

Payment System Disruptions and the Federal Reserve Following September 11, 2001[†]

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Abstract

The monetary and payment system consequences of the September 11, 2001, terrorist attacks are reviewed and compared to selected U.S. banking crises. Interbank payment disruptions appear to be the central feature of all the crises reviewed. For some the initial trigger is a credit shock, while for others the initial shock is technological and operational, as in September 11, but for both types the payments system effects are similar. For various reasons, interbank payment disruptions appear 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.

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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 and payment 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.

The nature of the September 11 shock to the payment system is explored by comparing the events to selected banking crises in U.S. history. Interbank payment disruptions were a common element in all of the crises reviewed. In some cases, insolvency concerns provided the primary spark for interbank payment disruptions. 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. (I will use the term "technological shock" to refer to a significant loss of operational capability due to either the loss or malfunction of physical capital or the loss of staff.) 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. But common to all the crises reviewed, the central propagation mechanism was the difficulty of transferring balances between banks.

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,

despite the horrific nature of the destruction they achieved, the perpetrators of the World Trade Center attacks seemed less interested in functional damage than in symbolic effect.

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 Henry Thornton and Walter Bagehot, as well as one of the purposes of the Federal Reserve Act: “to furnish an elastic currency.” Fed credit extension at the end of each day was virtually preordained by the Fed’s daylight overdraft policies, which assured that disruption-related increases in the demand for balances manifest themselves as intraday overdrafts which then became some form of overnight lending. 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 confluence of technology shock, whatever the cause, and banking sector weakness is not inconceivable, however.

The Federal Open Market Committee’s interest rate targeting procedures ensure that account balances are supplied 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. The huge additions of funds following September 11 were therefore a by-product of operating procedures designed to target the overnight funds rate. There is a sense, then, in which Bagehotian policy is built in to Federal Reserve operating procedures.

2. The Financial and Monetary Effects of the September 11, 2001 Attacks¹

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. Fatalities in that industry represented over 74 percent of the total civilian casualties in the World Trade Center attacks, and 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

¹ For an extended report on the effect of the September 11 attacks on financial markets, see General Accounting Office (2003).

group estimated that total 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.² Other telecommunications service providers had service disrupted as well, but virtually all of the post-9/11 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. European markets remained officially open but “most traders found it difficult to do much business.” (Schroeder 2001) 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.³ “(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 Jeff Ingber, the general counsel for the Government Securities Clearing Corporation, on the morning of Sept 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.⁴

² 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)

³ 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).

⁴ 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=>.

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 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,” 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 source of major 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.⁵ 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 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.⁶ 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.⁷ 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.

⁵ For accounts of BoNY’s experience, see Beckett and Sapsford (2001), Guerra (2001), Gibbons (2001), and MacRae (2001).

⁶ 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. For a description of repo clearing and settlement, see Fleming and Garbade (2002; 2003)

⁷ 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.

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 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.⁸ A bank's inability to send funds transfer payment instructions results in funds accumulating in that bank's account. Balances in the rest of the banking system would be correspondingly lower. At one point during the week after September 11, BoNY 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 and large negative aggregate position for 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. 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 of a percentile group.⁹ 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

⁸ 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.

⁹ 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.

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 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 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)

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 truck transport. (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.¹⁰

¹⁰ 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.¹¹ 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. (Mandaro 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: see Figure 2. (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. See Figure 3, which shows the cumulative change in currency in circulation following September 10. 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

¹¹ 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)

2001) Currency held outside banks only rose by \$1.6 billion. Some of the increase in vault cash 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.

The movements in currency demand following September 11 were pronounced, but not unusually large. Bank vault cash typically rises during the week and then falls on Friday as consumers and merchants withdraw cash to use over the weekend. The public's currency holdings display the opposite pattern, peaking over the weekend and falling during the week. Figure 4 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)¹²

¹² 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.

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 about the structural integrity of One Liberty Plaza next door. The Board of Governors in Washington, D.C., was evacuated 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; see Figure 5. (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 21.¹³ To facilitate completion of payments processing, the Fed extended the Fedwire closing times on the days following September 11.¹⁴

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. 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. Collections are often delayed by storms or other factors impeding transportation. The Fed often continues to grant credit on normal schedules during such incidents, 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 of \$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

¹³ 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.

¹⁴ 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.

night prevented further increases in float on Friday, and the weekend allowed check processors to catch up and work off the backlog.

Federal Reserve Bank staff contacted banks and armored carriers to reassure them that ample currency was available for withdrawal, hours of operation were being extended, and special deliveries could be arranged. In addition, banks were notified that the Fed would waive the fees that applied to certain banks accessing Fed cash services and would suspend “cross-shipping” rules aimed at preventing banks from depositing and then quickly withdrawing the same currency. The availability of currency supplies was never seriously in question; Reserve Bank inventories were \$157 billion on September 5, 2001, versus outstanding Federal Reserve notes in circulation of \$583 billion (much of which was abroad). The increase in demand for cash turned out to be less than \$5 billion: see below.

As mentioned above, and as detailed by Fleming and Garbade (2002), there was a dramatic increase in settlement fails following September 11. During normal times settlement fails are often associated with a “scarcity” of a 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 13.¹⁵ 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. These inevitably showed up on the banking system’s balance sheet and reduced 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 urged 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 11.¹⁶ (Board of Governors of the Federal Reserve System 2001c)

¹⁵ See <http://www.newyorkfed.org/newsevents/news/markets/2001/omo010911.html> for details.

¹⁶ 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)

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 financial markets and normal clearing and settlement activities.¹⁷ 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) Banks' demand for balances is determined by two factors: the amount needed to meet reserve requirements and clearing balance commitments ("balance requirement"), and the amount held in excess of those requirements to buffer against unanticipated late-day payment flows.¹⁸ The Trading Desk at the New York Fed normally adds or drains balances each morning based on estimates of demand and autonomous technical factors such as shifts in U.S. Treasury balances or changes in check float that would otherwise affect supply. If demand turns out higher than expected or autonomous factors unexpectedly lead to a deficiency, the result is usually either upward pressure on the federal funds rate later in the day or bank requests at the discount window for overnight loans, or both.

Because balance requirements must be met over a two-week period, banks have some flexibility with regard to when they hold the necessary balances. This tends to limit the pressure on the funds rate from unexpected movements in autonomous factors or demand – that is, demand should be fairly elastic at the target. In fact, under certain conditions the federal funds rate should be a martingale within a maintenance period, and should remain close to the target as long as market participants expect the Desk to supply balances on subsequent days to accommodate shifts in demand and autonomous factors. (Hamilton and Jordà 2002) One qualification to this principle is that while banks can take advantage of high rates by holding less than their balance requirement, overnight account balances below zero are penalized. As a result, if aggregate balances are low enough, banks will bid the funds rate up to avoid overnight overdraft penalties. In the opposite direction, the funds rate can fall below the target prior to settlement day if enough banks

¹⁷ Due to the physical condition of Lower Manhattan, Trading Desk operations were relocated mid-day Wednesday to a backup site outside the city.

¹⁸ Reserve requirements apply to a two week reserve maintenance period that ends on a Wednesday ("settlement day"). Clearing balances earn credits that can be applied toward Federal Reserve Bank financial services. Banks' vault cash holdings can be applied toward reserve requirements; the remaining reserve requirement is met with reserve account balances. See Meulendyke (1998) for a detailed description of open market operations.

have already held more reserves than they anticipate they will need for the period and are willing to offer their “surplus” reserves on the lending market at any positive rate. On settlement days demand is less elastic since banks face penalties for failing to meet balance requirements and they forego interest income if they hold excess balances. Although the Desk’s intervention on settlement morning is aimed at minimizing the expected deviation of the funds rate from the target over the remainder of the day, unexpected changes in autonomous factors and unexpected shifts in bank demand can push the funds rate away from the target.

The 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.¹⁹ The rates on the Desk’s repo transactions are set via auction. When the Desk wants to inject balances, it announces the maturity and terms, requests bids specifying the interest rate dealers are willing to pay and for how much money, and then 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. Those new balances are then reallocated throughout the banking system during the day as banks send payments to other banks and borrow and lend in the interbank fed funds market. In 2001 the Desk typically had a set of longer-term 28-day repos outstanding.²⁰ 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.

During the week following September 11, the Desk accepted all propositions 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

¹⁹ Reserve drains are accomplished using reverse repurchase agreements in which the Fed effectively borrows from dealers against collateral pledged from the System’s portfolio.

²⁰ 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)

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:

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, 1987.²¹ 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.²² 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

²¹ "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."

²² See www.frbdiscountwindow.org for details on the Federal Reserve's discount window policy.

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, 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 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 there could be an unanticipated flow of tax receipts into 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. Prior to settlement day, banks may be willing to hold less than their balance requirement, reckoning that they will be able to hold additional balances later in the maintenance period. On settlement day, however, their opportunity to substitute intertemporally is much more limited. Banks would tend to bid up the funds rate in an attempt to obtain the balances they desire, but if aggregate balances were insufficient, then some banks would be left short at the end of the day. 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.²³ 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.²⁴

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

²³ 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.

²⁴ 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).

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 could request a discount window loan at the discount rate, which they presumably would prefer because the cost is lower. Another difference between overnight overdrafts and discount window loans is that the latter are explicitly collateralized while the former are not necessarily collateralized.²⁵ In addition, some institutions with Federal Reserve accounts are ineligible for discount window credit.²⁶ 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 entitled the foreign central banks to receive dollars from the Federal Reserve in exchange for their respective currencies. 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. 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

²⁵ 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. 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.

