

# Payment System Disruptions and the Federal Reserve Following September 11, 2001<sup>†</sup>

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## Abstract

The monetary and payment system consequences of the September 11, 2001, terrorist attacks and the Federal Reserve's response are reviewed. Interbank payment disruptions appear to be a central feature of many U.S. banking crises, and interbank payment disruptions seem likely to recur. Federal Reserve credit extension following September 11 succeeded in massively increasing the supply of banks' balances to satisfy the disruption-induced increase in demand and thereby ameliorate the effects of the shock. Relatively benign banking conditions helped make Fed credit policy manageable. An interbank payment disruption that coincided with less favorable banking conditions could be more difficult to manage, given current daylight credit policies. Paying interest on reserves would facilitate improvements in daylight credit policy. Keywords: central bank, Federal Reserve, monetary policy, discount window, payment system, September 11, banking crises, daylight credit.

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## 1. Introduction

One of the most visible effects of the terrorist attacks of September 11, 2001, aside from the appalling loss of life and sizable loss of property, was the disruption to the workings of the financial system. The destruction of the World Trade Center towers in New York inflicted severe damage on banking and financial institutions in Lower Manhattan; markets closed, participants relocated to backup sites, communications links failed or were unreliable, settlement instructions were lost, payments were delayed, and the Federal Reserve at one point injected more than \$100 billion in additional liquidity, an unprecedented sum. At the core of it all was the disruption of interbank payments.

This paper reviews the effects of the September 11 attacks on banking and financial institutions, with a focus on the monetary, payment and settlement system consequences and the Federal Reserve's response. Government securities settlement was especially hurt by the attacks. Cantor Fitzgerald, a key interdealer broker, was devastated, losing 658 employees. Many market participants were forced to relocate to backup sites, where internal systems and communications were not as reliable. Several banks had difficulty processing payment instructions, and the resulting accumulation of large balances drove net balances in the remainder of the banking system negative, necessitating the Fed's huge injections.

Interbank payment disruptions following September 11 were similar in some respects to several historical U.S. banking crises. In some cases, insolvency concerns caused banks to pull back from extending credit in interbank payments. The banking crises of the National Bank Era (1863-1914), the settlement problems during the stock market crash of 1987, and the settlement strains after the failure of Bankhaus Herstatt in 1974, all fit in this category. In other cases the trigger was a technological shock, analogous to the damage resulting from the September 11 attacks.<sup>1</sup> Examples include the 1985 software "glitch" at Bank of New York that led to a \$22.6 billion advance from the Federal Reserve Bank of New York, and to some extent the 1987 crash. Impediments to transferring balances between banks were common to all.

A brief appraisal suggests that the probability of future interbank payment disturbances is not negligible. Despite substantial investments in reliability and security and an impressive record of performance and innovation, the heavy dependence of interbank payment arrangements on automated payment processing and telecommunications links makes occasional technological malfunctions reasonably likely. Moreover, history suggests that credit quality scares are a recurring feature of the financial system, despite substantial investments in supervisory activities, and from time to time may cause banks to retreat from payments-related extensions of credit, thereby impairing interbank payment arrangements. Of particular relevance in light of September 11, the possibility of sabotage aimed at damaging the operational capability of the banking and financial sector cannot be ruled out. It is worth noting in this regard that,

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<sup>1</sup> I use the term "technological shock" loosely here to encompass destruction of capital and loss of labor inputs as well as malfunctions and outages.

despite the horrific nature of the destruction they achieved, the World Trade Center attacks did not seem aimed primarily at functional damage.

Gleaning lessons for central bank policy from the experience of September 11 and its aftermath therefore appears worthwhile. Federal Reserve credit extension through discount window advances and overnight overdrafts was quite successful in supplying the additional bank balances necessitated by the disruption to interbank payment flows, consistent with the lender of last resort principles articulated by Walter Bagehot, as well as one of the purposes of the Federal Reserve Act: “to furnish an elastic currency.”

The Federal Open Market Committee’s interest rate targeting procedures supply account balances each day to satisfy demand at the target overnight rate. Normally open market operations aim at supplying the banking system’s forecasted reserve needs each day through purchases of U.S. government securities and short-term repurchase agreements with government securities dealers. The discount window serves as a backstop provider of funds. Following September 11, open market operations were aimed at satisfying the financing needs of the severely disrupted government securities dealer community, leaving to the discount window the task of elastically providing balances to satisfy demand at the target rate.

Fed credit extension at the end of each day was virtually preordained, however, by the Fed’s daylight overdraft policies, which automatically ensured that disruption-related increases in the demand for balances manifest themselves as intraday overdrafts which then became some form of overnight lending – either overnight overdrafts or outright discount window loans. These daylight credit policies, however, could make managing credit extension difficult in a crisis if the Federal Reserve wished to be selective about the account holders through which it was willing to channel reserve injections. From this viewpoint, it was fortuitous that the banking system was in relatively healthy condition on September 11. A convergence of technological shock to interbank payments, whatever the cause, and banking sector weakness is not inconceivable, however.

## **2. The Financial and Monetary Effects of the September 11, 2001 Attacks<sup>2</sup>**

On the morning of September 11, 2001, two hijacked commercial jet airplanes were flown into the World Trade Center. The two towers collapsed within hours, destroying or damaging a number of nearby buildings and spreading dust and debris across lower Manhattan. The devastating loss of life was concentrated in the financial industry, which accounted for over 74 percent of the total civilian casualties in the World Trade Center attacks. One firm, Cantor Fitzgerald, a key interdealer broker in the government securities market, lost 658 employees. (General Accounting Office 2003, p. 31) Property damage was extensive; an insurance industry group estimated that total

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<sup>2</sup> For an extended report on the effect of the September 11 attacks on financial markets, see General Accounting Office (2003).

insured claims would be about \$40 billion. (Zolkos 2003) The attacks caused major power outages and hazardous conditions that hampered activity in the area for weeks.

Much of the telecommunications infrastructure of lower Manhattan was unavailable for several days as a result of the attacks. (General Accounting Office 2003, pp. 37-8) The collapse of the 7 World Trade Center building sent steel I-beams into the adjacent Verizon communications center at 140 West Street. Switching equipment there controlled over 40 percent of lower Manhattan's phone lines and 20 percent of the lines serving the New York Stock Exchange. (Krane 2001) Service was lost on voice, data, PBX and internet lines affecting about 34,000 business and residential customers.<sup>3</sup> Other telecommunications service providers had service disrupted as well, but virtually all of the post-September 11 telecom outages in lower Manhattan resulted from the problems at 140 West Street. (Lower Manhattan Telecommunications Users' Working Group 2002)

Financial markets in New York generally ceased operations. The timing of the attacks – around 9 a.m. eastern time – meant that many markets had not yet begun trading. Many key market participants had substantial operations in or around the World Trade Center that were destroyed or damaged in the attacks, and had to relocate to backup facilities. The New York Stock Exchange and the Nasdaq Stock Market never opened for trading the day of the attacks. The facilities of the New York Board of Trade in Four World Trade Center were destroyed. Regional stock exchanges, the Chicago Board of Trade, and the Chicago Mercantile Exchange all closed as well. Equity markets reopened on Monday morning, September 17.

The government securities market was hit particularly hard by the World Trade Center attacks, in part because it opens earlier. Trading in U.S. government securities starts at 8 a.m. in New York, and repo trading starts as early as 7 a.m.<sup>4</sup> “(T)he bulk of government securities cash and repo trading takes place before 9:00 a.m., ... so September 11 was close to a full trading day.” (Green 2003, p. 3) According to one report, on the morning of September 11, some \$500 billion in repo transactions and about \$80 billion in government securities trades had already been executed when the planes hit. (Shephard 2002) Reconciling these trades would occupy back-office personnel for weeks.<sup>5</sup>

The government securities market also was hit particularly hard because many critical market participants were incapacitated. Dealers in U.S. government securities trade with each other through interdealer brokers (IDBs). Cantor Fitzgerald, who suffered tragic losses, was the largest IDB prior to the attack. Two other major IDBs were located

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<sup>3</sup> According to Ivan Seidenberg, president and CEO of Verizon: “The network damage was equivalent to a city the size of Reno or Cincinnati going out of service all at once. Two hundred thousand voice access lines went out, 100,000 PBX/Centrex lines went out, 3.6 million data circuits went out, 10 cellular towers were lost or damaged, and approximately 14,000 businesses and 20,000 residential customers were affected.” (Rosenberg 2001)

<sup>4</sup> A repurchase agreement (“repo” or “RP”), is a sale of securities coupled with an agreement to repurchase the securities at a higher price on a later date. See Fleming and Garbade (2003), Lumpkin (1998) and Shephard (2002).

<sup>5</sup> See Shephard (2002) and the sequence of GSCC “Important Notices” following September 11, at <http://www.ficc.com/gov/gov.imp.notices.jsp?NS-query=>.

in the WTC towers – ICAP PLC, formerly known as Garban-Intercapital, and Euro Brokers – but the only fatality was one Garban employee. Many other IDBs suspended operations in the aftermath of the attacks. The interdealer market operates by phone and screen-based trading systems. With phone contact through brokers disrupted, traders turned to online platforms, including BrokerTec, a consortium of fourteen primary dealers, and Cantor Fitzgerald’s own eSpeed Inc., which was able to continue operating out of their London offices. (Parry 2001; Mackenzie 2001) The Bond Market Association recommended that the market “be closed until further notice,” (although some trading did occur) and then later recommended reopening Thursday morning. (Bond Market Association 2001)

The failure of many communications links between government securities dealers and the market’s clearing and settling institutions was also a major source of disruption. The two main clearing banks for the government securities market, Bank of New York (BoNY) and J.P. Morgan Chase (JPMC), operated just a few blocks from the World Trade Center. JPMC was in the middle of migrating certain business operations to Tampa, Florida, and were able to resume operations from there. (McLaughlin-Moore 2002) BoNY had more difficulty.<sup>6</sup> Their headquarters, One Wall Street, was untouched a half a mile from the WTC, but had to be evacuated. BoNY’s main operations center at 101 Barclay Street, one block north of the World Trade Center, housed the bank’s funds transfer and broker/dealer systems, including the bond clearing and settlement systems. (MacRae 2001) Both facilities were evacuated on September 11, and operations were established at contingency sites outside the city in New Jersey and New York. The remainder of that week BoNY suffered intermittent connectivity problems that were not resolved until late Friday. By Monday, September 17, functionality had largely been restored, though there was a tremendous backlog of transactions to reconstruct and reconcile. (Beckett and Ip 2001; Cowan 2001)

A third major entity in clearing government securities trades was the Government Securities Clearing Corporation, as it was then known.<sup>7</sup> Instructions from counterparty government securities dealers are compared and confirmed by GSCC, which then establishes a net position for each dealer in each security issue, along with a net cash position, and interposes itself as counterparty to guarantee settlement. Positions are settled using the Fedwire Securities Service or the clearing banks.<sup>8</sup> GSCC remained operational after September 11, but many members were unable to deliver trade instructions for the 11th, and thus GSCC had information from only one side of the trade. GSCC’s connection to BoNY was lost for part of the week of the 11th and as a result they did not know what securities and cash they had received, and were at times unable to transmit settlement instructions to BoNY. (Costa 2001) Because the offices of so many

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<sup>6</sup> For accounts of BoNY’s experience, see Beckett and Sapsford (2001), Guerra (2001), Gibbons (2001), and MacRae (2001).

