Rethinking the Lender of Last Resort: New Evidence on the Stabilization of Money Markets Before the Federal Reserve

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Abstract

Short-term funding markets play a critical role in financial stability. Liquidity shocks regularly disrupted money markets historically, causing interest rate volatility and strong seasonality; a problem commonly thought solved by the creation of the Federal Reserve System in 1913-4. In contrast, this paper demonstrates that interest rates stabilized six years earlier, following large-scale imports of gold from France to quell the Panic of 1907 and the subsequent creation of a national lender of last resort mechanism under the Aldrich-Vreeland Act in 1908. The founding of the Fed generated little additional impact on funding market rates or short-term credit spreads. Moreover, the Fed failed to attract banks into its nascent discount market, while they could earn higher returns funding the rapidly expanding stock market between World War I and the 1929 crash.

JEL classification: E4, E5, G01, G1, N1, N2

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Liquidity freezes, such as those at the start of the 2020 COVID-19 pandemic, the 2008 Global financial crisis, and the collapse of Long Term Capital Management in 1998, set off asset fire sales, precipitous declines in stock prices, and spikes in short-term interest rates. If not forestalled, these financial crises wreak havoc on the broader economy. In the post-World War II era, the Federal Reserve has repeatedly stepped in to directly provide or arrange liquidity backstops to mitigate such crises. As a result, interest rates in the US now remain relatively stable, and, even in the midst of the 2008 liquidity freeze, short term rates rose only slightly.[1] In contrast, throughout the 19th and early 20th centuries, short-term interest rates fluctuated tremendously and spiked dramatically during the frequent episodes of market illiquidity. The so-called 'inelasticity' of the currency in the pre-Fed era exacerbated financial crises that often led to real economic recessions. A long strand of research into the impact of the Federal Reserve on money markets (summarized in Table 1) argues that its establishment shifted expectations about the availability of a liquidity backstop, significantly reducing interest rate volatility and seasonality, thus mitigating the risk of financial crises.

Despite the general consensus, some have questioned how immediate and effective the Fed's impact was. Griffiss (1923) provided one of the earliest analyses of the nascent Federal Reserve System and argued that banks converted only gradually and reluctantly to the Fed-sponsored discount market. This gradual adoption, in and of itself, suggests that this element of the monetary policy regime change had little immediate impact on money markets. Friedman and Schwartz (1963 (2008)) also questioned the efficacy of the early Fed and suggested that the precursor Aldrich-Vreeland Emergency Currency Act of 1908 had accomplished more effectively the monetary stabilization function of a LOLR[2]

Miron (1986) and Mankiw et al (1987) revived the issue of a monetary regime change and started a strand of quantitative literature on structural breaks in short-term interest rates. Miron (1986) argued that the Fed's seasonal open market operations eliminated the seasonality of nominal interest rates and thereby decreased the frequency of panics. Mankiw et al (1987) further examined the regime change embodied in the founding of the Fed and the speed of adjustment to the new regime. They found that the seasonality of 3-month rates declined in the 1920-33 period compared to the 1890-1910 period, and that rates followed nearly a random walk in that later period. They demonstrated further that the term structure of interest rates changed with the new monetary regime: long (6 month) rates became more responsive to short (3 month) rates after 1920. Subsequent analysis by Fisher and Wohar (1990) and Angelini (1994) called these results into question, and the latter

[1] See Gorton and Metrick (2012) on the run on repo during the 2008 crisis.

[2] See also Jacobson and Tallman (2019) on the Fed's behavior during World War I.

in particular raised the issue of the 1908 Aldrich-Vreeland act and its impact on expectations. Angelini (1994) identified May 1908 as a likely structural break in short-term interest rates, while Caporale and McKiernan (1998) found that both Aldrich-Vreeland and the founding of the Fed turn up as turning points. Caporale (2015), in contrast, found breaks in November of 1907 (following the October panic) and in September 1917 (World War I).

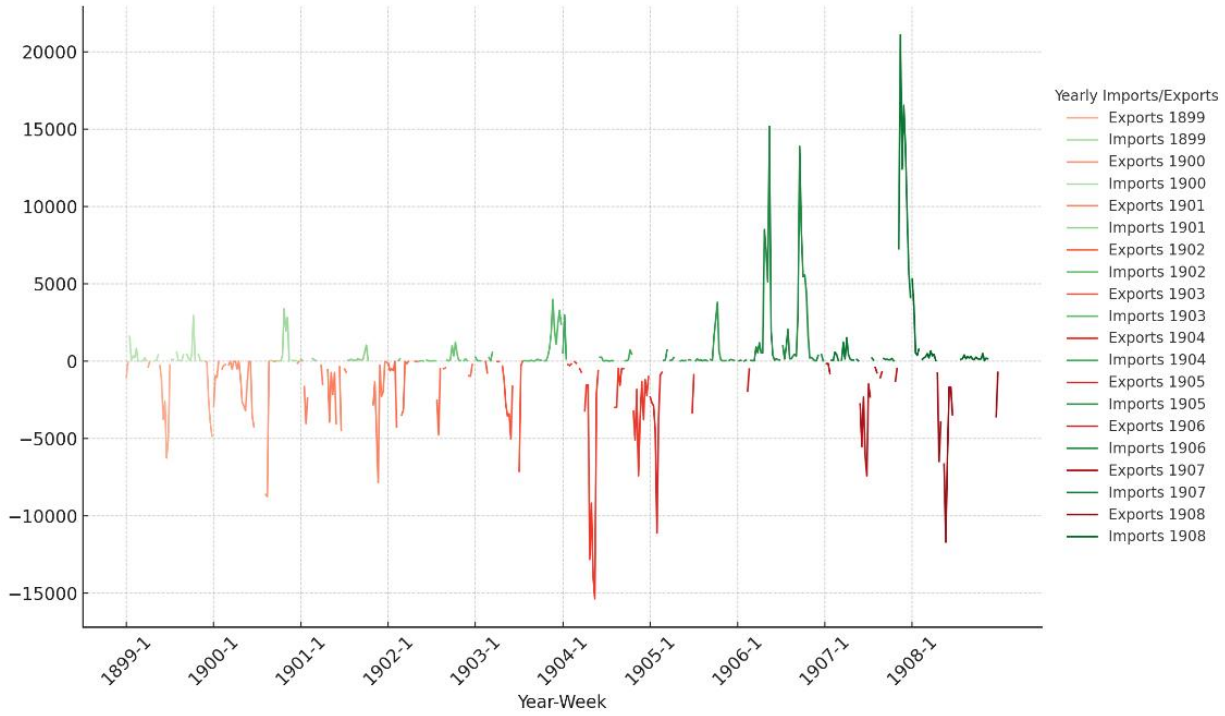
Past research suffers from a major shortcoming: the underlying data. All of the studies rely on old series of monthly average interest rates, and most studies use longer maturity loans, such as 30 day commercial paper. These data create two major problems for establishing the timing, significance, and causes of interest rate regime changes in the period prior to the Great Depression. First, the monthly data averages over the daily rates and therefore smooths over daily, intra-daily, and cross-sectional (collateral quality) rate variability. More important from a substantive perspective, banks did not use these longer-maturity loans as their preferred short-term instrument prior to the 1930's. Before they were chastened by the 1929 crash, banks around the country poured assets into loans to brokers, collateralized by corporate securities and intermediated in the NYSE's overnight funding market. This "call money" (alternatively "call loans") constituted the most important short-term money market instrument at the time of the creation of the Fed. This funding market was akin to today's repo market.

Thus, in this study, I correct past data problems by hand collecting from daily newspaper reports a new series of high, low, and "ruling" call loan interest rates, spanning from 1900 through 1933. Using these detailed *daily* data, I then analyze the time series behavior of interest rate levels, high-low spreads, volatility, and seasonality to determine the most likely timing of structural breaks and to identify shifts in seasonality patterns. This new data tells a different story: Call loan rates and high-low spreads dropped and stabilized in mid-January 1908, just three months after the Panic of 1907. The break appears several months before the Aldrich-Vreeland Emergency Currency Act passed and took effect in May of 1908. The initial rate decline more likely resulted from the concerted effort on the part of the US Treasury and money center banks (and the New York Clearing House) to increase liquidity in the system, bolstered by the critical gold infusion by the Bank of France starting in November of 1907.[3] Sustained net gold inflows accumulated over the last several weeks of 1907 through January 1908, at which point the usual lessening of seasonal demand for cash eased the credit crunch. Even after gold flows returned to normal in early 1908, however, call money rates remained persistently low and more stable. Thus, the results support the view

[3]Rodgers and Payne (2014) show, based on an event study, that the release of US gold eagles by the Bank of France bolstered stock prices, as measured by the Dow index. See also Gorton and Tallman (2018) and Eloriaga and Fohlin (2024) on the impact of gold. See Fohlin and Lu (2021) on the crash and recovery of trust company stocks, which were severely impacted by the run on liquidity during the 1907 panic.

that the new Aldrich-Vreeland lender of last resort mechanism helped stabilize the funding market longer term.

Figure 1: Net Gold Imports and Exports in New York City (weekly, 1899-1909)



Source: Gold net import and export data come from *The Commercial and Financial Chronicle*, as reported in Kemmerer (1910).

The study also reveals new insights into the seasonal patterns in funding market rates. Before the Aldrich-Vreeland Act, interest rates generally spiked not only during the autumn harvest, but even more so in December. That seasonality nearly disappeared after January 1908 and declined slightly further after the opening of the Fed in 1914. Moreover, I document that despite the existence of the Fed, call money rates returned to a cyclical (but not seasonal) pattern during both the post-WWI mini-bubble (1919-21) and the more dramatic bubble of the late 1920s. Nonetheless, call money interest rate volatility never returned to its pre-1908 highs and no longer experienced the enormous spikes seen during the Panic of 1907.

Analysis of call money volumes and interest rate spreads further demonstrates that even after the establishment of the Federal Reserve System in 1914, and its attempt to replace the call money market with a discount market that it could control, the call money market remained active and attracted high volumes of out-of-town funds until the stock market crash of 1929. Likewise, call money carried a (risk) premium over the Fed discount rates until the crash.

1 The Overnight Funding Market and Monetary Policy Regimes

Short-term funding plays a crucial role in providing liquidity to financial markets. Similar to modern-day repurchase agreements (repo), overnight call loans to brokers based on security collateral, facilitated the required daily clearing and settlement operations of the New York Stock Exchange throughout the nineteenth and early twentieth centuries. Until 1920, the NYSE lacked a full-fledged daytime clearinghouse, thus creating enormous broker demand for overnight call loan funding. Brokers also used call loans to finance stock purchases on margin. Lenders could call in these loans on short notice, but during normal times, most brokers could renew their call loans for weeks or even months. If a lender called his loan, a trader would usually need to seek out a new loan to pay off the previous loan in order to avoid liquidating securities. This process compounded the need for liquidity in the funding market.[4]

Because it offered appealing short-term returns, the New York call money market became the key market for the short-term investment of excess bank reserves. the call money market attracted funds from banks throughout the country-not just in New York City. Much of the funding in the call money market flowed from banks in agricultural regions of the country that experienced seasonal variations in liquidity demands revolving around their particular planting and harvesting cycles. These so-called 'country banks' funneled resources into the New York call money market via their correspondent banks in the city. Seasonal variation in agricultural financing demand induced push and pull cycles in the volume of funding supply from the interior to the New York call money market. When farmers needed cash during peak planting and harvesting seasons, their local country banks retrieved their funds from New York; when agricultural needs ebbed, country bank capital flowed bank into New York. Interest rates on stock exchange call loans therefore followed a similar seasonal pattern during the 19^{th} and early 20^{th} centuries.

