point on the reserve balance.

19. The optimality of this policy holds under quite general conditions. For example, a large number of common distributions for the exogenous shock to reserves are permissible. Among them are the normal, the exponential, and the gamma. See Vickson (1985).

controlling for some factors other than caps and fees that may have influenced individual banks' intraday overdrafts. In this section, we examine the monthly relation, from March 1985 through September 1995, between *aggregate* daylight overdrafts in Federal Reserve accounts and their hypothesized determinants. By aggregate overdrafts, we refer to the total of overdrafts summed across all institutions that have reserve accounts at Federal Reserve Banks.

### *Hypotheses about Aggregate Daylight Overdrafts*

We hypothesized that several aggregate factors would affect our measures of aggregate daylight overdrafts (data for many of these variables were not available at the individual bank level). Unless otherwise noted, we expected that these factors would affect the measures of maximum overdrafts that we constructed in the same direction that they affected average overdrafts.

First, we hypothesized that, *ceteris paribus*, the aggregate value of reserves in the banking system would affect the level of overdrafts. The greater the value of reserves, and thus the larger the average beginning-of-day balance in reserve accounts at Federal Reserve Banks, the smaller banks' overdrafts would be. We also hypothesized that the overall level of transactions that involved reserve accounts would affect the level of overdrafts. The greater the value of transactions over Fedwire, the larger the expected value of overdrafts would be.

We also looked at whether two categories of Fedwire transactions were likely to be especially "overdraft intensive": those related to the federal funds and repurchase agreement (repo) transactions undertaken by banks to fund their assets and those related to the securities transfers undertaken by primary securities dealers. The extent to which banks buy and sell reserves via federal funds and repo transactions over Fedwire affects the value of Fedwire transactions. In addition, transfers stemming from federal funds and repo transactions undertaken by the bank itself are more likely to generate overdrafts than are transfers originated by commercial transactions or transfers originating at another bank. Federal funds and repos tend to be delivered relatively late in the business day and returned relatively early, so banks that tend to rely on these sources of funds are likely to have fewer reserves during the day than if they tended to rely on deposits, for example. Thus, we hypothesized that even when the values of Fedwire funds and book-entry transactions were controlled for, the greater the proportion of banks' liabilities funded with federal funds and repos, the greater the overdrafts would be.

We tested whether the handling of a greater dollar volume of government securities transactions by primary securities dealers resulted in overdrafts, again after controlling for the value of Fedwire funds transactions. Like federal funds and repo transactions, government securities transactions tend to take place via Fedwire. Much of the value of securities transactions is handled by primary dealers, who tend to use a small number of large commercial banks to carry out their transactions. These dealers typically fund their daylight securities holdings with daylight overdrafts at their banks, which in turn tend to fund those overdrafts with overdrafts of their reserve accounts. Thus, we hypothesized that the greater the value of securities

transactions handled by primary dealers, the larger the overdrafts likely to be generated by a given value of Fedwire traffic.

We considered the possibility that the decrease in recent years of the number of securities-clearing banks changed the aggregate amount of daylight overdrafts. When a bank exited the securities-clearing business, its activities were typically taken on by a bank that already cleared securities and thus tended to overdraw its reserve account. Whereas the spreading of a given amount of clearing activity across a large number of banks might enable each of those banks to avoid overdrafts, with the positive beginning-of-day reserve balance of each bank buffering it against overdrafts, a decrease in the number of securities-clearing banks might raise the aggregate amount of overdrafts. On the other hand, to the extent that consolidation among securities-clearing banks increased the likelihood of intrabank clearing of securities ("on-us" transactions), at the expense of interbank clearing, the reduction of the number of securities-clearing banks might reduce aggregate overdrafts. We made no assumption about the net effect on overdrafts of these forces.

Of course, we also tested whether the imposition of caps and fees reduced daylight overdrafts. We predicted that caps might affect overdrafts generally, but would have particularly noticeable effects on maximum aggregate overdrafts. Because fees are applied to intraday average overdrafts, we expected them to have particularly strong effects on average daily aggregate overdrafts, but possibly to affect maximum aggregate overdrafts as well.

### *Regression Specification*

To estimate the effects of caps, fees, and other factors on our measures of daylight overdrafts, we specified an error-correction mechanism (ECM). This specification allowed for short-run dynamic effects that differed from long-run effects and generated statistically valid tests of both short-run and long-run effects.

The dynamics allowed for by the ECM might stem from at least two sources. The first is omission of some autoregressive variables. No regression specification can be complete, and because we cannot in general reject the presence of unit roots in the variables that we have included, it is likely that those we have not included also have strong autoregressive components.<sup>20</sup> Models of reserves management suggest that the volatility of exogenous payments flows affects overdrafts, for example. To the extent that volatility is autoregressive, the ECM reduces the effects of its omission on estimates of the included variables.

A second source of error-correction effects might be "counseling" from the Federal Reserve System. A bank whose overdrafts are unusually large sometimes receives counseling, which is meant to indicate to the bank that it should rein in its overdrafts. To the extent that a bank responds to this counseling, it might reduce its subsequent overdrafts relative to what they would otherwise have been.

Suppose that each of the measures of overdrafts that we use,  $DLO$ , responded

20. Each of the long-run relations passed tests for cointegration.

over the long run by  $\gamma$  to a one-unit change in the “explanatory” variables, whose vector is denoted  $X$ :

$$DLO_t = \gamma \cdot X_t. \quad (1)$$

Our ECM posited that the short-run change (the month-to-month difference) in daylight overdrafts,  $\Delta DLO_t$ , responds by  $\alpha$  to a one-unit change in the explanatory variables,  $\Delta X_t$ . In addition, our ECM implied that the month-to-month difference responded by  $\beta$  to the error-correction term,  $\epsilon_{t-1}$ :

$$\Delta DLO_t = \alpha \cdot \Delta X_t + \beta \cdot \epsilon_{t-1}. \quad (2)$$

In this case, the error-correction term,  $\epsilon_{t-1}$ , was the discrepancy between the actual level of daylight overdrafts recorded for the preceding month,  $DLO_{t-1}$ , and the level predicted for that month by the long-run relation between daylight overdrafts and the explanatory variables,  $\gamma \cdot X_{t-1}$ :

$$\epsilon_{t-1} = DLO_{t-1} - \gamma \cdot X_{t-1}. \quad (3)$$

The (absolute value of the) coefficient,  $\beta$ , on the error-correction term measures the extent to which the discrepancy in the prior period was offset in the current period. If overdrafts exceeded their long-run value, as given by equation (1), in the prior period, the ECM indicates that overdrafts would change this period by  $\beta \cdot \epsilon_{t-1}$  less than warranted by  $\Delta X_t$ . Given no change in  $X$  during this period, overdrafts would move toward the value implied by equation (1) by a fraction,  $\beta$ , of the prior period's discrepancy.