²⁶ 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

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 meant 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 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 unsatisfied 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 was 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 6 – 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 a higher probability of a further rate cut in 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 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 $\frac{3}{4}$ percent: see Table 2. The effective federal funds rate sank to $1\frac{1}{4}$ 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. The Nature of the Shock

Drawing lessons for central bank policy from the events of 9/11 calls for an understanding the nature of the shock to the interbank payment system and the nature of the economy's response. Because the events of September 11 were characterized by a tangible sense of crisis, and because the Federal Reserve's lender of last resort activities figured so prominently, I will look for useful analogies to other U.S. banking crises. The comparisons are instructive, both for the similarities and for the differences that emerge. While different initial shocks set events in motion, disrupted interbank payments are central to all the crises examined here. This suggests two lessons. First, interbank payments disruptions have more in common with other banking crises than previously appreciated. Second, the role of interbank payment arrangements in the instigation and propagation of banking crises deserves more attention.

Historical banking crises are numerous, and the literature on banking crises is large. My review is selective, and starts with the banking panics of the National Bank Era (1863-1914). These helped motivate the founding of the Federal Reserve, and disruptions to arrangements for interbank clearing and settling payments figured prominently. National Bank Era panics generally occurred in New York City, then, as now, the central

node in payments settlement, and spread to the interior (1893 was an exception). They were distinguished less by bank failures (apart from private banks that were better classified as brokerages) than by suspensions of payment by New York banks to banks in the “interior” – that is, New York banks refused to ship currency to redeem interior banks’ deposits. (Sprague 1910; Wicker 2000) These deposits served as the reserves used to settle interregional payments prior to the founding of the Federal Reserve, and the New York banks’ suspensions impaired their use as a settlement medium. (Watkins 1929) The ensuing loss of confidence in New York banks led the country banks to withhold remittances and withdraw reserves. Sprague speaks of the “dislocation of domestic exchanges” – that is, local interbank markets for correspondent balances at New York banks (pp. 293-4). Suspensions in New York thus added costs to local interbank payments elsewhere.

Wicker (2000, p. 146) observes that in the major panics of 1893 and 1907, “insufficient reserves were not the problem; it was the unequal distribution of those reserves among the large [New York] Clearing House banks. Reserve equalization would have forestalled the two panics.” Similarly, Sprague (1910, p. 276) says of the suspension of 1907: “It was directly due to uneven distribution of the reserves held by the New York banks and to the use of clearing-house loan certificates as the sole medium of settlement of balances at the clearing house.” In 1873, in contrast, the pooling of reserves by the New York Clearing House made possible the “ultra-liberal policy of continuing to pay out cash to the interior,” which was not observed in subsequent panics. (Wicker 2000, p. 33) Timberlake (1984), however, argues that the pooling of reserves was unnecessary because clearinghouse certificates could have accomplished the same goal of “equalizing reserves.” He agrees that the interbank distribution of reserves was the issue. The shock-induced maldistribution of reserve balances and the technological impediments to redistributing them were precisely the problem for the banking system following September 11.

There were significant differences between September 11 and nineteenth century banking panics, however. First, as noted above, the public’s movement from bank deposits into currency was relatively minor: see Figure 4. A slight pick up in currency withdrawals occurred, but this was as much banks’ preparation for possible consumer demand as it was an actual increase in consumer currency holdings. And some portion of the increase in the public’s currency holdings could well have reflected the transaction demand associated with the substitution of long-distance ground travel for airline travel in the two days after the attacks, rather than currency hoarding in response to concerns about potential bank closures. Bank runs were a common feature of National Bank Era, especially in 1893. (Wicker 2000) The absence of bank runs following September 11 could be attributable to the presence of federal deposit insurance, or it could have reflected widespread confidence in banks’ solvency.

Second, and related, insolvencies were not a crucial feature of the aftermath of September 11. In contrast, the initial trigger of a nineteenth century bank crisis was invariably an instance of default, insolvency or some other event that either causes or raises questions about the solvency of a particular bank or set of banks. (Calomiris and Gorton 1991) The banking industry was in relatively healthy condition prior to the

attacks. Despite the economic downturn of early 2001 and a gradual uptrend since the mid-1990s in noncurrent commercial and industrial loans, particularly at larger banks, capital ratios were relatively good, the number of problem banks was steady at a level that was low by historical standards, and the industry's ability to absorb losses appeared strong.²⁷ To be sure, the loss of property and life was widely expected to result in large claims for many insurance companies, but estimates available immediately after the event indicated that claims were likely to be well within the industry's capacity to absorb.²⁸ The airline industry was hit hard by the closing of the national airspace. And after the grounding was lifted, the stiffening of airport security controls and the increase in the perceived risk associated with air travel raised the implicit cost of airline service and cut sharply into demand; traffic was more than 20 percent below year-earlier levels in October 2001, compared to 4 percent above year earlier levels in August. Midway Airlines Corp., a North Carolina-based carrier listing \$318 in assets, announced on September 12 that it would permanently cease operations; it had filed for bankruptcy on August 13, 2001, but this was the only significant failure announced that week and it represented a pre-existing problem made worse by the attacks. The tourism and hospitality industries saw demand fall off as well, but the banking sector's exposure to these industries was relatively small. The two major government securities clearing banks, BoNY and JPMC, held enough capital to qualify as "well capitalized," according to the most recent call reports. In short, there were no obvious threats on the horizon that seemed capable of damaging the condition of the banking sector.

A corollary to the minimal concern regarding bank insolvencies was a lack of "contagion" effects following September 11. There was no evidence that any institution's financial health was adversely affected by payment difficulties at other banks. Thus, there appeared to be none of the "knock-on" or "domino" effects that are a central preoccupation of the literature on payment system risk.

Perhaps the most striking difference between nineteenth century bank panics and the September 11 episode is the behavior of interest rates. Bank panics were typically associated with spikes in short-term money market interest rates. To prevent such spikes, Walter Bagehot recommended that the central bank lend freely but at a "penalty rate," that is, a rate above prevailing market rates. In contrast, the Fed lent at below market rates to depository institutions. Since then, alterations in the discount window program have raised the interest rates on advances to above overnight market rates. (Board of Governors of the Federal Reserve System 2002a) Perhaps Fed lending would have looked more Bagehotian had such a program been in place then.

²⁷ See the Federal Deposit Insurance Corporation's Quarterly Banking Profiles for the third and fourth quarters of 2001. (Federal Deposit Insurance Corporation 2001) The Shared National Credit review for 2001, based on second quarter analysis and released on October 5 of that year, reported a continued deterioration in the quality of syndicated bank loans, but showed quality measures still significantly better than during the years of the recession of 1990-91. (Board of Governors of the Federal Reserve System, Federal Deposit Insurance Corporation, and Office of the Comptroller of the Currency 2001)

²⁸ An insurance industry group estimated that total insured claims for property damage would be about \$40 billion. (Zolkos 2003) As one analyst put it: "this is not an overly worrisome event, since the industry has the capital to absorb a hit of this magnitude." (Fitch Insurance Conference Call Summary 2001) Comments like this were typical in the weeks after September 11.

The proximate initial trigger of the disruptions following September 11 was the malfunctioning of automated systems for recording, processing and communicating payment obligations, together with the loss of many specialized professionals. These were by all accounts operational difficulties, not unanticipated financial losses. In this regard, the payment system events following September 11 resemble other late-twentieth century instances in which technological malfunctions disrupted interbank payments, perhaps the most noteworthy of which was BoNY's November 1985 overdraft, which resulted in a \$22.6 billion discount window advance to the Bank of New York. (*The Federal Reserve Bank of New York Discount Window Advance of \$22.6 Billion Extended to the Bank of New York 1985*) Faulty software prevented BoNY from sending securities to counterparties at times during the day on Thursday, November 21. This also prevented them from collecting the offsetting payments on those securities. (The exchange of a security and an offsetting payment are simultaneous under Fedwire's delivery-versus-payment regime.) They continued to receive securities and funds transfers but the inability to send securities meant that they ran up an overdraft during the day. Although the Fedwire securities system was kept open late to provide time to attempt to solve the problem, these attempts were unsuccessful and the securities system was closed at 1:30 a.m. on Friday morning and the funds system was closed at 2:15 a.m. BoNY borrowed \$700 million from the private sector after midnight, but ended the day overdrawn by \$23.6 billion.²⁹

The 1985 episode was due to software problems at a single institution. In contrast, available evidence indicates that payment processing problems affected a number of depository institutions besides BoNY following September 11. This may be because the technological effects of the September 11 attacks were far more widespread. Many banks and market participants were forced to operate from back up sites, and many communications links were problematic. In addition, the nature of the holdup in payments flows following September 11 was that many institutions had incomplete information on payments obligation incurred just before the attacks but not yet cleared and settled. Many government securities trades had been executed, but the confirmation and trade matching process had not occurred. The two clearing banks and the GSCC had many "half-legs" – trades for which they had received only one party's confirmation. Reconciliation was time-consuming and fraught with difficulties.

One other noteworthy difference between November 1985 and September 2001 is that in 1985 the direct effect of the disruption was a large negative balance at BoNY. In 2001, the direct effect was an accumulation of large positive balances at several institutions. Large positive balances imply large negative balances at other institutions,

²⁹ BoNY's initial estimate of its position at 2:15 was the basis for the discount window loan of \$22.6 billion, but that estimate was incorrect and BoNY incurred an additional \$1 billion in the form of an overnight overdraft. See the prepared statement of E. Gerald Corrigan, p. 6, in (*The Federal Reserve Bank of New York Discount Window Advance of \$22.6 Billion Extended to the Bank of New York 1985*). At the time of the most recent call report on September 30, 1985, BoNY had total assets of \$15.9 billion. Under the terms of the special loan agreement covering the advance, negotiated earlier on Thursday, the advance was secured by all of the assets of the bank as well as all of the customer securities they were empowered to pledge. The Federal Reserve Bank of New York estimated the book value of the assets securing the advance at \$36 billion.

absent Fed credit extension, so from that viewpoint the two incidents are similar. The difference is that Fed credit was extended to the institution at which the disruption occurred in 1985, while in 2001 credit was particularly necessary at institutions other than those whose outgoing payments were impeded.