Additionally, the volume of funding supply to the call money market was partly unpredictable because, even if planting and harvesting took place during roughly the same months each year, the exact timing and magnitude of agricultural financing demands varied from one year to the next. Moreover, with no official liquidity backstop for financial institutions, especially the New York call money market became particularly susceptible to sudden increases in demand for funds (runs) and to extreme rate spikes. This was particularly true during seasons of greatest agricultural demand for funding.

Sudden jumps in funding rates can precipitate downward spirals in asset prices because

[4]See Pratt (1903) and Griffiss (1923) for an in-depth description of the call money market.

lenders require traders to meet margin calls when asset prices decline. When money is scarce, traders have to sell assets to cover these margin calls. Asset sales drive prices down further, which trigger additional margin calls. Periodic unpredictable spikes in short-term interest rates cause uncertainty in financial markets and susceptibility to crises. Contemporary observers and economic historians have pointed to this seasonality and the unpredictable rate spikes that characterized the market as evidence of illiquidity in the money market and as drivers or amplifiers of financial panics in the latter 19th and early 20th centuries. As Moen and Tallman (2019) note, citing Sprague (1910):

"Among the many lessons which may be drawn from a study of the experiences of the national banks during crises, the entire absence of liquidness in call loans, so far as New York banks are concerned, is the most certain and by no means the least important."

The NYSE adapted and updated the call money market's structure and operations significantly over the early 20th century, especially during and shortly after World War I, and market participants naturally adjusted their behavior in response.

1.1 The Changing Structure of the Call Money Market

In the pre-World War I era, NYSE stock brokers usually executed trades on 10 percent margin from their customers and paid in full on delivery of the securities. To finance these trades, the stock broker would extend credit to his customer using 10 percent from his own capital and borrow the remaining 80 percent via the call money market.[5] While some financial institutions did lend directly to certain stock brokers, most call loans originated in the call money market housed in the New York Stock Exchange. While commercial banks and trust companies (collectively "banks" in the following) provided much of the supply of call money in the New York money market, certain railroad and insurance companies also lent on stock collateral during this period. As a rule, bankers relayed their available fund volume to a money broker on the exchange each morning. Meanwhile, stock brokers would adjust their demand for funds throughout the day as trading progressed.

This money market operated much like a commodity market, with a "money crowd" shouting out buy and sell orders around a physical trading post on the exchange floor. These brokers then negotiated among themselves over quantity and price on behalf of borrowing dealers and lending financial institutions. Lending rates depended on the quality of the collateral, with lower rates applied to what was at that time considered the safer collateral–railroad securities. As a result of this market design, lenders typically could not choose their own borrowers, meaning they had no opportunity to vet the risk of their counterparties.

[5] Pratt (1903)

Moreover, since only members could transact on the floor of the exchange, non-members had to trade through a member in order to access the call money market. A significant proportion of funds came from trust companies–institutions that were not regulated like the national banks and could not participate in the New York Clearing House Association (which offered some lender of last resort services to national banks in the city).[6] Thus, the funding of the call money market carried significant risk, and the system depended on the quality of the collateral securities and on trust in the NYSE's vetting of members.

While lenders could call in loans with essentially a few hours' notice, much of the call money lending rolled over from one day to the next. Ongoing loans paid the 'renewal' rate, which the money brokers typically set at the approximate average of rates negotiated on the first few million dollars in new loans each day (Griffiss, 1923). Since brokers negotiated loans individually, they did not always follow the ruling rate, and terms varied with some arbitrariness. Once brokers agreed on loan terms, the borrower would send the collateral and margin to the lender, whereupon the lender would approve the collateral and send the borrower a certified check in the amount of the loan.

This market structure introduced a major market friction: clearing the call loan market. Before the stock broker could obtain the securities to use as collateral for his call loan, he needed to provide funds to the securities seller. Moreover, when a lender called a stock broker's loan, but that broker still needed the funds, he had to borrow from another lender in order to pay back the first lender. The first bank would not return the borrower's collateral until he paid off the loan. Without his collateral, however, the borrower could not get a call loan from the new bank. This problem created the need for intra-day loans, also known as "daylight loans," in order to clear the call money market.

The intraday funding market operated via uncollateralized lending, also known as "overcertification," directly between stock brokers and their banks.[7] Overcertification literally meant that a bank would provide a stock broker with a certified check in an amount exceeding any funds or security available for backing the check. To ensure this overcertification privilege, a stock broker maintained an ongoing relationship with the bank and would keep a minimum cash balance in his account. A typical agreement allowed stock brokers to obtain certified checks at 20 times his account minimum (Pratt, 1903).

Because of the fundamentally bilateral nature of all of these transactions, day loans absorbed considerable sums of bank liquidity and theoretically posed significant risk to bank solvency–again, hinging critically on the quality of collateral and trustworthiness of the stock

[6]See Gorton and Tallman (2018) for in-depth discussion of the NYCH practices, particularly in response to panics.

[7]Pratt (1903) and McSherry and Wilson (2013)

broker. Notably, federal banking regulation outlawed overcertification for national banks, yet the practice continued widespread with little enforcement by the US Comptroller of the Currency. McSherry and Wilson (2013) cite an 1882 study by the Comptroller of the Currency that found that average daily overcertification amounted to more than 105 percent of bank capital for the New York City national banks and over 300 percent of capital for the nine "broker banks" they tested.

According to McSherry and Wilson (2013), in 1879, the Comptroller of the Currency threatened to prosecute banks that practiced overcertificaiton, but the regulator still permitted the New York City Bank Clearing House Association (NYCHA) to allow overcertification because of the role it played in the NYSE's overnight securities clearing process. The bank clearinghouse maintained the ability to suspend overcertification, which they did on occasion (such as the Panic of 1873) when they were concerned with the high risk. The NYCHA negotiated with NYSE officials to reduce risk and eventually prompted the creation of a stock clearinghouse at the NYSE in 1892. The NYSE clearing house finally allowed multilateral net settlement of securities transactions, however, it did not guarantee settlement of its brokers' trades. While this risk remained, the netting of trades significantly diminished the volume of daytime certification needed (McSherry and Wilson, 2013).

Despite all the apparent risk, according to Pratt (1903), no banks failed due to overcertification in the 1880s or 1890s, and only one bank–the Seventh National Bank–failed in 1901 because of its overcertification activity. Still, national banks moved away from overcertification after the founding of the NYSE clearinghouse. In a 1901 article on the topic, the *United States Investor* noted "Many of the strong national banks in the financial district no longer desire brokers' accounts, and refuse absolutely to overcertify their checks. In fact, since the establishment of the clearing house of the New York Stock Exchange, it is really now not necessary for brokers to require overcertifications." However, the *US Investor* (1901) article continues, "Some of the banks, however, still practice this dangerous policy and it is not at all an uncommon thing for them to many times overcertify the amount of their capital stock and surplus." As some banks became more conservative by requiring stock brokers to present some collateral, brokers began to leave these banks and move to less conservative banks and the unregulated trust companies. Thus, by the early years of the 20$^{\text{th}}$ century, the call money market depended increasingly on funding supply from riskier, thereby less dependable, sources. Despite such risks, and despite the dramatic losses during the Panic of 1907, the call money market operated in this manner until World War I.[8]

[8]Tallman and Moen (2012) find that call loans comprised 30 percent of the Big Six New York City banks' loan portfolios at the time of the Panic of 1907. These banks were the most likely to borrow clearinghouse loan certificates, and the volume of those loan certificates exceeded the contraction in banker balances. Moen and Tallman (2019) find that, leading up to the panic, interior ("country") banks and trust companies were

The outbreak of World War I forced sudden changes on the stock exchanges and therefore on its closely entwined call money market. First, the call loan market-and its rates-froze in place when the NYSE closed on July 31, 1914. It remained in limbo for the four and a half months of the NYSE closure, until the reopening of the exchange in mid-December of 1914. Once the market reopened, so did the call money market, and operations returned essentially to normal until the US entered the war in April 1917.

As the war progressed, and as funding demands for war provisions strained financial capacity, NYSE leaders and monetary authorities remained vigilant about inciting a panic due to lack of funds in the call money market and simultaneously worried about attracting money away from the Liberty Loan market. To keep order, the exchange established a money committee, a sub-committee of the capital committee, which worked to keep control of the market and dampen major swings in rates. Chaired by Benjamin Strong, Governor of the NY Federal Reserve Bank, the money committee operated from September 5, 1917 to January 10, 1919. The committee created a pool of funds to insure liquidity in the call loan market and prevent rate spikes. The pool, originally contributed by members of the committee, started with $100 million and quickly added another $100 million.

Liberty Loan issues first passed on April 24$^{\text{th}}$, 1917, with a tax-deductible rate of 3.5%. Despite the relatively low interest rate, their issue attracted funds from the money market, constraining funds available for call money and restricting that market's liquidity (Griffiss, 1923). The loan account of the exchange ran between $400-450 million, and the committee then apportioned this amount among all NYC banks using the money market (about 65 banks). Participation was essentially compulsory. The committee also regulated the demand side, capping the amount of funds each stock exchange firm could borrow.

According to contemporary observers (Griffiss, 1923), attitudes began to change around August of 1918. Borrowers wanted to borrow more, and lenders became more interested in lending, creating an overall sense of greater speculation. The changing tone caused the money committee to reverse course from encouraging lending to restraining it. The committee instituted a requirement for (strictly confidential) daily reports from exchange members on the volume of loans. The committee increased required margins on loans from 20/25 to 30/37.5 on mixed v. industrial collateral and encouraged shorter maturity on time loans-two to four months instead of four to six months.[9]

placing funds on call directly, bypassing the New York City national banks and the NYCHA. This practice hindered the efficacy of the NYCHA, and combined with over-certifying checks, amplified the loss of market liquidity when the panic struck.

[9]Mixed collateral involved a substantial proportion of railroad stocks in addition to industrial shares. Since rails were safer investments, lenders required a lower margin on those securities compared to industrial shares.

In September of 1918, Benjamin Strong wrote to the NYSE president, Henry Noble and essentially imposed a freeze on the level of funds allowed into the call money market: "It is obvious, however, that for the present there should be devoted to the security market no additional credit beyond the funds now used. Any tendency to expand the collateral loan account should, for the general good, under the present conditions, be checked."[10] Strong goes on, in that letter, to request daily reports from each exchange member on its use of call money, invoking patriotic duty and the need to prevent interference with financing the war:

> *"Lest any possible misunderstanding arise as to the object of this request, I am directed by the committee to explain that this is only one of a number of measures being undertaken by the committee with the object of exercising, by mutual understanding among the institutions and firms of this city, such reasonable and necessary control of the employment of credit as will insure no interference with the financial operations of the Government in conducting the war."*[11]

When the war ended, the federal government eventually released capital controls and disbanded the Money Committee, and the NYSE returned to free market operations for securities as well as for call money. But traders in the call money market opted to retain the wartime money desk, as they discovered the value of the much more orderly process it created. The continual improvement in information on supply and demand for funds, along with increasing speed and availability of clearing for securities and for loans, made the market much less fragmented after the war than before. For example, in the prewar system of bilateral negotiation of the daily renewal rate, nobody saw the complete picture of supply and demand in the money market. After the war, the money desk continued to keep track of the volume of funds and the rates contracted, thus improving information transparency.

