Funding Constraints, Market Liquidity, and Financial Crises:
Lessons from an Historical Experiment

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Abstract
We use the nineteenth and early twentieth century as a randomized historical experiment to examine the effect of funding liquidity on financial markets from 1815-1925. US markets were often illiquid and prone to crises in September and October because of financial stress from the harvest. We use the seasonal nature of early US financial markets to identify the impact of funding liquidity shocks on market volatility, stock returns, and market liquidity. We find that market volatility was much higher and market liquidity significantly lower in September and October than during the rest of the year. However, there was no such difference during the period when there were financial institutions such as the Second Bank of the US (1816-1836) and the Federal Reserve (1915-1925) that could reduce funding liquidity risk. Our results highlight the importance of the role of financial institutions in reducing funding constraints.

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The recent financial crisis raises serious concerns about the origins and effects of funding liquidity (the ease with which a trader can obtain funding) on financial markets. The argument has been made that the lack of funding liquidity can have serious negative consequences. For example, the inability of borrower to obtain funding for home mortgages can cause home prices to fall (Brunnermeier, 2009). Further, the inability of firms to sell commercial paper to finance continued operations can cause their stock prices to decline, as funding concerns cause them to abandon positive net present value projects. The Federal Reserve clearly believes that the consequences of funding illiquidity are negative because it has reacted strongly to inject liquidity into financial markets. Recent examples include the Fed’s decision to purchase unsecured 90-day commercial paper directly from corporations in late October 2008 and the recently-completed $1.25 trillion home mortgage bond purchase program. These actions are perhaps unsurprising given that Fed Chairman Bernanke is an expert in how shocks to funding liquidity can cause asset prices to decline through the balance sheet channel (Bernanke and Gertler 1990, 2000).

New research has identified other important effects of changes in funding liquidity on financial markets. Brunnermeier and Pederson (2009), for example, explore the relationship between funding liquidity and market liquidity – the ability to and the price at which one can buy or sell an asset. They argue that funding liquidity is an important determinant of market liquidity, market volatility, and market risk premiums. In particular, a decrease in funding liquidity (i.e. due to a change in traders’ wealth or a change in margin interest rates) can reduce market liquidity. Their analysis suggests that

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1 By Oct 29, the Federal Reserve had purchased commercial paper valued at $145.7 billion.
market liquidity, is likely to be low (meaning low trading volume and high bid-ask spreads) when funding liquidity is low – i.e. when margin costs are high. Hence, a negative shock to funding liquidity can also cause prices for risky assets to fall.

Brunnermeier and Pedersen (2009) point to the 1987 Stock Market Crash, collapse of Long-Term Capital Management (LTCM), and the recent sub-prime mortgage crisis as examples where funding constraints have played an important role in the onset and spread of a financial crisis.

Although funding liquidity may be an important driver of financial markets, it is difficult to identify the effect of a shock to funding liquidity from market liquidity given that the two factors are often jointly determined in theoretical models and in the marketplace (Brunnermeier and Pedersen, 2009). Fortunately, history provides a randomized natural experiment to identify the impact of an exogenous change in funding liquidity on financial markets as well as the importance of central and quasi-central banks for reducing funding constraints. During the nineteenth and early twentieth centuries, financial crises often occurred in September and October, including the major panics of 1819, 1857, 1873, 1890, and 1907. Financial markets were often illiquid during the fall harvest season because farmers borrowed funds from banks to finance the production and marketing of crops. We exploit the seasonal nature of these exogenous funding shocks using the call loan rate, the rate at which investors could buy on margin. Prior to the Great Depression, this forward-looking call loan rate was set by market forces. There is

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2 Brunnermeier and Pedersen (2009) analyze a shock to speculator capital - something which is hard to identify.

3 Most financial panics of the nineteenth century occurred just after asset values had fallen from business cycle peaks. See Calomiris and Gorton (1991) or Bernstein, Hughson, and Weidenmier (forthcoming) for details. Davis et. al (2009) provide evidence that business cycles from 1880 until the outbreak of World War I were caused by fluctuations in the size of the cotton harvest.
not a direct measure of funding liquidity today given that the Fed regulates the margin rate. Many modern studies of American financial markets rely on the interest rate differential between LIBOR and Treasury bills to calculate a measure of funding liquidity.\(^4\)

First, we investigate the effect of funding shocks on asset volatility. In particular, we compare the volatility of monthly stock returns and interest rates in September and October with the rest of the year over the period 1815-1925. We find that interest rate volatility in September and October was more than 50 percent higher in the fall than during the rest of the year. Stock volatility was more than 70 percent higher. However, market volatility in September and October was not significantly higher than the rest of the year during the two periods when there were financial institutions, the Second Bank of the United States (SBUS) (1816-1836) and the Federal Reserve (1915-1925), which could reduce liquidity risk. The results highlight the importance of funding liquidity as well as the role of financial institutions in preventing liquidity spirals and financial crises.

Next, we examine the impact of funding and market liquidity on stock returns by analyzing the dynamic relationship between the call loan rate, trading volume on the New York Stock Exchange, and stock returns from 1888 to 1925. We find that increases in the call loan rate Granger-cause stock returns at the one-percent level of significance. Impulse response analysis reveals that a one standard deviation shock to the call loan rate reduces stock returns by 2.7 percent after 36 months. An increase in the call loan rate only lowers stock returns in the pre-Federal Reserve period, however.\(^5\)

\(^4\) The creation of the SEC in the 1930s granted the Federal Reserve the right to set margin rates in financial markets.
\(^5\) Data on the call loan rate does not extend back to the period of the Second Bank of the United States.
lender-of-last resort appears to have significantly relaxed funding constraints and weakened the linkage between funding liquidity and stock returns.

Finally, we investigate how changes in market liquidity affect expected asset returns. We examine liquidity measures during financial crises to determine (1) whether bid-ask spreads rise and trading volume falls during financial crises and (2) whether there is a flight to quality, so that these effects are more pronounced for less-heavily-traded (i.e. smaller) stocks. We then estimate the liquidity premium for stocks in the Dow Jones Index from 1886-1925 along the lines suggested by Acharya and Pedersen’s (2005) liquidity-adjusted CAPM. Our preliminary evidence suggests that the creation of the Fed reduced the liquidity premium between high and low priced stocks.

The analysis begins with a brief history of early US financial markets. We then discuss the implications of the Brunnermeier and Petersen (2009) model of funding and market liquidity for early US financial markets. In the next subsection, we examine the relationship between changes in interest rates and stock returns. Finally, we analyze changes in liquidity during financial crises and estimate the liquidity premium using Acharya and Pedersen’s (2005) liquidity-adjusted CAPM. We conclude with a discussion of the implications of the results for future studies of the importance of funding liquidity for financial markets.

I. US Financial Markets, 1815-1925

A. Antebellum Period

Banking institutions in the United States evolved continuously over the nineteenth and early twentieth centuries, culminating in the founding of the Federal Reserve in 1913.
Established in 1791, the First Bank of the United States (FBUS) was chartered for 20 years and served as the banker of the US government. The FBUS was a semi-public national bank where foreigners held a large non-voting stake in the institution. Although the FBUS did not have the explicit ability to print money, the financial institutions performed many traditional banking functions. The FBUS served as a depository for government revenues and played an important role in the Louisiana Purchase. The financial institution attempted to regulate state banks that had over-issued bank notes and tried to coordinate credit policies across the different branches of the FBUS (Cowen, 2000, 2008). Cowen (2006) argues that the FBUS triggered a financial panic in 1792 by initially discounting too many bills thereby adding excessive liquidity to the economy. The FBUS abruptly changed course by reducing the supply of credit which initiated a panic in American financial markets. Secretary Hamilton purchased securities on the open market to curtail the financial crisis (Sylla et al., 2009). The bank closed its doors in 1811 after Congress failed to renew its charter in 1808.