<sup>7</sup> GSCC merged with the MBS Clearing Corporation on January 1, 2003, to form the Fixed Income Clearing Corporation, a subsidiary of the Depository Trust & Clearing Corporation. See [www.ficc.com](http://www.ficc.com). For a description of repo clearing and settlement, see Fleming and Garbade (2002; 2003).

<sup>8</sup> Government security trades are settled T+1, that is, the business day following the trade. For repos, GSCC settles only the close (maturity) leg of the trade and the start leg for forward repos (repos beginning T+1 or later); GSCC does not settle the start legs of RPs that start the same day.

key market participants were destroyed, and because connectivity was problematic for several days following September 11th, there was a dramatic increase in the volume of settlement “fails” – failures to deliver U.S. government securities rose from \$1.7 billion per day the week of September 5 to \$190 billion the week ending Wednesday, September 19. (Fleming and Garbade 2002)

BoNY’s role in clearing and settling government securities transactions placed it at a critical node in interbank payment flows. The two clearing banks hold funds and securities on behalf of government securities dealers. When counterparties both use the same clearing bank, settlement involves offsetting transfers of securities and funds on the books of that bank. When counterparties are customers of different clearing banks, settlement involves an exchange of funds for securities between the two. The two clearing banks process a substantial portion of the payments that flow across the Fedwire system.

The communications and operations difficulties plaguing BoNY meant that not all funds payment instructions were getting sent as intended. On the Federal Reserve’s Fedwire Funds Transfer System, payments are initiated by the sender of funds.<sup>9</sup> A bank that is unable to send funds transfer payment instructions would tend to accumulate funds in its account. Balances in the rest of the banking system would be correspondingly lower. At one point during the week after September 11, BoNY was publicly reported to be overdue on \$100 billion in payments. (Beckett and Sapsford 2001) A handful of New York banks found themselves in a similar situation – unable to make payments or loan funds. (Markets Group of the Federal Reserve Bank of New York 2002, pp. 6, 24) Balances accumulated in these banks’ accounts and resulted in a corresponding reserve drain from the remainder of the banking system.

The increase in account balances was more widespread than a few money center banks, however. Figure 1 shows the account balance distribution from the beginning of August through September 21. For each day, selected percentile balances are plotted. For example, the top line shows, for each day, the account balance of the bank at the 99.9th percentile; 99.9 percent of banks have smaller balances. Thus each line could represent a different bank each day. The number of account holders was about 8,500 each day; so there are eight or nine banks in each tenth-percentile group.<sup>10</sup> Figure 1 shows that the increase in account balances extended down to around the 90th percentile of the balance distribution. In other words, about 800 banks experienced a noticeable increase in their account balance. Interestingly, the increase was proportionally larger at the upper end of the distribution, as one would expect if those observations represented banks with larger typical payment flows. For example, on a typical day in August, fewer than 8 banks held balances greater than half a billion, whereas on September 11 and 17, more than 16 banks

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<sup>9</sup> On the Fedwire Securities Service, the party sending the security initiates the transaction, which results in the immediate and simultaneous transfer of the security against offsetting payment – “delivery versus payment.” Thus, for a security transfer the party receiving funds (and sending securities) initiates the transaction.

<sup>10</sup> Eight banks were assigned to the above-99.9-th percentile group, nine banks were assigned to the group between the 99.9th and 99.8th percentiles, eight banks the next group, and so on. The figure for a given percentile is the minimum balance within the group.

held balances that large. Of course, there is no guarantee that banks retained their relative position within the bank balance distribution. But Figure 1 indicates that the disruption to payment flows affected far more than just a couple of New York banks.

It seems implausible that all of the institutions that showed higher account balances following September 11 were directly damaged by the attacks. Some of the accumulation of funds in banks' accounts appeared to have resulted from the breakdowns in the fed funds market. Several federal funds brokers were disabled in the attacks and did not resume operations until the following Monday. Banks with excess balances found it difficult to locate borrowers. The general disruption in payment flows would also have meant uncertainty for many banks about whether scheduled incoming payments would be received as planned. This may have induced banks to delay or withhold payments. (McAndrews and Potter 2002) On the other hand, Federal Reserve statements (described below) may have encouraged banks to anticipate a more liberal discount window lending than usual. With the discount rate 50 basis points below the prevailing funds rate target, the attractiveness of resorting to the window may have inhibited funds market borrowing.

Other markets were affected by the World Trade Center attacks as well. Although Fedwire and the Clearing House Interbank Payments System (CHIPS), operated by the New York Clearing House (as it was known then – the name has since been changed to The Clearing House), continued to function, payment processing was delayed at many banks and closing times were pushed back. (McAndrews and Potter 2002; Goldenberg and Stock 2001; New York Clearing House 2001) The majority of the commercial paper that was scheduled for presentment on September 11 and 12 was not paid, but rolled over and settled on Thursday. (Bond Market Association 2001) Issuance resumed fairly quickly, however, and proved a relatively viable source of liquidity in the following days. (Goldenberg 2001) The Moscow International Currency Exchange (MICEX), which used BoNY as its dollar settlement bank, suspended trading on Thursday afternoon due to BoNY's problem but then resumed trading after switching to JPMC. (Russian rouble firms on low liquidity 2001; Danielyan 2001)

Retail payment card networks – credit, debit, ATM cards, and the automated clearinghouse networks – remained operational, except for scattered problems at bank ATMs in New York City, and at BoNY's ATM network, which crashed entirely on the 11th and wasn't restored until the evening of September 19th. (In the Shadow of Tragedy, U.S. Payment System Stands Strong 2001; The Bank of New York's ATM Network Restored 2001; Mandaro 2001) BoNY announced it would refund ATM fees for customers that used other banks' ATMs. The grounding of airline flights seriously hampered inter-regional check clearing for a time, as banks and the Federal Reserve scrambled to arrange for substitute transportation. (Edwards 2001; Mollenkamp, Pinkston, and Schlesinger 2001) On Thursday, September 13, the Federal Aviation Administration began reopening U.S. airspace and gave check air couriers approval to resume its chartered flights.<sup>11</sup>

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<sup>11</sup> The Federal Reserve Banks contract with private air couriers to transport checks overnight between Federal Reserve Bank offices. A private air courier, Airnet, is a major transporter of checks for banks.

In New York and Washington, bank branch closings were widespread on September 11th, but many banks outside those cities closed branches briefly as well. Some state banking agencies and the Office of the Comptroller of the Currency issued statements allowing banks to close at their discretion. The Banking Commissioner for the State of Connecticut ordered all banks and credit unions to close.<sup>12</sup> Bank of America and Wachovia closed their headquarters, which are housed in several tall towers that dominate the Charlotte, North Carolina skyline. (Mollenkamp, Pinkston, and Schlesinger 2001) Wachovia and Chicago-based Bank One closed branches nationwide early in the afternoon on Tuesday, but were open as usual the next day. The Chicago Tribune reported that “a handful of bank branches in or around major landmarks such as the Sears Tower” were closed. (Allison 2001)

Some banks discouraged cash withdrawals by customers. The Municipal Credit Union, whose back offices were near the WTC, limited customers to \$500 withdrawals when their 11 branches reopened on Thursday. (Padgett 2001) For a day after the attack Citibank recommended that customers limit cash withdrawals to \$5,000. (Chaffin and Silverman 2001) Wells Fargo, a San Francisco-based bank, placed limits on per-person cash withdrawals that reportedly varied across locations from \$1,000 to \$5,000, and Washington Mutual, based in Seattle, imposed a limit of \$2,500. (Ip, Sims, and Beckett 2001) Some armored carriers suspended operations in New York City, and transportation difficulties impeded some deliveries of currency elsewhere in the country. Deliveries of newly printed notes from the Bureau of Engraving and Printing to some Federal Reserve Banks were delayed by the airline grounding, as were currency shipments to Alaska and Hawaii. (Blackwell 2001)

Reports of increased cash withdrawals by bank depositors were common, especially on the East Coast. (Mandaró 2001; In the Shadow of Tragedy, U.S. Payment System Stands Strong 2001; Breitkopf 2001) Concord EFS, an ATM payment processor, reported a surge in ATM card usage on their network Tuesday afternoon and Wednesday morning. (Bills, Breitkopf, and Green 2001; Breitkopf 2001) At 8 p.m. volume was 31 percent higher than the previous week. The biggest surge was at point-of-sale terminals, especially at gasoline retailers, perhaps reflecting the substitution of automotive for airline travel. Concord’s network traffic was down in the hours immediately following the attacks, however. Credit card networks reported lower volume for several days after the attacks, consistent with the sharp drop in retail sales. (Bills, Breitkopf, and Green 2001)

Currency in circulation increased by \$4.4 billion from Monday to Wednesday. In comparison, total currency in circulation was \$614 billion on September 5, of which more than half was estimated to be overseas. Nearly \$3 billion of the \$4.4 billion reflected an increase in banks’ vault cash holdings, consistent with heightened cash shipments from the Federal Reserve banks. (Edwards 2001; Ip, Sims, and Beckett 2001) Currency held outside banks only rose by \$1.6 billion. Some of the increase in vault cash

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<sup>12</sup> Only in the order to reopen, issued at 7:15 p.m. on the 11th, did the Commissioner reassure consumers that they “should remain confident that their savings in banks and credit unions are not at risk and are insured by the Federal Deposit Insurance Corporation (FDIC) and the National Credit Union Administration (NCUA), respectively.” (State of Connecticut Department of Banking 2001a, b)

holdings probably reflected banking system preparations for a further expected currency drain later in the week. In the event, there was a \$2.6 billion increase on Friday. The public's currency holdings stabilized in the following weeks, falling during the week and rising on the weekends, as is typical. Vault cash holdings trended downward.