As the increasing volume of transactions taxed the system, involving large amounts of inefficient overcertification, the NYSE opened the Stock Clearing Corporation on April 26, 1920 and finally began daytime settlement through the "Day Branch." Daytime clearing practically eliminated the need for the unsecured day loans–overcertification–that they had employed under the previous system of collateral transfers. Soon thereafter, in 1921, the Stock Clearing Corporation began clearing loans directly through the Day Branch.[12] A lender would send a check in the name of the clearinghouse for the account of the borrower and would secure collateral through the clearinghouse. On the other side, the borrower (or his previous lender) would deposit collateral with the clearing house. This process obviated the third party certification of checks.

The system operated in this manner until the Great Depression. The 1929 crash and ensuing financial crisis brought about a major rethinking of the country's financial structure

[10]Quoted in Griffiss (1923), p. 31.
[11]Quoted in Griffiss (1923), p. 33.
[12]See Meeker (1922).

and regulation and ushered in the modern regulatory era for financial markets and corporate securities. The 1933-34 creation of the Securities and Exchange Commission and related regulations set up led to a virtual end to volatility and seasonality in the money market, and the use of call money declined.

1.2 Monetary Policy Regimes 1900-1933

The US monetary system also underwent dramatic change during the 30 years before the Great Depression, particularly in the time between the Panic of 1907 and the start of World War I. While we think of the founding of the Federal Reserve System in 1914 as the start of true central banking in the United States, the process began many years earlier, as Congress grappled with the problem of financial panics that cropped up repeatedly under the National Banking System. That system, founded with congressional acts in 1863 and 1864, created a system of nationally-chartered and regulated banks and bank notes but lacked any central bank to establish monetary policy or provide lender of last resort facilities. While that system continued until the founding of the Fed, the passage of the Aldrich-Vreeland Act in 1908, and its establishment of an emergency currency issuance system, created a novel monetary policy regime, under which the federal government effectively instituted a lender of last resort (LOLR), even without a central bank or associated interest rate setting mechanism.[13] Thus, for the current study, I delineate three distinct monetary policy regimes: 1. The National Banking era (1900 - May 1908), 2. The Aldrich-Vreeland era (June 1908 - November 1914), and 3. The Federal Reserve era (November 1914 onward).

The Panic of 1907 underscored in stark terms the severe vulnerability of the financial markets to a freeze in money markets and finally pushed Congress into legislative action on the problem, which had been widely known and discussed for many years.[14] Just three weeks after the October crisis, Congress was making concrete plans to introduce a new currency bill, and by early December, they were hammering out details and meeting with bankers in New York. Barely two months after the crisis, on January 7, 1908, Sen. Nelson Aldrich presented a bill to establish a lender of last resort facility, and it passed out of the Senate finance committee on January 30th. After rounds of adjustments and amendments, including a joint-conference committee, Congress passed the Aldrich-Vreeland Act on May 30, 1908, creating the National Monetary Commission and establishing the first nationwide liquidity backstop system for banks.

The law-described by contemporary J. Laurence Laughlin as "a curious compound of

[13]The appendix provides a timeline of monetary and financial events and regime changes.

[14]See Fohlin and Gehrig (2023) on the impact of the liquidity freeze on stocks on the NYSE during the Panic of 1907 and Fohlin and Lu (2021) on contagion among the trust companies during the same episode.

conflicting views, compromise, haste, and politics"-provided for a stock of extra currency available in cases of emergency, backed by deposits of railway bonds and certain approved commercial paper and other bank assets.[15] The system called for the creation of currency associations, led by at least 10 national banks in a given locale. In the law's first six years (its original lifespan ended July 1, 1914), only 21 associations, representing 352 national banks ($381 million in capital), appeared, and none of them had requested funds (Goodhue, 1916, p. 1039, and Secretary of the Treasury, 1915, p. 126).

Whether the mere existence of the backstop precluded its need under typical cyclical conditions is difficult to assess, because demand conditions also changed as the market downturn and post-panic recession chastened speculators for some time. The incipient crisis at the onset of the war in late July of 1914 did finally prompt the use of the renewed version of the law that accompanied the Federal Reserve Act of 1913. Treasury Secretary McAdoo and Comptroller Williams pushed banks to form currency associations and take on emergency currency, such that 24 new associations formed, representing over 2,000 national banks-1,363 of which accepted emergency currency of approximately $300 million (Goodhue, 1916 and Secretary of the Treasury, 1915). Since the stock market, and by association the call money market, closed before the emergency currency implementation, we cannot assess the impact of emergency currency usage on the call money market. Within two weeks of the markets' reopening on December 12, 1914, banks had redeemed over 2/3 of the emergency currency outstanding. Six months later, they had redeemed all but $200,000 of the remainder (Goodhue, 1916, p. 1039).[16]

Meanwhile, Congress passed the Federal Reserve Act on December 23, 1913, and the Federal Reserve banks opened for business on November 16, 1914, in the midst of the stock exchange closure and while the Aldrich-Vreeland currency provisions remained in force. This overlap complicates the identification of the impact of the founding of the full-fledged central bank, as opposed to the simpler LOLR facility embodied in Aldrich-Vreeland. After the Federal Reserve System transitioned into full operation, the early war boom had taken hold, and the call money and stock market went into full swing. For a time, no need appeared for a liquidity intervention.

Still, the founding of the Fed involved new regulations on member banks, such as limitations on the lending by country banks with correspondents in New York. Balances kept in New York banks could not count as reserves, and simultaneously, the Fed began to develop a discount market to provide substitute investments for the country banks. Nonetheless, according to contemporary accounts (Griffiss, 1923) country banks continued to lend in the

[15] Laughlin (1908), p. 490.

[16] See also Jacobson and Tallman (2015)

New York call money market, because of the extreme ease with which bankers could add and subtract funds with just a telegraph notice. In addition, the rates on call money often exceeded those in the acceptance market, such that in many circumstances, banks preferred to keep excess reserves there.[17] Interestingly, Griffiss highlights the impersonal nature of the New York call money market as a feature that attracted country banks into lending there. In their local acceptance markets, bankers could suffer from the ill will of a borrower in the event that the banker needed to retrieve his funds. In New York, all parties understood the arms-length process, and country banks avoided the need to preserve relationships with borrowers there. Furthermore, Griffiss hypothesizes that the Federal Reserve System's division of the country into twelve districts hampered the development of a national discount market:

> *Attempts are being made to bring the country bankers to the point of investing in the bill market by means of educating them as to what the market is and what place it holds in the economic organization of the country. Whether or not these attempts will be rewarded with any marked success remains to be seen; but it is undoubtedly a hard task to turn the country bankers away from a type of investment, which they consider so liquid and safe as the call loan. It is the easier and lazier way to invest liquid funds. Some of the country banks are not even members of the Federal Reserve System and some of the bankers do not know what the acceptance market is.*

Thus, nearly 10 years after the founding of the Fed, call money still remained the focus of country bank investments of secondary reserves.

2 Data

In evaluating the impact of monetary policy regime changes, the principal variable of interest is some measure of interest rates, particularly short-term rates on money market instruments. For this study, I analyze patterns in the rate on call loans. Most previous time series analyses have focused on 30-day or 6-month loan rates; however, as the background section explored in detail, in the period prior to the 1930s regulation, especially before the development of a liquid national discount market, call loans represented the key investment vehicle for short-term funds. Moreover, these loans facilitated trading in stocks and bonds and therefore provide the critical link between funding markets and stock markets. The 30-day and 6-month rates may behave somewhat differently from call money, whose rates were more variable than longer rates for most of the period of the studies.

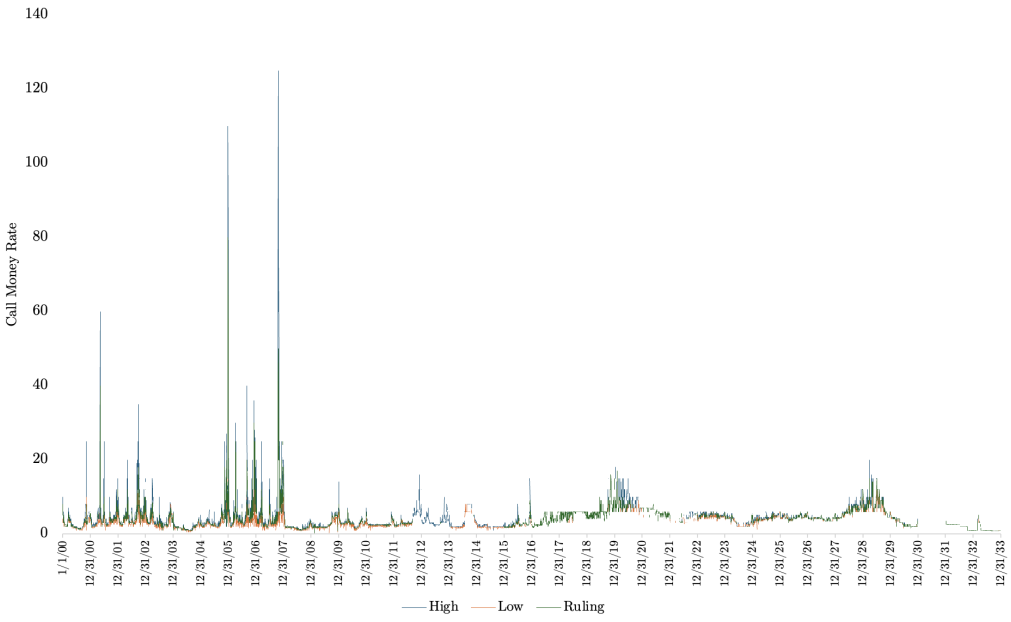
The more significant difference in my data lies in the high frequency. Existing data from the NBER (McCauley) are monthly averages. Monthly frequency interest rates, as well as averaging of rates within each month, prevents identifying or quantifying brief rate

[17] For analysis of credit spreads, see Fohlin (2022).

spikes or accurately measuring volatility, particularly over the short intervals of financial panics-sometimes lasting only a day or two. Yet these brief rate spikes often cause serious disruptions to financial market and bank operations and can escalate into insolvency events and trigger runs.

For the period between 1900 and 1922, the data come from the daily money market report published in the *New York Tribune* (accessed via the Library of Congress historical newspaper website "Chronicling America"). Data from 1923 through 1933 come from the daily money market report published in the *Wall Street Journal*, via Proquest.[18] The reports vary over time in the variety of rates they report-sometimes including opening and closing quotes-however, most of the daily reports include high, low, and ruling rates. While the newspapers do not define "ruling" rate, the term indicates the rate that applied to most loans originated in the first hours of the market on the given day, as discussed in the background section in this paper. The analysis here focuses on the most complete series: high, low, and ruling rates (Figure 2).

Figure 2: Call Money Rates, Daily 1900-1933



Source: Data was manually collected from The New York Tribune (1900-22), via Library of Congress, and The Wall Street Journal (1923-33), via Proquest. See discussion in text.

Some simple descriptive statistics elucidate the pattern of call money rates over the three monetary policy regimes: The National Banking era, Aldrich-Vreeland era, and the Federal

[18]Thanks to Emory students Aziz Aldakhel, Shirley Ren, Wenjing Yang, Lifan Zhang, and Sichen Zhu, who searched methodically through each days' paper and entered the rates.