After the War of 1812, the United States government established a successor to the FBUS that performed many of the same functions. The United States now believed that the government needed a bank that could serve the public and private sectors, especially in a time of war. Chartered for twenty years, the Second Bank of the US (SBUS) (1816-1836) was initially regarded as not very successful because of its role in the Panic of 1819 by discounting too many bills, i.e., lending against bills issued by private banks as a discount. The performance of the bank changed under the directorship of Nicholas Biddle, however. President of the SBUS from (1823-1836), Biddle brought several

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6 During almost the entire nineteenth century, the money supply in the United States with determined by the amount of specie.
important institutional changes to the operation of the bank that reduced frictions in credit markets even though the SBUS did not have the legal authority to print money. He established a series of branch banks and national payment system for government revenue. The SBUS had some ability to control the money supply by altering the length of time that they held onto bank notes before presenting them for redemption (Bodenhorn, 2000). Knodell (1998) finds that centralized management by the bank of domestic exchanges reduced exchange rate volatility in the Midwest. Hilt (2009) provides evidence that because of its relatively conservative lending policy, the SBUS was able to provide funding liquidity in the form of short-term loans to financial institutions during Wall Street’s first corporate governance crisis in 1826.

Despite bringing many changes to the makeup and structure of America’s financial system, the bank had many detractors, most notably President Andrew Jackson. The President was a big opponent of the bank and its director Nicholas Biddle. He vetoed legislation in 1833 that would have renewed the charter of the Second Bank of the United States. Jackson then established a series of “pet” banks that served as depositories for revenue collected from land sales by the Federal government. The “pet” banks effectively rendered the SBUS powerless as the financial institution no longer had federal funds to support short-term credit operations and could not limit money creation (Atack and Passell, 1994).

Shortly after the SBUS ceased operations, the United States experienced the Panic of 1837. The Panic and accompanying recession is widely regarded as one of the most severe in American history, with the money supply falling by 34 percent between 1838 and 1842 and prices decreasing 33 percent from 1839 to 1843. Some scholars point to the
elimination of the SBUS as playing an important role in the financial crisis. The SBUS checked rapid expansion of the money supply by wildcat banks in the west by presenting notes for redemption (Highfield, O’Hara, and Smith, 1996; Knodell, 2006). Rousseau (2002) argues that a series of interbank transfers and a western land boom that required payment in specie as a result of the Specie Circular (1836) drained New York City banks of coin and triggered a financial panic. Temin (1837) points to contractionary monetary policy by the Bank of England in response to a gold drain as the most important factor in triggering the Panic of 1837. The central bank raised interest rates in 1836 that caused a specie outflow from the United States.

The remainder of the antebellum period is often characterized as the “Free Banking Era.” Most states adopted laws that allowed individuals to start banks. The banking system grew dramatically over this period and helped spur economic growth. Savings banks, insurance companies and short-term credit market also developed during the antebellum period. An active market for commercial paper began to develop in the 1830s as a short-term method of finance for corporations (Myers, 1944). The call loan market also became an important short-term debt instrument during the antebellum period. Banks from around the United States would send funds to New York that brokers and banks would lend to stock speculators to purchase stock on margin. Investors were generally required to provide collateral that amounted to 80 to 90 percent of the value of the stock loan. Collateral usually took the form of government bonds or high grade railroad bonds. In the event of a stock market crash, the bank or broker could sell the collateral on the open market to minimize their losses.
A. Post-Bellum Period

The American Civil War brought many changes to the US financial system. The US Congress passed the National Banking Acts of 1863, 1864, and 1865 that established a uniform currency, raised funds to fight the Civil War, and standardized the banking system. The legislation required banks to maintain a certain level of capital and purchase government bonds that were held by the US Treasury. In turn, banks could issue notes up to 90 percent of the par value of its bonds.

The National Banking Act established a three-tiered reserve system. The first tier consisted central reserve cities such as Chicago and New York City. The second consisted of reserve city banks and the third tier was comprised of country banks. Reserve city banks could hold half of their reserves as deposits in central reserve cities. Country banks, on the other hand, could hold as much as 60 percent of their reserves as deposits in New York City.

The National Banking System created incentives for banks to deposits funds in New York City and other central reserve cities. Reserve in central reserve city banks paid two percent interest while reserves held in second tier and third-tier banks did not pay interest. The system led to the “pyramiding of reserves” problem where funds tended to accumulate in central reserve city banks. Financial institutions in central reserve city banks often used the deposits from second and third tier banks for the purpose of issuing call loans to investors who used the fund to purchase stock on margin. The short-term debt instrument was callable on demand by the broker and banker that issued the obligation. Alternatively, the investor could pay off the call loan at anytime. A shock to a
second or third tier bank could create problem, however, as the financial institutions called in their stock loans. The action could trigger a liquidity spiral and lead to a financial crisis.

US financial markets were particularly vulnerable to a financial crisis during the fall harvest season. Indeed, some of the largest financial crisis of the nineteenth and early twentieth century occurred during the fall, including the Panics of 1873, 1890, and 1907 (Kemmerer, 1911; Sprague, 1910). Loan and currency demand increased as farmers used credit to harvest and market their crops. The increase in the demand for funds led to a rise in interest rates given that the supply of funds was relatively fixed because the US was on the gold standard and did not have a central bank. This means that a large withdrawal was more likely to lead banks or financial institutions to call in their stock loans. This might trigger a bank run if depositors are unsure about the solvency of the bank. Other banks might also call in their stock loans. The domino effect could spread throughout the financial system and lead to a panic. Monetary stringency in the fall harvest season could be exacerbated if the US economy had already experienced a business cycle turning point earlier in the year that led to a decline in bank asset values (Calomiris and Gorton, 1991).

The frequent occurrence of financial crisis during the National Banking Period ultimately led to reform of the financial system. Following the Panic of 1907 in which JP Morgan and a small group of bankers provided liquidity to the New York financial market to shore up financial markets and avert a larger crisis, the general public led the call for monetary reform. In May 1909, Congress passed the Aldrich-Vreeland Act that granted certain banks the authority to issue emergency currency during a financial crisis. The Aldrich-Vreeland Act was only used once before the establishment of the Federal Reserve System in 1913.
Reserve. Secretary of Treasury William McAdoo invoked the act in July 1914 to prevent a financial crisis in the United States following the outbreak of World War One (Silber, 2005. 2007a, 2007b). The Aldrich-Vreeland Act also created the National Monetary Commission to investigate the possibility of creating a central bank for the United States. The Federal Reserve Act was passed in 1913 and the central bank began using open market operations in January 1915.

II. Funding Liquidity and Historical Financial Markets

The seasonal nature of nineteenth and early twentieth century financial markets provides a laboratory to examine the impact of an exogenous change to funding liquidity. Our proxy for funding liquidity is the call loan interest rate, the rate at which investors could buy and sell on margin. Unlike today, when margin rates are determined by the Federal Reserve, the call loan rate was determined by the supply and demand for excess reserves in the New York market. During this period, the amount of excess reserves was largely determined by agricultural shocks. The call loan rate could be very volatile during the harvest season because agricultural shocks to loan demand were large and there was not a financial institution or lender of last resort (for most of the pre-1925 period) to increase the money supply or provide funding liquidity.