Substituting equation (3) into equation (2) produces

$$\Delta DLO_t = \alpha \cdot \Delta X_t + \beta \cdot (DLO_{t-1} - \gamma \cdot X_{t-1}). \quad (4)$$

Applying nonlinear least squares to equation (4) produced statistically valid estimates of the adjustment speed,  $\beta$ , and of the short-run ( $\alpha$ ) and long-run ( $\gamma$ ) responses of daylight overdrafts to the explanatory variables, as well as of their standard errors.<sup>21</sup> Tables 2, 3, and 4 show the results of estimating equation (4) with various measures of overdrafts.<sup>22</sup>

21. Though we need not have done so, we restricted equation (3) to include the same explanatory variables in the short-run as in the long-run determination of daylight overdrafts. West (1988) and Sims, Stock, and Watson (1990) show that the standard errors for this specification are properly calculated by a standard regression program.

22. We also estimated equation (1) with ordinary least squares, both with and without an AR(1) term for the disturbances. The estimated long-run effects from these regressions were similar to the ECM results shown in Tables 2, 3, and 4. One reason for preferring the ECM results is that the estimated adjustment coefficients were statistically significantly less than 1, which indicates that short-run dynamics were relevant.

### *Specification of Aggregate Variables*

The dollar value series used to estimate equation (4) (expressed in billions of dollars) were converted to real terms by dividing by the consumer price index, which had been indexed to equal 1 in January 1995.

Measures of aggregate overdrafts were constructed from data on overdrafts at fifteen-minute intervals throughout the Fedwire operating day. Because the Fedwire day runs from 8:30 A.M. through 6:30 P.M., we had forty-five observations of overdrafts per bank per day for the February 1985 through September 1995 period. Aggregate book-entry securities overdrafts were the sum across banks of overdrafts in the book-entry subaccounts, ignoring positive total balances. Aggregate funds overdrafts were the sum across banks of the overdrafts in the funds subaccounts, again ignoring positive balances. A bank's total overdraft is the amount by which the sum of its funds and securities subaccount balances is negative, which is less than or equal to the sum of the overdrafts in its two subaccounts. (A bank's total overdraft will equal the sum of the overdrafts in its two subaccounts if neither subaccount has a balance greater than zero.) Thus, total aggregate overdrafts were *not* the sum of the subaccount overdrafts, but rather the sum, across banks, of overdrafts in the total reserve account, again ignoring positive balances. Overdrafts were expressed as the absolute value of these negative balances.

Because no one measure seemed sufficiently informative about overdrafts, we constructed, for each month, three measures of aggregate overdrafts—the maximum, the average daily maximum, and the average—for each category of overdrafts (total, funds, and book-entry). The first measure is the maximum aggregate overdraft recorded at any time during the month, the second is the "typical" amount at which overdrafts peaked each day during the month, and the third is the "typical" amount of overdrafting at any time during the month.

For most of the sample period—January 1987 onward—monthly data was available for the dollar value of both funds transfers and of securities-related transfers over Fedwire; for 1985 and 1986, we had annual data for both components. The only quarterly data for transfers available for 1985 and 1986 were for funds transfers, and that data reported transfers as the sum of the value of transfers processed by the sending *and* the receiving offices—unless the transfer was within a Federal Reserve District, in which case the transfer was only counted once. To reduce the problem that the available quarterly data double-counted some transfers but not others, we used that data to distribute the annual data for 1985 and 1986 into values for the eight quarters of 1985 and 1986. The quarterly series we constructed added up to the annual series for funds transfers that did not double-count some transfers but was perfectly correlated with the available quarterly data. We followed a similar strategy to estimate monthly data before 1987 for the value of securities-related transfers. The strategy differed somewhat because we had no related quarterly data for securities-related transfers for 1985 and 1986. First, we constructed quarterly average values from annual data, distributing the annual data for 1985 and 1986 by imposing the same growth rate in quarterly data that we observed in the annual data, subject to the constraint that the constructed quarterly data summed to the annual

data. Then we set the monthly values for each quarter of the two years equal to the derived quarterly average value.

For our measure of reserves we used monthly averages of depository institutions' deposits at Federal Reserve Banks.<sup>23</sup> As our proxy for dealers' securities transactions, we used data for purchases and sales of U.S. government securities (U.S. Treasury bills and coupon securities, federal agency securities, and mortgage-backed securities), as reported to the Federal Reserve Bank of New York by primary dealers.<sup>24</sup>

We hypothesized that the larger the dollar value of federal funds transactions, the larger daylight overdrafts would be. Although we had no measure of the dollar value of federal funds transactions, we did have data for banks' holdings of federal funds and repos. For our measure of the dollar value of federal funds and repos held by commercial banks we used the difference between borrowings at all commercial banks and Treasury tax and loan notes held at the large weekly reporting banks.<sup>25</sup> These data came from the *Federal Reserve Bulletin*. To express this measure of the composition of banks' funding, we standardized it by the dollar value of aggregate bank credit.<sup>26</sup>

We constructed several indicator variables for changes in Federal Reserve policies on daylight overdrafts. The first indicator variable equaled zero for each month until Regime B commenced in March 1986, when caps on intraday credit were introduced, and one thereafter. The second and third indicator variables were for the two cap reductions in 1988: The second equaled zero until January 1988, when caps were reduced 15 percent, and one thereafter; the third equaled zero until May 1988, when the remainder of the 25 percent reduction in the cap level occurred, and one thereafter. The fourth indicator variable was equal to zero until January 1991, when the cap on the sum of the net debit on CHIPS and daylight overdrafts on Fedwire funds was replaced by a cap on sum of Fedwire funds and book-entry overdrafts, and one thereafter.<sup>27</sup> The fifth indicator variable equaled zero until October 1993, when new rules for posting times for the debits and credits associated with check

23. We found nearly identical results when we used data for the aggregate amount of required reserves.

24. Transactions were reported at principal value and therefore did not include accrued interest. Beginning in June 1994, forward transactions as well as immediate transactions are included in the definition of U.S. government transactions. Immediate delivery refers to purchases or sales of securities (other than mortgage-backed federal agency securities) for which delivery is scheduled in five business days or less and "when-issued" securities that settle on the issue date of offering. Transactions for immediate delivery of mortgage-backed securities include purchases and sales for which delivery is scheduled in thirty business days or less. Forward transactions are agreements made in the over-the-counter market that specify delayed delivery. Forward contracts for mortgage-backed agency securities are included when the time to delivery is more than thirty days. These data are reported in the *Federal Reserve Bulletin*.

25. Only very large banks have any appreciable Treasury tax and loan notes. Borrowings also include discount window borrowings.

26. We also considered standardizing the data for required reserves and for securities transactions. However, regressions fit better with the standardized funding variable and with the nonstandardized data for required reserves and securities transactions.

27. Banks incurring "frequent" and "material" book entry overdrafts were required to collateralize their entire book-entry exposure.

clearings and ACH transfers and other non-Fedwire payments took effect, and one thereafter.

The first four of these indicator variables reflect changes in policy toward caps on daylight overdrafts. Because the values of those caps were determined in part by the value of the capital that banks had, we also included with each of the four indicator variables a variable formed by multiplying bank capital by that indicator variable. The difference between commercial banks' monthly average total assets and liabilities—the "residual"—served as a proxy for the aggregate capital of commercial banks.<sup>28</sup> The estimated net effect on daylight overdrafts of imposing a cap, then, is the sum of (1) the coefficient on the indicator variable and (2) the product of the value of the bank capital variable and the coefficient on the variable formed by multiplying bank capital by the indicator variable.