Reserve era (Table 2a). In addition, I separately analyze the period of the market closure in the first four and a half months of World War I (August-mid-December 1914) as well as the period in which the NYSE Money Committee controlled the call money market. The average rate during the National Banking Era significantly exceeded that in the subsequent periods, especially the relatively quiet Aldrich-Vreeland period between the Panic of 1907 and the start of WWI. The difference is most dramatic and significant for the daily high rates but applies to the low and ruling rate as well. The difference in low and ruling rates comes primarily from the particularly low rates and lack of financial panics or other disturbances during the Aldrich-Vreeland era. A comparison of variances underscores the differences among the monetary policy regimes: variances on the high and ruling rates fell dramatically with the creation of the first liquidity backstop and stayed low after the founding of the Fed. The high rate never surpassed 25 percent and the ruling rate peaked at 17 percent in the post-NBA period.

One final measure gives further insight into the intra-day variation of the money market: the high-low rate spread (bottom panel of Table 2a). That spread averaged over two percentage points during the National Banking Era, but it averaged 52 basis points in the Aldrich-Vreeland period and only 31 basis points after the creation of the Fed. Interestingly, the spread widened during the closure of the market at the start of WWI and during the Money Committee period, when the money market was under regulation to maintain market order.

Figure 2 clearly shows that interest rates dropped abruptly in January 1908 and remained low and much more stable for much of the subsequent 6-7 years before the Fed opened for business. Only late in July of 1914 did call money rates creep higher, and even then, they only rose to 4-5 percent just before the closure of the exchange on July 31st, 1914. At that point, rates rose to 6 percent and then froze at 6-8 percent for the duration of the shutdown of financial markets that lasted from August 1st to December 12th, 1914. During the closure, call loans remained in limbo, but as soon as the market reopened, rates declined again for another extended stretch.

3 Estimated Structural Breaks in Call Money Rates

Basic statistical tests demonstrate that the level and variance of call money rates are significantly lower between January 1908 and December 1915 than they are from January 1900 through December 1907. Call money rates are not significantly lower nor less volatile after the opening of the Fed in November 1914. Structural break tests provide some additional statistical support for this observation.

3.1 Structural Break Test

The Bai-Perron (2003) test is commonly used for the evaluation of structural shifts, potentially multiple, in linear models. The test evaluates the equality of the constant across the periods. Because the number of breaks (k) is unknown, the Bai-Perron test uses the double maximum test, testing l globally optimized breaks against the null of no structural breaks. The supF type test of no structural break versus k breaks is defined by

$$F(\hat{\delta}) = \frac{1}{T}\frac{T-(k+1)q-p}{kq}(R\hat{\delta})'(R\hat{V}(\hat{\delta})R')^{-1}(R\hat{\delta}),$$

where $\hat{\delta}$ is the optimal l-break number evaluated, R is a matrix such that

$$(R\hat{\delta})' = \hat{\delta}_0' - \hat{\delta}_1' - \cdots - \hat{\delta}_{k+1}',$$

and $\hat{V}(\hat{\delta})$ is the estimated variance covariance matrix of $\hat{\delta}$, which is robust to serial correlation and heteroskedasticity.

The Bai-Perron test results indicate several statistically significant structural breaks in call money rates, most important of which is the break in the high rate in mid-January of 1908 (Table 3), which corresponds with the most obvious break from visual inspection of the graph. The low and ruling rate also broke significantly in mid-January of 1908. Other breakpoints appear for all three rates but with varying significance. The single break point in the low rate in April 1918 is statistically significant, while that for the ruling rate at the very end of August 1917 is not. World War I also turns up as a break point for the high rate, but the turning point comes much earlier in the war, November 1916, before the US entered.

The 1920 recession that resulted from the Fed's rapid post-WWI monetary tightening corresponds to a short-term increase in call money rates, but the test only picks up a break in the ruling rate in March of 1922. The low rate only shows a break as the stock market began its final run up in the end of 1928.

Financial firms also have to manage the volatility surrounding their short term borrowing costs. The graphical evidence and basic means and variance tests already indicate that the volatility of the high rate dropped after 1908. I next search for structural breaks in the volatility of the call money rate, using the high-low rate spread, which serves as a proxy for intra-day rate volatility. That spread could also measure a risk premium on collateral, to the extent that the reported rates combine all deals on a given day, and the package of securities pledged as collateral could vary considerably. Once again, the single most important structural break in volatility appears in January 1908 (Table 3). With two breaks

allowed, the Bai-Perron test turns up breaks in June 1904 (marking the start of climbing interest rates) along with January 1908, while adding a third break keeps those two breaks and adds October 1923. Once again, no breaks appear at the founding of the Fed or even during World War I.

Even allowing for four or five breaks turns up no structural break in volatility or the high call money rate surrounding the opening of the Federal Reserve System. More important were the return to greater volatility in 1913-following a lengthy post-1907 lull-and the rising volatility due to the expansion of the market bubble in summer of 1928. In other words, the opening of the Federal Reserve System in itself had no immediate impact on the volatility of the call money market, and even its actions during the war show little direct effect.

3.2 Robustness Checks

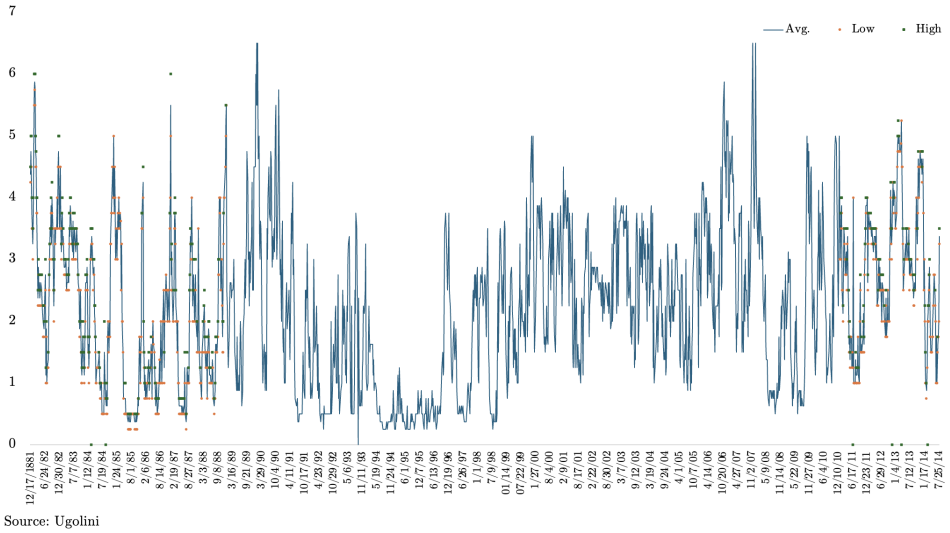
In order to check the robustness of the results, I re-run the structural break tests using alternative periods and data sets. First, I exclude the data for the period of the Money Committee (September 5, 1917 to January 10, 1919). I find even stronger evidence of breaks in January 1908 and still no breaks around the founding of the Fed.[19]

Next, in order to zero in on the founding of the Federal Reserve specifically and eliminate the effects of the enactment of Aldrich-Vreeland and the effects of the WWI money committee, I run the same tests on the period from the start of Aldrich-Vreeland to the start of the Money Committee (Feb. 1908-Sept 1917). Using this heavily constrained period produces an apparent break for high and low rates in September and August 1909, respectively (Table 4). Other breaks appear in 1910, 1911, and 1914, but none emerges around the passage of the Federal Reserve Act of 1913 or coinciding with the opening of the Federal Reserve banks in November or December of the following year.

Finally, because of integration between the London and New York markets in the pre-war period, one might wonder whether the breaks found in the US data relate to factors beyond national borders. While the timing of the break at 1908 is consistent with the introduction of the Aldrich-Vreeland plan in the US, it is possible that a break in the London market might have played a role. While daily data are not available, Stefano Ugolini has collected weekly call money rates for 1881-1914 (Figure 3). Break tests for these London data indicate the presence of no statistically significant structural break in the London call money rate up to 1914, which is the end of the available data series (Table 5).

[19] results are available on request.

Figure 3: London Call Money Rate (weekly, 1881-1914)



Source: Ugolini

4 Seasonality and Monetary Policy Regimes

Many economists and historians have pointed out that interest rate volatility during the National Banking Era became most severe during the fall harvest season, particularly in October. Bernstein et al (2010) analyzed the existing monthly average data and showed that, indeed, during the National Banking Era, average rates were higher and more volatile in September and October than the rest of the year. The pattern mostly disappeared during what they call the "Fed era," combining the 1908-14 period with the period after the actual founding of the Fed.

4.1 Comparison of Means and Volatility

Analyzing the new daily data instead of monthly averages also reveals new insights into the month-to-month variation in interest rates both within and between monetary regimes. The new data show strikingly that average call money rates peaked in December (Figure 4), not in October-even though the highest rate days often fell in October. The daily high rate over all December days in the period from 1900 to May 1908 averaged nearly 12 percent. During the same period, the October daily rates averaged slightly less than 8 percent. The daily low rate averaged approximately 5 percent for Decembers, compared to 3.3 percent for October daily lows. The so-called 'ruling' rate averaged 8.7 percent for December days and 5.7 for October days. Moreover, the daily spread between high and low rates exhibits strong seasonality during the National Banking Era and also peaked in December; averaging 6.6

percent for that month, compared to 4.5 percent for October. Tight money often elevated rates in November and September as well. Throughout the National Banking Era, those months ranked third and fourth in average rates and spreads.

The seasonal pattern weakens dramatically, during the Aldrich-Vreeland era (June 1908-July 1914).[20] Notably, December remains the peak month for all rates and for the high-low spread, albeit at significantly lower average rates throughout the year. As expected, by now, the small level of remaining seasonality disappears after the founding of the Federal Reserve System, however, high, low, and ruling rates all averaged higher levels during the Fed era than they had during the Aldrich-Vreeland era. At the same time, the intraday spread between high and low rates fell to less than 50 basis points, usually considerably less, making it difficult to discern a seasonal effect.

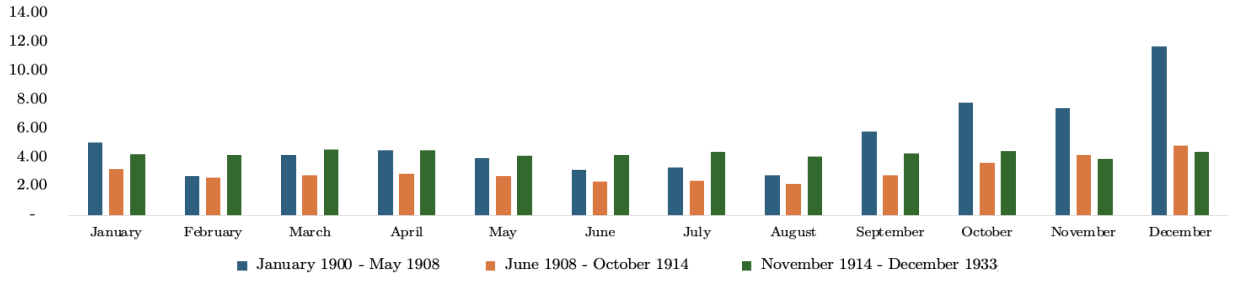
T-tests confirm the significance of these results (Table 6). Whether we examine just September and October-the typical harvest months-or include November and December as well, comparisons of mean rates during the National Banking Era and during the Aldrich-Vreeland era indicate significantly higher average rates in the autumn season than in the first two-thirds of the year. The seasonal variation is most severe in the 'high' rate of interest, but it persists even for the 'low' rates. The t-tests also demonstrate the lack of significance in the seasonality of average call money rates during the Fed era. The mean high-low spread is even lower in the autumn months than the other seasons, but the difference in means is tiny and statistically insignificant.