We use the call loan rate as a direct measure of funding liquidity to test the predictions of the Brunnermeier and Pedersen (2009). One testable implication is that stock and interest rate volatility should be higher in September and October given that major financial panics often occurred in the fall harvest period (in part) because of lower
funding liquidity. We therefore compare the volatility of stock returns and the call loan rate in the fall harvest months with the rest of the year.\(^7\) Then we investigate how a change in funding constraints affects financial markets for the period 1815-1925. The pre-1925 period is unique in American history given that the US had two financial institutions that performed central banking functions to varying degrees: (1) the Second Bank of the United States and (2) the Federal Reserve. The existence of a quasi or fully functional central bank means that liquidity crises should be less likely to occur because the central bank can lend more generously or create money to lend to prevent large increases in the call loan rate which could otherwise lead to liquidity crises. Furthermore, the demise of the SBUS provides a rare opportunity to analyze the impact of dismantling a financial institution that had some control over monetary and credit policy.

Second, to the extent that speculators are long and their positions are financed by buying on margin, stock prices should fall with an increase in the call loan rate. The fall could be temporary – or longer lasting depending on the availability of credit and the importance of the balance sheet channel (Bernanke and Gertler 1990). Third, if speculators also provide liquidity in the stock market, market liquidity would decline with an increase in the call loan rate as shown by a rise in bid-ask spreads and a decline in trading volume.

Brunnermeier and Pedersen’s (2009) model also predicts that a shock to funding liquidity should affect all asset prices – there is commonality in liquidity. This follows because a change in the call loan rate should affect all securities and traders in the marketplace. The effects could also be non-linear because a large increase in the call loan

\(^7\) Bernstein, Hughson and Weidenmier (forthcoming) show that volatility in the commercial paper rate should also increase.
rate could result in a credit freeze, forcing leveraged investors and market makers to liquidate their positions. For speculators who were not financially constrained, however, it is unlikely that changes in the call loan rate would have much of an effect on their margin accounts.

The testable implications can be summarized as follows:

1. Stock and short-term interest rate\(^8\) volatility should be higher during the fall as long as there is not a financial institution that can increase funding liquidity.

2. Call loan rates should Granger-cause (1) low stock returns and (2) higher bid-ask spreads or lower trading volume when there is not a lender of last resort. This effect should diminish when there are financial institutions that can significantly reduce funding liquidity risk.

3. There should be commonality in funding liquidity so that bid-ask spreads are correlated across stocks.

4. Funding liquidity should be significantly lower in September and October when there is not a financial institution that can increase funding liquidity in the event of a crisis.

We now turn to the empirical analysis to analyze the effect of funding constraints on financial markets over the period 1815-1925.

II. Empirical Analysis

A. Data

To analyze the impact of funding liquidity on market liquidity, we use financial data from several different sources. For short-term interest rates, we use call loan money rates (1857-1925) from the NBER macro-history database and the commercial paper rate\(^8\). Short-term interest rate proxies include the commercial paper and call loan rates.
(1835-1925) from Global Financial Data (GFD).\(^9\) Trading volume is taken from the NYSE website and the *New York Times*. For the stock market, we use Goetzmann, Ibbotson, and Peng’s, (2001) hereafter GIP, comprehensive monthly stock market indexes of the pre-CRSP era for the period 1815-1925. End-of-month bid-ask data are taken from the *New York Times*. The GIP data is the broadest index publicly available for the pre-CRSP period and covers more than 600 securities during our sample period. Month-end prices were obtained by searching for the last transaction price for each stock in a given month from the *New York Times* and other financial newspapers. When a closing price was not available, the most recent bid and ask prices were averaged, in keeping with the methodology employed by CRSP. The GIP index significantly improves on the Cowles Index and the Dow Jones Industrial Average, the other two widely employed indexes from this period.\(^{10}\)

**B. Volatility Tests**

**Stock Market Volatility**

To investigate the importance of funding liquidity, we first examine its effect on stock volatility over the period 1815-1925. We expect a strong link between funding liquidity shocks and stock returns in periods where the US did not have a quasi-central banks (SBUS) or a lender of last resort (Fed/AV), (1837-1908). In particular, high call

\(\footnote{9}{The commercial paper rates from GFD are taken from the *Commercial and Financial Chronicle* and the *Financial Review*. The call loan rates are taken from Macaulay (1938).}\)

\(\footnote{10}{The Cowles Index is value weighted over the period from 1872-1925, causing a large cap bias in computed index returns. Prices are also calculated by averaging monthly high and low prices which induces serial correlation in the Cowles Index of monthly returns. As shown in Bernstein, Hughson and Weidenmier (forthcoming), the first-order autocorrelation coefficient for the Cowles Index is 26 percent versus six percent for the price-weighted GIP index.}\)
loan rates should be associated with lower stock returns for three reasons: 1) the balance sheet channel identified by Bernanke and Gertler (1990), 2) equity demand falls when funding liquidity is tight and interest rates are rising and 3) expected gross equity returns must be higher during periods of market illiquidity because of the increased costs of market making.

We therefore compare stock return volatility using data from only the months of September and October with volatility using data drawn only from the rest of the year. This strategy is motivated by the observation that funding liquidity for asset purchases could dry up during the harvest season because farmers either unexpectedly withdrew funds or took out unexpectedly large loans to finance the production and marketing of crops. We compute average stock return volatility for each calendar month and then compare average variances between September and October with the rest of the year. We exclude the Civil War years to minimize the effect of the conflict on the empirical results. Over the period 1815-1925, the monthly standard deviation of stock index returns is 5.16 percent. It is 5.76 percent during the months of September and October compared with 5.04 percent for the rest of the year, a difference that is significant at the one percent level.

Although the baseline results suggest that stock volatility is higher during the harvest season, we divide the sample into several sub-periods to test the robustness of the results. The baseline empirical results could be driven by the antebellum period when the agricultural sector was a much larger fraction of the US economy. Historical estimates of US GNP suggest that agriculture accounted for about 80 percent of American economic

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11 We do this to avoid aggregating across months which may have different interest rate volatilities due to the harvest cycle.
activity in 1840 and 1850 and nearly 40 percent in 1870. Agriculture’s share of GNP averaged approximately 35 percent in the 1870s, 22.5 percent around the turn of the century, 17 percent in 1908, 16 percent by 1916 and 11.6 percent in 1925 (US Bureau of the Census, 1976). As shown in Table 1, the baseline empirical results are not driven by agriculture’s greater share of economic activity in the antebellum period. Stock volatility in the post-bellum period (5.94 percent) is actually higher than in the antebellum period (7.12 percent). One possible explanation for this result is that the National Banking Act of 1863 created an additional incentive for country banks to deposits their funds in New York City and other reserve center banks because they received interest on the deposits. In turn, financial institutions expanded the supply of call loans that increased funding and liquidity risk in the presence of a large withdrawal or agricultural shock in the fall harvest months.

Another important feature of the early US financial markets was the existence of financial institutions that could reduce funding and liquidity risk. The SBUS actively discounted bills and even provided some loans to financial institutions during America’s first corporate crisis in New York City during the fall of 1825. The bank’s charter was not renewed in the early 1830s as President Jackson vetoed the bill and established a series of pet banks. Table 1 shows stock volatility during the antebellum period. During the operation of the SBUS (1816-1836), stock return volatility across the months of September and October averaged 2.44 percent versus 2.76 percent the rest of the year. This difference is not statistically significant at conventional levels. Following the demise of the SBUS, stock volatility increased to 6.45 percent in September and October
versus 5.18 percent during the rest of the year for the period 1837-1860. The effect is statistically significant at the five percent level.