Figure 2 shows that the swings in currency demand around September 11 might have been a bit elevated, but were well within typical ranges. Vault cash holdings, however, were somewhat higher than trend over the weekend of September 15-16. Banks appeared to have built up a large buffer of cash, but experienced a demand surge that was smaller than anticipated.

### **3. The Federal Reserve's Response**

Virtually every instrument available to the Federal Reserve – open market operations, discount window lending, payment services, supervision and regulation, and communication – was pressed into service following the September 11 attacks. At first, Fed communications were the most visible response. At 9:44 a.m. on the 11th, a broadcast message was sent to banks over the Fedwire system stating that the system was “fully operational at this time and will remain open until an orderly closing can be achieved.” At 11:25 a.m. another broadcast stated that “The discount window is available to meet liquidity needs.” Around noon the Board of Governors issued the following press release.

The Federal Reserve System is open and operating. The discount window is available to meet liquidity needs.

Later in the day the Boston Fed released a statement on behalf of the Fed's financial services functions with more specifics. Fed Governor Edward Gramlich, traveling in Tucson, Arizona that day, was quoted as saying, “The Fed is the lender of last resort. If credit is needed to make transactions go, the Fed will provide it.” (Gilbert and Thomas 2001) Reached by phone in Basle, Switzerland, New York Fed President William McDonough said “I'm sure that central bankers everywhere will do everything possible to maintain calm and seek to ensure the world economy functions smoothly in the face of this horrendous deed.” (Ip and McKinnon 2001)<sup>13</sup>

Conditions in Lower Manhattan affected operations at the Federal Reserve Bank of New York, just three blocks to the east of the WTC. During the day on Wednesday, staff began relocating to an operations center outside the city, and early Wednesday evening remaining staff were forced to evacuate the Manhattan building due to concerns

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<sup>13</sup> Vice Chairman Roger Ferguson was the only member of the Board of Governors in Washington on September 11: Laurence Meyer was in China, Edward Gramlich was in Arizona, Edward Kelley was on vacation, and two seats were vacant. (Ip and VandeHei 2001) Chairman Greenspan was flying from Switzerland, where he had been attending an international meeting of central bankers, when his plane turned back as a result of the closure of U.S. airspace. He returned to Washington Wednesday morning on a military plane.

about the structural integrity of One Liberty Plaza next door. The Board of Governors in Washington, D.C., was evacuated on September 11 along with many other government offices in the city, although “about 100 staffers remained at work.” (VandeHei et al. 2001) Concern about employee safety caused the Boston Fed to evacuate and led many other Federal Reserve Banks to staff critical functions only.

The disruption to communications links impaired many institutions’ ability to initiate payment instructions. The number of payments processed over the Fedwire funds transfer and securities systems fell on September 11 and remained low for the rest of the week. (Coleman 2002; McAndrews and Potter 2002) Payments on those systems occurred significantly later in the day, and intraday (“daylight”) overdrafts were significantly larger. The Fed waived daylight overdraft fees from September 11 through September 21.<sup>14</sup> To facilitate completion of payments processing, the Fed extended the Fedwire closing times on the days following September 11.<sup>15</sup>

Check collection, as noted above, was severely hampered by the lack of air transport, and it was clear at the outset that the presentment of checks to paying banks would be delayed significantly. This meant delays for the Fed in collecting funds from paying banks. Normal Fed policy is to credit banks that deposit checks according to a schedule that replicates, on average, the schedule on which the Fed collects good funds, so that Fed “check float” – the excess of credits to banks for deposited checks over the funds collected from other banks on those checks – is typically near zero. Positive Fed check float represents an implicit loan to the banking system as a whole; depositing banks are credited before offsetting debits are made to paying banks. The Fed often continues to grant credit on normal schedules when collections are delayed by storms or other factors impeding transportation, but sometimes delays credit until presentments are actually made. On September 11, anticipating a general need for liquidity in the banking system, a decision was made and announced late in the afternoon to continue to extend credit on normal availability schedules. Fed check float, which averaged \$766 million per day in the first eight months of 2001, resulted in a net injection of funds of \$47 billion on Thursday and \$44 billion on Friday: see Table 1, which displays the factors affecting account balances for the days around September 11. In comparison, the value of checks collected by the Reserve Banks averaged \$40 billion per day in 2001, suggesting that the two-and-a-half day courier grounding delayed roughly half the Fed’s checks each day. In addition, the Reserve Banks picked up check volume from banks that found the Fed’s availability schedule attractive relative to the availability they could obtain on their own. The reopening of U.S. airspace on Thursday night prevented further increases in float on Friday, and the weekend allowed check processors to catch up and work off the backlog.

As mentioned above, and as detailed by Fleming and Garbade (2002), there was a dramatic increase in failures to settle government securities trades following September 11. During normal times settlement fails are often associated with a “scarcity” of a

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<sup>14</sup> The Fed charges a small fee, equivalent to 36 basis points on an annualized basis, for overdrafts in excess of a deductible for each bank. See Coleman (2002) for a discussion of the Fed’s daylight credit policies.

<sup>15</sup> The funds transfer service, which normally closes at 6:30 p.m. ET, was extended to 9:00 p.m., 11:30 p.m., 11:00 p.m., and 8:30 p.m., Tuesday through Friday, respectively. The securities transfer system, which normally closes at 3:15 ET, was extended to 7:15 p.m., 10:45 p.m., 8:30 p.m., and 6:30 p.m.

specific issue. To help alleviate such scarcities and help limit fails, the Federal Reserve loans out securities from its System Open Market Account, subject to self-imposed limits on the fraction of SOMA holdings of any given issue that can be lent. The Fed relaxed the terms of the securities lending program on September 11 by suspending per dealer limits, and then further loosened terms on September 13.<sup>16</sup> Because settlement fails were still a problem two weeks after the attacks, the Fed raised the security lending program limit from 45 percent to 75 percent of each issue, beginning September 27 and continuing into October. Acute settlement problems with the on-the-run ten-year note led the U.S. Treasury to reopen the issue on October 4 and hold an unusual “snap” auction of new ten-year securities.

In the days following September 11, banking regulators realized that disruptions were causing significant increases in the size of bank portfolios. Failures to settle various transactions left offsetting payment and security delivery obligations sitting on the balance sheets of market participants, along with the underlying cash or securities that were awaiting delivery, reducing bank capital ratios. In addition, many firms drew on bank lines of credit in response to operational difficulties rolling over commercial paper. On Friday September 14, federal banking regulators issued a Joint Interagency Statement noting that many banks may experience temporary balance sheet growth, and urging banks to contact their regulators should they anticipate a resulting decline in their regulatory capital ratio. The Federal Reserve later issued a Supervisory Letter allowing banks some flexibility in calculating capital ratios for the third quarter of 2001. (Spillenkothen 2001) Bank regulators also encouraged banks to lend to customers (“take prudent steps to make credit available to sound borrowers”) affected by the events of September 11.<sup>17</sup> (Board of Governors of the Federal Reserve System 2001c)

### *3.1. Monetary Injections I: Open Market Operations*

Federal Reserve open market operations and credit extension injected unprecedented quantities of funds into the banking system in the days following September 11. Injections were necessitated by the accumulation of balances at operationally constrained banks and the willingness of many banks to hold larger than normal account balances under conditions of uncertainty about clearing and settlement arrangements. Movements in autonomous factors also affected the magnitude of the required injections.

Monetary policy operations during the week following September 11 had to adapt to the disruption of clearing and settlement activities. Normally, operations aim to supply a level of bank balances each day that satisfies the banking system’s demand at an overnight federal funds rate equal to the target rate set by the Federal Open Market Committee. (Markets Group of the Federal Reserve Bank of New York 2002) The

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<sup>16</sup> See <http://www.newyorkfed.org/newsevents/news/markets/2001/omo010911.html> for details.

<sup>17</sup> The Comptroller of the Currency announced that “national banks that support recovery efforts in communities affected by the September 11 terrorist attacks will receive credit under the Community Reinvestment Act.” (Office of the Comptroller of the Currency 2001)

Trading Desk adds balances by lending in the repo market – that is, by entering into repurchase agreements with dealers in U.S. government securities whereby the Desk effectively advances funds against pledged collateral.<sup>18</sup> The rates on the Desk’s repo transactions are set via auction. When the Desk wants to inject balances, it announces the maturity and requests bids specifying the interest rate dealers are willing to pay and the amount they wish to borrow. The Desk selects the bids with the highest rates down to the point at which it has accepted bids for the amount of funds it wishes to inject. Settlement takes place on the books of BoNY or JPMC, since all of the primary dealers clear through one of those banks. An injection of funds thus increases the banking system’s balances in the first instance by increasing the account balances of BoNY or JPMC. These new balances are then reallocated throughout the banking system during the day as banks send payments to other banks and borrow or lend in the interbank market. In 2001 the Desk typically had a set of longer-term 28-day repos outstanding.<sup>19</sup> Overnight and/or very short-term operations are used to accommodate day-to-day fluctuations in needs. Term repos totaling \$22.755 billion were outstanding on September 11: see Table 1. Short-term operations averaged close to \$8 billion in 2001, excluding the September 6-19 maintenance period. (Markets Group of the Federal Reserve Bank of New York 2002)

Prior to the initial attack, the Desk had decided on the basis of available data to arrange no open market operation for the day. In the wake of the attacks, the discount window was considered the most effective means of providing any additional liquidity that the banking system might need that day, consistent with the Board’s noon statement (see above). By Wednesday morning the extent of the disruption to government securities settlement was coming into view, as was the likelihood that the banking system’s needs would be substantially elevated. Beginning Wednesday and continuing through the following Monday, the Desk conducted open market operations with the aim of satisfying dealer financing needs (Markets Group of the Federal Reserve Bank of New York 2002, p. 22), a shift from the usual focus on bank needs.<sup>20</sup>

During the week following September 11, the Desk accepted all bids at or above the target federal funds rate, which was then 3.5 percent: see Table 2. Operations totaled \$38.25 billion on Wednesday, \$70.20 billion on Thursday, and \$81.25 billion on Friday, all for overnight funds. The \$8.75 billion in term repos that matured Thursday the 13th were not rolled over, and thus Thursday’s overnight operation brought total RPs outstanding to a little over \$84 billion.