One striking similarity between the two episodes is that the effects of the disruption to interbank payments were focused within the banking system. Some bank customers experienced difficulties in transferring funds, but in neither case did there appear to be runs on banks or other evidence of loss of depositor confidence.³⁰ Again, the presence of deposit insurance and the fact that the disruptions were largely seen as independent of bank insolvency concerns probably helped reassure depositors. Related, neither incident resulted in any net outlay from the federal financial safety net, ex post, apart from the implicit subsidy of below-market discount window advances and the potential underpricing of credit risk.³¹

Two other postwar episodes of interbank payment disruption have more in common with the nineteenth century panics. During the sharp fall in stock market prices the week of October 19, 1987, the unusually large trading volume caused confirmation problems for several equities-related options markets. (The Presidential Task Force on Market Mechanisms 1988; Bernanke 1990) Communications difficulties, including a two and a half hour Fedwire outage on October 20, interrupted the flow of payments between New York and options-market accounts in Chicago. (Garsson 1988) On top of the technological problems, the fall in asset prices had eroded the net worth of many traders and specialist firms that acted as market makers, leading creditors, including banks, to decline to advance funds as usual to cover settlement and margin-call payments. Incomplete information contributed to the difficulties; the volatility of market prices and the delay in price reporting made it difficult for banks to know if their customers were solvent. Although payment system disruptions did not have the starring role in the 1987 market break – the inability of market makers to absorb heavy selling on October 19 and 20 took center stage – they did contribute to the impairment of the efficiency of market mechanisms.

The Federal Reserve's response to the 1987 market break in many ways paralleled the response following September 11. At 8:15 a.m. on Tuesday morning, October 20, the Board of Governors issued a brief statement:

³⁰ Bank customers were directly affected by the BoNY's ATM system outage on September 11 and after and the destruction of some bank branches, but these were not the result of the disruptions to interbank settlement.

³¹ Corrigan's testimony stated that the 1985 BoNY discount window advance was made at 54 basis points below that day's prevailing fed funds rate. With the penalty rate on BoNY's overnight overdraft, and the fact that BoNY had to finance its holdings of securities it owed to the Federal Reserve Bank of New York but the latter was entitled to the accrued interest on those securities, Corrigan calculated that "the net financial result of all transactions between Bank of New York and the Federal Reserve Bank of New York" was in favor of the latter. (Corrigan 1990, p. 8) The Federal Reserve's discount window program has been revised. (Board of Governors of the Federal Reserve System 2002a) Among other changes, the interest rates on advances are now above the federal funds target rate.

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.³²

The Fed's September 11 statement echoes this affirmation of reserve supply intentions. In 1987, the Fed reportedly "encouraged" banks to lend to their customers, including stock specialist firms, paralleling bank regulatory agencies' statements following September 11. (Bernanke 1990) In 1987, the Fed relaxed firewall restrictions on transactions between banks and affiliates, and allowed Continental Illinois to inject funds into First Options, its options-clearing subsidiary.³³

The failure of Bankhaus Herstatt on June 26, 1974, led to the disruption of interbank payments to settle foreign exchange trades. (Remolona et al. 1990) Herstatt, a medium-sized German commercial bank active in the foreign exchange market, was closed by banking authorities at 4:00 p.m. local time in Köln – mid-morning in New York. Chase Manhattan, Herstatt's U.S. correspondent bank, refused to honor about \$620 million in payment orders and checks drawn on the account. Many of these were settlement for the dollar leg of foreign exchange trades on which Herstatt had already received the deutschemark leg. At that time, settlement for foreign exchange trades was accomplished by having each party initiate the side of the trade on which they were the payer; for example, a trader selling dollars sent instructions to their U.S. correspondent to pay the counterparty, while the trader selling deutschemarks sent payment instructions to their German correspondent.³⁴ Settlement takes a number of days, and often one payment becomes irrevocable before the other payment can be confirmed. This leaves counterparties vulnerable to the risk that one party irrevocably delivers one leg but the counterparty fails to deliver the other leg, a scenario that is now known as "Herstatt risk."³⁵

Following the Herstatt failure, New York banks would not make payments on foreign exchange trades until they received confirmation that the other payment had been received. Large balances accumulated and other payments were delayed as a result. The following week, the New York Clearing House banks changed the terms on their CHIPS net settlement system.³⁶ Prior to that, CHIPS payments had been irrevocable – the sender could not recall them once they were entered into the system. Under the special temporary procedure adopted in the wake of Herstatt's failure, payments were conditional until 10:00 a.m. the next morning. This made banks more comfortable sending payments, but reduced the extent to which banks could rely on funds that came through CHIPS. There were no incidents of runs caused by the Herstatt failure. (Kaserer 2000)

³² Quoted in The Presidential Task Force on Market Mechanisms (1988).

³³ See Walter (1996) for an introduction to bank firewall regulations.

³⁴ Foreign exchange settlement still takes place in this fashion, except for participants in the Continuous Linked Settlement system. See Kahn and Roberds (2001) and Lacker (2001).

³⁵ Non-German creditors of Bankhaus Herstatt recovered between 58.78 and 86 percent of their claims under a settlement agreed to on February 24, 1975. Payments were made June 9, 1975. (Becker 1976)

³⁶ See www.theclearinghouse.org/.

In both the Herstatt and the 1987 cases, risk considerations led to a pull back in the private extension of payment system credit. A wide variety of payment processing activities are conducted in a way that involves the extension of credit, at least briefly, reflecting a choice regarding the trade-offs between credit risk on the one hand and the resource cost and timeliness advantages of credit-intensive arrangements on the other. When events lead to revisions in assessments of the associated credit risks, banks sometimes have an incentive to rein in credit exposures and shift to less credit-intensive arrangements. These are generally more time consuming, and the result is generally payment delays and increased demand for reserves. A banking sector retreat from credit exposure in payment arrangements can be seen as an instance of the widely observed propensity for bank lending standards to vary with aggregate economic conditions. Weinberg (1995) argues that such variations are to be expected in well functioning credit markets, and need not represent market failure. In both the Herstatt and the 1987 stock market cases, it seems plausible that an increase in the lending standards applied to payments-related credit extensions was warranted on objective risk-assessment grounds.

To summarize this review, late nineteenth century U.S. banking crises, the Bankhaus Herstatt failure, the 1985 BoNY software glitch, 1987 stock market crash, and the September 11 events were all characterized by interbank payments disruptions. In the BoNY 1985 and the September 11 episodes technological difficulties rather than heightened credit risk served as the initial trigger. In the nineteenth century and the Herstatt episodes, insolvencies and potential credit losses were the initial trigger. During the stock market crash credit concerns were the trigger and a technological malfunction occurred in the midst of the troubles as well, although there is dispute about the extent to which it had significant independent effects. In all of the episodes reviewed, however, the propagation of the shocks was similar. The redistribution of reserves among banks was impeded and payments were delayed. Moreover, bank runs either did not occur or were secondary; the main event in all was in the interbank payment system.

Two types of interbank payment disruptions have been identified, therefore – credit-shock induced and technology-shock induced – based on the nature of the initial triggering events. They 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 costs of minimizing that exposure by increasing payment speed, both types of shocks can be seen unanticipated disturbances to the frontier of feasible arrangements.

5. Future Shocks

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 these deserve policy-makers attention. Indeed, central banks around the world have

devoted significant attention to the risks associated with the operation of interbank payment systems.³⁷

My selective review suggests that technology-shock-induced interbank payment disruptions are a phenomenon of the last few decades. This seems reasonable, given the significant changes that have taken place in the record-keeping and communications technologies employed in the banking industry over the last century, particularly for interbank payments. One hundred years ago, the New York Clearing House functioned as the central node for U.S. interbank payments, and its operations were largely as they had been since the 1850s.³⁸ Bank clerks met daily and exchanged paper, with net obligations settled by payment of reserves in the form of specie or paper notes. Modern interbank payments are made by electronic transfers, with bank computers connecting directly with the computers of the Federal Reserve Banks or clearinghouse systems such as CHIPS or CLS. For a bank of any size, the internal processing of payment instructions, even before they result in the issue of interbank payment instructions, is also highly automated.

Reliance on electronic processing and communications makes critical payments activities vulnerable to periodic interruptions in the normal functioning of these technologies. It seems reasonable to conjecture that, in contrast, the paper-based systems of the nineteenth century were less vulnerable to malfunctions. The reliability and security of electronic payments processing arrangements are presumably the implicit result of a wide array of benefit-cost decisions. At a fundamental level, the likelihood of future technological malfunctions rests on prospects for these benefit-cost trade-offs. Experience strongly suggests that such calculations are not likely to lead to the complete elimination of the risk of malfunctions.

Perhaps the most obvious potential source of payment system disruption is the malfunctions to which any automated system is subject. The software outage that afflicted BoNY in 1985 is an archetypal case, but power outages, storms and other unanticipated infrastructure break downs would have to be included in this category. 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) The stock exchange and government securities trading had already closed for the day when the outage occurred at around 4:15 p.m. All but one reopened the next day for a full day of trading. Most banks switched to backup power generators and there were few reports of processing delays. The federal funds market was affected by the lack of power at several funds brokers, but trading continued with higher volatility that afternoon. Several foreign banking organizations reportedly suffered failed backup power facilities and/or lost telecommunications links. (Financial and Banking Information Infrastructure Committee 2003) Excess reserve holdings during the two-week maintenance period that included the blackout averaged \$5.9 billion per day, more

³⁷ Witness the series of publications by the Committee on Payment and Settlement Systems: www.bis.org/cpss/cpsspubl.htm

³⁸ Compare Cannon (1901) and Gibbons (1859).

than twice as high as the next largest two-week excess reserve figure from September 11, 2001, through October 2003, suggesting that some payment flows were impeded.³⁹

Power outages and storm-related disruptions recur so often that preparing for them is a routine business activity. It appears that disruptions in this category would have to be unusually severe to result in a significant dislocation in the payment systems. But again, benefit-cost calculations are not likely to lead to complete elimination of the possibility of dislocations due to technical malfunctions.