We also used indicator variables to signal the changes in fees for daylight overdrafts in April 1994, when the fee rose from zero to ten basis points (annual rate), and in April 1995, when it rose from ten to fifteen basis points. For the first of the two, we set the value at zero until February 1994 and then, to reflect banks' likely gradual adaptation to the fee increase, which had been announced long in advance, raised the value of the indicator gradually. We set the February 1994 value at 0.1, raised it 0.2 for each succeeding month through June, and set it equal to one starting in July 1994. We took a similar approach for the second indicator variable: We set it at zero until February 1995, at 0.1 for February 1995, raised it 0.2 for each succeeding month through June, and set it at one starting in July 1995. This second variable was constructed to measure the effects of the April 1995 fee increase on top of the earlier increase.

Because the dollar value of the deductible that is subtracted from a bank's overdrafts before overdraft fees are levied rises with the dollar value of the bank's capital, we also constructed variables intended to determine whether overdrafts rise as bank capital rises. These variables, which interacted bank capital with the indicator variables for the fee increases, proved to be insignificant. Therefore, we chose a specification that omitted interacted capital and fee variables.

We also included an indicator variable to mark daylight overdraft "prevention week," a week in early December 1993, during which an industry trade association urged its members to minimize their use of overdrafts. The effort apparently reduced overdrafts during December, so we included a variable that was equal to one for December 1993 and zero otherwise.

Finally, we included as variables in our regressions both the number of banks each month that cleared securities and that number multiplied by the real value of securities transactions handled by primary dealers. Neither of these variables proved to be statistically significant when entered individually or jointly. Thus, we do not report or show the results of regressions that included those variables.

28. This measure of capital is not identical to regulatory capital.

## 7. RESULTS FOR TOTAL FEDWIRE DAYLIGHT OVERDRAFTS

Tables 2, 3, and 4 present the results of estimating equation (4) using as dependent variables the changes in daylight overdrafts in the entire reserve account, in the funds-related subaccount, and in the book-entry securities-related subaccount.<sup>29</sup> In each table, the dependent variables are the first differences in monthly data of the maximum, the average daily maximum, and the average aggregate overdraft. The summary statistics at the bottom of the tables refer to the levels of the overdraft measures rather than to their first differences. The same explanatory variables were used for each regression in the three tables.

The estimates of the long-run effects ( $\gamma$ ) on overdrafts are shown in the top group of rows of each table, the estimated short-run responses ( $\alpha$ ) are presented in the middle group of rows, and the estimated adjustment coefficient ( $\beta$ ) is shown in the bottom row of coefficient estimates.<sup>30</sup>

### *The Estimated Effects of Caps*

Rows 1 and 2 of Table 2 present the estimates of the long-run effects of the cap variables on total daylight overdrafts. Because the indicator variables for the changes in caps (and those variables interacted with bank capital) are so highly correlated, the data did not yield precise estimates of their separate effects. Therefore, at little cost to overall fit, we included the pair of cap variables for only one of the overdraft caps.<sup>31</sup> Somewhat contrary to our intuition, the March 1986 cap variables were the single pair of cap variables that minimized the standard error of the regression. Therefore, all three tables present estimates of the coefficients for the variables associated with the March 1986 imposition of overdraft caps. The significantly positive coefficients on the product of the indicator and capital variables indicate that the more capital in banks, the higher the caps on overdrafts and the higher the observed overdrafts. These findings accord with our hypotheses.

On the other hand, there is little evidence that the initial effect of the imposition of caps was a decline in total overdrafts, by any of the three measures of overdrafts. The long-run estimated impact of overdraft caps at any time  $t$  is the sum of (1) the coefficient in row 1 and (2) the product of the coefficient in row 2 and the value of the capital variable at time  $t$ . Because the March 1986 real value of bank capital that we used was \$265 billion, the estimated initial effects shown in Table 2 were (insignificantly) *positive*, rather than negative as would be expected had caps been effective.<sup>32</sup> For example, the estimated initial response to the imposition of the overdraft cap was an increase of about \$20 billion in the maximum overdraft during the month

29. In all three tables,  $t$ -statistics are shown in parentheses below the coefficient estimates.

30. Though a constant term was included in the  $X$  vector, we do not report its estimate.

31. The estimated coefficients for the other variables were little affected by variation of the particular pair of cap variables included in the regressions.

32. Nor did we find that the initial effects of the other caps were reductions in overdrafts when the variables associated with the other cap dates were used.

TABLE 2

THE EFFECTS OF CAPS AND FEES ON TOTAL DAYLIGHT OVERDRAFTS  
 (MONTHLY, FEBRUARY 1985–SEPTEMBER 1995)

Explanatory Variables	Dependent Variable		
	Maximum Overdraft (1)	Average of Daily Maximum Overdraft (2)	Average Overdraft (3)
<b>Long-run Effects of</b>			
1. Cap Indicator	-95.9 (3.96)	-87.1 (2.57)	-44.2 (3.13)
2. Cap Indicator Interacted with Bank Capital	0.443 (4.70)	0.395 (3.00)	0.198 (3.58)
3. 1994 Fee Implementation	-102.7 (17.22)	-92.7 (10.98)	-42.7 (11.91)
4. 1995 Fee Increase	-26.6 (3.66)	-16.7 (1.66)	-8.0 (1.88)
5. Value of Fedwire Securities-Related Transfers	0.0047 (4.44)	0.0042 (2.89)	0.0023 (3.66)
6. Value of Deposits at Federal Reserve Banks	-1.82 (8.89)	-1.79 (6.14)	-0.78 (6.31)
7. Share of Bank Credit Funded by Fed Funds and Repurchase Agreements	5.07 (4.38)	4.95 (3.01)	1.86 (2.74)
8. Value of U.S. Government Securities Trans- actions by Primary Dealers	0.026 (0.35)	-0.036 (0.35)	0.055 (1.28)
9. Overdraft Prevention Week Indicator	-39.7 (2.69)	-73.9 (3.17)	-31.7 (3.12)
<b>Short-run Effects of</b>			
10. Cap Indicator	-22.9 (0.34)	-40.8 (1.16)	-16.2 (0.92)
11. Cap Indicator Interacted with Bank Capital	0.115 (0.46)	0.161 (1.23)	0.063 (0.95)
12. 1994 Fee Implementation	-60.8 (2.79)	-73.8 (6.19)	-42.0 (6.92)
13. 1995 Fee Increase	-20.0 (0.83)	-8.1 (0.62)	-8.7 (1.34)
14. Value of Fedwire Securities-Related Transfers	0.0020 (2.45)	0.0014 (3.13)	0.0006 (2.42)
15. Value of Deposits at Federal Reserve Banks	-1.55 (3.44)	-0.80 (3.35)	-0.46 (3.88)
16. Share of Bank Credit Funded by Fed Funds and Repurchase Agreements	5.15 (2.29)	2.81 (2.36)	1.30 (2.19)
17. Value of U.S. Government Securities Trans- actions by Primary Dealers	0.058 (1.28)	0.044 (1.84)	0.040 (3.34)
18. Overdraft Prevention Week Indicator	-21.4 (2.60)	-28.5 (6.57)	-12.8 (5.78)
<b>Adjustment Speed</b>	0.814 (8.97)	0.312 (4.29)	0.370 (4.82)
<b>Summary Statistics</b>			
Mean of Dependent Variable (Billions of 1995 Dollars)	114.9	96.5	49.9
Standard Error of Regression (Billions of 1995 Dollars)	7.51	3.97	1.99
R-Squared	0.94	0.98	0.98
Durbin-Watson Statistic	2.09	1.95	1.91

NOTE: Each dollar value series was converted to real terms by dividing by the January 1995 consumer price index. Below each coefficient estimate is its *t*-statistic.