The ratio of variance tests indicate that rate and high-low spread volatility also varied seasonally during both the National Banking Era and the Aldrich-Vreeland period, but the ratio declined considerably with the institution of Aldrich-Vreeland. Notably, even after the founding of the Fed, the seasonality of variance remains for the low rate and for the high-low spread, and the values of variance are higher than they had been during the Aldrich-Vreeland era. Only the variance of the high rate loses its seasonality during the latter period, but those values are also much greater than they had been under Aldrich-Vreeland.

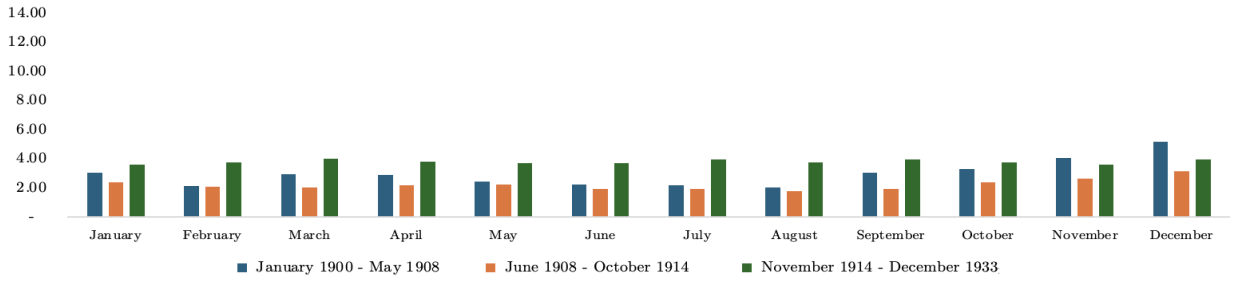
[20]The analysis excludes the months of the stock exchange closure, August-November 1914, due to the freezing of the call money market at the same time.

Figure 4: Call Rates By Month

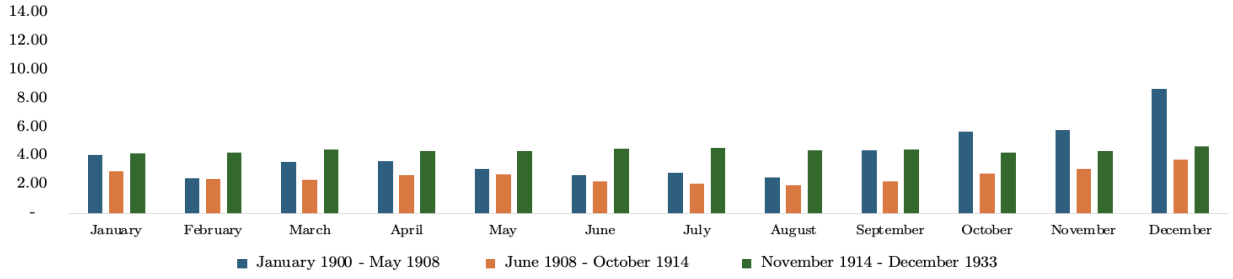
(a) Mean High Rate



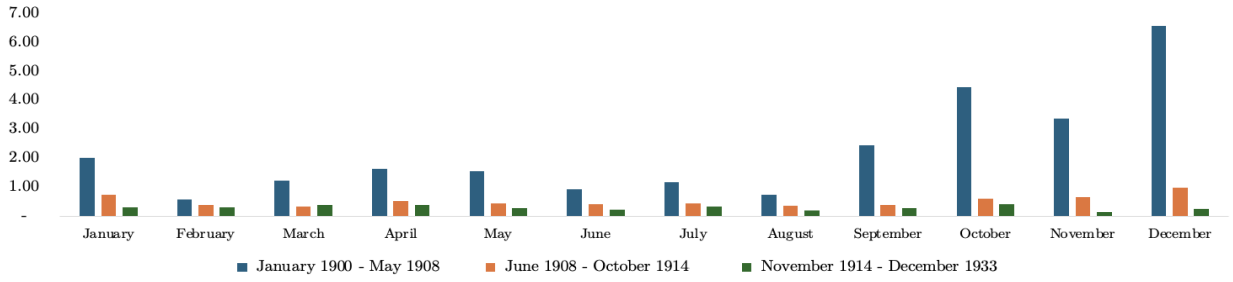
(b) Mean Low Rate



(c) Mean Ruling Rate



(d) Mean High-Low



4.2 Time Series Tests

Filtering the data for seasonality allows identification of recurring seasonal changes in the data as well as changes in the trend of the series. The X-12-ARIMA method allows us to decompose the series into a seasonally adjusted series, a trend-cycle, and the seasonal fluctuations.[21] Since seasonal effects are not necessarily fixed and may evolve over time, the advantage of using this method is that it estimates the seasonal evolving patterns by using moving averages to successively average a timespan of data that changes. This provides estimates of seasonal factors that vary from year to year. For a closer look at the three monetary policy regimes, I break the data into the three periods and run the ARIMA procedure on the sub-periods.

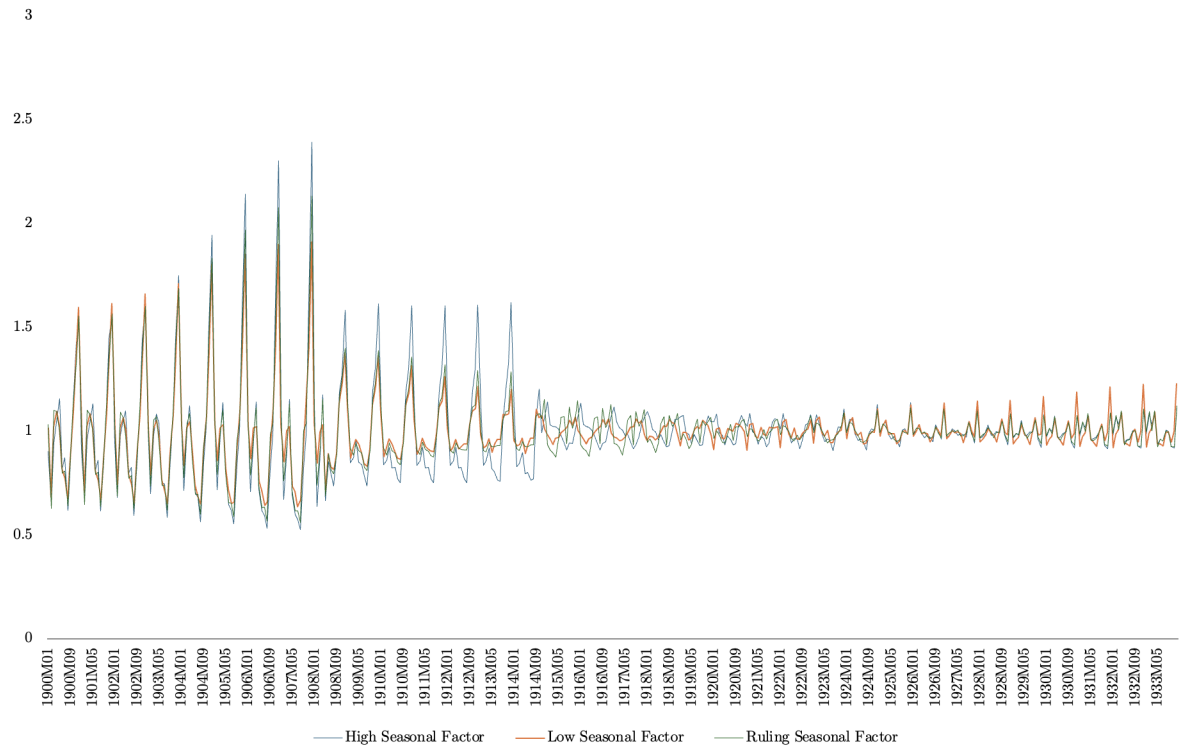
The ARIMA analysis of the seasonal factor in interest rates and the high-low rate spread reinforces the previous results. Seasonality clearly diminished in 1908 and virtually disappeared after World War I. Using the intra-day high-low measure, we can see that the seasonal factor faded even faster after 1907 than did the seasonality of the level of rates. The results highlight the striking reduction in the seasonal factor at 1908 and again after 1914. These tests also indicate that the high and "ruling" rates suffered more from seasonality than the low rates. Those borrowers who could still borrow at the low rate not only enjoyed lower rates, but they also benefited from greater stability over the course of each year. Notably, the seasonal factor peaks in 1907, the year of the greatest financial panic of the pre-Fed era. Here again, the seasonal factor for intra-day high-low spread breaks primarily after 1907, with little visible seasonality thereafter.[22]

[21] For a detailed discussion of X-12-ARIMA, which was developed by the United States Census Bureau, see Findley et al.(1998).

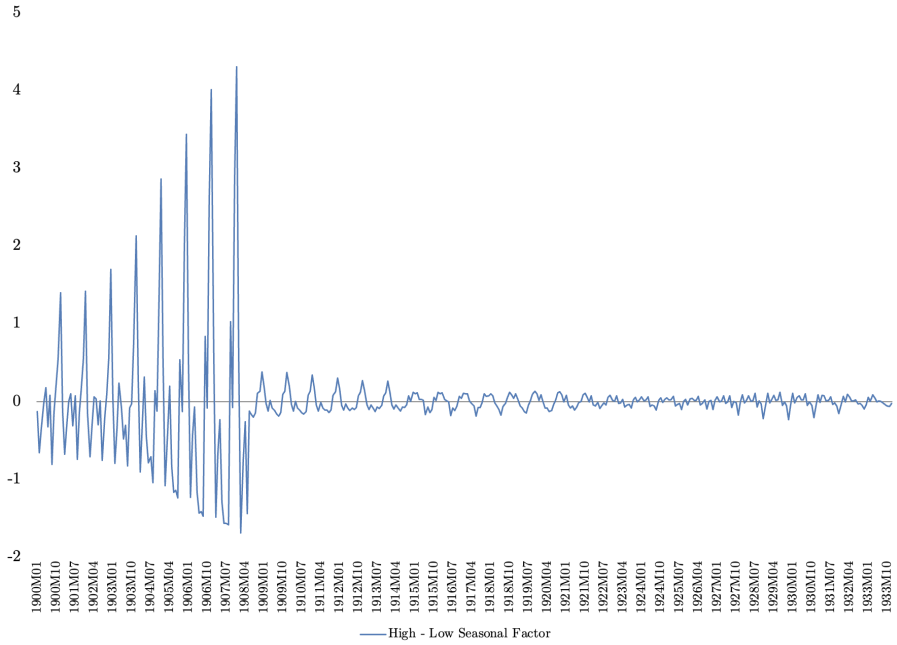
[22] Continuous models covering the entire period smooth transitions but follow the same pattern.

Figure 5: Seasonal Factor in High, Low, and Ruling Rates on New York Call Money, 1900-1933 (by sub-period)

(a)



(b)



5 Loan Volumes and Credit Spreads

The imposition of new policies by the Federal Reserve System naturally raises the question of lending volume. We would also like to be able to analyze interest rates as the price produced by the equilibration of supply and demand for call money. Rate spikes could result from a sudden contraction in supply or a positive shift in demand-or a combination of the two. In crisis episodes, such as the Panic of 1907, contemporary reports described both forces at play.[23] Unfortunately, only anecdotal quotes exist on the volume of call loans during the pre-WWI period, making it impossible to test for a structural break. Griffiss (1923) gives volume data for 1919-21, and the Fed reports weekly call loan volume data for 1917 onward in its 1941 compilation of monetary statistics (Figure 7).