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. The exchange reopened “defiantly” the next day, however, and banking and financial activity appeared to return to normal quickly. (Brooks 1969) Both the 1920 and the 2001 attacks seem to have been aimed at killing as many people as possible connected with the financial and commercial activity symbolized by the physical location of their targets, rather than inflicting as much long-term damage as possible to the functioning of the financial system, consistent with a strategy of maximizing the publicity value of the attack. Thus the payments system problems following September 11 can be seen as collateral damage rather than the direct objective of the attacks. Nonetheless, the iconic status of financial markets seems enduring and could draw terrorists to financially-related targets in the years ahead.

The vulnerability of the payments system to a physical attack that directly targets operational capabilities is unclear. One observer of the damage sustained by the Verizon building on September 11 noted that “(i)f they really wanted to do damage, they would have taken out the telco building. They went after the thing that had press potential.” (Coffield 2001). An article in the trade publication, *American Banker*, in December 2001 discusses potential terrorist threats to the financial system, and quotes market participants that claim that “with only a little extra effort” terrorists could have crippled the financial system. (Bach 2001) The attack on the World Trade Center seemed designed for maximal symbolic value rather than maximal functional impairment, despite videotape in which Osama bin Laden cites quantitative measures of the losses due to the attacks. (Bin Laden hails economic losses from Sept. 11 attacks 2002)

The vulnerability of interbank payments infrastructures to attack is not limited to physical assaults. The scenario of a computer virus debilitating critical payments processing systems is not beyond the realm of possibility. Most viruses target personal computers and travel over the internet, while interbank payments usually flow from mainframe to mainframe over dedicated lines. As a result, one might think that interbank payments are far better insulated from virus attacks than one’s home PC. Nonetheless, recent incidents have demonstrated the vulnerability of critical computer networks,

³⁹ See the Board of Governors of the Federal Reserve System H.3 release at www.federalreserve.gov/releases/h3/hist/.

including those of the banking sector. For example, Bank of America's ATM network was knocked out by the SQL Slammer internet worm in January, 2003; 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 after attacks by the Sobig.F virus. Recent reports suggest that the planners of the September 11 attacks have recently sought the ability to launch assaults targeting digital devices that allow remote control of services such as fire dispatch and pipeline equipment, and "had 'far more interest' in cyber-terrorism than previously believed." (Gellman 2002)

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. 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) Such attacks obviously trigger upgrades in security to prevent against similar future attacks, but in the resulting "arms race," successful future attacks cannot be ruled out. A hacker attack could conceivably force a bank to shut down important payments processing systems in order to prevent further losses, despite the attendant disruption to legitimate payments, similar to the credit-risk provoked pull-back from payment system credit extension in the Herstatt and 1987 market crash episodes.

To summarize this brief review then, it appears plausible to assign at least some positive probability to future interbank payment disruptions roughly similar in effect to that of September 11.

6. Implications for Central Bank Policy

6.1. Central bank credit policy

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 a calming effect during the first two days after the attacks, judging by the frequency with which the statement was repeated in news coverage of the event. In short order, market participants were able to see evidence of Fed action. Late Thursday afternoon, the Board of Governors released the H.4.1, which reports data on the Fed's balance sheet for the night before. It showed the discount window borrowing of \$46 billion for Wednesday.⁴⁰ Coming on the heels of Wednesday's

⁴⁰ 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.

super-sized open market operation of \$38.25 billion, the figures showed the Fed following through on the commitment implicit in Tuesday's announcement. Aggregate funds injection figures were widely cited in the days following the attacks as measures of the Fed's provision of funds.

The Fed's clear communications regarding its intention to supply balances as needed conforms well to classic lender of last resort principles. Bagehot (1991, p. 85) argued that a central bank ought to provide assurance of support in advance, in order to alleviate uncertainty in the minds of the public regarding the central bank's course of action in a crisis, thereby contributing to stability and helping to avert panic. (Humphrey and Keleher 1984) It also conforms well to more recent analyses that emphasize limitations on a central bank's ability to commit to a desired lending policy. (Goodfriend and Lacker 1999) Articulating a willingness to lend eliminated an important potential source of uncertainty in the minds of market participants. Confidence in the Fed's willingness to carry through on that commitment seemed warranted on September 11, because the condition of the banking system, through which lending would be channeled, was known to be relatively healthy going into the day.

Federal Reserve credit extension was very effective at increasing the supply of bank balances. Banking system balances went from \$13 billion on September 10 to over \$120 billion on the 13th: see Table 1. The end-of-day need for balances could not have been forecast with any degree of precision at the time of day that open market operations were conducted, even with the delay of operations on some days. Moreover, open market operations were focused on meeting the financing needs of the government securities dealer community, which had been severely affected by communications breakdowns and the difficulties at BoNY, rather than on supplying the balance needs of the banking system, although that was a welcome by-product. If the Fed had not accommodated the increased demand for balances, either through open market operations or overnight overdrafts, banks likely would have bid up the funds rate in the open market. A sharp rise in overnight interest rates could have significantly changed the tenor of that week in financial markets. A scramble for balances could have led banks to liquidate assets, driving down financial asset prices, driving up longer-term interest rates, and perhaps could have led to a 1987-style impairment of market mechanisms, further exacerbating the scarcity of funds. Federal Reserve credit extension after September 11 thus served its Bagehotian function of providing an elastic supply of central bank liabilities, preventing a spike in interest rates, and thus limiting the secondary repercussions of the initial disturbance that gave rise to the increase in demand.⁴¹

Federal Reserve credit extension following September 11 was unsterilized, in the sense that it resulted in a net increase in the monetary base. Goodfriend and King (1988) argue that unsterilized central bank lending is best thought of as "monetary policy" and is

⁴¹ In Bagehot's doctrine, the central bank is typically viewed as preventing a shock-induced fall in the money stock. (Humphrey and Keleher 1984) In September 11, the task was to respond to a shock-induced *increase* in the demand for reserves. One purpose of the Federal Reserve Act, according to its preamble, is "to furnish an elastic currency."

unnecessary given the ability of open market operations to achieve the same result.⁴² The Fed's current operational policies make open market operations an imperfect substitute for end-of-day credit extension, however. The Trading Desk policy generally intervenes only a limited number of times a day, usually once or twice in the morning when repo markets are liquid. Moreover, the close of the Fedwire securities transfer system at 3:30 p.m. limits same-day repo trading after that time. Thus the Desk generally does not, under current policies, respond to events after the typical morning intervention time, although on September 12 the Desk announced that it might intervene again that day should it be necessary. (Ip, Sims, and Beckett 2001) Although the Desk intervened somewhat later in the day following September 11, the Fedwire funds transfer system was closing late in the evening that week. Arranging repos near midnight would have been difficult, if not impossible. (Groshen et al. 2002)

The difficulty of injecting the requisite balances after September 11 without end-of-day Fed credit extension does not refute Goodfriend and King's thesis, however. Eschewing credit extension would have required different operating procedures on the part of the Trading Desk. Current Desk practice presumes the availability of end-of-day Fed credit. In fact, the Desk's strategy following September 11 was predicated on the availability of discount window lending to meet what was expected to be a large and difficult to forecast demand for balances. Thus to argue that foregoing credit extension would not have supplied sufficient balances given the Desk's actions doesn't take into account how differently the Desk might have acted had credit extension been unavailable. Moreover, one could argue that the appropriate question concerns how private sector banks would behave under an alternative *regime* for supplying central bank liabilities. In other words, are there alternative Desk procedures which could substitute for unsterilized credit extension? Although it is beyond the scope of this paper to answer this question, this would appear to be an open question. Thus Fed credit extension following September 11 would not appear to have a direct bearing on the Goodfriend-King thesis.

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. Seventy five percent of account holders incurred daylight overdrafts – 5,300 out of 8,500 institutions – 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 a commensurate amount. Open market operations and check float added balances, but a substantial “financing 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.

⁴² 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.

Suppose we take this as a measure of the balances whose transfer was blocked by payment processing disruptions, plus any possible increase in precautionary holdings – in other words, as a measure of the disruption-induced increase in 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” factors (chiefly the net effect of the foreign RP pool) 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 \$50 billion gap to 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.

Depository institution behavior could well have been different had they believed that the Reserve Banks would not make discount window advances to cover their overdrafts, and this might have mitigated the extent to which end-of-day Fed lending was preordained. Normally, prospects of an overnight overdraft would give a bank an incentive to borrow on the fed funds market at rates up to the overnight overdraft penalty rate (four percentage points above the overnight funds rate), if the discount window was unavailable to them. In that case, some banks that were holding additional balances after September 11 might have been willing to lend those balances at a higher fed funds rate. The additional supply of reserves lending called forth by the funds rate increase would have reduced the amount of balances the Fed needed to provide through end-of-day credit. The Federal Reserve rescinded overnight overdraft penalties, however, for the days immediately following September 11; overnight overdrafts by depository institutions were assessed at the fed funds rate, while non-depositories were assessed the extended credit rate plus 55 basis points. Banks would have had little incentive to bid up the funds rate to elicit additional balances had the discount window been unavailable.

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 controls banks’ use of daylight credit.⁴³ The Fed’s 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; for these banks intraday payments could result in daylight overdrafts in excess of their caps. *Preventing* an overnight overdraft to a bank requires shutting off intraday

⁴³ See www.federalreserve.gov/paymentsystems/psr/default.htm

credit by putting the bank on the monitor in reject mode at a zero net debit cap.⁴⁴ Without taking such action across the board, end-of-day credit extension was virtually automatic.