On Monday morning, September 17, the FOMC met by conference call at 7:30 a.m. eastern time and voted to lower the target for the federal funds rate by 50 basis points to 3 percent. In its statement the Committee said:

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<sup>18</sup> Reserve drains are accomplished using reverse repurchase agreements in which the Fed effectively borrows from dealers against collateral pledged from the System’s portfolio.

<sup>19</sup> Effective September 18, 2003, the Trading Desk began using 14-day term RPs instead of 28-day RPs. (Federal Reserve Bank of New York 2003)

<sup>20</sup> Government securities dealers hold securities inventories overnight, which they finance by entering into repurchase agreements with institutional investors seeking safety and liquidity. This traditional market was disrupted on September 11, and by stepping up repo activity, the New York Fed helped fill the gap.

The Federal Reserve will continue to supply unusually large volumes of liquidity to the financial markets, as needed, until more normal market functioning is restored. As a consequence, the FOMC recognizes that the actual federal funds rate may be below its target on occasion in these unusual circumstances.

The Desk added \$57.25 billion in funds later that morning via overnight repos, accepting every proposition at or above the stop-out rate of 3 percent, the new funds target rate. Term repos for about \$2 billion rolled off Monday and were not replaced, bringing total outstanding repos to \$69.25 billion. The next two days, the Desk accepted bids below the target but added a smaller quantity of balances each day. On Wednesday, the Desk also executed term repos worth \$22.75 billion with maturities of 14, 21 and 28 days, for commencement and settlement the following day, the beginning of the next maintenance period, in order to reduce the level of intervention that would be necessary. (Markets Group of the Federal Reserve Bank of New York 2002, p. 24) Open market operations were closer to normal scale over the following days.

### *3.2. Monetary Injections II: Federal Reserve Credit*

The second half of the Federal Reserve's two-sentence press release following the attacks was devoted to lending: "The discount window is available to meet liquidity needs." While this might have been seen as an unmistakable implication of first sentence's message that the Fed was "open and operating," it was widely interpreted as evidence that the Fed was willing to lend to ease payment strains in the aftermath of the attacks. The statement echoed the Fed's reaffirmation of readiness on the morning of the stock market crash of October 20, 1987.<sup>21</sup> In fact, Governor Gramlich indicated that his statement (quoted above) was "in the spirit" of a statement by Chairman Greenspan in 1987. (Gilbert and Thomas 2001) Several other Fed officials reinforced that message over the course of the next few days.

Discount window borrowing is generally arranged at the end of the day, sometimes after the close of business, although borrowing can be arranged earlier in the day and banks often are in contact with their Federal Reserve Bank lending officers before a formal request is made.<sup>22</sup> For many years prior to January 2003, the interest rate applicable to discount window loans was generally below the federal funds rate target and thus below the general level of short-term interest rates, giving banks an incentive to borrow at the window to exploit the spread. (Board of Governors of the Federal Reserve System 2002a) Regulations governing the use of the discount window limited borrowing by requiring that an institution first exhaust other available sources of funds and explain its need for adjustment credit. In addition, banks were prohibited from using discount window credit to finance lending in the federal funds market. (Under current policy the "primary rate" is usually 100 basis points over the target funds rate, and the administrative conditions intended to limit borrowing have been eased.) In practice,

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<sup>21</sup> "The Federal Reserve, consistent with its responsibilities as the nation's central bank, affirmed today its readiness to serve as a source of liquidity to support the financial and economic system."

<sup>22</sup> See [www.frbdiscountwindow.org](http://www.frbdiscountwindow.org) for details on the Federal Reserve's discount window policy.

interpretation of the regulations by Reserve Banks effectively limited most borrowing to situations in which banks experienced unanticipated late-day drains and were unable to cover their shortfall in the fed funds market. In this context, a noon-time statement emphasizing the availability of the discount window was likely seen as a distinct regime shift.

The discount window serves as an outlet for unmet demand for Reserve Bank account balances. The Trading Desk estimates autonomous factors affecting reserve supply before they undertake open market operations in the morning, but unanticipated variations in these factors can occur. For example, banks may make unusually large currency withdrawals from Federal Reserve Banks, or an unanticipated flow of tax receipts could swell the Treasury's account, draining private sector balances. In such cases, the balances added by the Desk might be insufficient to satisfy the banking system's demand for balances at the target funds rate. The Fed's discount window thus serves to limit the tendency of the funds rate to rise above the target.

The Federal Reserve has an additional channel by which banking system balances can increase. Most banks are entitled to incur intraday overdrafts, also known as daylight credit, subject to a system of caps and fees.<sup>23</sup> The daylight overdraft cap is set as a multiple of capital for a depository institution that qualifies through a self-assessment of its creditworthiness, credit policies, and operational controls and procedures. Some depository institutions qualify for smaller caps, and five percent of depository institutions have a zero daylight overdraft cap.<sup>24</sup>

When the Fedwire funds transfer system closes (normally at 6:30 p.m.) banks effectively are no longer able to obtain funds from other banks. A negative account balance at the end of the day becomes an overnight overdraft if no further action is taken, and a penalty is incurred equal to the effective federal funds rate plus 400 basis points. Alternatively, the bank with sufficient collateral could request a discount window loan at the discount rate, which they presumably would prefer because the cost is lower. Another difference is that discount window loans are explicitly collateralized while overnight overdrafts are not necessarily collateralized.<sup>25</sup> In addition, some institutions with Federal

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<sup>23</sup> The Federal Reserve's Payment System Risk Policy governs the extension of daylight credit: see Coleman (2002) for details. A daylight overdraft fee of 36 basis points at an annual rate applies throughout the day to overdrafts over a deductible set at 10 percent of an institution's capital. In other words, if the fee was compounded for 24 hours a day over the course of an entire year it would come to 36 basis points. Currently, Fedwire is only open for 18 hours a day however, so the effective maximum fee works out to 27 basis points annually.

<sup>24</sup> Multiples vary from 1.125 to 2.25 times (risk-based) capital. Some depository institutions qualify for a *de minimus* cap of 20 percent of capital; others have a zero cap. These net debit caps apply to any single day's daylight overdraft. A separate cap applies to the two-week average daylight overdraft. See Coleman (2002).

<sup>25</sup> Discount window borrowing requires that a bank execute the lending agreement contained in Operating Circular 10, which secures *any* borrowing, including daylight and overnight overdrafts, with the collateral pledged to the Federal Reserve. See [www.frbdiscountwindow.org](http://www.frbdiscountwindow.org). Discount window lending must be secured "to the satisfaction of the Reserve Bank," which normally requires that the Reserve Bank obtain a perfected security interest in the pledged collateral. If a lending agreement is in place and sufficient collateral has been pledged, then overnight overdrafts are implicitly collateralized, but a lending agreement is not required for access to daylight and overnight overdrafts. For a bank without a lending agreement in place and which has not posted collateral, overnight overdrafts would be uncollateralized.

Reserve accounts are ineligible for discount window credit.<sup>26</sup> For the period from September 11 through September 21, the Federal Reserve waived daylight overdraft fees for all account holders and eliminated the penalty on overnight overdrafts for depository institutions; depository institutions were charged the effective federal funds rate on overnight overdrafts while non-depository institutions were charged the “extended credit” rate, which was 4 percent at the time, plus 55 basis points.

Foreign financial institutions operating in the U.S. also faced payment flow disruptions, and some experienced balance deficiencies in the days after September 11. “In some cases, however, these institutions encountered difficulties positioning the collateral at their U.S. branches to secure Federal Reserve discount window credit.” (Board of Governors of the Federal Reserve System 2002b, p. 142) The Federal Reserve arranged new or expanded swap lines with three central banks in order to help meet those needs. These swap lines, totally \$90 billion, entitled the foreign central banks to receive dollars from the Federal Reserve in exchange for their respective currencies.<sup>27</sup> When a foreign central bank drew on one of these lines, the New York Fed credited them with dollar balances, which they then lent on to foreign financial institutions. This mechanism had the effect of adding dollar balances to the banking system while interposing foreign central banks between the Federal Reserve Banks and foreign financial institutions. Table 1 lists the total amount drawn on these swap lines around September 11.

Following September 11, the demand for overnight Federal Reserve credit – discount window advances and overnight overdrafts – reflected the banking system’s residual need for funds. The Desk’s repo operations added substantial amounts of balances on Wednesday, Thursday, and Friday. Check float added additional billions on those days as well. But as the end of the day approached, the banking system’s net demand for balances had to be brought into line with supply. Some banks were able to adjust their holdings to a desired level. Others were constrained by disruptions in communications and processing, and were unable to send payments and reduce their holdings to a planned or desired level. The sum of banks’ positive balances, either intended or constrained, exceeded the Fed’s earlier injections by large amounts.

The banking system’s net end-of-day deficit thus implied that many banks were short on balances. Banks with deficiencies had two options; they could either bid for borrowed funds in the market or turn to the Federal Reserve for overnight credit. Federal Reserve statements were likely interpreted as implying a fairly elastic supply of funds at the discount rate. Given that assumption, there was no need to bid up the funds rate. And

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<sup>26</sup> The Board of Governors has defined “depository institution” for purposes of Regulation A (governing extensions of credit by Federal Reserve Banks) as ruling out financial institutions that are not required to meet reserve requirements. These include banker’s banks, corporate credit unions, and the government sponsored enterprises. Some of these institutions can waive their exemption from reserve requirements and become eligible for regular access to the discount window. In certain cases, Federal Reserve Banks may extend credit to nondepositories: “In unusual and exigent circumstances and after consultation with the Board of Governors, a Federal Reserve Bank may extend credit to an individual, partnership, or corporation that is not a depository institution if, in the judgment of the Federal Reserve Bank, credit is not available from other sources and failure to obtain such credit would adversely affect the economy.” 12 C.F.R. 201

<sup>27</sup> The lines were for \$50 billion with the European Central Bank, \$30 billion with the Bank of England, and an increase of \$8 billion (from \$2 billion to \$10 billion) with the Bank of Canada.

the Fed ultimately followed through with the provision of credit as expected. Discount window borrowing rose from an average of about \$200 million in the year prior to the week of September 11 to \$37 billion that night and overnight overdrafts rose from an August 2001 average of \$9 million to around \$2 billion: see Table 1. Overnight credit of over \$38 billion was required by the banking system because there were no open market injections that day and check float had added only \$4 billion. Moreover, currency withdrawals had drained \$2 billion from bank balances. On Wednesday, the Desk injected over \$38 billion, check float added another \$23 billion, but there was still an additional \$50 billion in demand for balances at the end of the day. Balance injections picked up on Thursday, with check float adding \$47 billion and the Desk adding a net of \$61 billion (after letting \$9 billion in term repos roll off), only \$8 billion in overnight Fed credit was required; overdrafts fell below \$500 million and discount window advances fell to \$8 billion. Check float was still substantial Friday night and the Desk added even more balances that day, finally satisfying demand; overnight credit extensions were negligible. Float receded Monday, but the Desk's generous balance provision kept Fed overnight credit to a minimum. Borrowing rose on Wednesday, the last day of the maintenance period, but then subsided.