Though we cannot analyze the impact of the founding of the Fed, the evidence does show two interesting phenomena: first, correspondent funds for call loans still made up half of all lending early in 1919 and grew rapidly to exceed own account funds of New York banks by 1920 (Figure 7). Out of town bank funds continued to grow in the mid- to late-twenties, reaching about double the own account funds near the peak of the 1929 bull market. Clearly, the founding of the Fed and its gradual development of a discount market failed to deter lending in the call money market. The 1929 crash led to an exodus of out-of-town funds, which continued to dwindle throughout the remainder of the period. Second, the volume of call loans seems to follow roughly the same pattern, albeit with less variability, as the trading volume of the NYSE (Figure 6). This pattern highlights the importance of liquidity in the overnight lending market for the smooth functioning of the stock market-a topic for ongoing research. Future work will also improve our understanding of the causal relationships among volume of loans, interest rates on loans, volume of stock market trading, and stock market liquidity.

The analysis of call money rates during monetary regime change also relates to the question posed by Mankiw et al (1987) of the impact of the Fed on the term structure of interest rates and on the credit spreads among various short rates. We can use the monthly (1890-1941) and weekly (1919-38) rates on a variety of instruments-call money, Fed discounts, 90-day stock market loans, 90 day prime bankers' acceptances, and 4-6 month prime commercial paper-from the Fed's 1941 Monetary Statistics (Figure 8). The monthly average series covers a long stretch of time but naturally smooths over rate volatility. Still, credit spreads clearly varied tremendously throughout the period until the early 1930s. In

[23]Fohlin et al (2016) provide extensive contemporary reporting from the financial press.

Figure 6: Call Loan and NYSE Trading Volumes 1919-1921

Source: Griffiss (1923)

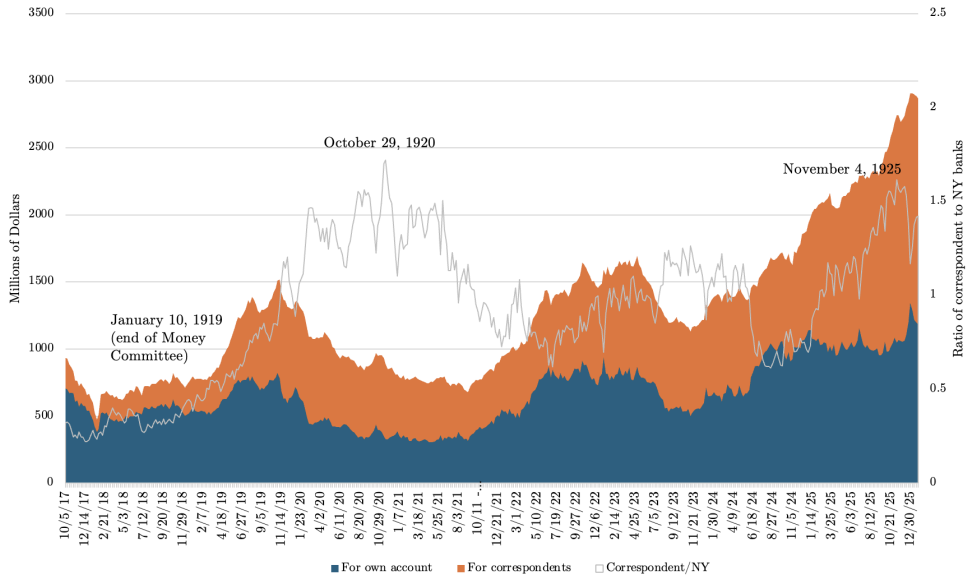
both the monthly and weekly series (Figure 8), the mostly negative rate spreads between call loans and 90-day stock exchange loans imply, as expected, that 90 day loans carried a maturity risk premium over call money, under normal market conditions. Episodes of liquidity crunches clearly punctuate the pattern with spikes of large positive spreads, most frequently during the period before Aldrich-Vreeland but also, at a lower level, leading into the steep recession of 1920-21 and the market crash of 1929. These spikes in money market credit spreads disappeared with the creation of the SEC.

Call money also commanded a risk premium over Fed discounts following World War I until the 1929 crash, but not during the initial few wartime years of the Federal Reserve's operation, nor following the crash. These patterns in credit spreads support the contention that the nascent Fed did not succeed in attracting banks to develop the discount market for many years. Meanwhile, stock market speculation and expected risk of stock collateral in the late teens pushed demand for call money and increased those rates. The Fed's sudden tightening at the end of the war and corresponding contraction in stock market speculation activity decreased the spread until the late 20s bubble began. In order to rigorously analyze the term structure relationship and credit spreads, one would need to collect additional higher-frequency data similar to the call money data presented in the previous sections.[24]

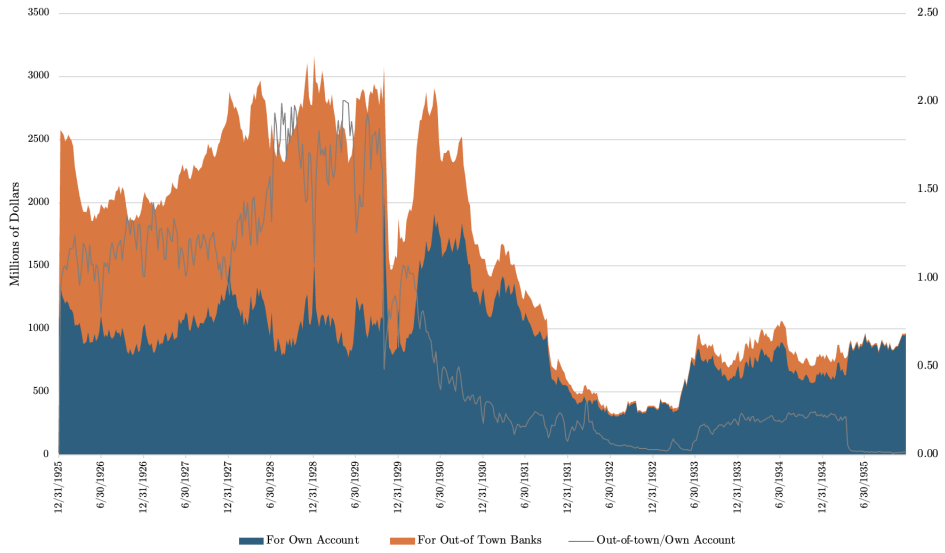
[24]Structural break tests based on the monthly and weekly data support the visual analysis and are available

Figure 7

(a) Street Loans of Daily Reporting Banks, New York, 1917-26, Weekly



(b) Broker (Call) Loan Volume, 1926-35



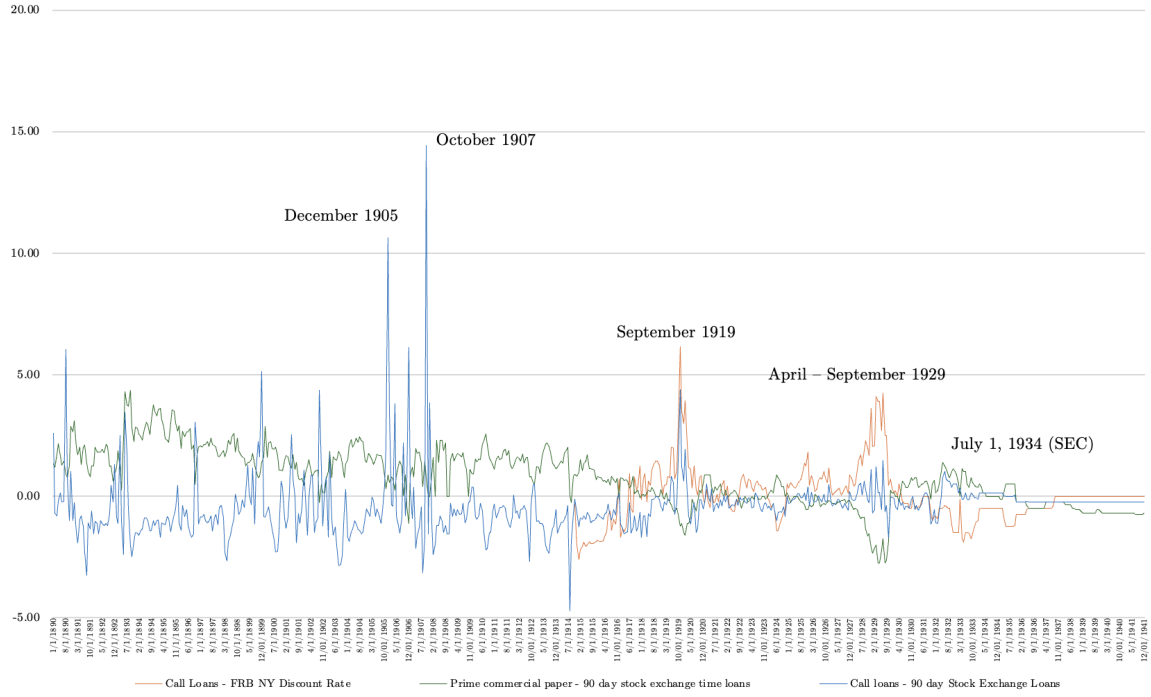
Source: Hand coded from Board of Governors (1943) Table. 140-(Street Loans Made By Daily Reporting Banks In New York City, Weekly, October 1917-January 1926)

Source: Griffiss (1923) Table 141-(Loans to Brokers and Dealers, Secured by Stocks and Bonds), Made by Weekly Reporting Member Banks in New York City, Weekly, 1926-1935

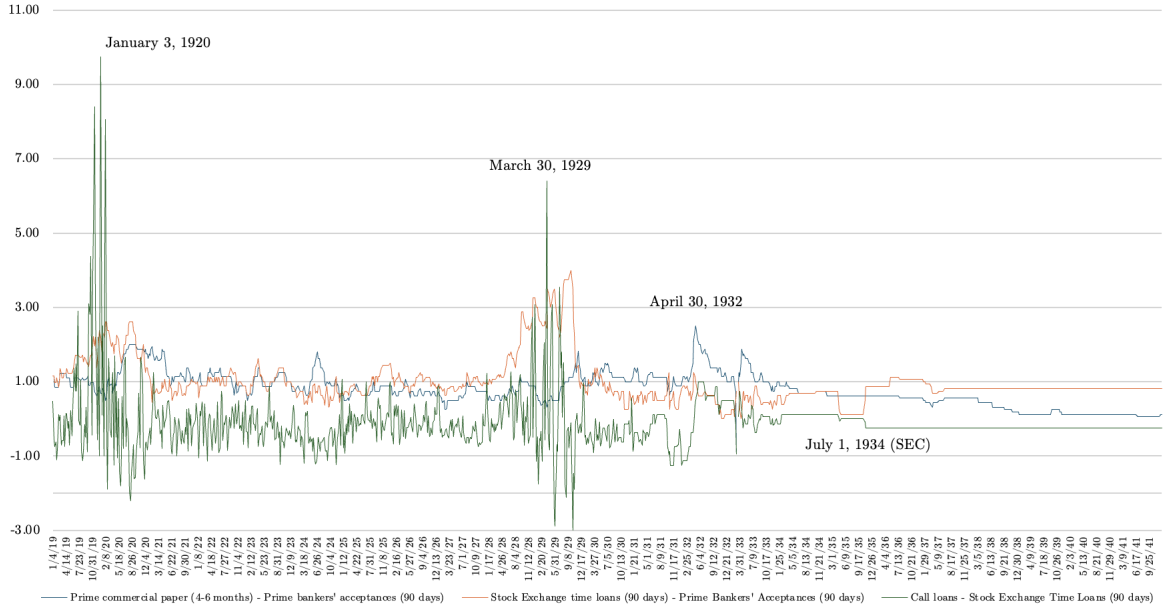
on request.