Despite the equivalence between the reserves injection capability of overnight overdrafts and discount window lending, there were good reasons to prefer to advance credit through the discount window. As mentioned above, discount window lending is generally collateralized, providing greater security to the Reserve Bank, while overnight overdrafts may or may not be collateralized. (See note 25) Goodhart argues that requiring collateral also has the effect of helping to screen out insolvent borrowers. (Goodhart 2002) In addition, the Federal Reserve clearly wanted to encourage banks to consider availing themselves of the discount window should the need arise. Following September 11, many banks had difficulty operating in the federal funds market because of problems with communications links and processing systems. Anticipating that the Federal Reserve would likely grant a request for a discount window loan, may have encouraged some banks to forego strenuous efforts to obtain funds. Fed lending thus helped reduce the deadweight costs of trading in a difficult situation.

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.

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 with shock-induced losses that threatened banks' solvency. Central bank lending policy, to the extent that it provides qualifying institutions with a backstop line-of-credit service on terms more advantageous than private lines, inevitably seeks to balance the benefits of emergency liquidity provision against 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) At times this will require denying credit extension when to lend would postpone a warranted winding up and foster future moral hazard. This can be difficult, because the short term calculus is generally tilted toward leniency; the cost of enhanced moral hazard lies out into the future, while the pressures to assist are immediate. (Goodfriend and Lacker 1999) At other times the optimum is at the opposite corner solution, and lending is clearly in the public interest. Arguably, September 11 was just such a case.

Had the banking sector been in some difficulty at the time of an interbank payment disruption, it might have been difficult to sort out the deserving institutions –

⁴⁴ 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).

solvent but illiquid – from the insolvent. Goodhart (2002) argues that it is not generally possible to distinguish between illiquidity and insolvency, and that “nowadays illiquidity implies at least a *suspicion* of insolvency.” He grants that there are some exceptions, however, and cites the 1985 BoNY incident as an example because the bank was clearly solvent, at least to supervisors. Prior to the incident, the bank’s condition was well understood, and there was no apparent reason to believe that the incident itself had directly caused losses large enough to threaten BoNY’s capital cushion. Just a few years later, during the banking and savings and loan crisis, however, the chance that a randomly chosen depository institution was in danger of serious distress was surely nonnegligible. Had such a technological malfunction occurred at a bank to which the Reserve Banks would not otherwise have wished to lend, policy makers would have faced a choice between ameliorating the effects of the disruption and exacerbating moral hazard or minimizing moral hazard but allowing the disruption to be resolved without central bank assistance. The funds transfer outage in the midst of the 1987 stock market crash demonstrates that such a confluence of events is not out of the question.

Lending policy could be difficult to manage during a payment system disruption if the central bank wants to selectively control which institutions are granted credit. Under the Federal Reserve’s current policy, this would require rejecting payments that would otherwise send a bank into overdraft. Federal Reserve Bank officials continually monitor the condition of individual account holders, particularly institutions in deteriorating financial condition, and adjust daylight credit policy accordingly – for example, they can place an institution on the real-time monitor, so that payments that would cause an overdraft above a specified threshold are rejected. One problematic scenario could occur if a significant number of institutions are in weakened financial condition, but not yet weak enough to be on the monitor. An interbank payment disruption that is associated with further deterioration in the financial condition of these institutions, to the point that real-time monitoring would be warranted, could pose problems. Newly restricting the payments of a number of deteriorated institutions in the midst of the event could contribute to the disruption. The resulting rejected payments would be added to the already elevated flow of items that required special managerial attention. The Fed’s payments system regime relies fairly heavily on extensions of intraday credit – larger by far than banks’ typical end of day balance.⁴⁵ And payments processing relies heavily on standardized practice; payment flows are automated to optimize given an established policy regime. The availability of intraday credit is a key determinant of a bank’s payments processing choices; how much credit to grant customers and counterparties, who to use as correspondent, who to clear through, and so on. The sudden withdrawal of a bank’s intraday credit could require an abrupt reorganization of the bank’s payments processing.

Because withdrawing intraday credit can impose costly adjustments on banks, central banks will often find it a hard step to take. This will be particularly true in a crisis,

⁴⁵ 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.

when a central bank will be naturally hesitant to add any strain to an already strained banking system. From the point of view of ex ante efficiency, a central bank might want to have banks 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 make investments and adopt arrangements which commit them to large adjustment costs should daylight credit be withdrawn. In the event of a disruption, the central bank then finds it difficult to impose adjustment costs on the bank. Anticipating leniency, banks make investment decisions ex ante that assume continued access to central bank credit ex post, an assumption that is, because of their investments, confirmed.

This is a particular instance of the dilemma that Goodfriend and Lacker (Goodfriend and Lacker 1999) discuss. They draw the parallel between central bank lending and private line of credit lending, and note that private credit line contracts are structured to provide the parties with incentives ex post to take actions that, from an ex ante point of view, balance expected costs and benefits. How does central bank lending differ from presumptively efficient private line of credit arrangements? In private lending, the lender's profit motive provides an incentive to withdraw the line when the borrower's credit worthiness has deteriorated. To prevent overly opportunistic (and inefficient) exercise of this option, the contract prevents the lender from doing so unless specific covenants have been violated or there has been a "materially adverse change" in the financial condition of the borrower. And since withdrawal is not required in those cases, the borrower and lender are free to renegotiate terms when it is mutually beneficial. A central bank, in contrast, is not solely profit motivated. Heightened aversion to being accused of mismanaging a crisis, Goodfriend and Lacker argue, can tilt central bank incentives away from the long-run moral hazard concerns and toward minimization of crisis-related dislocations.

The Federal Reserve's daylight credit policy well illustrates this dilemma. The current policy, with relatively limited use of real-time monitoring, cedes effective control of lending decisions to account holders, who can obtain central bank credit in a crisis simply by running up an intraday overdraft. Granted, Reserve Bank credit officers can and do place troubled institutions on the monitor as their condition deteriorates.⁴⁶ During a payment system disruption, however, events unfold quickly and there will be a natural reluctance, for the reasons described above, for a Reserve Bank to place a bank newly on the monitor to limit credit extension.

Note that moral hazard has a particularly concrete manifestation in this setting. Operational preparedness is central to coping with payment system disruptions, and for private sector banks it's a classic risk-return issue. To the extent that central bank crisis response eases the costs of the disruption, banks' incentives to reduce the risk of such

⁴⁶ Certain provisions of the Federal Deposit Insurance Corporation Improvement Act of 1991 (FDICIA) are designed to discourage Federal Reserve lending to critically undercapitalized institutions and in some circumstances it imposes losses on the Fed in the event a borrower fails. This encourages the use of the monitor for such institutions.

disruptions will be to some degree muted. This tension between central bank crisis response and private sector preparedness is at the heart of decades of payment system risk policy around the world. Strenuous central bank pressure on the private sector to step up efforts to control payment system risk suggests that central bankers believe that private reliance on central bank crisis intervention tends to blunt incentives to mitigate risk.

Exacerbating the dilemma for the Federal Reserve is the fact that the prohibition of interest on reserves dramatically enhances the value of daylight credit.⁴⁷ The current regime of high costs for overnight credit and the relatively low cost (36 basis points at an annual rate) of daylight credit makes it less costly for banks to minimize the foregone interest cost of overnight reserve balances than if daylight credit were unavailable. This reduces the deadweight societal loss banks incur to avoid the tax on overnight balances. (Lacker 1997; Zhou 2000; Martin 2002) As a result, limiting daylight credit would be costly in normal times; perhaps less so if interest were paid on reserves, however.

The notable lack of a significant flight to currency in the aftermath of September 11 limited the stress on the banking system, but this could turn out differently in a future disruption episode. Bank runs have occurred as recently as the 1980s, and as in late nineteenth and early twentieth century runs, they tended to be local affairs associated with the insolvency of state-level deposit insurance funds or just the lack of deposit insurance. Most interbank payment disruptions are not associated with run-like behavior by consumers, which suggests that official assurances that technological malfunctions are at fault have been viewed as credible. Should a disruption occur at a time of banking sector weakness, consumers may have a more difficulty disentangling insolvency from disruption-induced illiquidity. This would amplify the difficulties facing central bank policy makers.

Nonpublic central bank information about a payment system participant, gleaned either from bank regulatory agencies or from the central bank's direct supervisory role, can play an important role in the resolution of payment system disruptions. Bank supervisors often have better information about a bank's condition than market participants. One element of the folklore surrounding the 1985 BoNY incident is the story that their counterparties were skeptical of their claims that a software problem was to blame, and obtained direct assurances from senior Federal Reserve officials that it was. One can easily imagine why a supervisory relationship might provide sharper incentives for truthful revelation than would an arm's length relationship with market counterparties. Information channeled through supervisory staff might therefore be more credible than direct communications, and in a crisis this might facilitate efficiency-enhancing collaboration among market participants that would otherwise be discouraged by mistrust.

⁴⁷ Required clearing balances earn credits that can be applied to the purchase of Reserve Bank payments services. The amount is set before the maintenance period begins, so marginal intra-period reserves do not earn interest.

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 is probably 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.⁴⁸ 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) Uncertainty about the economic outlook widened significantly. In the subsequent weeks incoming reports showed that consumer confidence dropped sharply, manufacturing activity contracted further, and unemployment rapidly increased. (Goodfriend 2002) Consequently, the FOMC cut its target for the federal funds rate by ½ percent steps on September 17, October 2, and November 6, and then by ¼ percent on December 11, bringing the rate down to 1¾ percent.