### 3.3. Interest rates

Short term interest rates generally declined in the days following September 11. The FOMC cut the target overnight funds rate by 50 basis points, from 3.5 percent to 3 percent, at a special meeting convened before markets opened on Monday morning the 17th, and then cut another 50 b.p. at its next scheduled meeting on October 2nd. The week before, numerous news stories after the attacks had carried conjectures about imminent Fed rate cuts, although market participants were unsure of the timing. Overnight rates were steady the week of September 11 – see Figure 3 – but the fall in the implied rate on the September federal funds futures contract to below 3.4 percent on September 13 – see Table 3 – indicates that some market participants expected the funds rate to decline before the end of the month. They may have expected a move before the October 2 meeting. Alternatively, they may have anticipated that with the large amount of reserves injected by the Fed, banks with excess balances at the end of the maintenance period would drive the funds rate down. The fact that the October contract closed at 2.87 on the 13th suggests that rate cuts were expected. By the close on Friday, the market was pricing in a 2.8 percent average funds rate for the month of October, suggesting expectations of one 50 b.p. cut and a substantial probability of another. After the Monday morning move, markets quickly priced in even lower rates for October. Eurodollar futures prices indicated a downward revision in expected mid-2002 short rates of about a half a percent in the week after September 11. The downward shift in the yield curve accompanying the FOMC's rate cuts following September 11 is consistent with market perceptions that the cuts would not be soon reversed.

Overnight interest rates sagged at the start of the week after the attacks due to the overhang of balances that had been added the week before. The first three days of that week were the last three days of the reserve requirement maintenance period. Because

many banks had been forced to hold large balances the previous week, the banking system ended the maintenance period with a large excess reserve position – \$38 billion, compared to a maximum excess position of \$1.7 billion over the period between Y2K and September 11. As a result, the Desk aimed to leave relatively low levels of balances each day. Autonomous factors were draining reserves, however, (see Table 1, second panel, column labeled “Other”) and so the size of the needed operations remained large. The Desk “had to accept the vast majority of propositions – even those offered at rates well below the new 3 percent target level – in order to arrange RPs of sufficient size.” (Markets Group of the Federal Reserve Bank of New York 2002, p. 24) On Wednesday, the Desk accepted all propositions submitted, the lowest of which was ¾ percent: see Table 2. The effective federal funds rate sank to 1¼ percent on Tuesday and below that on Wednesday: see Table 3. Rates returned to normal a couple of days into the next maintenance period.

#### **4. Part and future payment disruptions**

Interbank payment disruptions have featured prominently in several past banking crises.<sup>28</sup> For example, on November 21, 1985, faulty software prevented the Bank of New York from sending securities to counterparties, which thereby prevented collection of the offsetting payments and caused BoNY to end the day overdrawn by \$23.6 billion at the New York Fed, nearly 50 percent more than the entire assets of the bank as of their previous call report. BoNY borrowed from the New York Fed, using the unsent securities and other bank assets as collateral. (*The Federal Reserve Bank of New York Discount Window Advance of \$22.6 Billion Extended to the Bank of New York* 1985) As in 2001, technological impediments interfered with interbank payments and led to large Federal Reserve credit advances.

In several banking crises, credit risk concerns led banks to pull back from the extension of credit in interbank settlement. During the sharp fall in stock market prices the week of October 19, 1987, a two and a half hour Fedwire outage interrupted payments between New York and options-related accounts in Chicago. (Garsson 1988) In addition, credit concerns regarding traders and specialists led several banks to decline to make payments covering settlement and margin calls. The Fed issued a statement emphasizing the availability of the discount window and reportedly “encouraged” banks to cover their customers accounts. (Bernanke 1990) In 1974, the closure of Bankhaus Herstatt, a medium-sized German bank, caused their U.S. correspondent bank to dishonor about \$620 million in payments, including the dollar legs of foreign exchange deals on which Herstatt had already received the deutschemark leg. (Kaserer 2000; Remolona et al. 1990) For some time afterwards, New York banks would not make payments on foreign exchange trades until the other side of the transaction was confirmed, resulting in slower and less reliable settlement. Further back in time, the banking panics of the National Bank Era (1863-1914) were distinguished less by bank failures than by

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<sup>28</sup> Fuller accounts of the historical interbank payment disruptions described in this section are given in Lacker (2003).

suspensions of payments by New York banks to “interior” banks. (Sprague 1910; Wicker 2000) This disrupted the interbank markets for New York correspondent balances and contributed to an “uneven distribution of reserves” that subsequent writers agree was the root cause of the banking crises.<sup>29</sup>

This suggests defining two types of interbank payment disruptions—credit-shock induced and technology-shock induced—based on the nature of the initial triggering events. These might seem different enough to warrant treatment as separate phenomena. But to the extent that the choice of an interbank payment arrangement is viewed as balancing a trade-off between the costs of credit risk exposure during clearing and settlement, and the technological costs of minimizing that exposure by increasing payment speed, both types of shocks can be seen unanticipated disturbances to the frontier of feasible interbank arrangements.

If September 11 and the three other episodes cited above are taken as instances of a single class of events – interbank payment disruptions – then the occurrence of at least four over the last thirty years (about as often as recessions over that time period) suggests that they deserve policy-makers’ attention. Future disruptions seem plausible, especially in light of the shift in the banking industry’s record-keeping and communications technologies over the last century from paper to electronics, particularly for interbank payments. The reliability and security of electronic payments processing arrangements presumably reflect a wide array of benefit-cost calculations, which are not likely to completely eliminate the risk of malfunctions. Perhaps the most obvious potential malfunctions are software or hardware outages, such as the one that afflicted BoNY in 1985. Power outages, storms and other unanticipated infrastructure break downs would have to be included in this category as well.<sup>30</sup> Deliberate terrorist attacks on physical infrastructure are obviously capable of interrupting normal payment functions, and September 11 was not the first such attack. At about noon on September 16, 1920, a horse-drawn wagon carrying hundreds of pounds of explosives was detonated at the corner of Wall and Broad Streets in Lower Manhattan, killing thirty people instantly and causing the stock exchange to close, although it reopened “defiantly” the next day and banking and financial activity appeared to return to normal quickly. (Brooks 1969) The iconic status of financial markets could make them attractive targets in the years ahead.

Recent incidents suggest that critical payments processing systems could be vulnerable to computer virus attacks, or “cyberterrorism,” despite the heightened security surrounding payment-related infrastructure. Bank of America’s ATM network was knocked out by the SQL Slammer internet worm in January, 2003, and several other large banks were affected as well, though to a smaller degree. (Breitkopf 2003; Lee 2003) In June of the same year, the BugBear virus specifically targeted financial institutions. (Weiss 2003) During an attack by the Blaster worm in August, 2003, CSX temporarily stopped railroad service and Nordia, Scandinavia’s largest bank, closed 80 branches across Finland. (Guth 2003) Shortly thereafter, two Baltic banks shut down their systems

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<sup>29</sup> See Wicker (2000, p. 146), Sprague (1910, p. 276), and Timberlake (1984).

<sup>30</sup> For example, the Northeast blackout of August 14, 2003 affected the financial system, although disruptions were minimal. (Financial and Banking Information Infrastructure Committee 2003; Kite 2003)

after attacks by the Sobig.F virus. Computer virus attacks are purely destructive in the sense that they do not result in a direct wealth transfer to the attacker. Electronic payments systems would appear to be inviting targets for attacks that aimed instead at transferring wealth to the perpetrator. Citibank's funds transfer system was penetrated in August 1995 by a Russian hacker who was able to move at least \$10 million in funds to accounts at other banks. (Caldwell 1995) In short, future interbank payment disruptions similar in scope to September 11 seem quite plausible.

## 6. Implications for Central Bank Policy

### 6.1. Central bank credit policy

The Federal Reserve's response to the banking system disruptions following September 11, 2001, conformed fairly well to classic lender of last resort doctrine. Bagehot's prescription was for the central bank to (1) clearly preannounce the intention to (2) lend freely, (3) at a penalty rate, (4) on good collateral. (Goodhart 2002; Humphrey and Keleher 1984; Bordo 1990; Bagehot 1991) Judging by the frequency with which the statement was repeated in news coverage of the event, the Federal Reserve System's announcement that "the discount window is available to meet liquidity needs," along with other reinforcing communications by Federal Reserve officials, appeared to have significantly reduced uncertainty regarding the Fed's intentions in the days after the attacks. Late afternoon on September 13, the Board of Governors released the regular weekly report on the Fed's balance sheet for the night before showing large discount window borrowings of \$46 billion.<sup>31</sup> Federal Reserve lent quite freely during the crisis, consistent both with Bagehot and the preamble of the Federal Reserve Act ("furnish an elastic supply of currency"), increasing the supply of bank balances from \$13 billion on September 10 to over \$120 billion on the 13th: see Table 1. Although lending took place at a discount rate 50 basis points *below* the prevailing market rate, rather than above, as required by (3), the Fed did prevent interest rates from rising, and thereby limited secondary repercussions from the disruptions.<sup>32</sup> Moreover, as noted above, no bank runs materialized. Finally, all discount window lending and much of the overdraft lending was on a collateralized basis. Thus the Federal Reserve's response was consistent with at least three of Bagehot's four dicta.