(column 1). Allowing for the initial impact of the short-run dynamic terms (rows 10 and 11) raises that figure more than \$5 billion.

Although the estimates (row 2) suggest that the easing of caps due to increasing bank capital allowed for larger total overdrafts, the absence of evidence that the initial imposition of caps reduced overdrafts casts suspicion on the interpretation that the estimated positive effects of bank capital reflect the loosening of the overdraft cap associated with increased bank capital. These results may not be that surprising, however, when we recall that until January 1991 caps did not apply to overdrafts attributable to book-entry securities transfers. And even after that date, banks could effectively raise their own caps by pledging collateral to cover their securities-related overdrafts.

### *The Estimated Effects of Fees*

- Rows 3 and 4 of Table 2 present the estimated long-run effects of fees on total daylight overdrafts. The estimated long-run reduction in the (monthly) maximum daylight overdraft due to the 1994 imposition of a ten-basis-point fee on daylight overdrafts was \$103 billion; the 95 percent confidence interval for that estimate ranged from \$91 billion to \$114 billion. The reduction in the average daily maximum overdraft was about \$93 billion, with the 95 percent confidence interval ranging from \$76 billion to \$109 billion. The average overdraft fell almost \$43 billion, with the 95 percent confidence interval ranging from \$36 billion to \$50 billion. Thus, fees significantly reduced daylight overdrafts.

These estimates are somewhat larger than would be obtained by comparing averages of overdrafts before and after the imposition of fees. For example, the average maximum overdraft in the six months before April 1994 exceeded the average in the six months after April 1994 by \$57 billion. The reason the regression-based estimate is larger presumably is that without the advent of fees, overdrafts after April 1994 would have been larger than they were before April 1994. In that case, estimating the effect of fees by the change in the averages underestimates the effect of the fees.

The estimated long-run effect of the April 1995 fee increase on the maximum total overdraft was large (\$26.6 billion) and significant (*t*-statistic = 3.66). Though the long-run effects on the average daily maximum overdraft and the average overdraft were not statistically significant at conventional levels (*t*-statistics of about 1.8), the estimated reductions of \$16.7 billion and \$8.0 billion are notable. The estimated long-run effects of the five-basis-point increase in April 1995 tend, across most of our regressions, to be about one-quarter as large as those of the ten-basis-point increase in April 1994. Thus, the dollar reduction in overdrafts per-basis-point increase in the fee resulting from the 1995 increase was about half that resulting from the 1994 increase. A *t*-test shows that the 1995 fee increase produced a statistically significantly smaller per-basis-point reduction in overdrafts than the 1994 fee increase did.

### *The Effects of Other Factors*

Row 5 of Table 2 shows the estimated long-run effects of greater values of Fedwire book-entry securities transactions on total overdrafts. Notably absent from Tables 2–4 is the dollar value of Fedwire funds transfers. The reason is simple: This variable was never close to being a significant determinant of any of the overdraft measures we examined. By contrast, the estimated long-run effect of the value of book-entry transactions was significant for all three measures of total overdrafts. The estimates imply that each extra billion dollars of Fedwire securities-related transfers produced an increase of a bit more than \$4 million in maximum and average maximum overdrafts; average overdrafts rose about half as much per billion dollar increase in securities-related transfers.

Higher levels of deposits in banks' reserve accounts were estimated to reduce total overdrafts significantly in the long run, in both a statistical and an economic sense (row 6). Both maximum and average maximum overdrafts declined an estimated \$1.80 per dollar increase in reserve account balances. We were surprised that the reductions were larger than dollar for dollar. Average overdrafts fell an estimated \$0.78 per dollar increase in reserves, not significantly less than a dollar-for-dollar response.

Row 7 of Table 2 shows the estimated long-run effects on total overdrafts of a one-percentage-point increase in the share of bank credit funded by federal funds and repos. This share of banks' funding, which moves predominantly over Fedwire, was a significant determinant of each measure of total overdrafts. A one-percentage-point increase in that share raised the maximum and average daily maximum overdrafts about \$5 billion. As usual, the effect on the average overdraft was smaller, but still detectable.

In contrast to the other factors, the long-run effects of primary dealers' securities transactions were not found to be significant determinants of total overdrafts: Only the estimated response of the average overdraft had a *t*-statistic above one (row 8).

Overdraft prevention week (early December 1993) apparently reduced total maximum overdrafts sufficiently to affect the average maximum over the month as well as the average overdraft for the month. The estimated long-run effect on the maximum overdraft during December 1993 was significant (*t*-statistic = 2.69) (row 9), as was the short-run effect (row 18). The estimated sizes of the effects of this voluntary reduction in overdrafts were surprisingly large. The estimated long-run effect was to reduce the average daily maximum overdraft, for example, \$73.9 billion, which puts its estimated effect at four-fifths as large as the estimated effect of the 1994 fee increase.

Changes in these explanatory variables generally affected the short-run dynamics of overdrafts (rows 10–18) in much the same way that changes affected the longer-run movements of overdrafts. The short-run effects tended to be less statistically significant and smaller in size, however. The most noticeable difference was in the coefficients for securities transactions (rows 8 and 17): Whereas we detected no longer-run effects, we found that securities transactions were a significant determinant of average overdrafts.

The adjustment speed coefficient for the maximum overdraft of 0.814 indicates that four-fifths of the excess of the maximum overdraft over its value predicted by equation (1) was gone by the following month. Much smaller fractions of the excess of the average maximum and average overdrafts tended to be gone by the next month. This is just the pattern we expected to find: Autocorrelation of the error-correction terms is likely to be much stronger in monthly averages than in data for the monthly maximum overdraft.

## 8. RESULTS FOR SECURITIES-RELATED AND FUNDS-RELATED OVERDRAFTS

Tables 3 and 4 apply the same specification used in Table 2 to the value of overdrafts attributed to book-entry securities transfers and to funds-related transfers.<sup>33</sup> The reserve balance in the book-entry securities subaccount plus that in the funds subaccount is the total reserve balance. Because overdrafts are a nonlinear transformation of balances, however, total overdrafts do not equal the sum of overdrafts attributed to book-entry securities transfers and those attributed to funds transfers. Nonetheless, analyzing these two components as if they summed to total Fedwire overdrafts is a close approximation.<sup>34</sup> As a result, the coefficient estimates in Table 2 approximate the sum of those in Tables 3 and 4.

There are few important differences between the determinants of securities-related and total overdrafts: The pattern of responses of securities-related overdrafts mimics the pattern of responses of total overdrafts, differing primarily by being somewhat smaller in general. The long-run responses to fee increases are representative: The responses of securities-related overdrafts were about four-fifths as large as those of total overdrafts.