The first rate cut, adopted on a special conference call at 7:30 a.m. September 17, was noteworthy. Unscheduled intermeeting policy moves are not common, but economic developments sometimes warrant re-evaluating policy rather than waiting for the next meeting. The September 17 meeting clearly fit that pattern. The timing of the meeting was relatively unusual, however – intermeeting decisions are generally released during regular business hours. Equity markets were scheduled to reopen Monday morning, however, after having been closed since the attacks. Widespread commentary debated the extent to which prices were likely to fall, given intervening declines on overseas markets. The early hour of the call had the advantage of providing market participants with information on the FOMC’s policy move sooner than if the Committee had waited until normal business hours to convene. This may have helped dampen the fall in asset prices Monday morning.

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. And yet financial asset prices respond rapidly. 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,

⁴⁸ 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 September 12-14, three orders of magnitude larger.

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 “smooths” 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-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) accommodating 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. For example, the statement accompanying an initial rate cut in response to a liquidity disturbance could note that there is an unusual degree of uncertainty regarding the warranted policy response, and that if conditions warrant a reversal might be forthcoming relatively quickly. In fact, the minutes of the FOMC’s September 17 meeting state:

These actions were taken against the backdrop of heightened concerns and uncertainty created by the recent terrorist attacks and their potentially adverse effects on asset prices and the performance of the economy.

This would seem to have encouraged market participants to believe that because a relatively singular event had occurred, little by way precedent was being set.

6.3. The Path to Recovery

One key issue policy makers faced in the days immediately following September 11 was how fast to attempt to restore normal market functioning. This issue arose most critically in regard to the New York equity markets. Reopening would require costly work to restore telecommunications functioning, and the safety of the work environment in Lower Manhattan. Just as the equity markets “defiantly” resumed trading following the 1920 bombing, there was a powerful psychological desire to see the markets return to normal functioning after September 11. For example, on the day of the attacks, Gary Gensler, a former Treasury department official, said: “Keeping the markets closed shows that terrorists brought you to bay, and it also creates more uncertainty.” (Schroeder 2001) At a news conference on Wednesday, Richard A. Grasso, chairman of the New York Stock Exchange, vowed that U.S. stock trading would resume no later that Monday. “It

is clearly the goal to bring this market up as quickly as is humanly possible,' Grasso said." (Blustein and Day 2001) But there was a risk of bringing the markets back too soon. If too few participants were functioning again, poor liquidity could hamper trading and exacerbate the expected price declines. Moreover, physical conditions in Lower Manhattan were unpleasant and potentially harmful. The symbolic value of a return to normalcy was very attractive, however.

The Federal Reserve faced a resumption timing issue with regard to open market operations. Supplying reserve needs was a high priority, but the restoration of normalcy could have a reassuring effect. It took some time to engineer. The overhang of the previous week's reserve injections weighed down the funds rate at the beginning of the week of the 17th: see Table 1. As the close of the maintenance period on Wednesday approached, payment processing returned to normal and the movement of balances around the banking system was less constrained. The enormous balance balances some banks had held the week before meant that they had already met balance requirements and now had an incentive to loan excess funds aggressively. The funds rate sagged below the target until the maintenance period was over.

One striking aspect of the financial market's path to recovery is the range of cooperative behavior that was observed. Press reports on financial institutions' efforts to restore their operations were replete with descriptions of firms providing office space and logistical support to help competitors get back on their feet. Cooperation was suggestive of collusion at some points however. Accounts of foreign exchange market activity in the two days immediately following the attacks reported on a "gentlemen's agreement" among large banks not to sell the dollar and to discourage such trades by speculative accounts. Similar agreements were said to have been in effect in the federal funds and RP markets on Wednesday. On Friday, September 14, the Washington Post reported:

In advance of the planned reopening of U.S. stock markets on Monday, major securities firms and corporations have reached an extraordinary agreement to prop up prices by buying shares if a flood of sell orders threatens to send markets into a free fall, industry and government sources said yesterday. Federal securities regulators have made it clear they will permit these and other market practices that might raise legal questions in ordinary circumstances, the sources said. (Day and Berry 2001)

Such seemingly altruistic behavior could have stemmed from the patriotic spirit of the days after the attack, or it could have represented self-interested efforts to prevent asset price dips that they believed would be fear-driven and temporary. In the foreign exchange case, what was effectively achieved was a phased reopening, in which the market reopened for everyone but speculative short sellers at first. The stock market agreement, if true, would represent a collective market-making effort, a coordinated, SEC-sanctioned, version of the widespread stock buy backs following the 1987 stock market crash, somewhat analogous to the coordination of collective efforts through clearinghouse actions in response to nineteenth century U.S. banking crises.

7. Conclusion

The September 11, 2001 terrorist attacks, whose human consequences were so horrendous, had monetary and payment system consequences that are worth examining. This review has brought together disparate source material pertaining to these consequences. Just two years after the events there is a wide array of information available, but this treatment is hardly exhaustive. It relied mainly on published sources, especially press reports, for nonquantitative information, and on nonproprietary official statistics for quantitative data. More surely will emerge as time passes, memoirs are published, and further confidential material is made public.

A key idea that emerges from this study is that disruptions to interbank payment arrangements, whether due to technological impediments or credit quality concerns, have been central to several banking crises and are likely to recur. Putting interbank payments at center stage offers an informative view of past and present banking crises and payments system disruptions, which are often thought of as distinct phenomena. It takes us beyond somewhat amorphous discussions of “liquidity,” and casts light on the functioning of specific economic arrangements. A focus on interbank payments also highlights the common issues for lender of last resort policy that come into play in both types of events, particularly the difficulties associated with limited commitment. 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: 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 account balances. The "Other" factor aggregates the net effect of other Federal Reserve assets and liabilities, and consists predominantly of the System's holding 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 |

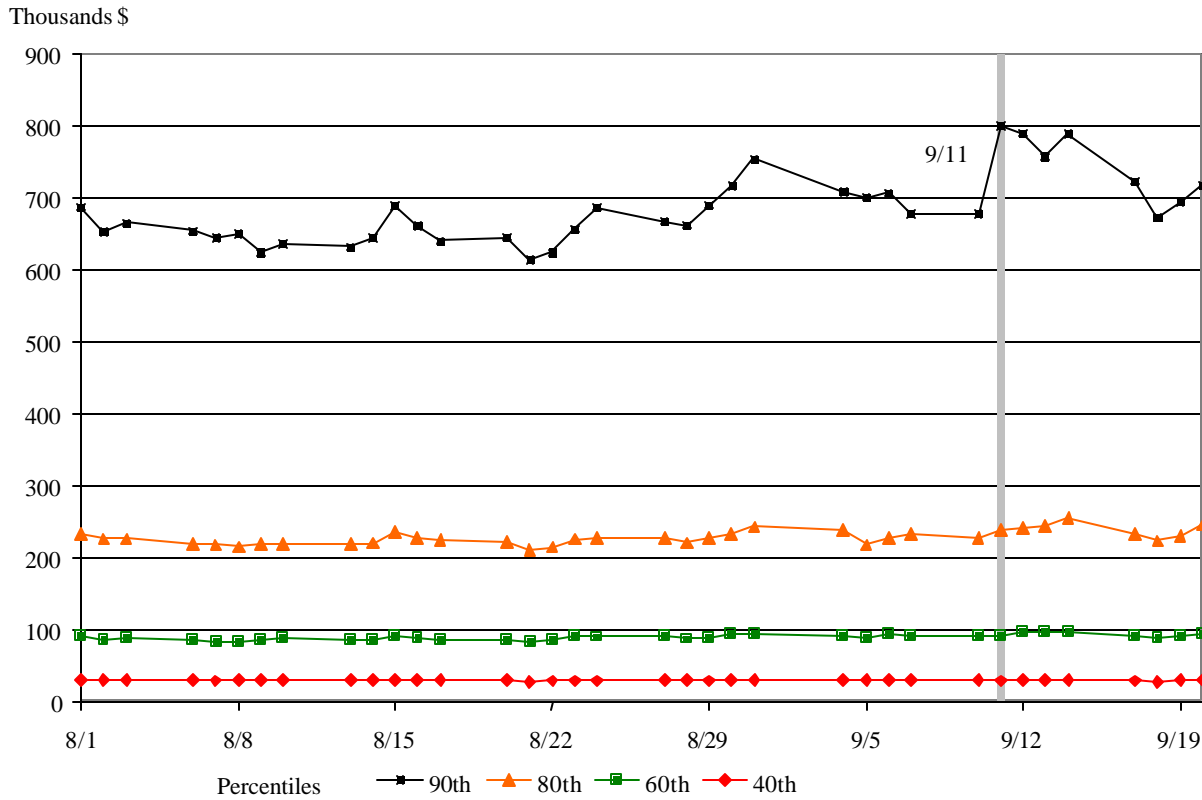
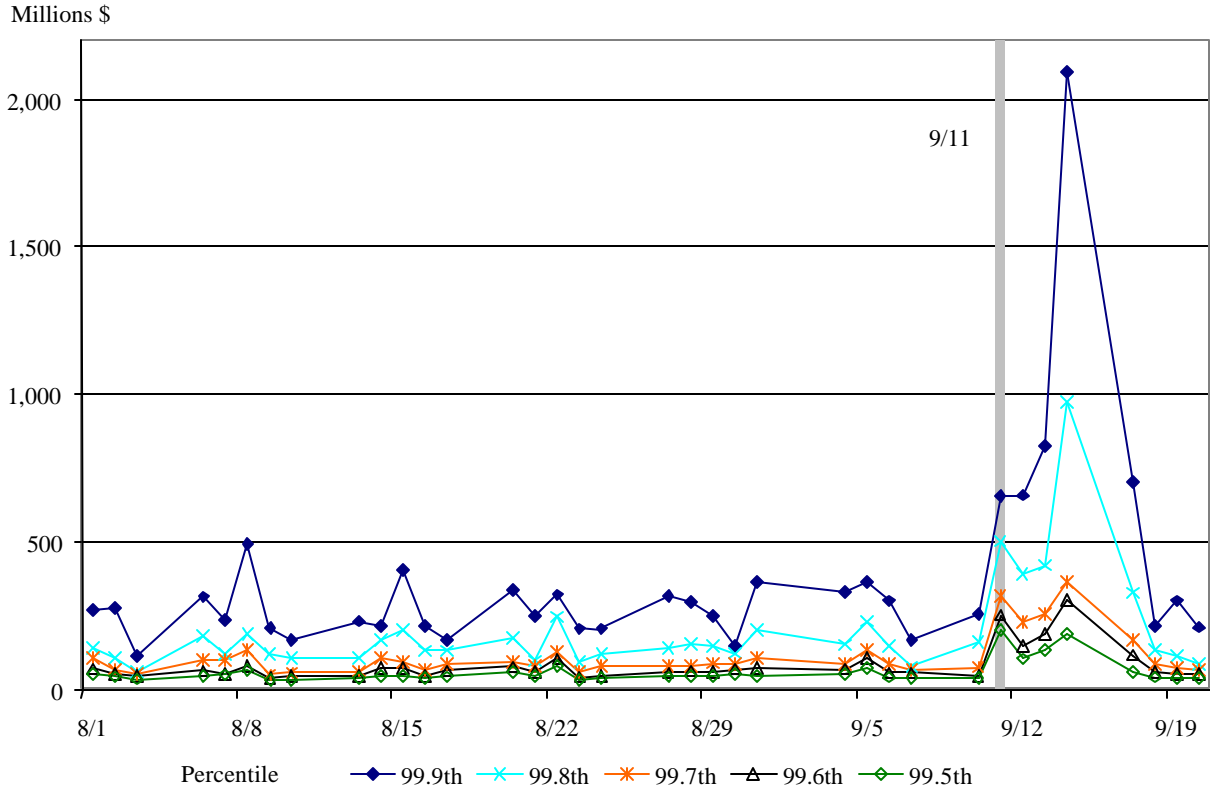
Table 3. Selected Interest Rates, September 6 to 21, 2001