The Federal Reserve was another important financial institution created during our sample period. We re-estimated stock volatility from 1870 (the post-Civil War period) until 1925. Stock return volatility averaged 7.07 percent in September and October prior to the founding of the Fed versus 5.94 percent for the rest of the year. The effect is statistically significant at the one percent level. After the founding of a central bank, however, average monthly volatilities are lower during the harvest months (3.92 percent) than during the rest of the year (4.78 percent). The difference is not statistically significant. The results for the post-bellum period are consistent with the findings of Bernstein, Hughson, and Weidenmier (Forthcoming). Overall, the results suggest that the presence of the Second Bank of the United States and the Federal Reserve significantly reduced liquidity risk in financial markets.

*Interest Rate Volatility*

We also examine the interest rate volatility during the nineteenth and early twentieth century. The call loan rate was one of the most important short-term interest rates in early US financial markets because investors often borrowed stock on margin using government securities as collateral. We divided the sample period into several sub-periods to test the robustness of the results and to test whether the effects of the establishment of a lender-of-last resort on financial markets—the creation of the Fed in 1913. The creation of the Fed took place in two steps: 1) the Passage of the Aldrich-
Vreeland Act in 1908 that allowed certain banks to issue emergency currency during a financial crisis and 2) the Federal Reserve Act of 1913 that authorized the establishment of a central bank that began open market operations in January 1915.

The empirical results are presented in Table 2A. The analysis shows that interest rate volatility was (statistically) twice as high in the fall than during the rest of the year prior to the passage of the Aldrich-Vreeland Act. 12 As shown in Table 2A, this large difference is true regardless of whether we use 1857 (the start of the sample period), 1863 (start of National Banking Period), or 1870 (post-Civil War period) as the starting point for the empirical analysis. 13 The volatility of short-term interest rates declined by more than 70 percent in the months of September and October following the passage of the Aldrich-Vreeland Act in 1908 – from 4.05 percent from 1870 until the passage of the Aldrich-Vreeland Act vs 1.85 percent afterward. After the passage of the Aldrich-Vreeland Act, interest rate volatility in September and October is no longer significantly different from interest rate volatility in the rest of the year (1.81 percent during the harvest months and 1.85 percent during the rest of the year). The results are consistent with the stock volatility analysis: the establishment of a lender of last resort increased funding and market liquidity.

We follow up the analysis of the call loan rate with an analysis of the commercial paper rate from 1835-1925. As shown in Table 2B, we find that volatility in the commercial paper rate was more than 60 percent higher in the months of September and October compared to the rest of the year in the pre-Aldrich Vreeland period 1857-1908. The result is statistically significant at the one percent level. The basic tenor of the results

12 Bernstein, Hughson, and Weidenmier (forthcoming) show that there is no similar effect during the spring planting season – volatility in the spring is indistinguishable from that during the rest of the year.
13 The results are also robust to excluding the panic of 1873 and starting the empirical analysis in 1880.
remains unchanged if the Civil War is dropped from the analysis and we restrict the analysis to the National Bank Period before the passage of Aldrich-Vreeland. Again we also find that after the passage of the monetary reform legislation, the volatility of the commercial paper rate decline more than 50 percent over the entire sample period. Interest rate volatility is not statistically different from the rest of the year.

C. Funding Liquidity, Market Liquidity, and Stock Returns

Bernanke and Gertler (1990) argue that funding constraints can reduce the ability of firms to borrow. If this inability to borrow persists, it can lead to lower stock prices and a financial crisis. Brunnermeier and Pedersen (2009) suggest that funding liquidity and liquidity can be mutually reinforcing, leading to a liquidity spiral and a financial crisis. Therefore, we next examine the relationship between funding liquidity, market liquidity, and stock returns. Our proxy for market liquidity is monthly trading volume on the NYSE.

Figures 1a, 1b, and 1c and Table 3 show average and cumulative average returns for the GIP index in the six-month window during periods when there is a spike in the call loan rate. A spike in the call loan rate is defined as a period when the call loan rate is greater than two standard deviations (11.72%) above its mean. The two figures suggest that stock returns fall during periods when there is a reduction in funding liquidity (as measured by the call loan rate).

To formally test the importance of funding and market liquidity for the equity market, we analyze the dynamic relationship between the call loan rate, trading volume
and stock returns during the period 1888-1925 using a three-variable vector autoregression. A lag length of two months is employed for the empirical analysis based on the Akaike Information Criteria (AIC). We also include a dummy variable that takes a value of one in the month of January 1915 given that NYSE trading volume increased by 547 percent when the exchange reopened after closing in August 1914 following the outbreak of World War I. The Granger-causality results are reported in Table 5.

The Granger-causality tests show that the call loan rate predicts stock returns at the one-percent level for the entire sample period. This finding is consistent with the Brunnermeier and Pedersen (2008) model which suggests that an increase in funding constraints reduces stock prices. We do not find evidence that trading volume Granger-causes stock returns, however. Regarding trading volume, we find that both the call loan rate and stock returns Granger-causes movements in our proxy for market liquidity. This suggests that funding liquidity and increases in stock prices are important drivers of trading volume (market liquidity). Finally, the empirical results suggest that stock returns and market liquidity do not Granger-cause the call loan rate. The finding is consistent with the interpretation that the call loan rate is largely driven by agricultural (seasonal) and real shocks that lead banks outside of New York City to call in their stock loans.

We follow up the Granger-causality tests by estimating impulse response functions to examine the dynamic relationship between innovations in the call loan rate, trading volume, and stock returns. We give call loan rates the first ordering in the Choleski decomposition based on the theory that funding constraints are an important

\[\text{We also tested the call loan rate for a unit root using the ADF-GLS test. The null hypothesis could easily be rejected at the one percent level of significance for the entire sample period.}\]

\[\text{The empirical results are robust to running the models without the January 1915 dummy variable.}\]
driver of stock returns and the historical evidence that seasonal agricultural and real shocks are a determinant of call loan rates and propagator of pre-WWI financial crises. The cumulative impulse response functions along with 95 percent confidence intervals for the entire sample period for a one-standard deviation shock to the call loan rate are reported in Figure 2. A one-standard deviation shock to the call loan rate (1.7 percentage points) reduces stock returns by 2.7 percent after 36 months. This suggests that the call loan rate was accompanied by an even larger drop in stock returns during a financial crisis. During the panic of 1907, for example, the size of the structural shock to the call loan rate was nearly 17 percentage points (or nearly 10 times the size of the one-standard deviation shock). This means that the shock to funding liquidity coincided with almost a 27 percent drop in stock returns during a financial panic. As for trading volume, a one-standard deviation shock to the call rate reduces market liquidity by almost 16 percent. The effect is not quite statistically significant at the 10 percent level of significance. This suggests that the effect of a shock to funding liquidity is greatest on stock prices rather than market liquidity.

Figure 3 shows the impulse responses for trading volume. A one-standard deviation shock to our proxy for market liquidity does not significantly change the call loan rate or stock returns. Figure 4 reports the impulse response analysis for stock returns. Innovations in equity prices significantly increase trading volume but do not impact the call loan rate. The baseline empirical results suggest that the shocks to the call loan rate may impact market liquidity through stock prices.