Figure 8: Credit Spreads

(a) Monthly, 1890-1941



(b) Weekly, 1919-38



6 Conclusion

This paper sheds new light on the creation of the first nationwide lender of last resort in the United States and its impact on the dynamics of the money market in the early 20th century. Employing a novel daily series of interest rates on call loans at the New York Stock Exchange--the most important segment of the US money market at the time-the analysis uncovers a major structural break in rates in mid-January of 1908. At that point, call money rates dropped suddenly, became significantly less volatile, and lost most of their seasonal pattern.

The newly-pinpointed structural break precedes the founding of the Federal Reserve System by more than six years. The initial drop in call money rates followed several weeks of large-scale gold imports, actively supported by the release of gold to the US by the Bank of France, which had already stabilized US equity prices (the Dow index) and thereby mitigated the run on the financial institutions that funded the equity market.

The stability continued, however, even after the gold flows ebbed, signaling a shift to a new regime. The Panic of 1907 jolted into action both the leaders of the banking and financial sector and the US Congress, which had been for years proposing and disposing of plans to reform the currency system of the United States. This new energy for a solution to the widely-recognized problem of severe, episodic "monetary stringency" under the existing regime with no lender of last resort led to generalized expectations of a new era of monetary policy. The New York Times, among other periodicals, began reporting on the new discussions in late November of 1907 and reported on a key senator's trip to New York City to meet with bankers in early December. The publicity surrounding the infusion of treasury notes into the financial system in the late autumn, followed by the news that J.P. Morgan and others deemed this emergency liquidity no longer needed by the end of the year, also settled money markets going into 1908. The most tangible evidence of impending regime change, however, came with the introduction of multiple "currency" bills in Congress starting on January 7, 1908 and the passage of the Aldrich-Vreeland Emergency Currency Act in May of 1908.

The Aldrich-Vreeland system allowed emergency note issuance by banks-through currency associations-in times of liquidity crunches, based on a vastly expanded range of collateral, including commercial paper and bills. Thus, the law set up a new, stabilizing monetary regime that created greater confidence in ongoing money market liquidity. Notably, US Treasury reports from the original six-year lifespan of the Aldrich-Vreeland system indicate that no such emergency currency entered use before the start of World War I. Thus, it appears that the mere availability of the liquidity backstop altered behavior in the money markets, such that no sudden stop took place and even cyclical agricultural needs ceased causing dramatic interest rate seasonality. The first major test of the system came with the

closure of the NYSE due to the start of WWI on July 31, 1914. The money market froze in place at that point, since only a few, unofficial stock transactions could take place for months. The availability of Aldrich-Vreeland emergency currency, with an expanded set of backing assets, provided the necessary mechanism to infuse the banking system with liquidity and to prevent a more serious financial crisis.

The analysis of interest rate spreads further demonstrates the importance of the call money market to regional banks well after the founding of the Federal Reserve. Until the 1929 crash, call money carried a risk premium over Fed discounts, and the early Federal Reserve struggled to attract banks to the discount market. Banks outside of New York City continued to funnel high and increasing volumes of funds into the call money market, driven by stock market speculation and the rate premium. The 90-day stock exchange loans typically carried a premium over call loans under normal conditions. These spreads spiked during liquidity crises, particularly before the Aldrich-Vreeland Act, the 1920-21 recession, and the 1929 market crash, but stabilized after the establishment of the SEC.

Clearly, the improvements in the monetary and financial system following the Panic of 1907 and again during and after World War I led to a more transparent, orderly, and liquid money market with safeguards that prevented the stock exchange funding market from propagating or exacerbating financial panics. These findings are all the more notable in light of the results on call money lending volume, demonstrating that banks persisted in lending overnight to the stock market for many years following the creation of the Fed and its attempts to shift bank lending into the federal funds market instead. Together, the analysis here shows that the early 1908 policy reaction to the Panic of 1907 created a fundamental regime change and a structural break in money market behavior. The first 15 years of the Federal Reserve System, rather than creating a new regime, continued and institutionalized that existing liquidity backstop.

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Table 1: Literature on Structural Breaks in Money Market Interest Rates

Paper	Method	Sample	Results
Miron (1986)	OLS regression	1890-1928 (monthly)	1914 founding of the Federal Reserve decreased seasonal
Mankiw et al (1987)	Switching regression	1890-1933 (monthly)	1914 (between December 1914 and March 1915)
Fishe and Wohar (1990)	Switching regression	Dec 6 1907 to March 1 1918 (90 day rate)	June 1912 or February 1915
Angelini (1994)	Check robustness of MMW and FW	1890-1933 (monthly)	May 1908.
Kool (1995)	Multi State Kalman Filter (MSKF)	1895 - 1928 (monthly)	October 1917
Caporale and Mckiernan (1998)	GARCH	1890-1933 (monthly)	Founding of the Fed and Aldrich-Vreeland Act.
Newbold, Leybourne, Sollis and Wohar (2001)	Logistic model test parameter transitions (I(0) v I(1)).	1890-1933	June 1917
Bernstein et al (2010)	Diff-in-diff regression	1870-1925	Seasonality declined after 1908
Caporale (2015)	Bai and Perron (1998, 2003) structural break	1890-1933 (monthly)	Nov. 1907 (banking panic), Sept 1917 (WW1)

Table 2a: Descriptive Statistics for New York Call Money Rates, 1900-1933 (Daily)

	National Banking	**Aldrich-Vreeland**	**Market Closure**	**Fed Era***	**Money Committee**
High					
Mean	5.18	3.02	6.78	4.29	5.23
Median	3.50	2.50	7.00	4.00	5.00
Variance	55.50	2.17	2.07	6.46	0.61
Highest	125.00	20.00	8.00	25.00	6.50
Lowest	0.88	1.00	3.50	0.75	4.00
n	2058	1534	66	3064	13
Low					
Mean	2.93	2.19	5.72	3.80	4.13
Median	2.50	2.00	6.00	4.00	4.00
Variance	3.32	0.61	1.02	3.93	0.96
Highest	25.00	6.00	8.00	15.00	5.75
Lowest	0.50	0.25	3.00	0.75	3.00
n	2054	1190	66	3022	17
Ruling					
Mean	4.06	2.56	4.85	4.39	5.16
Median	3.00	2.38	4.88	4.25	5.50
Variance	19.54	0.94	0.03	5.24	0.89
Highest	80.00	8.00	5.00	17.00	6.00
Lowest	0.88	0.25	4.63	0.75	3.00
n	2398	1145	6	3277	329
High-Low					
Mean	2.22	0.52	1.06	0.31	1.50
Median	0.75	0.50	1.00	0.00	1.50
Variance	41.49	0.24	0.81	0.40	2.00
Highest	119.00	8.00	2.50	9.00	2.50
Lowest	-8.00	-0.75	0.00	-1.00	0.50
n	2040	1190	66	2882	2

Note: Data on call loans issued in New York, as printed in the New York Tribune and Wall Street Journal, rounded to two decimals. For details, please see text.

* Excludes money committee.

Table 2b: Comparison of Means and Variances

Mean-Equivalence Tests						
	NB	AV	Fed	NB vs. AV	AV vs. Fed	NB vs. Fed
	Means			p values		
High	5.18	3.02	4.29	0.000	0.000	0.000
Low	2.93	2.19	3.80	0.000	0.000	0.000
Ruling	4.06	2.56	4.39	0.000	0.000	0.000
High-Low	2.22	0.52	0.31	0.000	0.000	0.000
Variance Ratio Tests						
	NB	AV	Fed	NB vs. AV	AV vs. Fed	NB vs. Fed
	Variances			p values		
High	55.50	2.17	6.46	0.000	0.000	0.000
Low	3.32	0.61	3.93	0.000	0.000	0.000
Ruling	19.54	0.94	0.96	0.000	0.000	0.000
High-Low	41.29	0.24	0.40	0.000	0.000	0.000

Note: Averages or variances of two groups are significantly similar if the p value is greater than 0.05. Excludes 1914 NYSE closure and Money Committee periods.

Table 3: Estimated Structural Breaks in Daily Call Money Rates (1900-1933)

High		
Breaks	SupF	Dates
1	6.22	1/14/1908
2*	24.42	1/16/1908, 11/22/1916
3*	24.33	3/16/1904, 3/10/1908, 11/22/1916
Udmax*	24.42	
Wdmax*	35.05	
Obs	6668	
Low		
Breaks	SupF	Dates
1*	65.97	4/18/1918
2*	102.91	1/16/1908, 4/18/1918
3*	84.48	1/16/1908, 4/18/1918, 12/07/1928
Udmax*	102.91	
Wdmax*	122.30	
Obs	6282	
Ruling		
Breaks	SupF	Dates
1	8.42	8/31/1917
2*	32.30	1/18/1908, 6/01/1917
3*	42.90	1/18/1908, 6/01/1917, 3/20/1922
Udmax*	42.90	
Wdmax*	61.76	
Obs	7149	
High - Low		
Breaks	SupF	Dates
1*	16.25	1/14/1908
2*	27.04	6/02/1904, 1/29/1908
3*	35.11	6/02/1904, 1/29/1908, 10/31/1923
Udmax*	35.11	
Wdmax*	50.55	
Obs	6113	

Note: Test uses trimming of 15%. Test statistics employ HAC covariances constructed with Prewhitening with 1 lag g, Quadratic-Spectral kernel and Andrews bandwidth, following Bai-Perron (2003). The test assumes common data distribution. The resulting dates are globally determined breaks. Excludes NYSE 1914 closure.

* Significant at the 0.05 level.

Table 4: Estimated Structural Breaks in Daily Call Money Rates (1908-1917)

High		
Breaks	SupF	Dates
1*	77.48	9/14/1909
2*	48.04	9/14/1909, 1/08/1914
3*	32.42	9/14/1909, 9/04/1912, 1/07/1914
Udmax*	77.48	
Wdmax*	77.48	
Obs	1952	
Low		
Breaks	SupF	Dates
1*	128.21	10/1/1909
2*	94.63	8/02/1909, 7/25/1910
3*	68.18	8/05/1909, 7/28/1910, 1/20/1914
Udmax*	128.21	
Wdmax*	128.21	
Obs	1606	
Ruling		
Breaks	SupF	Dates
1*	65.43	1/1/1909
2*	41.38	9/08/1909, 7/14/1910
3*	29.61	9/09/1909, 7/15/1910, 6/06/1916
Udmax*	65.43	
Wdmax*	65.43	
Obs	1643	
High - Low		
Breaks	SupF	Dates
1*	39.90	1/16/1911
2*	25.79	9/30/1909, 1/16/1911
3*	18.84	9/30/1909, 1/16/1911, 6/30/1914
Udmax*	39.90	
Wdmax*	39.90	
Obs	1584	

Note: Test uses trimming of 15%. Test statistics employ HAC covariances constructed with Prewhitening with 1 lag g, Quadratic-Spectral kernel and Andrews bandwidth, following Bai-Perron (2003). The test assumes common data distribution. The resulting dates are globally determined breaks. Excludes NYSE 1914 closure.