The modern lender of last resort literature emphasizes the distinction between sterilized and unsterilized central bank lending. The former constitutes "banking policy," according to Goodfriend and King (1988), while the latter is best thought of as "monetary

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<sup>31</sup> The September 13, 2001, H.4.1 release also showed average daily figures for the week ending September 12. These showed discount window borrowing averaged \$11.7 billion over that week, from which market participants could infer that discount window borrowing was likely to have been about \$36 billion on Tuesday the 11th, if borrowing was about average earlier in the week.

<sup>32</sup> Lending at a penalty rate provides a natural mechanism whereby the extension of central bank credit is self-reversing. (Humphrey and Keleher 1984) By lending freely at below-market rates following September 11, the Fed preempted the interbank lending market. Also, in Bagehot's doctrine, the central bank is typically viewed as preventing a shock-induced fall in the money stock. After September 11, the task was to respond to a shock-induced *increase* in the demand for reserves.

policy” in the sense that it results in a net increase in the monetary base. Goodfriend and King (1988) argue that unsterilized central bank lending is unnecessary given the ability of open market operations in principle to achieve the same result.<sup>33</sup> Groshen et al (2002) claim that the events following September 11 show that open market operations are not equivalent to discount window lending, because such lending responded to late-in-the-day reserves demand, the magnitude of which was unknown at the time of the Desk’s morning intervention. The Desk was not attempting to satisfy reserve demand, however, so their failure to do so should not be taken as evidence that they could not have done so. Moreover, Goodfriend and King’s thesis is that an alternative *policy regime* could replace discount window lending with open market operations. For example, the Desk could conduct repo operations after the close of Fedwire (when discount lending now takes place). Under such a regime, banks would have an incentive to hold repo-eligible collateral in order to access Desk liquidity operations, and the Fed could mitigate the moral hazard problems potentially associated with discount window lending.

One feature of the Fed’s end-of-day credit extension following September 11 that went unnoticed in popular accounts is that it was virtually preordained by the Fed’s intraday credit policies. As mentioned above, depository institutions with accounts at a Federal Reserve Bank can apply for daylight overdraft privileges, and these are routinely utilized. Seventy five percent of account holders – 5,300 out of 8,500 institutions – incurred daylight overdrafts at some point during the third quarter of 2001, according to Coleman (2002). When payment processing disruptions caused several banks to accumulate large account balances after September 11, other account balances necessarily were driven down by the same amount. Open market operations and check float added balances, but a substantial gap remained. In the absence of discount window lending, and if banks had been unable to reallocate reserves among themselves, banks would have been overdrawn by the amount of this gap. To illustrate, consider Wednesday September 12. Account balances ended the day \$95 billion higher than they had been on Monday. (See Table 1) Suppose we take this as a measure of the disruption-induced increase in reserve demand. Check float added \$23 billion toward meeting the increased need, foreign central bank draws on FX swap lines added \$5 billion, and overnight repos added another \$38 billion. Currency withdrawals by banks had drained \$4 billion by Wednesday, and other technical factors drained an additional \$16 billion. At the end of the day, reserve demand was up by \$95 billion, but supply was up by a net of only \$46 billion. That left a roughly \$50 billion gap that would show up first as daylight overdrafts and would then be filled by end-of-day Reserve Bank lending, either as discount window credit or as overnight overdrafts. Ultimately, \$46 billion of the gap was met at the discount window and \$4 billion was met through overnight overdrafts.

For the Reserve Banks to *not* extend end-of-day credit following September 11, they would have had to shut down the discount window *and* prevent daylight overdrafts. The Federal Reserve’s Payments System Risk Policy governs banks’ use of daylight

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<sup>33</sup> Sterilized lending is “banking policy”, that is, redirecting the allocation of credit toward a particular institution, holding the monetary base as given. Goodfriend and King would argue that Bagehot’s principles pertain to unsterilized lending, i.e. for the conduct of monetary policy, in an institutional setting without other means (i.e. OMOs) for injecting reserves.

credit.<sup>34</sup> The Reserve Banks' Account Balance Monitoring System tracks banks' balances in real time during the day and can be used to control a bank's intraday overdrafts by rejecting any payment with settlement-day finality (e.g. funds transfers) that would cause the bank to exceed its pre-agreed net debit cap. "Real-time monitoring," as it is called, is used to reduce the risks posed by "institutions in deteriorating financial condition or institutions with a history of excessive overdraft activity." (Board of Governors of the Federal Reserve System 2001a) Approximately five percent of banks were monitored in reject mode as of early 2001. (Board of Governors of the Federal Reserve System 2001b) For the rest, ABMS tracks their daylight position, but does not prevent breaches of their net debit cap; these banks intraday payments could incur daylight overdrafts in excess of their caps. *Preventing* an overnight overdraft to a bank requires shutting off intraday credit by putting the bank on the monitor in reject mode at a *zero* net debit cap.<sup>35</sup> Without taking such action across the board, end-of-day credit extension was virtually automatic.<sup>36</sup>

The role of central bank credit in settlement arrangements is the subject of a recent theoretical literature that starts with Freeman (1996), and includes Green (1997), Lacker (1997), Zhou (2000), and Freeman (2002). Freeman's 1996 model shows that when some type of monetary asset is essential to settle the debts used in making payments, there can be a role for discount window lending that increases the supply of the monetary asset. Zhou (2000) recasts and extends Freeman's model to study central bank provision of daylight credit. The positive role for central bank credit in these models emerges in circumstances in which some agents are unable to contact other agents with whom they need to settle. This is accords well with September 11, when some key banks faced impediments to payments communications.

The provision of daylight credit can be motivated by the legislative prohibition of interest on reserves. (Lacker 1997) Banks manage their account balances in part to minimize the foregone interest cost of overnight balances. Minimizing end-of-day balances is far easier when low-cost daylight credit is available – the Reserve Banks charge 36 basis points at an annual rate for intraday credit. This reduces the deadweight societal loss banks incur to avoid the tax on overnight balances. (Lacker 1997; Zhou 2000; Martin 2002) Paying interest on reserves would reduce the need for cheap daylight credit from the central bank.<sup>37</sup>

Depository institution behavior could well have been different had they believed that the Reserve Banks would not grant credit relatively freely at the end of the day.

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<sup>34</sup> See [www.federalreserve.gov/paymentsystems/psr/default.htm](http://www.federalreserve.gov/paymentsystems/psr/default.htm)

<sup>35</sup> A policy of putting every bank on the monitor in reject mode, although not necessarily with a zero cap, is referred to as "universal real-time monitoring." This policy was considered in the early 1990s and then again in 2000. See Board of Governors of the Federal Reserve System (2001b).

<sup>36</sup> A corollary to the observation that end-of-day credit extension would have injected sufficient balances automatically is that the quantity of balances injected after September 11 was independent of the Reserve Banks' decision to provide credit for check deposits on the normal schedule, a decision that resulted in over \$40 billion in check float late in the week. If policy had kept check float within historical bounds by delaying availability in accordance with actual check presentment, the difference, all else equal, would have emerged as an additional \$40 billion demand for end-of-day credit.

<sup>37</sup> Bills before Congress (H.R. 758 and S. 1967) would allow the Reserve Banks to pay interest on reserves.

Normally, the pre-requisites for use of the discount window and the overnight overdraft penalty rate (four percentage points above the overnight funds rate) give banks an incentive to bid the funds rate up if they are short of funds. The Fed's statements encouraged banks to believe that discount window policy would be relaxed, and overnight overdraft penalties were rescinded for the days immediately following September 11.<sup>38</sup> Banks therefore had little incentive to undertake strenuous efforts to obtain funding in the interbank market. As a result, the net funding gap met by overnight Federal Reserve credit extension might have been significantly lower had more restrictive credit policies been in place.

Federal Reserve Bank lending could have presented far more difficult policy issues had the shock coincided with significant weakness in the U.S. banking sector, either due to pre-existing financial distress or shock-induced losses that threatened banks' solvency. Central bank credit policy generally attempts to restrict lending to insolvent or failing institutions, in order to reduce the costs of "distortions in the price signals that are used to allocate resources, induced excessive risk-taking, and, to limit the resultant moral hazard, greater government supervision and regulation." (Greenspan 2001) As noted above, the banking system was in relatively good condition at the onset of the crisis, which meant that relatively few banks were on the daylight credit monitor. Pre-existing weakness on a scale like that of the late 1980s and early 1990s could have forced Reserve Banks to choose between starving the banking system of the funds it needed and lending to an institution to which it would not otherwise have wished to lend. Moreover, the crisis itself did not cause significant credit losses to banks. Had potentially significant losses been suspected, the Reserve Banks would have faced a similar dilemma, but most likely with much less precise information on the extent and location of the emerging financial distress, consistent with Goodhart's (2002) observation that it is not generally possible to distinguish between illiquidity and insolvency, and that "nowadays illiquidity implies at least a *suspicion* of insolvency."

Under the Federal Reserve's current policy, controlling overnight credit requires rejecting payment instructions that would otherwise send a bank into *daylight* overdraft. Newly restricting the payments of a number of deteriorated institutions in the midst of a crisis could contribute to the disruption in interbank payments, which rely fairly heavily on extensions of intraday credit that are larger by far than banks' typical end of day balances.<sup>39</sup> From the point of view of *ex ante* efficiency, a central bank might want banks to believe that should their condition deteriorate significantly enough, daylight credit would be withdrawn, consistent with a general policy of withdrawing safety net support from failing institutions. Providing daylight credit on liberal terms during normal times, however, encourages banks to adopt arrangements which commit them to large adjustment costs should daylight credit be withdrawn. In the event of distress, the central bank then finds it difficult to impose those adjustment costs on the bank. Anticipating

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<sup>38</sup> Overnight overdrafts by depository institutions were assessed at the fed funds rate, while non-depositaries were assessed the extended credit rate plus 55 basis points.

<sup>39</sup> Aggregate average daylight overdrafts – the sum of all depository institutions' average daylight overdrafts – in August 2001 were \$32.8 billion. (Coleman 2002) Peak daylight overdraft – the largest of the aggregate banking system overdraft during a given day – averaged \$92.9 billion across the month of August 2001. Account balances averaged \$15 billion.

such leniency, banks make investment decisions *ex ante* that assume continued access to central bank credit *ex post*, an assumption that is, because of banks' investments, confirmed. This is a instance of the commitment problem in central bank lending that Goodfriend and Lacker (1999) discuss. Heightened aversion to being accused of mismanaging a crisis, they argue, can tilt central bank incentives away from the long-run moral hazard consideration and towards minimization of crisis-related dislocations.