We next consider the importance of the creation of the Federal Reserve, an institution designed to “furnish an elastic currency” and act as a lender of last resort to
reduce the incidence of financial crises in the late nineteenth and early twentieth century (Bernstein, Hughson, and Weidenmier, forthcoming; Friedman and Schwartz, 1963; Meltzer, 2003; Miron, 1986). We separately estimate Granger-causality tests for both the pre-Fed period (1888-1914) and the Fed period (1915-1925).\footnote{We employed a lag length of two months for the pre-Fed period and three months for the Fed period based on the Akaike Information Criteria.} The results for the pre-Fed period are reported in Table 4. In the pre-Fed period, the call loan rate Granger-causes trading volume and stock returns at the five-percent level of significance. Stock returns and trading volume do not Granger-cause the call loan rate. Stock returns and the call loan rate both Granger-causes movements in market liquidity proxied by trading volume. The Granger-causality and impulse response analysis from the pre-Fed period are nearly identical to the results for the entire sample period.\footnote{The impulse response analysis for the pre-Fed period are available from the authors by request.}

In the Federal Reserve period, the relationship between the call loan rate and stock returns is quite different. As shown in Table 6, the call loan rate does not Granger-causes stock returns. A one-standard deviation shock to the call loan rate does not have a statistically significant effect on stock returns. Both the call loan rate and stock returns predict movements in market liquidity. However, innovations in the call loan rate and stock returns do not have a statistically significant on trading volume in the impulse response analysis after bootstrapping the standard errors. Consistent with the results for the full sample period, stock returns and trading volume do not Granger-cause movements in the call loan rate. A shock to trading volume and stock returns, shown in Figures 6 and 7, do not significantly change the call loan rate. Overall, we interpret the results as evidence that the establishment of a central bank caused market participants to no longer interpret (temporary) spikes in the call loan rate as harbingers of reduced

---

16 We employed a lag length of two months for the pre-Fed period and three months for the Fed period based on the Akaike Information Criteria.
17 The impulse response analysis for the pre-Fed period are available from the authors by request.
funding liquidity because of the increased availability of credit provided by the Fed. As a result, stock prices do not decline in response to a rise in the call loan rate.

One potential shortcoming of the empirical results is that NYSE trading volume is not a very good proxy market liquidity. As pointed out by Brown et al (2008), the Consolidated Stock Exchange competed head-to-head with the NYSE over the period 1885-1926. The rival exchange primarily traded large NYSE stocks and averaged more than a 20 percent market share over its existence. The Consolidated traded as much as 60 percent of NYSE in the mid-1890s. To account for this potential bias, we construct the variable TOTALVOLUME that is the sum of monthly NYSE volume and Consolidated trading volume. We then re-estimate the baseline VAR. As shown in Table 7, the baseline results do not qualitatively change. The call loan rate Granger-causes trading volume and stock returns at the five percent level of significance. Trading volume and stock returns do not Granger-cause the call loan rate, providing additional evidence that the call loan rate leads movements in equity prices and market liquidity. We also find similar results for the pre-Fed and Fed periods using the broader measure of market liquidity. The call loan rate does not Granger-cause stock returns after the establishment of a central bank.¹⁸

C. Market Liquidity

We next investigate how changes in market liquidity effect expected asset returns. We estimate a version of Acharya and Pedersen’s (2005) liquidity adjusted CAPM for Dow Jones securities over the period 1886-1925 to determine whether more liquid stocks

¹⁸ The impulse response functions are also similar to those reported using only NYSE volume. The graphs of the impulse response functions are available from the authors by request.
have greater sensitivity to changes in market liquidity and the influence of the passage of
Aldrich-Vreeland and the Federal Reserve Act on this liquidity premium.

Acharya and Pedersen begin by assuming that a single-period version of the
conditional CAPM holds in the economy without transaction costs, so that a single-period
conditional CAPM in net returns holds in the economy with transactions costs. That is:

$$E_t(r_{i,t+1}) = r^f + \lambda_i \frac{\text{cov}_i(r_{i,t+1} - c_{i,t+1}, r_{M,t+1} - c_{M,t+1})}{\text{var}_t(r_{M,t+1} - c_{M,t+1})},$$

where the percentage liquidity cost, $c_i^t = C_i^t / P_{i,t-1}$, $C_i^t$ is the liquidity cost of security $i$ in
dollars, $P_{i,t-1}$ is the previous period’s price for security $i$, $r_i^t$ is the individual security
return, $r_M^t$ is the market return, $r^f$ is the risk-free rate, and $\lambda_i = E_t(r_{M,t+1} - c_{M,t+1} - r^f)$ is the
conditional market risk premium with transaction costs.

From these assumptions Acharya and Pedersen (2005 proposition 1) show that

$$E_t(r_{i,t+1}) = r^f + \lambda_i \text{cov}_i(r_{i,t+1}, r_{M,t+1}) + \lambda_i \frac{\text{cov}_i(c_{i,t+1}, c_{M,t+1})}{\text{var}_t(r_{M,t+1} - c_{M,t+1})} + \lambda_i \frac{\text{cov}_i(c_{i,t+1}, r_{M,t+1} - c_{M,t+1})}{\text{var}_t(r_{M,t+1} - c_{M,t+1})}$$

$$- \lambda_i \frac{\text{cov}_i(r_{i,t+1}, c_{M,t+1})}{\text{var}_t(r_{M,t+1} - c_{M,t+1})} - \lambda_i \frac{\text{cov}_i(c_{i,t+1}, r_{M,t+1})}{\text{var}_t(r_{M,t+1} - c_{M,t+1})}.$$

That is, expected excess return is equal to the sum of

1. the expected illiquidity cost
2. $(\lambda_i) \times$ (a standard CAPM beta, adjusted for transaction costs)
3. $(\lambda_i) \times$ (a procyclical liquidity term which says that required returns must be
   higher if asset liquidity has a positive covariance with market liquidity.)
4. $(\lambda_i) \times$ (a term that says that required returns are larger if an asset has higher
   returns in times of market illiquidity) x (-1)
To estimate an unconditional version of this relation, additional assumptions are required. In keeping with the methodology of Acharya and Pedersen we make the assumption of constant conditional covariances of innovations in illiquidity and returns which yields the following result:

\[
E(r^i_t - r^f_t) = E(c^i_t) + \lambda(\beta^{3i} + \beta^{2i} - \beta^{3i} - \beta^{4i}) \text{ where }
\]

\[
\beta^{3i} = \frac{\text{cov}(r^i_t, r^M_t - E_{t-1}(r^M_t))}{\text{var}(r^M_t - E_{t-1}(r^M_t) - [c^M_t - E_{t-1}(c^M_t)])}, \text{ (term (2) above)}
\]

\[
\beta^{2i} = \frac{\text{cov}(c^M_t - E_{t-1}(c^M_t), c^i_t - E_{t-1}(c^i_t))}{\text{var}(r^M_t - E_{t-1}(r^M_t) - [c^M_t - E_{t-1}(c^M_t)])}, \text{ (term (3) above)}
\]

\[
\beta^{3i} = \frac{\text{cov}(r^i_t, c^M_t - E_{t-1}(c^M_t))}{\text{var}(r^M_t - E_{t-1}(r^M_t) - [c^M_t - E_{t-1}(c^M_t)])}, \text{ (term (4) above)}
\]

\[
\beta^{4i} = \frac{\text{cov}(c^i_t - E_{t-1}(c^i_t), r^M_t - E_{t-1}(r^M_t))}{\text{var}(r^M_t - E_{t-1}(r^M_t) - [c^M_t - E_{t-1}(c^M_t)])}, \text{ (term (5) above)}
\]

\[
\lambda = E(r^M_t - c^M_t - r^f_t)
\]

For our empirical analysis we use the price-weighted GIP stock return index as our market return proxy and innovations in bid-ask spread as our estimate for stock specific market liquidity. Individual innovations in market liquidity are determined by applying the coefficients of an AR(2) on an equal weighted average of all bid-ask spreads to each individual stock bid-ask, when lagged values are available. For innovations in market returns we subtract the long-term expected market return, as proxied by mean monthly

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19 As Acharya and Pedersen do, we cap the maximum illiquidity at 30 percent to prevent noisy outliers from driving the results.
price-weighted GIP returns from 1815-1886, from market returns each month. We then compute liquidity betas for a high liquidity portfolio and a low liquidity portfolio, where each portfolio is equally-weighted and is formed each month based on either monthly volume or price. These liquidity betas are estimated for the entire sample period as well as two sub-periods: 1886-May-1908 (when the Aldrich-Vreeland-Fed period begins) and June 1908-1925. In the liquidity beta computations in the sub-periods, the denominator is the variance of the net market return in the period over which the betas are computed. The results are shown in detail in Table 8.