The responses of funds-related overdrafts also mimic those of total overdrafts, though they tend to be considerably weaker in significance and in strength. Not surprisingly, one of the variables that significantly affected funds-related overdrafts is the share of bank credit funded via federal funds and repos (rows 7 and 16). Nor were we surprised to find that the value of securities transferred over Fedwire (rows 5 and 14) affected securities-related overdrafts, but that such transfers had little effect on funds-related overdrafts. Securities transactions by primary dealers generally had stronger effects on securities-related than on funds-related overdrafts (rows 8 and 17). We were surprised, however, that maximum funds-related overdrafts were affected by the value of securities-related transfers. Also surprising is the finding, not shown here, that Fedwire funds transfer volume was not a significant determinant of funds-related overdrafts.

33. Funds-related overdrafts include check, ACH, and other payment transactions that affect reserve or clearing account balances.

34. The *R*-squared of a regression of the average daily maximum total overdraft on the averages of the daily maximums for book-entry transfers and for funds transfers is 0.87. With an AR(1) error term added, the *R*-squared jumps to 0.99. Thus, viewing overdrafts in the subaccounts as summing to total Fedwire overdrafts is a reasonable approximation. If the components summed exactly to the total, the sums of regression coefficients in the component regressions would sum exactly to the coefficients in the total regressions.

TABLE 3

THE EFFECTS OF CAPS AND FEES ON SECURITIES-RELATED DAYLIGHT OVERDRAFTS  
(MONTHLY, FEBRUARY 1985–SEPTEMBER 1995)

Explanatory Variables	Dependent Variable		
	Maximum Overdraft (1)	Average of Daily Maximum Overdraft (2)	Average Overdraft (3)
<b>Long-run Effects of</b>			
1. Cap Indicator	-99.7 (3.27)	-81.9 (1.46)	-42.9 (2.55)
2. Cap Indicator Interacted with Bank Capital	0.474 (3.99)	0.393 (1.80)	0.195 (2.98)
3. 1994 Fee Implementation	-83.7 (11.13)	-69.5 (4.95)	-36.5 (8.64)
4. 1995 Fee Increase	-22.8 (2.48)	-13.7 (0.81)	-7.1 (1.40)
5. Value of Fedwire Securities-Related Transfers	0.0034 (2.55)	0.0046 (1.86)	0.0019 (2.51)
6. Value of Deposits at Federal Reserve Banks	-1.96 (7.52)	-2.14 (3.91)	-0.67 (4.35)
7. Share of Bank Credit Funded by Fed Funds and Repurchase Agreements	2.97 (2.03)	3.27 (1.16)	0.64 (0.79)
8. Value of U.S. Government Securities Trans- actions by Primary Dealers	0.088 (0.94)	-0.104 (0.57)	0.032 (0.63)
9. Overdraft Prevention Week Indicator	-43.5 (2.35)	-107.0 (2.42)	-47.9 (3.40)
<b>Short-run Effects of</b>			
10. Cap Indicator	-58.2 (0.79)	-24.7 (0.71)	-16.5 (1.13)
11. Cap Indicator Interacted with Bank Capital	0.257 (0.94)	0.098 (0.76)	0.064 (1.17)
12. 1994 Fee Implementation	-53.1 (2.22)	-38.2 (3.12)	-29.5 (5.55)
13. 1995 Fee Increase	-19.0 (0.71)	3.9 (0.30)	-3.3 (0.61)
14. Value of Fedwire Securities-Related Transfers	0.0010 (1.13)	0.0015 (3.57)	0.0006 (2.94)
15. Value of Deposits at Federal Reserve Banks	-1.28 (2.61)	-0.23 (0.96)	-0.15 (1.56)
16. Share of Bank Credit Funded by Fed Funds and Repurchase Agreements	4.37 (1.77)	1.10 (0.94)	0.52 (1.07)
17. Value of U.S. Government Securities Trans- actions by Primary Dealers	0.093 (1.86)	0.048 (2.00)	0.032 (3.25)
18. Overdraft Prevention Week Indicator	-16.3 (1.80)	-26.3 (6.15)	-13.3 (7.45)
<b>Adjustment Speed</b>	0.710 (7.99)	0.183 (2.69)	0.256 (3.60)
<b>Summary Statistics</b>			
Mean of Dependent Variable (Billions of 1995 Dollars)	86.2	68.2	27.0
Standard Error of Regression (Billions of 1995 Dollars)	8.27	3.93	1.64
R-Squared	0.93	0.98	0.98
Durbin-Watson Statistic	2.05	2.09	2.01

NOTE: Each dollar value series was converted to real terms by dividing by the January 1995 consumer price index. Below each coefficient estimate is its *t*-statistic.

TABLE 4

THE EFFECTS OF CAPS AND FEES ON FUNDS-RELATED DAYLIGHT OVERDRAFTS  
(MONTHLY, FEBRUARY 1985–SEPTEMBER 1995)

Explanatory Variables	Dependent Variable		
	Maximum Overdraft (1)	Average of Daily Maximum Overdraft (2)	Average Overdraft (3)
<b>Long-run Effects of</b>			
1. Cap Indicator	-13.5 (0.99)	1.9 (0.16)	1.0 (0.13)
2. Cap Indicator Interacted with Bank Capital	0.029 (0.54)	0.002 (0.06)	-0.004 (0.12)
3. 1994 Fee Implementation	-13.7 (4.10)	-13.5 (4.96)	-7.2 (3.89)
4. 1995 Fee Increase	-2.1 (0.51)	-1.7 (0.51)	-0.1 (0.05)
5. Value of Fedwire Securities-Related Transfers	0.0016 (2.67)	0.0005 (1.13)	0.0003 (0.89)
6. Value of Deposits at Federal Reserve Banks	-0.21 (1.78)	-0.43 (4.57)	-0.18 (2.83)
7. Share of Bank Credit Funded by Fed Funds and Repurchase Agreements	1.95 (2.99)	1.79 (3.39)	1.31 (3.68)
8. Value of U.S. Government Securities Trans- actions by Primary Dealers	0.028 (0.66)	0.028 (0.82)	0.022 (0.97)
9. Overdraft Prevention Week Indicator	3.7 (0.45)	3.6 (0.54)	5.5 (1.23)
<b>Short-run Effects of</b>			
10. Cap Indicator	29.1 (0.58)	3.9 (0.21)	3.4 (0.33)
11. Cap Indicator Interacted with Bank Capital	-0.119 (0.64)	-0.017 (0.24)	-0.014 (0.36)
12. 1994 Fee Implementation	-22.5 (1.38)	-17.1 (2.93)	-8.4 (2.54)
13. 1995 Fee Increase	-17.1 (0.96)	-8.0 (1.25)	-2.9 (0.83)
14. Value of Fedwire Securities-Related Transfers	0.0009 (1.52)	-0.0001 (0.40)	-0.0001 (0.65)
15. Deposits at Federal Reserve Banks	-0.36 (1.07)	-0.51 (4.29)	-0.27 (4.02)
16. Share of Bank Credit Funded by Fed Funds and Repurchase Agreements	1.29 (0.77)	1.33 (2.21)	0.80 (2.36)
17. U.S. Government Securities Transactions by Dealers	-0.002 (0.04)	0.015 (1.24)	0.008 (1.21)
18. Overdraft Prevention Week Indicator	1.3 (0.22)	-0.3 (0.14)	0.5 (0.42)
<b>Adjustment Speed</b>	1.081 (11.29)	0.477 (5.86)	0.397 (4.92)
<b>Summary Statistics</b>			
Mean of Dependent Variable (Billions of 1995 Dollars)	56.7	47.5	22.9
Standard Error of Regression (Billions of 1995 Dollars)	5.65	2.01	1.12
R-Squared	0.35	0.86	0.83
Durbin-Watson Statistic	1.94	1.98	2.01

NOTE: Each dollar value series was converted to real terms by dividing by the January 1995 consumer price index. Below each coefficient estimate is its *t*-statistic.