| Date | Effective Fed Funds Rate | Fed Funds Futures Contract Rates* | | | EuroDollar Futures Contract Rates^ | | | 2 Yr US Govt Yield | 10 Yr US Govt Yield |
|--------|-----------------------------|-----------------------------------|-----------|-----------|------------------------------------|-----------|------------|-----------------------|------------------------|
| | | Sept. 2001 | Oct. 2001 | Nov. 2001 | Dec. 2001 | Mar. 2002 | Sept. 2002 | | |
| 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

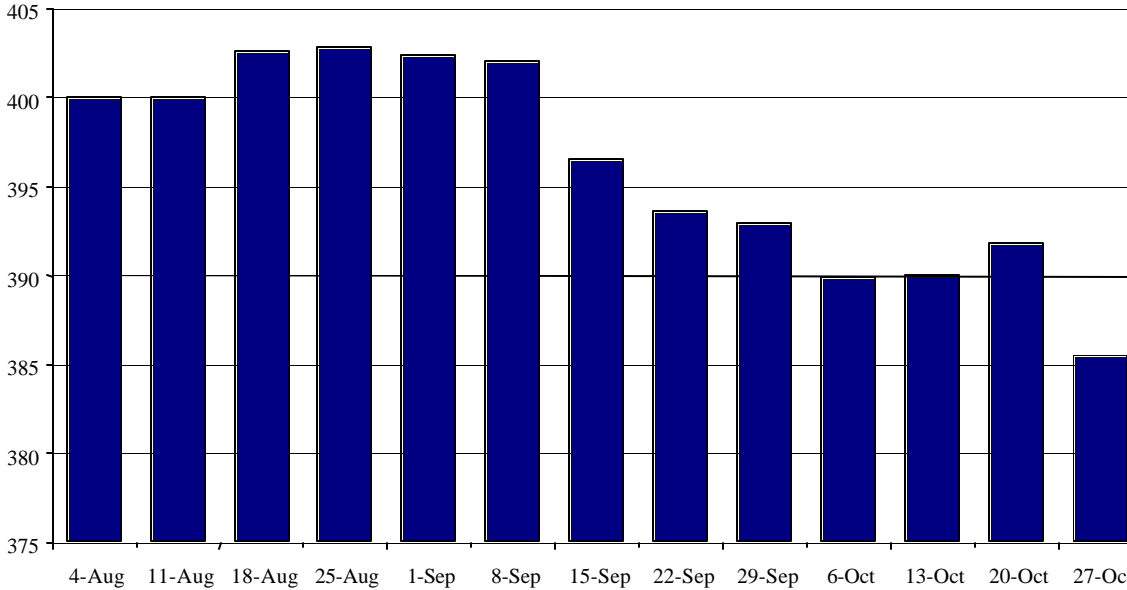
Figure 1
Account Balance Distribution, August 1 - September 20, 2001



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

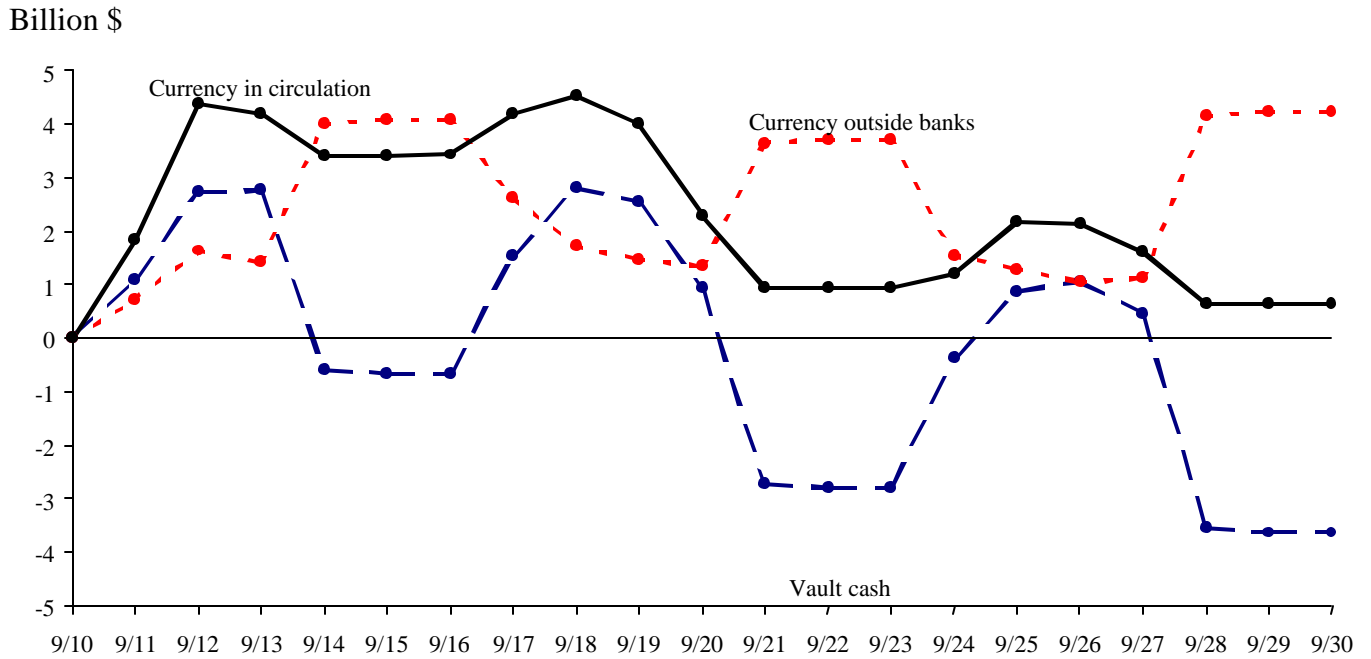
Figure 2
Retail Chain Store Sales Index,

1977 = 100



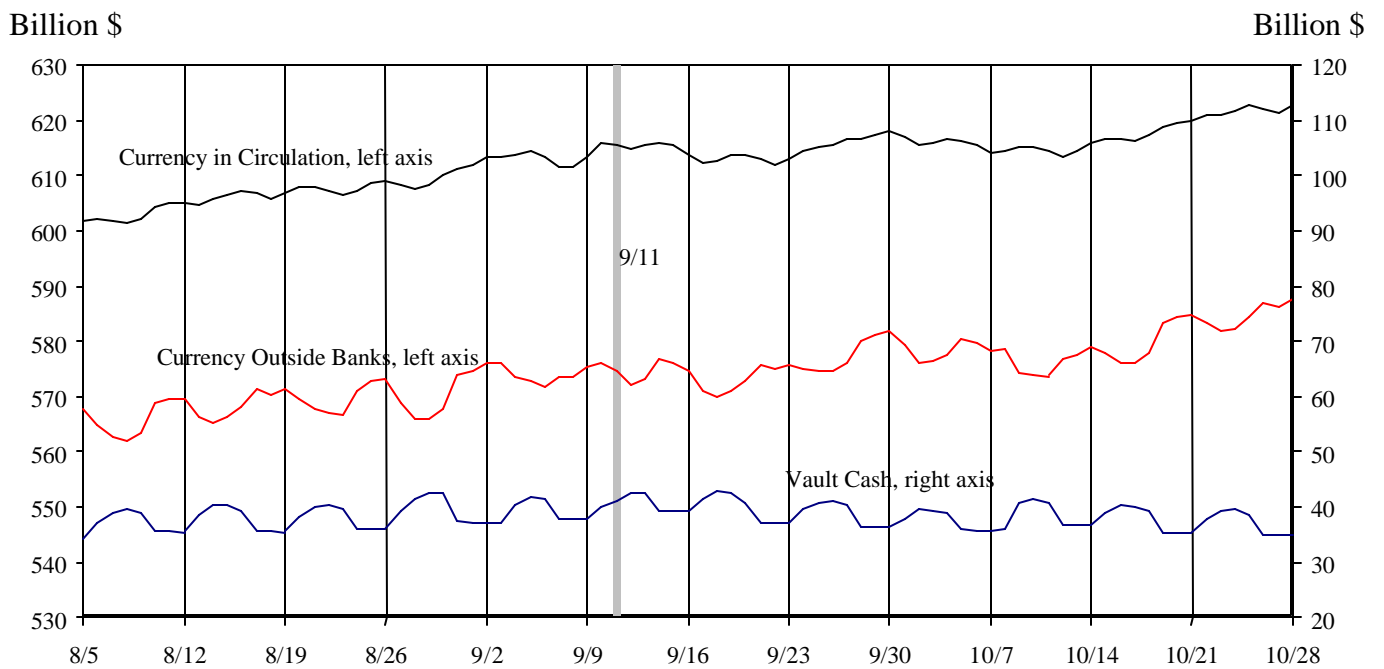
Source: Bank of Tokyo-Mistubishi, Ltd and UBS Warburg.