The betas are collinear so the effects of liquidity can best be considered by examining $\beta_2-\beta_3-\beta_4$, rather than considering the effects separately. The table reveals that the aggregate effects of the liquidity betas on expected returns equal the market risk premium x 0.0215, or, assuming a market risk premium of seven percent, roughly 14 basis points per year for high-priced stocks and the market risk premium 0.0530 or roughly 35 basis points per year for low-priced stocks over the full sample. After Aldrich-Vreeland, the liquidity premium due to liquidity betas falls slightly for low-priced stocks and rises slightly for high-priced stocks. The direction of the difference in liquidity betas is the direction we would expect with a more elastic supply of currency, but the changes in liquidity betas due to the change in regime are far too small to be anything more than suggestive. We obtain similar results using volume to separate into two portfolios but the results are less stark. In the future, we hope to expand our sample to include the universe of stocks listed on the NYSE for the period 1885-1925. We expect

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20 Using residuals from a variety of regressions with lagged market return and liquidity proxies instead of the market returns less historical expected returns as innovation proxies does not substantial alter any results or conclusions.
that including more low price/low volume stocks will show that the introduction of a lender of last resort had a much bigger impact in reducing the liquidity premium.

Next, we investigate whether liquidity costs, \( c_i \), change for the two portfolios due to the existence of the Fed. For the overall market, the average cost, \( c_M \) before the monetary regime change is 0.34 percent, whereas afterward, perhaps surprisingly, it is an almost identical 0.35 percent. In addition, \( c_{\text{low volume}} \) fell from 0.48 percent before the regime change to 0.46 percent afterward and \( c_{\text{high volume}} \) actually rose from 0.19 percent to 0.23 percent. What is more striking is that the volatility of \( c_{\text{low volume}} \) fell from 0.33 percent to only 0.13 percent in the Fed period (whereas the volatility of \( c_{\text{high volume}} \) rose from 0.08 percent to 0.11 percent. The biggest effect appears to be the reduction in volatility for the low-priced stock portfolio.

III. Conclusion

How do funding constraints impact financial markets? This question has recently received a considerable amount of attention by financial economists. We provide a historical perspective on this question by examine the impact of an exogenous change in margin/capital requirements on market volatility, market liquidity, and stock returns. The pre-World War I period is a unique period in American financial history where the market’s funding constraint was largely determined by agricultural shocks. For much of the nineteenth and early twentieth centuries, country banks deposited reserves with financial institutions in New York City and other reserve center cities. The New York

\( ^{21} \) Analysis of changes in the level of costs could be confounded by the diminishing role of the Consolidated Stock Exchange after 1900 as discussed in Brown, Mulherin, and Weidenmier (2008) which could explain the absence of a significant decline in observed bid-ask levels.
City banks often used these funds to extend credit in the form of call loans to speculators. In the event of a large withdrawal from country banks, the New York City banks might call in their loans to increase their reserve position. This might lead to a bank run followed by a liquidity spiral and financial crisis.

We analyze the impact of this exogenous shock to the market’s funding constraint using the new GIP Index of stock prices from 1815-1925 and the call loan rate, a direct measure of funding liquidity. The empirical analysis suggests that market volatility was more than 50 percent higher during September and October. Large negative stock returns and the frequency of liquidity spirals were also significantly greater during the fall harvest season. We find that market liquidity, market volatility, or the frequency of large negative stock returns are significantly larger in September and October during the periods when the Second Bank of the United States and the Federal Reserve were in operation. The SBUS and the Federal Reserve were able to provide seasonal funds to reduce liquidity risk during the fall. Overall, we interpret our results as consistent with Brunnermeier and Pederson’s theory that funding constraints can be an important driver of market liquidity and market risk premiums.

Finally, we note that the existence of a lender of last resort, even if it is only a quasi-central bank plays a crucial role in determining market reaction to financial shocks. The ability of the Fed to lend breaks the link between an interest rate shock and negative stock returns which we observe over and over during the nineteenth century, when a central bank did not exist. We take this as evidence that market participants felt that a lender of last resort was likely to head off prolonged periods of tight money which could
affect the ability of firms to obtain funding, as the Fed has recently done, both in the mortgage and commercial paper markets.

References


Commercial and Financial Chronicle, various issues. 1880-1925.


Cowen, D. 2000. The origins and economic impact of the First Bank of the United


Table 1
Monthly Stock Return Volatility during Varying U.S. Banking Regimes

The equality of variance for stock returns was tested over various sample periods from 1815-1925. The critical values for the equality of variance tests were found using an F-test.

<table>
<thead>
<tr>
<th>U.S. Banking Regime</th>
<th>Sample Period</th>
<th>Average Monthly Standard Deviations</th>
<th>F-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Second Bank of the U.S.</td>
<td>1816-1836</td>
<td>Rest of the Year: 2.76%</td>
<td>0.35</td>
</tr>
<tr>
<td>Antebellum Period</td>
<td>1837-1860</td>
<td>Sept. &amp; Oct.: 2.44%</td>
<td></td>
</tr>
<tr>
<td>Pre Aldrich-Vreeland National Banking System (Ex Civil War)</td>
<td>1870- May 1908</td>
<td>Rest of the Year: 5.94%</td>
<td>0.04</td>
</tr>
<tr>
<td>Aldrich-Vreeland &amp; Federal Reserve Period</td>
<td>June 1908 - 1925</td>
<td>Sept. &amp; Oct.: 7.12%</td>
<td>0.03</td>
</tr>
</tbody>
</table>

The average monthly standard deviations are shown in the table above.
Table 2
Monthly Interest Rate Volatility

A: Call Loan Rate Volatility during Varying U.S. Banking Regimes

<table>
<thead>
<tr>
<th>U.S. Banking Regime</th>
<th>Sample Period</th>
<th>Average Monthly Standard Deviations</th>
<th>F-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre Aldrich-Vreeland Period</td>
<td>1857- May 1908</td>
<td>2.99%</td>
<td>0.00</td>
</tr>
<tr>
<td>Pre Aldrich-Vreeland National Banking System</td>
<td>Feb 1863 - May 1908</td>
<td>3.12%</td>
<td>0.00</td>
</tr>
<tr>
<td>Pre Aldrich-Vreeland National Banking System (Ex Civil War)</td>
<td>1870- May 1908</td>
<td>2.97%</td>
<td>0.00</td>
</tr>
<tr>
<td>Aldrich-Vreeland &amp; Federal Reserve Period</td>
<td>June 1908 - 1925</td>
<td>1.86%</td>
<td>0.84</td>
</tr>
<tr>
<td>Federal Reserve Period</td>
<td>1915-1925</td>
<td>1.92%</td>
<td>0.79</td>
</tr>
</tbody>
</table>
B: Commercial Paper Rate Volatility during Varying U.S. Banking Regimes