## 6.2. *Interest rate policy*

The role of interest rate policy in the aftermath of payment system disruptions has received little attention. The direct role of interest rate reductions in addressing the immediate payment system problems seems fairly limited. The additional amount of balances that were required to achieve a 50 basis point reduction in the overnight funds rate was probably at least two orders of magnitude smaller than the amounts added the previous week.<sup>40</sup> Fulfilling the need for additional balances to offset the effects of the payments processing disruptions did not, by itself, require reducing interest rates.

The interest rate cuts following September 11 are probably best viewed as addressing the medium- and longer-term macroeconomic consequences. The FOMC had already cut the federal funds rate target in seven steps over the course of 2001 from 6.5 percent down to 3.5 percent in August. In the days immediately following the attacks, it became apparent that they had had "considerable adverse repercussions on an already weak economy." (Board of Governors of the Federal Reserve System 2002b) Consequently, the FOMC cut its target for the federal funds rate by ½ percent on September 17, during an unusual 7:30 a.m. conference call that allowed announcing the move before markets reopened for the first time since the 11th. Further ½ percent cuts followed on October 2, and November 6. A ¼ percent cut on December 11, brought the rate down to 1¾ percent.

A tension arises when interest rate policy responds with alacrity to sudden payment disturbances like September 11 or the market turmoil in September 1997 following the Russian debt default. The real economic effects of the shock, as opposed to the immediate perturbation in the demand for reserves, are highly uncertain at first. In the event that significant real effects subsequently become evident, an immediate sequence of rate cuts ends up paying off. In the event that adverse real effects turn out to be of smaller magnitude than expected, some unwinding of the initial cuts may be warranted. If so, the desire to reverse field may conflict with a desire to continue to foster market expectations that the central bank "smoothes" interest rate changes. (Goodfriend 1991) Central banks typically change their target rate "through a series of small adjustments in the same direction, drawn out over a period of months, rather than through an immediate once-and-

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<sup>40</sup> Estimated responses of excess reserves to changes in the target rate are typically \$100 million or less. Thus the amount of additional reserves needed to reduce the target on September 17 was unlikely to have been larger than \$100 million. In comparison, overnight credit, open market operations, check float, and FX swap draws added well over \$100 billion each day on September 12-14, three orders of magnitude larger.

for-all response to the new development.” (Woodford 2003) As Goodfriend emphasizes, this increases the central bank’s influence over longer term interest rates, but, as Woodford emphasizes, it requires history-dependence in interest rate settings. That is, the ability of a change in the overnight target rate to carry with it much of the short end of the yield curve requires that market participants believe that it is not likely to be reversed. The tension following a sudden shock is that if adverse effects prove smaller than expected, the central bank will be forced to choose between (1) confirming expectations of smoothing but risking an overly accommodative policy, and (2) responding to emerging economic developments but eroding the central bank’s reputation for smoothing. (Cook and Korn 1991; Goodfriend 1993) Enhanced communication would appear to offer a means of mitigating this tension. If the central bank could convince the public of the unusual nature of the shock, then it could act more flexibly in the aftermath without altering expectations regarding their behavior in normal times.

## **7. Conclusion**

The September 11, 2001 terrorist attacks, whose human consequences were so horrendous, had monetary and payment system consequences that are also worth examining. This review highlights the interbank payment disruptions that were at the heart of the crisis and have been central to several other U.S. banking crises. Several lessons emerge for central bank policy. Managing Federal Reserve credit extension could have been far more difficult had the banking system not been in relatively sound condition or had the disaster caused significant bank losses. The System’s daylight credit policies made reserve injections virtually automatic, but contributed to the potential difficulty in managing credit extension. Paying interest on reserve balances would facilitate improvements in daylight credit policy. As with credit policy, clear communications can contribute to effective interest rate policy in a crisis. The broader message that emerges here is that the fine-grained structure of central bank credit policy is critical to how an economy responds to a shock to the monetary and financial systems of this magnitude and destructiveness.

**Table 1. Factors Affecting Account Balances of Depository Institutions, September 10-21, 2001**

*End of day balances, billion \$*

Date	Repos		Check float	Swap draws	Currency	Other	Overnight credit		Balances
	Term	Overnight					Discount	Overdrafts	
Sep 10	23	0	1	0	-611	601	0	0	13
Sep 11	23	0	4	0	-613	595	37	2	47
Sep 12	23	38	23	5	-616	585	46	4	109
Sep 13	14	70	47	20	-615	577	8	0	121
Sep 14	14	81	44	9	-615	578	0	0	111
Sep 17	12	57	12	0	-615	579	0	0	45
Sep 18	12	36	9	0	-616	578	0	0	19
Sep 19	12	28	4	0	-615	584	3	0	15
Sep 20	33	7	3	0	-614	583	1	0	13
Sep 21	33	1	1	0	-612	588	2	0	12

*Cumulative change from September 10, billion \$*

Date	Repos		Check float	Swap draws	Currency	Other	Overnight credit		Balances
	Term	Overnight					Discount	Overdrafts	
Sep 10	0	0	0	0	0	0	0	0	0
Sep 11	0	0	3	0	-2	-6	37	2	33
Sep 12	0	38	23	5	-4	-16	46	4	95
Sep 13	-9	70	47	15	-4	-24	8	0	108
Sep 14	-9	81	43	-11	-3	-24	0	0	98
Sep 17	-11	57	11	0	-4	-22	0	0	32
Sep 18	-11	36	8	0	-5	-23	0	0	6
Sep 19	-11	28	4	0	-4	-17	3	0	2
Sep 20	10	7	2	0	-2	-18	1	0	0
Sep 21	10	1	0	0	-1	-14	2	0	-1

Source: L.6.1, Board of Governors of the Federal Reserve System. Balances are the deposits of depository institutions with the Federal Reserve Banks, and include required clearing balances. Check float equals "Items in process of collection" minus "Deferred availability cash items" from the Consolidated Statement of Condition of the Federal Reserve Banks. Swap draws are the amounts foreign central bank utilized under the foreign exchange swaps announced during the week of September 11. Currency is currency in circulation; it drains reserves and thus has a negative effect on reserve balances. The "Other" factor aggregates the net effect of other Federal Reserve assets and liabilities, and consists predominantly of the System's holdings of U.S. government securities.

**Table 2. Summary Results of Repurchase Financing, September 12-19, 2001**

Date	Total Props (Billion \$)	Accepted Props (Billion \$)	High Bid (Financing Rates for Overnight Repurchase Agreements)	Low Bid	Stop-Out	Weighted Avg
Sep 12	46.25	38.25	3.60	3.25	3.50	3.54
Sep 13	70.20	70.20	4.00	3.50	3.50	3.60
Sep 14	81.25	81.25	3.75	3.50	3.50	3.54
Sep 17	59.55	57.25	3.15	2.90	3.00	3.07
Sep 18	37.75	36.25	2.30	1.75	2.00	2.16
Sep 19	27.60	27.60	1.20	0.75	0.75	1.00

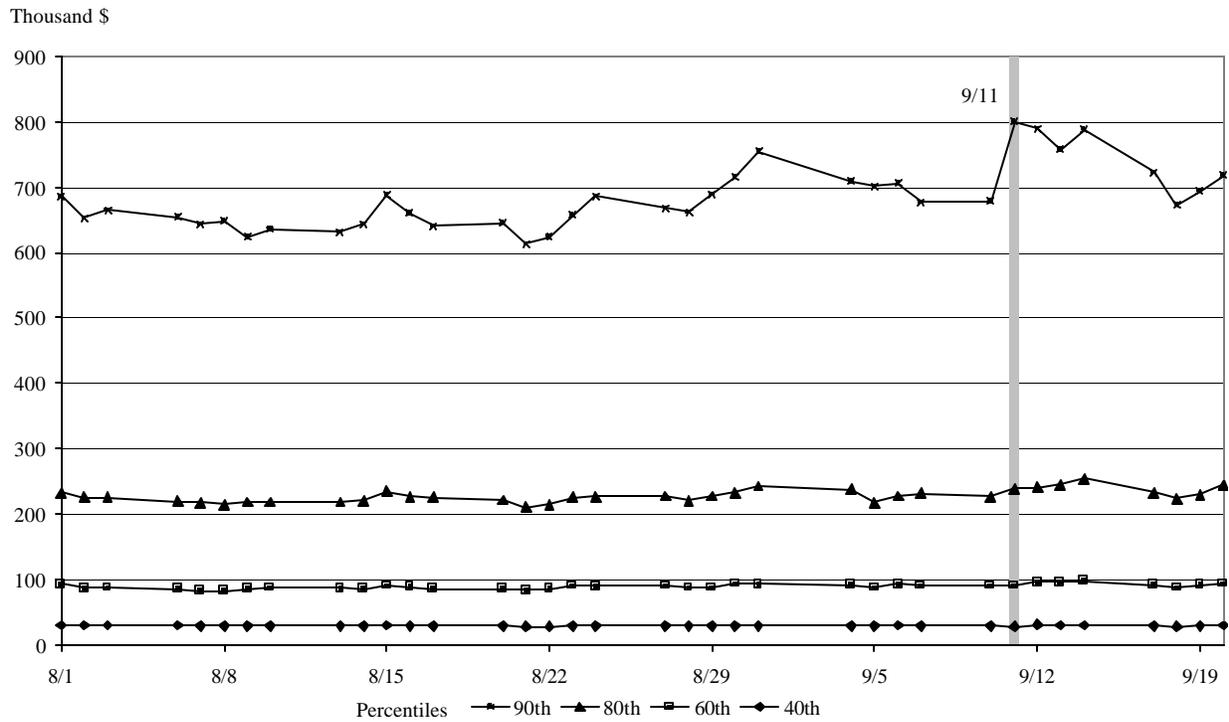
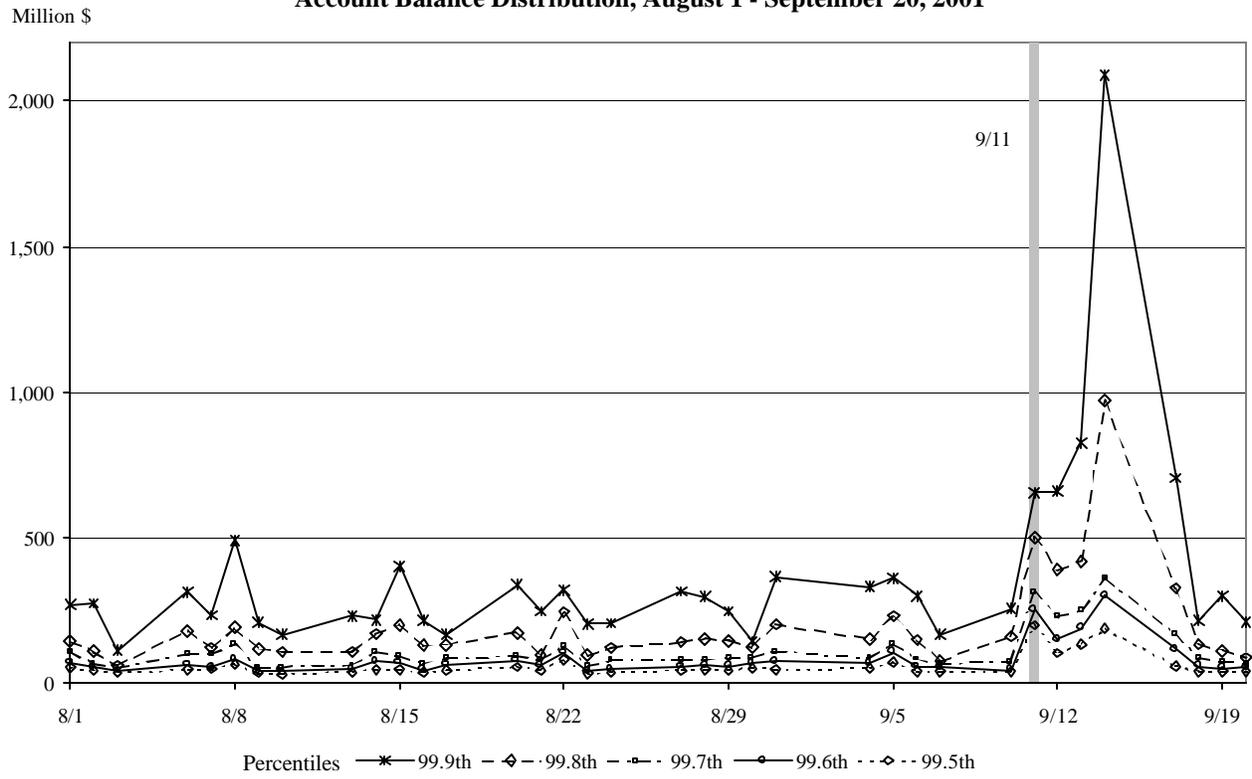
**Table 3. Selected Interest Rates, September 6 to 21, 2001**