Figure 3
Cumulative Changes in Components of Currency in Circulation from
September 10, 2001



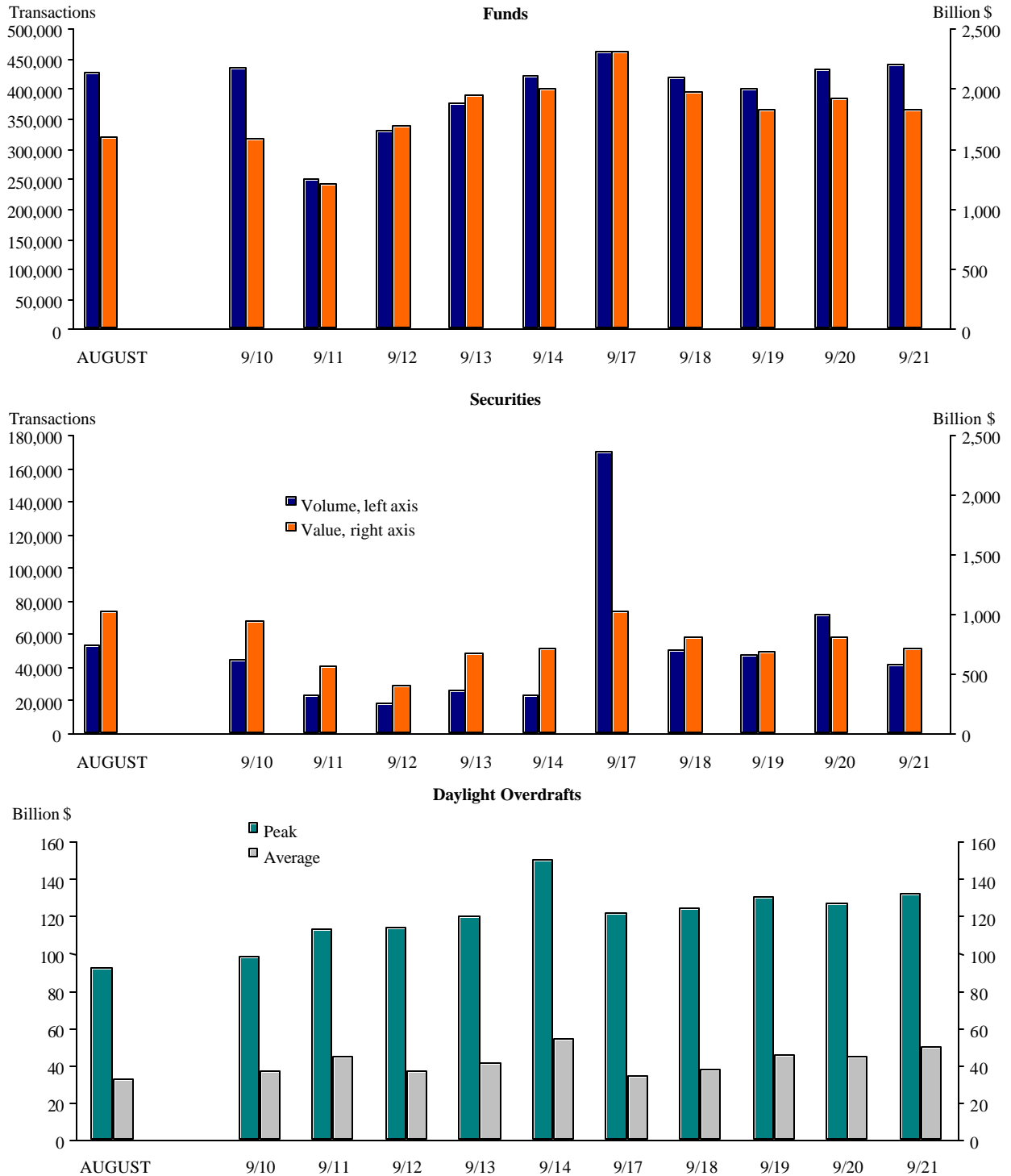
Source: FAME database and EDDS, Board of Governors

Figure 4
Currency in Circulation, 2001



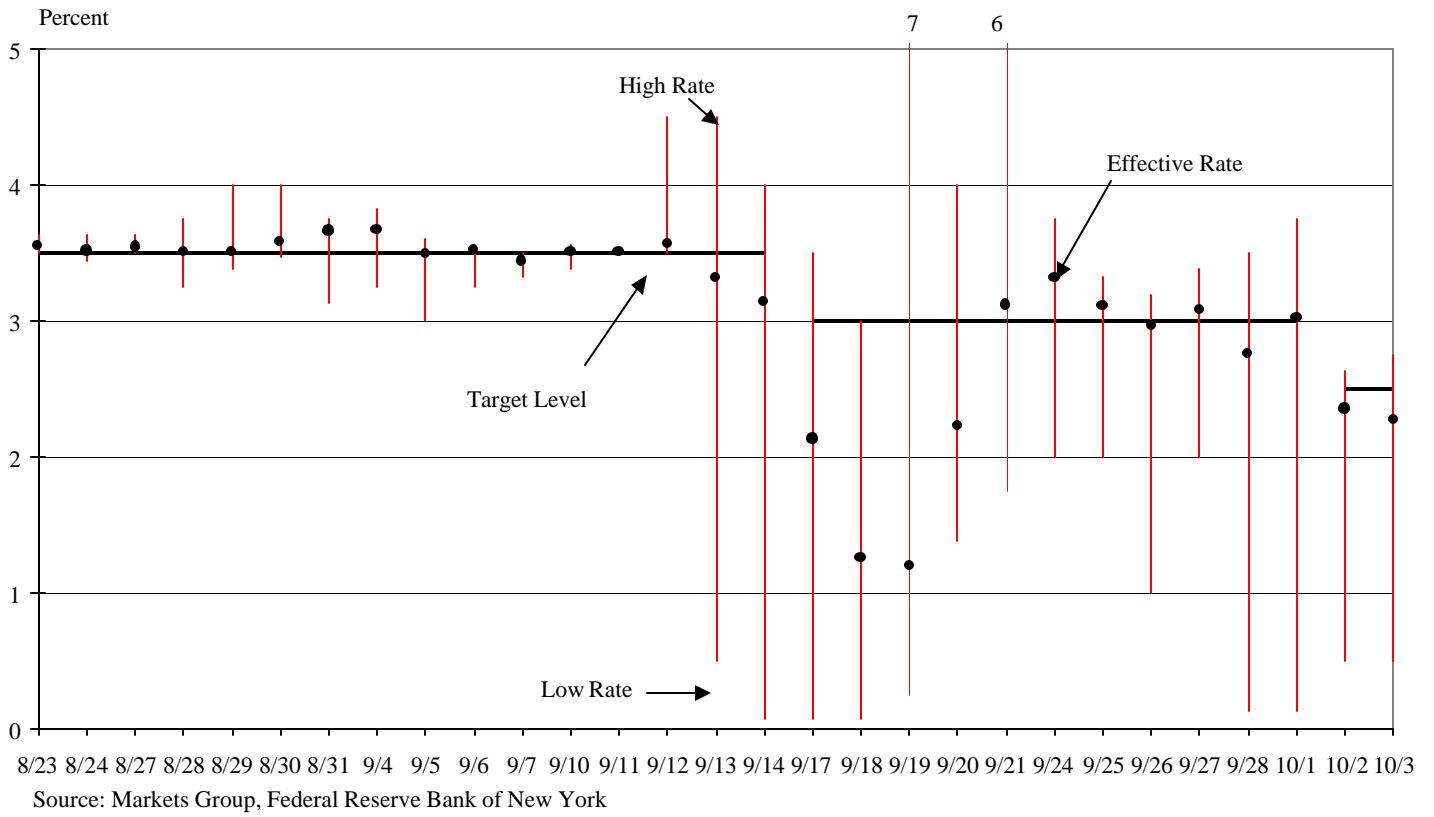
Source: FAME Database and EDDS, Board of Governors

Figure 5
Daily Fedwire funds and book-entry securities transfers and daylight overdrafts for September 10-21, 2001, compared with August 2001



Notes: The PEAK daylight overdraft is determined by adding the account balances of all depository institutions in a negative position for each minute during the day and then selecting the largest negative end-of-minute balance. The aggregate AVERAGE daylight overdraft is the sum of all DI's average daylight overdrafts. A DI's average daylight overdraft is the sum of negative end of minute balances divided by total minutes in the standard Fedwire operating day. August is a monthly average of the daily data. Source: Coleman (2002).

Figure 6
Federal Funds Rates around September 11, 2001: High, Low, and Effective Rates



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