<table>
<thead>
<tr>
<th>U.S. Banking Regime</th>
<th>Sample Period</th>
<th>Average Monthly Standard Deviations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre Aldrich-Vreeland Period</td>
<td>Dec 1835- May 1908</td>
<td>Rest of the Year: 3.54% Sept. &amp; Oct.: 6.03% F-Test: 0.00</td>
</tr>
<tr>
<td>Pre Aldrich-Vreeland National Banking System</td>
<td>Feb 1863 - May 1908</td>
<td>1.93% 5.46% 0.00</td>
</tr>
<tr>
<td>Pre Aldrich-Vreeland National Banking System (Ex Civil War)</td>
<td>1870- May 1908</td>
<td>1.86% 5.92% 0.00</td>
</tr>
<tr>
<td>Aldrich-Vreeland &amp; Federal Reserve Period</td>
<td>June 1908 - 1925</td>
<td>1.23% 1.27% 0.78</td>
</tr>
<tr>
<td>Federal Reserve Period</td>
<td>1915-1925</td>
<td>1.30% 1.45% 0.52</td>
</tr>
</tbody>
</table>

Average Monthly Standard Deviations

- 0%
- 1%
- 2%
- 3%
- 4%
- 5%
- 6%
- 7%

Dec 1835 - May 1908 Pre Aldrich-Vreeland Period
Feb 1863 - May 1908 Pre Aldrich-Vreeland National Banking System
1870- May 1908 Pre Aldrich-Vreeland National Banking System (Ex Civil War)
June 1908 - 1925 Aldrich-Vreeland & Federal Reserve Period
1915-1925 Federal Reserve Period

Rest of the Year
Sept. & Oct.
F-Test
Table 7
Call loan rate spikes are defined as periods when call loan rate is above 11.72% (2 sigma above mean) and the change in call loan rate MoM is greater than 3.65% (1 sigma).

<table>
<thead>
<tr>
<th>Call Loan Rate Spike Month Offset</th>
<th>Average Cumulative Return</th>
<th>Average Monthly Return</th>
<th>Stdev</th>
<th>Number Points</th>
<th>Standard Error</th>
<th>T-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1857-1925 (no event occurs after 1907)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td>-0.4%</td>
<td>-0.3%</td>
<td>5.0%</td>
<td>15</td>
<td>1.3%</td>
<td>-0.27</td>
</tr>
<tr>
<td>-2</td>
<td>0.3%</td>
<td>0.8%</td>
<td>4.3%</td>
<td>15</td>
<td>1.1%</td>
<td>0.74</td>
</tr>
<tr>
<td>-1</td>
<td>0.5%</td>
<td>-0.4%</td>
<td>8.2%</td>
<td>15</td>
<td>2.1%</td>
<td>-0.18</td>
</tr>
<tr>
<td>0</td>
<td>-5.1%</td>
<td>-6.4%</td>
<td>11.5%</td>
<td>15</td>
<td>3.0%</td>
<td>-2.17</td>
</tr>
<tr>
<td>1</td>
<td>-8.6%</td>
<td>-3.4%</td>
<td>8.7%</td>
<td>15</td>
<td>2.2%</td>
<td>-1.53</td>
</tr>
<tr>
<td>2</td>
<td>-5.4%</td>
<td>2.8%</td>
<td>10.1%</td>
<td>15</td>
<td>2.6%</td>
<td>1.07</td>
</tr>
<tr>
<td>3</td>
<td>-4.5%</td>
<td>0.6%</td>
<td>8.3%</td>
<td>15</td>
<td>2.2%</td>
<td>0.28</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Call Loan Rate Spike Month Offset</th>
<th>Average Cumulative Return</th>
<th>Average Monthly Return</th>
<th>Stdev</th>
<th>Number Points</th>
<th>Standard Error</th>
<th>T-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1873 removed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td>-0.6%</td>
<td>-1.1%</td>
<td>4.2%</td>
<td>10</td>
<td>1.3%</td>
<td>-0.84</td>
</tr>
<tr>
<td>-2</td>
<td>-0.3%</td>
<td>0.3%</td>
<td>4.0%</td>
<td>10</td>
<td>1.3%</td>
<td>0.26</td>
</tr>
<tr>
<td>-1</td>
<td>-0.1%</td>
<td>0.0%</td>
<td>8.2%</td>
<td>10</td>
<td>2.6%</td>
<td>0.00</td>
</tr>
<tr>
<td>0</td>
<td>-5.4%</td>
<td>-6.5%</td>
<td>11.9%</td>
<td>10</td>
<td>3.8%</td>
<td>-1.74</td>
</tr>
<tr>
<td>1</td>
<td>-7.6%</td>
<td>-2.2%</td>
<td>7.6%</td>
<td>10</td>
<td>2.4%</td>
<td>-0.93</td>
</tr>
<tr>
<td>2</td>
<td>-4.5%</td>
<td>2.9%</td>
<td>9.6%</td>
<td>10</td>
<td>3.0%</td>
<td>0.96</td>
</tr>
<tr>
<td>3</td>
<td>-4.4%</td>
<td>-0.7%</td>
<td>7.5%</td>
<td>10</td>
<td>2.4%</td>
<td>-0.30</td>
</tr>
</tbody>
</table>
Table 4
Granger-Causality Tests
Full Sample Period, September 1886-1925

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Excluded Variable</th>
<th>Wald Test Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Call Loan Rate</td>
<td>NYSE Trading Volume</td>
<td>0.204</td>
</tr>
<tr>
<td>Call Loan Rate</td>
<td>Stock Returns</td>
<td>4.3235</td>
</tr>
<tr>
<td>NYSE Trading Volume</td>
<td>Call Loan Rate</td>
<td>7.0575**</td>
</tr>
<tr>
<td>NYSE Trading Volume</td>
<td>Stock Returns</td>
<td>11.169***</td>
</tr>
<tr>
<td>Stock Returns</td>
<td>Call Loan Rate</td>
<td>9.651***</td>
</tr>
<tr>
<td>Stock Returns</td>
<td>NYSE Trading Volume</td>
<td>0.379</td>
</tr>
</tbody>
</table>

*denotes significance at the 10 percent level; **denotes significance at the 5 percent level; ***denotes significance at the 1 percent level.

Table 5
Granger-Causality Tests
Pre-Fed Period, September 1886-1914

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Excluded Variable</th>
<th>Wald Test Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Call Loan Rate</td>
<td>NYSE Trading Volume</td>
<td>0.137</td>
</tr>
<tr>
<td>Call Loan Rate</td>
<td>Stock Returns</td>
<td>3.656</td>
</tr>
<tr>
<td>NYSE Trading Volume</td>
<td>Call Loan Rate</td>
<td>6.044**</td>
</tr>
<tr>
<td>NYSE Trading Volume</td>
<td>Stock Returns</td>
<td>9.922***</td>
</tr>
<tr>
<td>Stock Returns</td>
<td>Call Loan Rate</td>
<td>6.976**</td>
</tr>
<tr>
<td>Stock Returns</td>
<td>NYSE Trading Volume</td>
<td>0.667</td>
</tr>
</tbody>
</table>

*denotes significance at the 10 percent level; **denotes significance at the 5 percent level; ***denotes significance at the 1 percent level.