Just as the data in Table 3 suggest with regard to securities-related overdrafts, the data in Table 4 indicate that the April 1994 fee increase reduced funds-related overdrafts significantly. Unlike Table 3, however, Table 4 does not reveal any significant response of funds-related overdrafts to the 1995 fee hike.

#### 9. ELASTICITY OF THE AGGREGATE DEMAND FOR DAYLIGHT OVERDRAFTS

In the regressions reported in Tables 2, 3, and 4, we used two qualitative variables for the increases in daylight overdraft fees: one for the increase from zero to ten basis points and one for the increase from ten to fifteen basis points. Using qualitative variables had the advantage of producing direct estimates of the effects on overdrafts of each of the two fee increases. For example, row 3 in Table 2 shows that the April 1994 introduction of a ten-basis-point fee reduced the average daily maximum total overdraft in the long run by an estimated \$92.7 billion (1995 dollars); row 4 shows that the estimated long-run effect of the April 1995 fee increase from ten to fifteen basis points was an additional \$16.7 billion (1995 dollars).

These estimates also suggest that the demand for daylight overdrafts was not linear: The estimated reduction in maximum total overdrafts per basis point when the fee was raised from zero to ten basis points was nearly twice as large as the per-basis-point reduction estimated for the increase from ten to fifteen basis points. The *t*-test that indicated that the 1995 fee increase produced smaller per-basis-point reductions in overdrafts than the 1994 fee increase did also imply that the demand curve was statistically significantly nonlinear over this range of fee increases.

The overdraft fee was zero for all but the last year and a half of our sample period. Using some of the most common nonlinear specifications (for example, log and reciprocal) of the fee variable would have removed all but that short period from our estimation period. We were reluctant to use a nonlinear transformation of the dependent variable because the relations of overdrafts to some of the other explanatory variables, such as deposits at Federal Reserve Banks, seemed likely to be linear. To allow the data to indicate the extent to which the responses of overdrafts to fees were nonlinear, we reestimated the specification used for Table 2 after removing the two qualitative fee variables and replacing them with two quantitative variables: the level of the overdraft fee in basis points and the square of the fee level. The results are presented in Table 5.

Except for the coefficient estimates for the fee variables, the overall fit and individual coefficients in Table 5 are almost the same as those in Table 2. The long-run effects of both the level and the square of the fee variables are statistically significant. Calculation of the estimated slope of the demand for overdrafts shows that the demand curve slopes negatively over the entire range of fees so far observed. The positive coefficients on the square of fees indicate that the demand for overdrafts steepens as fees rise.

Figure 6 shows the demand curve for the average daily maximum total overdrafts implied by column 2 of Table 5. The demand curve plotted in Figure 6 shows how

TABLE 5

THE EFFECTS OF CAPS AND FEES ON TOTAL DAYLIGHT OVERDRAFTS  
(MONTHLY, FEBRUARY 1985—SEPTEMBER 1995)

Explanatory Variables	Dependent Variable		
	Maximum Overdraft (1)	Average of Daily Maximum Overdraft (2)	Average Overdraft (3)
<b>Long-run Effects of</b>			
1. Cap Indicator	-96.4 (3.91)	-85.9 (2.78)	-44.0 (3.29)
2. Cap Indicator Interacted with Bank Capital	0.445 (4.64)	0.383 (3.19)	0.194 (3.73)
3. Fee	-13.4 (9.87)	-14.5 (7.98)	-6.6 (8.31)
4. Square of Fee	0.32 (3.15)	0.45 (3.50)	0.20 (3.59)
5. Value of Fedwire Securities-Related Transfers	0.0047 (4.46)	0.0039 (2.95)	0.0021 (3.67)
6. Value of Deposits at Federal Reserve Banks	-1.83 (8.73)	-1.74 (6.55)	-0.76 (6.55)
7. Share of Bank Credit Funded by Fed Funds and Repurchase Agreements	5.07 (4.30)	5.09 (3.35)	1.93 (2.98)
8. Value of U.S. Government Securities Trans- actions by Primary Dealers	0.018 (0.24)	0.031 (0.33)	0.082 (1.97)
9. Overdraft Prevention Week Indicator	-39.9 (2.64)	-75.5 (3.52)	-33.0 (3.39)
<b>Short-run Effects of</b>			
10. Cap Indicator	-23.2 (0.34)	-29.5 (0.87)	-10.8 (0.64)
11. Cap Indicator Interacted with Bank Capital	0.116 (0.46)	0.116 (0.92)	0.041 (0.65)
12. Fee	-4.3 (1.12)	-11.3 (5.85)	-6.1 (6.27)
13. Square of Fee	0.06 (0.21)	0.49 (3.71)	0.23 (3.58)
14. Value of Fedwire Securities-Related Transfers	0.0020 (2.43)	0.0014 (3.36)	0.0006 (2.59)
15. Value of Deposits at Federal Reserve Banks	-1.54 (3.41)	-0.76 (3.30)	-0.44 (3.86)
16. Share of Bank Credit Funded by Fed Funds and Repurchase Agreements	5.16 (2.28)	2.43 (2.12)	1.13 (1.97)
17. Value of U.S. Government Securities Trans- actions by Primary Dealers	0.056 (1.21)	0.058 (2.51)	0.047 (4.06)
18. Overdraft Prevention Week Indicator	-21.3 (2.59)	-28.8 (6.93)	-12.9 (6.13)
<b>Adjustment Speed</b>			
	0.800 (9.07)	0.324 (4.82)	0.373 (5.16)
<b>Summary Statistics</b>			
Mean of Dependent Variable (Billions of 1995 Dollars)	114.9	96.5	49.9
Standard Error of Regression (Billions of 1995 Dollars)	7.53	3.79	1.89
R-Squared	0.94	0.98	0.98
Durbin-Watson Statistic	2.12	2.00	1.96

NOTE: Each dollar value series was converted to real terms by dividing by the January 1995 consumer price index. Below each coefficient estimate is its *t*-statistic.