Date	Effective Fed	Fed Funds Futures Contract Rates*			EuroDollar Futures Contract Rates^			2 Yr US	10 Yr US
	Funds Rate	Sept. 2001	Oct. 2001	Nov. 2001	Dec. 2001	Mar. 2002	Sept. 2002	Govt Yield	Govt Yield
Sep 6	3.52	3.515	3.330	3.250	3.440	3.535	4.160	3.637	4.873
Sep 7	3.44	3.455	3.215	3.240	3.265	3.360	4.020	3.505	4.790
Sep 10	3.5	3.485	3.195	3.110	3.280	3.360	4.035	3.504	4.835
Sep 11	3.5	3.470	3.130	3.050	3.100	3.150	3.890	3.517	4.809
Sep 12	3.56				3.270	3.395	4.065		
Sep 13	3.31	3.370	2.870	2.800	2.875	2.945	3.665	2.984	4.623
Sep 14	3.13	3.340	2.800	2.725	2.795	2.840	3.545	2.866	4.553
Sep 17	2.13	3.200	2.680	2.585	2.680	2.765	3.580	2.939	4.623
Sep 18	1.25	3.020	2.615	2.510	2.640	2.735	3.615	2.947	4.707
Sep 19	1.19	2.800	2.460	2.360	2.440	2.555	3.455	2.814	4.691
Sep 20	2.22	2.805	2.530	2.390	2.525	2.650	3.535	2.879	4.742
Sep 21	3.11	2.890	2.510	2.410	2.455	2.605	3.510	2.867	4.691

\* Source: Chicago Board of Trade; Rates are end of day

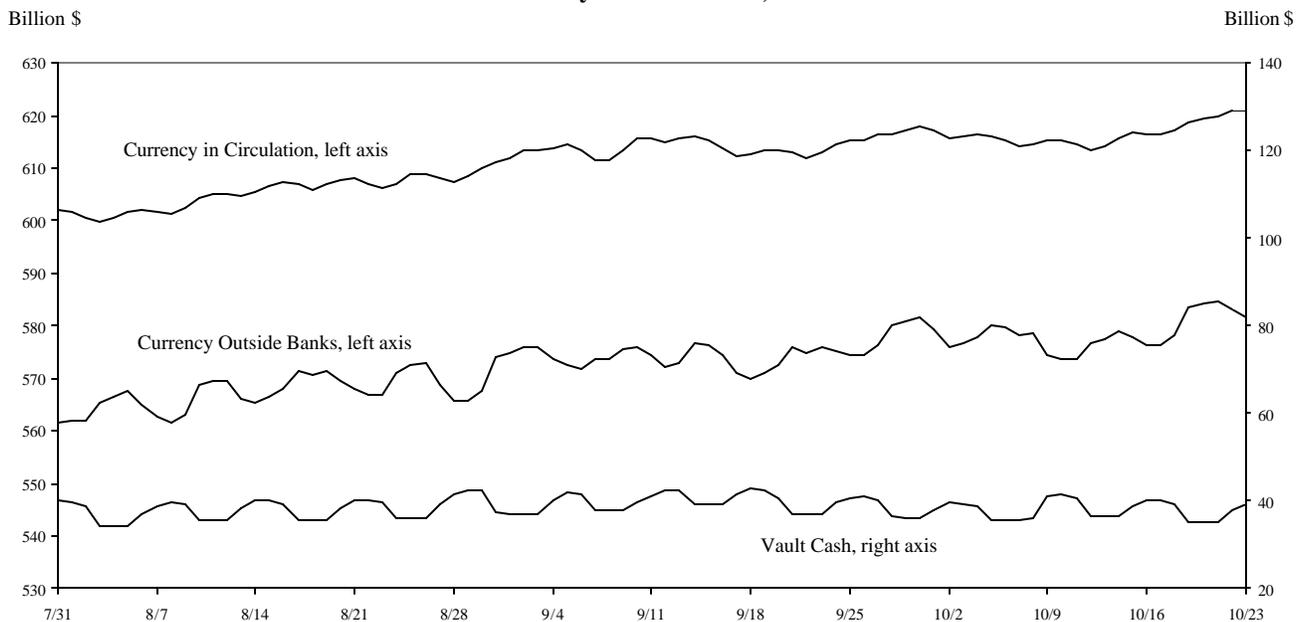
^ Source: Chicago Mercantile Exchange; Rates are end of day

**Figure 1**  
**Account Balance Distribution, August 1 - September 20, 2001**



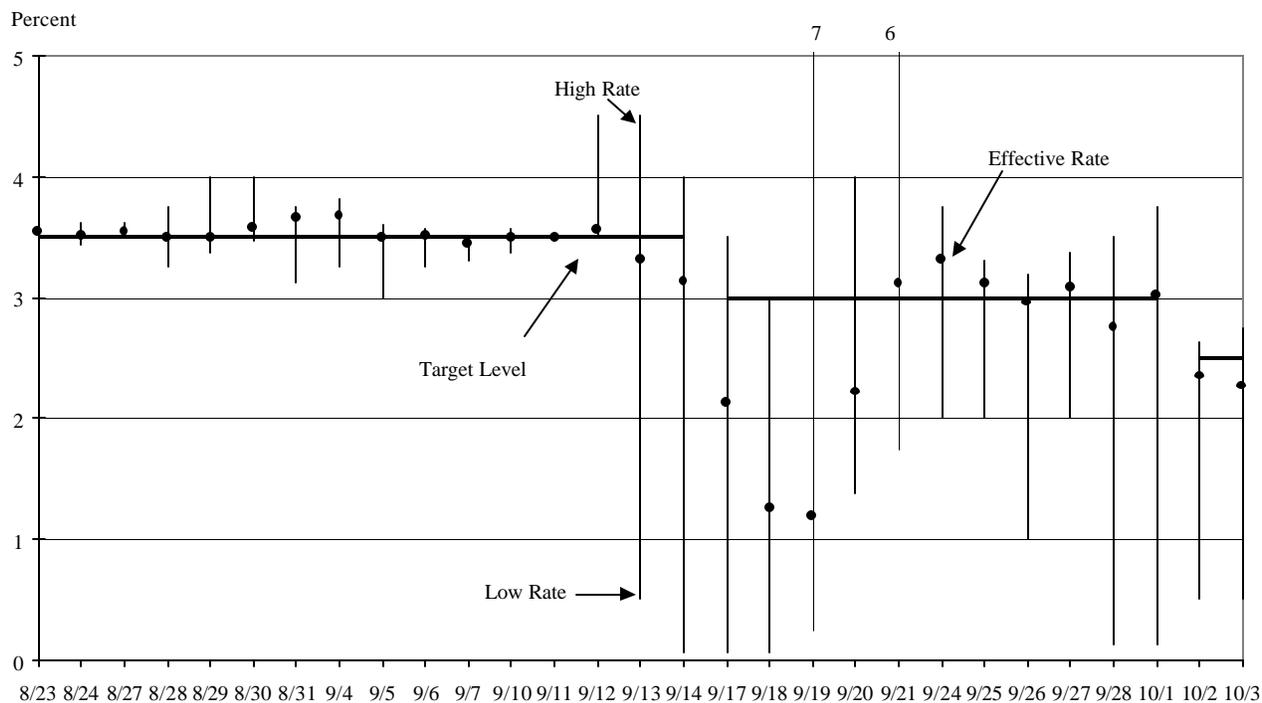
Source: Daylight Overdraft Reporting and Pricing System, and author's calculations

**Figure 2**  
**Currency in Circulation, 2001**



Source FAME database and EDDS, Board of Governors

**Figure 3**  
**Federal Funds Rates around September 11, 2001: High, Low, and Effective Rates**



Source: Markets Group, Federal Reserve Bank of New York

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