Table 6
Granger-Causality Tests
Fed Period, 1915-1925

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Excluded Variable</th>
<th>Wald Test Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Call Loan Rate</td>
<td>NYSE Trading Volume</td>
<td>0.965</td>
</tr>
<tr>
<td>Call Loan Rate</td>
<td>Stock Returns</td>
<td>5.672</td>
</tr>
<tr>
<td>NYSE Trading Volume</td>
<td>Call Loan Rate</td>
<td>7.525*</td>
</tr>
<tr>
<td>NYSE Trading Volume</td>
<td>Stock Returns</td>
<td>7.740*</td>
</tr>
<tr>
<td>Stock Returns</td>
<td>Call Loan Rate</td>
<td>4.862</td>
</tr>
<tr>
<td>Stock Returns</td>
<td>NYSE Trading Volume</td>
<td>2.858</td>
</tr>
</tbody>
</table>

*denotes significance at the 10 percent level; **denotes significance at the 5 percent level; ***denotes significance at the 1 percent level.
<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Excluded Variable</th>
<th>Wald Test Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Call Loan Rate</td>
<td>Total Trading Volume</td>
<td>0.219</td>
</tr>
<tr>
<td>Call Loan Rate</td>
<td>Stock Returns</td>
<td>4.356</td>
</tr>
<tr>
<td>Total Trading Volume</td>
<td>Call Loan Rate</td>
<td>6.568**</td>
</tr>
<tr>
<td>Total Trading Volume</td>
<td>Stock Returns</td>
<td>11.356***</td>
</tr>
<tr>
<td>Stock Returns</td>
<td>Call Loan Rate</td>
<td>9.634***</td>
</tr>
<tr>
<td>Stock Returns</td>
<td>Total Trading Volume</td>
<td>0.320</td>
</tr>
</tbody>
</table>

*denotes significance at the 10 percent level; **denotes significance at the 5 percent level; ***denotes significance at the 1 percent level.
Table 8
Properties of Liquidity Portfolios

This table reports properties of liquidity portfolios for high and low-priced stocks during the full sample period (1885-1925) as well as for the pre-Aldrich-Vreeland sub-period (prior to May 1908) and the post-Aldrich-Vreeland Subperiod (June 1908-December 1925). As in Acharya and Pedersen, the beta values obtained are multiplied by 100.

<table>
<thead>
<tr>
<th>Beta</th>
<th>HighPrice</th>
<th>LowPrice</th>
<th>HighVol</th>
<th>LowVol</th>
<th>Full</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-AV $\beta_1$</td>
<td>98.32</td>
<td>154.51</td>
<td>132.18</td>
<td>108.68</td>
<td>120.62</td>
</tr>
<tr>
<td>Pre-AV $\beta_1$</td>
<td>83.79</td>
<td>121.54</td>
<td>108.49</td>
<td>98.65</td>
<td>103.89</td>
</tr>
<tr>
<td>FullPeriod $\beta_1$</td>
<td>87.10</td>
<td>132.39</td>
<td>118.09</td>
<td>102.83</td>
<td>110.39</td>
</tr>
<tr>
<td>Post-AV $\beta_2$</td>
<td>0.08</td>
<td>0.09</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>Pre-AV $\beta_2$</td>
<td>0.01</td>
<td>0.16</td>
<td>0.05</td>
<td>0.14</td>
<td>0.09</td>
</tr>
<tr>
<td>Full Sample $\beta_2$</td>
<td>0.05</td>
<td>0.14</td>
<td>0.07</td>
<td>0.12</td>
<td>0.10</td>
</tr>
<tr>
<td>Post-AV $\beta_3$</td>
<td>-1.27</td>
<td>-2.98</td>
<td>-2.50</td>
<td>-1.38</td>
<td>-1.95</td>
</tr>
<tr>
<td>Pre-AV $\beta_3$</td>
<td>-1.35</td>
<td>-3.59</td>
<td>-2.44</td>
<td>-2.67</td>
<td>-2.55</td>
</tr>
<tr>
<td>FullPeriod $\beta_3$</td>
<td>-1.09</td>
<td>-3.44</td>
<td>-2.52</td>
<td>-2.09</td>
<td>-2.30</td>
</tr>
<tr>
<td>Post-AV $\beta_4$</td>
<td>-1.45</td>
<td>-1.58</td>
<td>-1.43</td>
<td>-1.57</td>
<td>-1.50</td>
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<tr>
<td>Pre-AV $\beta_4$</td>
<td>-0.46</td>
<td>-1.75</td>
<td>-0.55</td>
<td>-1.82</td>
<td>-1.15</td>
</tr>
<tr>
<td>Full Sample $\beta_4$</td>
<td>-1.01</td>
<td>-1.72</td>
<td>-0.94</td>
<td>-1.80</td>
<td>-1.37</td>
</tr>
<tr>
<td>Post-AV $\beta_2 \cdot \beta_3 \cdot \beta_4$</td>
<td>2.80</td>
<td>4.64</td>
<td>4.02</td>
<td>3.03</td>
<td>3.53</td>
</tr>
<tr>
<td>Pre-AV $\beta_2 \cdot \beta_3 \cdot \beta_4$</td>
<td>1.83</td>
<td>5.50</td>
<td>3.04</td>
<td>4.63</td>
<td>3.78</td>
</tr>
<tr>
<td>Full Sample $\beta_2 \cdot \beta_3 \cdot \beta_4$</td>
<td>2.15</td>
<td>5.30</td>
<td>3.53</td>
<td>4.01</td>
<td>3.77</td>
</tr>
</tbody>
</table>
Figure 1a. Call loan rate spikes are defined as periods when call loan rate is above 11.72% (2 sigma above mean) and the change in call loan rate MoM is greater than 3.65% (1 sigma). Graphs are based on full 1857-1925 sample

**Average Monthly GIP Returns around Call Loan Rate Spike Months**
Figure 1b. Call loan rate spikes are defined as periods when call loan rate is above 11.72% (2 sigma above mean) and the change in call loan rate MoM is greater than 3.65% (1 sigma). Graphs are based on full 1857-1925 sample.

Average Cumulative GIP Returns around Call Loan Rate Spike Months
Figure 1c. Call loan rate spikes are defined as periods when call loan rate is above 11.72% (2 sigma above mean) and the change in call loan rate MoM is greater than 3.65% (1 sigma). Graphs are based on full 1857-1925 sample.

**T-Stat of GIP Returns around Call Loan Rate Spike Months**
Figure 2. Cumulative Impulse Response to One-Standard Deviation Shock to the Call Loan Rate, September 1886-1925

Graphs by irfname, impulse variable, and response variable

Results2, callrate, NYSEVol

Results2, callrate, stock
Figure 3. Cumulative Impulse Response to a One-Standard Deviation Shock to NYSE Trading Volume, September 1886-1925
Figure 4. Cumulative Impulse Response to a One-Standard Deviation Shock to Stock Returns, September 1886-1925

Graphs by irfname, impulse variable, and response variable
Figure 5. Cumulative Impulse Response to One-Standard Deviation Shock to the Call Loan Rate, 1915-1925

Graphs by irfname, impulse variable, and response variable
Figure 6. Cumulative Impulse Response to a One-Standard Deviation Shock to NYSE Trading Volume, 1915-1925

Graphs by irfname, impulse variable, and response variable
Figure 7. Cumulative Impulse Response to a One-Standard Deviation Shock to Stock Returns, 1915-1925

Graphs by irfname, impulse variable, and response variable

- 95% CI
- cumulative orthogonalized irf