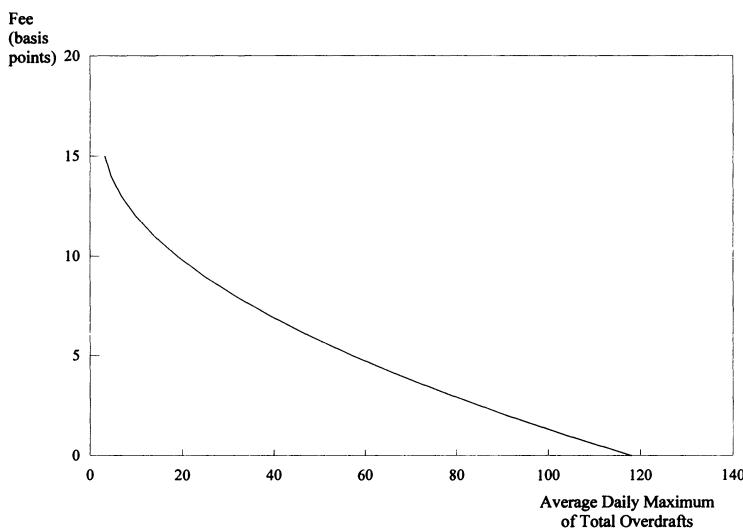


FIG. 6. The Demand for Daylight Overdrafts. These data show the response, relative to the March 1994 overdraft level of \$118.1 billion (1995 dollars), implied by the estimates in column 2 of Table 5 of average maximum total overdrafts to various levels of fees.

much the average daily maximum total overdrafts were estimated to decline for various levels of the overdraft fee. The estimates in Table 5 imply that the initial increase in the overdraft fee from zero to ten basis points reduced the estimated average daily maximum total overdraft by \$99.3 billion (1995 dollars). This estimate is consonant with the estimate of \$92.7 billion (1995 dollars) in Table 2.<sup>35</sup> The estimated reduction attributed to the fee increase from ten to fifteen basis points in Figure 6 is \$15.6 billion (1995 dollars), compared with an estimated reduction in Table 2 of \$16.7 billion (1995 dollars).

Table 6 presents, for both fee increases, the (own-price) "model-consistent arc" (MCA) elasticities of demand for overdrafts implied by the specification used in Table 5 for each of the three measures of overdrafts. We opted for arc elasticities because (1) the largest of the two changes in fees started from a fee of zero, thereby precluding calculation of the point elasticity at a fee of zero and (2) the only other fee change was a 50 percent increase, which would have made the estimated reduction in overdrafts misleading if the elasticity changed appreciably over that arc of the demand curve.

To prevent shifts in demand from contaminating our calculation of the elasticity along the demand curve, we calculated the MCA elasticity as

35. The small number of distinct observations of fees (observations of 0, 10, and 15 basis points) made it likely that the specifications in Tables 2 and 5 would provide similar estimates of the effects of the observed fee increases, and they do.

TABLE 6  
PRICE ELASTICITIES OF DEMAND FOR DAYLIGHT OVERDRAFTS

Month Fee Changed	Measures of Overdrafts								
	Total			Securities-Related			Funds-Related		
	Maximum Overdraft (1)	Average of Daily Maximum Overdraft (2)	Average Overdraft (3)	Maximum Overdraft (4)	Average of Daily Maximum Overdraft (5)	Average Overdraft (6)	Maximum Overdraft (7)	Average of Daily Maximum Overdraft (8)	Average Overdraft (9)
1. April 1994	-0.48	-0.72	-0.52	-0.44	-0.73	-0.93	-0.11	-0.15	-0.17
2. April 1995	-1.12	-0.70	-0.52	-0.97	-0.73	-1.09	-0.09	-0.06	-0.04

$$\eta_{MCA} = \frac{(\tilde{q}_2 - q_1)/((q_1 + \tilde{q}_2)/2)}{(p_2 - p_1)/((p_1 + p_2)/2)} \quad (5)$$

where  $p_1$  and  $p_2$  are the first-period and second-period fees and  $q_1$  is the observed first-period quantity.  $\tilde{q}_2$  differs from the first-period quantity only to the extent implied by the estimated fee coefficients. In the specification used for Table 5, where both the level and square of price were used to explain quantity:

$$\tilde{q}_2 = q_1 + \alpha \cdot (p_2 - p_1) + \beta \cdot (p_2^2 - p_1^2) \quad (6)$$

where  $\alpha$  is the coefficient on the level of fees and  $\beta$  is the coefficient on the square of fees.<sup>36</sup>

Table 6 shows that the estimated demand elasticities ranged from -0.04 to -1.12. For the maximum and the average daily maximum overdraft categories, the elasticities for total overdrafts tended to be quite close to those for securities-related overdrafts. For average overdrafts, the elasticities for total overdrafts were about midway between those for securities- and funds-related overdrafts. The funds-related elasticities were uniformly small, ranging from -0.04 to -0.17.

The elasticities for the two periods were generally similar; in fact, in four cases (columns 2, 3, 5, and 7), they were identical or nearly so.<sup>37</sup> The most notable difference was the large increase from 1994 to 1995 in the estimated elasticity for securities-related maximum overdrafts, which presumably was the primary source of the even-larger increase in the total maximum overdraft elasticity. Thus, even

36. MCA elasticities can be calculated for arcs outside the range of experience because they do not require actual second-period quantities.

37. The Federal Reserve had announced that it would raise the level of overdraft fees to twenty-four basis points in April 1995 but then it raised them to only fifteen basis points. A fee level of twenty-four basis points is considerably above the highest level observed (fifteen basis points) in our data. A positive estimated coefficient on the square of fees implies that if fees were raised sufficiently high, overdrafts would rise rather than fall. One of the dangers of extrapolating outside the range of experience is that the functional form that approximates the relation within that range is a poor approximation outside that range. In this case, we estimated positive MCA elasticities for six of the nine categories for an increase of the overdraft fee to twenty-four basis points.

though Table 2 shows that the estimated reduction in overdrafts per basis point of fee increase was smaller in 1995, the estimates in Table 5 imply that the elasticity was larger.

#### 10. WHY DID FEES REDUCE SECURITIES-RELATED OVERDRAFTS MORE THAN FUNDS-RELATED OVERDRAFTS?

Data aggregated across banks did not allow us to determine the *reasons* behind the patterns of overdraft reduction. We considered two hypotheses: (1) banks faced scale economies in reducing overdrafts in general and (2) it was cheaper at the margin for banks to reduce securities-related overdrafts than to reduce funds-related overdrafts. These two hypotheses are not mutually exclusive. Banks may have faced significant scale economies in reducing either securities-related or funds-related daylight overdrafts, or both. Scale economies may have stemmed from fixed costs, for example, the fixed costs associated with purchasing, developing, and installing computer hardware and software. Or the fixed or variable costs associated with reducing securities-related overdrafts may have been appreciably lower than the costs of reducing funds-related overdrafts.<sup>38</sup>

Banks with the largest overdrafts before the implementation of fees also tended to be banks that had large securities-related overdrafts. Thus, the larger absolute reductions in, and larger elasticities of, securities-related overdrafts relative to funds-related overdrafts in response to increases in overdraft fees are consistent with scale economies and with securities-related overdrafts having been cheaper to reduce. To see whether banks may have faced scale economies in reducing their funds-related overdrafts, we looked to see if banks that had larger funds-related overdrafts reduced their overdrafts relatively more than banks that had smaller funds-related overdrafts. To do so, we calculated the percentage change in average daily overdrafts from the period before fees to the period after fees were implemented.<sup>39</sup> Using data for each of the fifty banks with the largest average overdrafts before fees were implemented, we plotted in Figure 7 these percentage changes in overdrafts against the banks' average daily overdraft before fees were implemented (OLD-AVOD).<sup>40</sup> If scale economies were important in reducing funds-related overdrafts,

38. The more important fixed costs were, the less likely we would have found that the second, 1995 fee increase reduced overdrafts. Had fixed costs been particularly important, banks more likely would have borne them when fees were first implemented, and overdrafts would have declined then rather than when fees were raised later.