* Significant at the 0.05 level.

Table 5: Estimated Structural Breaks in Weekly London Call Money Rates (1900-1914)

Average		
Breaks	SupF	Dates
1	1.59	2/1/1911
2	4.40	4/04/1908, 11/25/1911
3	5.60	1/20/1906, 4/04/1908, 11/25/1911
Udmax	5.60	
Wdmax	8.07	
Obs	762	

Note: Test uses trimming of 15%. Test statistics employ HAC covariances constructed with Prewhitening with 1 lag g, Quadratic-Spectral kernel and Andrews bandwidth, following Bai-Perron (2003). The test assumes common data distribution. The resulting dates are globally determined breaks. Excludes NYSE 1914 closure period.

Table 6: Seasonality and Monetary Policy Regimes

National Banking Era					
	Jan-Aug	**Sep-Dec**	**t value**	**F value**	**p value**
High					
Mean	3.79	8.22	−13.01		0.000
Variance	14.10	132.86		0.11	0.000
Low					
Mean	2.51	3.88	−16.78		0.000
Variance	1.79	5.44		0.33	0.000
High-Low					
Mean	1.28	4.27	−9.95		0.000
Variance	8.12	108.96		0.07	0.000
Aldrich-Vreeland Era					
	Jan-Aug	**Sep-Dec**	**t value**	**F value**	**p value**
High					
Mean	2.64	3.86	−16.39		0.000
Variance	0.90	3.91		0.23	0.000
Low					
Mean	2.06	2.51	−9.07		0.000
Variance	0.41	1.00		0.41	0.000
High-Low					
Mean	0.46	0.67	−6.55		0.000
Variance	0.22	0.29		0.75	0.002
Fed Era					
	Jan-Aug	**Sep-Dec**	**t value**	**F value**	**p value**
High					
Mean	4.29	4.29	−0.01		0.990
Variance	6.43	6.52		0.99	0.802
Low					
Mean	3.79	3.82	−0.35		0.727
Variance	3.71	4.39		0.85	0.002
High-Low					
Mean	0.32	0.29	1.04		0.299
Variance	0.42	0.35		1.19	0.002

Note: The first p-value for each rate comparison results from a test comparing the averages of the two groups, "autumn" versus the rest of the year. The second p-value gives the significance of the ratio of variance test, which tests that the ratio of variances is close to 1 (same across the two "seasons" of the year).

Appendix A

Table A1: Chronology of Financial and Monetary Events

Date	Call money market	NYSE	LOLR	Monetary policy/regulation
5/9/1901		No. Pacific panic		
10/23/1907		Panic of 1907	New York Clearing House	
1/8/1908				1st Aldrich bill (S. 3023) introduced
1/30/1908				1st Aldrich bill (S. 3023) reported out by Committee on Finance
5/30/1908			Aldrich-Vreeland Act passed	
12/23/1913			Federal Reserve Act passed	Federal Reserve Act passed
6/30/1914			Aldrich-Vreeland Act extended (for one year)	
7/31/1914	loans/rates frozen	Market closed	Aldrich-Vreeland currency issued	Gold flows restricted
11/16/1914			Federal Reserve banks opened	Federal Reserve banks opened
12/12/1914	loans/rates unfrozen	Market reopened (with constraints)		
4/6/1917		US entry into WWI		
4/27/1917		First Liberty Loan issued		
9/5/1917	money committee began controlling broker loan market			
Aug/Sept 1918	increased margin requirements			
11/11/1918		End of WWI		
1/10/1919	end of money committee (continued centralized structure)			
4/26/1920		Establishment of Stock Clearing Corporation and first settlement through the Day Branch.		
9/16/1920		Wall Street explosion. Thirty killed and over 100 injured.		
1920-21		Significant price declines		Fed rate increase/ sharp recession
3/22/1921	Stock Clearing Corporation began clearance of loans for members.			
10/28/1929		Black Monday crash (13% decline)		
10/29/1929		Black Tuesday crash (12% decline)		

Detailed Timeline of the Panic of 1907

- **Spring 1906:**
  - San Francisco earthquake in April causes widespread destruction in the city, prompting huge insurance claims on London insurers.
  - U.S. Treasury Department under Secretary Leslie Shaw implements policies to stimulate gold imports into the United States.
  - This generates a significant inflow of $50 million in gold in April-May 1906.
- **Late 1906:**
  - Bank of England raises its discount rate in response to large gold outflows to the U.S.
  - Bank of England threatens another rate increase if American finance bills are not paid upon maturity without renewal.
- **1907:**
  - Finance bills are suspended during 1907, constricting the system of arbitrage that minimized actual gold shipments.
  - Because of this, and despite high U.S. interest rates, the United States exports $30 million in gold to London during the summer.
  - New York money market left with an uncharacteristically low volume of gold entering the fall season.
- **October 16, 1907:**
  - F. Augustus Heinze's attempt to corner the stock of United Copper Company fails.
- **October 19, 1907:**
  - Two banks associated with Heinze call for aid from the New York Clearinghouse due to large deposit withdrawals.
- **October 21, 1907:**
  - National Bank of Commerce announces it will stop clearing checks for Knickerbocker Trust Company.

  - J.P. Morgan organizes a meeting of trust company executives to discuss ways to halt the panic.

- **October 22, 1907:**
  - Knickerbocker Trust undergoes a run, paying out $8 million before suspending operations.

- **October 23, 1907:**
  - Trust Company of America experiences a severe run, paying out $13 million.
  - Secretary of the Treasury George Cortelyou meets with major New York financiers to discuss plans to combat the crisis.

- **October 24, 1907:**
  - Call money on the New York Stock Exchange becomes nearly unobtainable.
  - J.P. Morgan arranges for $25 million to be made available on the stock exchange floor.
  - Trust Company of America pays out another $8-9 million.

- **October 25, 1907:**
  - Another money pool of about $12.5 million is arranged by Morgan for the stock market.

- **October 26, 1907:**
  - New York Clearinghouse issues clearinghouse loan certificates to increase currency supply.

- **October 26 - November 16, 1907:**
  - Over $110 million in clearinghouse loan certificates issued in New York City.
  - Nearly $500 million in currency substitutes circulate throughout the country.

- **October 28, 1907:**
  - New York City Mayor approaches Morgan for help with the city's financial crisis.

- **October 29, 1907:**

  - Morgan, Stillman, and Baker agree to underwrite a $30 million bond issue for New York City.

- **November 1907:**
  - Bank of England raises its discount rate to 7%, the highest since 1873, to protect its gold reserves and in response to the crisis in the U.S.

- **November 4, 1907:**
  - U.S. Steel acquires Tennessee Coal, Iron, and Railroad Company stock from Moore and Schley brokerage to prevent its collapse.
  - $25 million loan arranged for Trust Company of America and Lincoln Trust.

- **November 22, 1907:**
  - Bank of France agrees to release American gold eagles (U.S. gold coins held in its vaults) for export to the United States to help ease the liquidity crisis.

More Details on Suspension of Finance Bills in 1907

The suspension of finance bills in the summer of 1907 by England was primarily a response to mounting financial pressures and a tightening of gold reserves. Finance bills were short-term credit instruments that facilitated international trade and capital flows, often used to finance imports and exports without immediate payment. These bills were also a tool for arbitrage, allowing banks to exploit interest rate differentials between countries.

However, in 1907, the financial environment became increasingly strained due to several factors:

- **Gold Outflows:** The United States had been attracting significant amounts of gold from Europe due to higher interest rates. This led to a depletion of gold reserves in countries like England, creating pressure on the Bank of England to maintain its gold reserves.

- **Interest Rate Defense:** To defend its gold reserves and prevent further outflows, the Bank of England raised its discount rate. However, the finance bills allowed for continued capital flows out of the country, undermining these efforts.

- **Market Instability:** The global financial environment was becoming unstable, with the U.S. financial system showing signs of strain that would culminate in the Panic of

1907. Suspending finance bills was a defensive measure to protect England's financial stability and gold reserves during a period of increasing uncertainty.

By suspending the use of finance bills, England sought to reduce the outflow of capital and gold, stabilize its banking system, and prepare for potential financial turbulence. This suspension was part of a broader strategy to tighten credit conditions and safeguard the national economy against external financial shocks.

Appendix B: Unit Root Test for Structural Break

Following Caperale (2015), I test for structural breaks using the unit root test. Perron (1989) showed the unit root test is biased toward a false unit root null when a structural break is present in the data. He goes on to propose three possible alternative models: (A) one structural break in the intercept, (B) one structural break in the slope, and (C) a structural break in the intercept and slope.

While Perron (1989) treated the breaks as exogenous, Zivot and Andrews (2002) argue this approach leads to an over rejection of the unit root null. Instead, they suggest treating the breaks endogenously. Following the empirical literature, I use the specification from Perron (1997), which is similar to Zivot and Andrews (2002) but allows for a structural break under the null hypothesis, and consider Models A and C.

Consider the following variables in terms on break date T_b:

$$DU_t(T_b) = \mathbb{1}(t \geq T_b),$$

and

$$DU_t(T_b) = \mathbb{1}(t \geq T_b) \cdot (t - T_b + 1),$$

where $\mathbb{1}(\cdot)$ is the indicator function, $DU_t(T_b)$ is the variable representing an intercept break taking the value 0 for all dates before T_b and 1 thereafter; and $DU_t(T_b)$ is the variable representing a trend break taking the value 0 for all dates before T_b and is the re-based trend thereafter.

Model A is of the form:

$$r_{it} = \kappa_i + \alpha_i r_{it-1} + \beta_i t + \theta_i DU_t(T_b) + \sum_{j=1}^{k} c_{ij} \Delta r_{it-1} + \epsilon_{it},$$

and Model C is of the form:

$$r_{it} = \kappa_i + \alpha_i r_{it-1} + \beta_i t + \theta_i DU_t(T_b) + \gamma_i DT_t(T_b) + \sum_{j=1}^{k} c_{ij} \Delta r_{it-1} + \epsilon_{it},$$

where Δ is the first difference operator, k is the number of lagged terms, and r_{it} and ϵ_{it} are the call money rate and error term for type i and time t, respectively. Perron (1989), k is chosen so that the coefficient on the last lag term is significant while including any higher lag terms would make their coefficients insignificant at the same level.

For Models A and C, the null hypothesis is that $\alpha_i = 1$ with break at time T_b. Results from the tests can be found in table B.1.

Table B.1: Perron (1997) test for unit roots with structural breaks

High		
	Model A	Model C
Perron test Statistic	-10.56^{**}	-10.78^{**}
k	40	40
Breakpoint	10/13/1907	10/23/1907
Critical Values at 1%, 5%, 10%, respectively	-5.35,-4.85,-4.61	-5.72,-5.18,-4.90
Low		
	Model A	Model C
Perron test Statistic	-6.69^{**}	-6.73^{**}
k	38	34
Breakpoint	10/01/1929	6/21/1918
Critical Values at 1%, 5%, 10%, respectively	-5.35,-4.86,-4.61	-5.72,-5.18,-4.89
Ruling		
	Model A	Model C
Perron test Statistic	-9.84^{**}	-10.90^{**}
k	40	40
Breakpoint	12/28/1905	12/23/1907
Critical Values at 1%, 5%, 10%, respectively	-5.35,-4.86,-4.61	-5.72,-5.18,-4.89

** Significant at the 0.01 level.

The table presents results of the Perron (1997) test for unit root structural breaks in three series for call money rates-daily high, daily low, and ruling rate 1900-1933.