39. We used data on average daily overdrafts because fees are based on that measure of overdrafts. The data for the period before fees were implemented came from the six-month period October 14, 1993, through April 13, 1994; the data for the period after fees were implemented came from the six-month period June 30, 1994, through December 31, 1994. The sample consisted of the fifty banks that had the largest average daily overdrafts during the six months before fees were implemented in April 1994. To preserve the confidentiality of the data, we omitted data for the three banks with the largest average daily total overdrafts in the period before fees were implemented. Two of these banks were securities-clearing banks. Including those two banks or the third omitted bank changed the visual impression and the statistical significance of the regression line very little.

40. OLDAVOD is measured in billions of dollars.

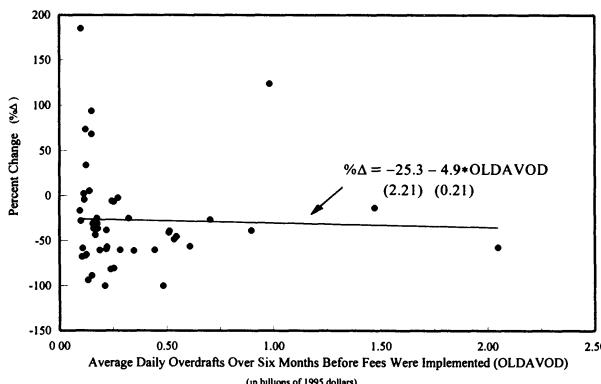


FIG. 7. Percent Change in Average Overdrafts across Banks after Fees Were Implemented. Percent change for each bank is one hundred times the result of subtracting one from the ratio of average daily overdrafts after fees were implemented (June 30, 1994–December 31, 1994) to average daily overdrafts before fees were implemented (October 14, 1993–April 13, 1994). Data in parentheses under regression line coefficients are *t*-statistics.

then we would expect banks with relatively larger overdrafts before fees were implemented to achieve larger percentage reductions in their overdrafts. No such pattern is apparent. Figure 7 shows that banks with approximately the same pre-implementation overdrafts differed widely in the percentage reductions in average overdrafts. Of the banks with relatively low average overdrafts before fees were implemented, a few reduced post-fee-implementation overdrafts by nearly 100 percent and others reduced their overdrafts very little. Furthermore, the banks that initially had large overdrafts showed little tendency to reduce their overdrafts by any greater proportion than did banks with small overdrafts. The regression line fitted through the data points in Figure 7 confirms these characteristics of the data: It does have a small negative slope ( $-4.9$ ), but the *t*-statistic of  $-0.21$  for the slope indicates no statistically significant relation between the amount of overdrafting before fees were implemented (OLDAVOD) and the ensuing percentage reduction in average overdrafts. These data, then, provide little support for the hypothesis that fixed costs produced scale economies and that, as a consequence, banks with larger funds-related overdrafts were likely to reduce their overdrafts by larger percentages than banks that had smaller funds-related overdrafts.

On the other hand, the data for individual banks suggest that those banks where securities clearing was concentrated reduced their overdrafts much more than did other banks: Daily average total overdrafts declined 27 percent at banks that did little securities clearing and about twice that at securities-clearing banks (not shown in Figure 7). Thus, securities-related overdrafts may have been relatively cheaper to reduce than were funds-related overdrafts, apart from any scale economies. Unfortunately, because the few banks that could be regarded as securities-clearing banks had overdrafts of roughly similar magnitude, we could not infer whether securities-related overdrafts had scale economies. Thus, while we cannot discern if scale

economies were important in reducing securities-related overdrafts, they do not seem to have been important in reducing funds-related overdrafts.

## 11. CONCLUSIONS

The Federal Reserve's policy on payment system risk over the past decade has been designed to change the balance of risks associated with the extension of daylight credit throughout the payments system. One goal has been to reduce the credit risk taken by the Federal Reserve, and thus ultimately by taxpayers, in providing daylight credit. At the same time, the Federal Reserve has sought to prevent the risks of disruption of the payments system from rising to unacceptable levels. The main implements in this rebalancing of risk have been caps and fees on banks' overdrafts of their reserve accounts.

Our empirical results suggest that caps alone did little to reduce daylight overdrafts, at least through September 1995. That is not to say that caps could not reduce overdrafts. Until relatively recently, cap policy exempted from caps securities-related overdrafts, which account for a large portion of total overdrafts. Data from a longer sample period might well indicate that the overdraft cap policy in effect during 1995 and thereafter did reduce overdrafts.

By contrast, the evidence is compelling that the imposition of fees reduced daylight overdrafts. The evidence also points to very large responses to fees. We estimate that the April 1994 increase in the fee from zero to ten basis points per annum reduced the average daily maximum overdraft on the Fedwire system a little more than \$90 billion and the average total overdraft at any time during the day a little more than \$40 billion. These reductions, not surprisingly, were concentrated in securities-related overdrafts as opposed to funds-related overdrafts: The estimated reduction in the average daily maximum securities-related overdraft was five times the reduction in the same measure of funds-related overdrafts. The difference was due partly to the much larger volume of securities-related overdrafts and partly to the larger price elasticities of demand for securities-related overdrafts.

The evidence is less compelling but nonetheless indicative that the increase in the fee to fifteen basis points per annum in April 1995 also reduced daylight overdrafts, again primarily those related to securities transfers. Though our estimated reduction in average daily maximum total overdrafts of about \$17 billion is not statistically significant at conventional levels, dismissing this fee increase as ineffective seems unwarranted for two reasons. First, we had only six months of data since the 1995 increase. A longer sample period might permit more precise estimates of the effects of the increase. Second, we did find a statistically significant reduction in maximum daily overdrafts. On the other hand, having only three distinct fee levels (0, 10, and 15 basis points) suggests caution in interpreting the estimated reductions and associated elasticities.

We found strong statistical support for the effects of other factors on daylight overdrafts. For example, the higher banks' beginning-of-day reserve balances at

their Federal Reserve Banks, the lower were their daylight overdrafts. Also, daylight overdrafts rose significantly with the dollar value of securities transfers over Fedwire and with the share of banks' funding by federal funds and repurchase agreements.

These results highlight a number of unresolved issues in payments research. One is whether the costs of reducing securities-related overdrafts are substantially lower than the costs of reducing funds-related overdrafts, as their relative price elasticities may suggest. If they are, modeling those differences and deriving appropriate policies would be useful to policymakers.

Another unresolved issue is what determines the determinants of overdrafts. Policymakers control some of those determinants, such as caps, fees, and reserve requirements (which affect banks' reserve account balances at their Federal Reserve Banks). Policymakers interested in payments issues would be well served by research into what factors change the determinants of overdrafts, such as the aggregate value of Fedwire transfers and the extent to which banks are funded by borrowing via federal funds and repos. One question of topical interest is whether the ongoing consolidation of the banking industry will reduce the number of interbank payments by raising the number of intrabank payments, thereby reducing the use of Fedwire and the demand for overdrafts. Research along these lines could help policymakers interpret overdraft developments and set cap and fee policy.

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