Monetary Policy Regimes and Money Market Stability: Did the Founding of the Fed Matter?

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Abstract

This paper presents the first high-frequency (daily) database of overnight lending rates in the NYSE's call money market from 1900-1933 in order to test whether the founding of the Federal Reserve System reduced money market volatility and eliminated the seasonal monetary tightening that led to periodic panic-driven interest rate spikes in the pre-Fed era. The new data dramatically improves on the existing overly-smoothed, monthly average rates used in past work and reveals two key sets of findings: first, the opening of the Federal Reserve System in November 1914 had an insignificant effect on interest rate levels and volatility and only a mild effect in reducing seasonality. Second, interest rates and volatility show a significant structural break in January 1908, and seasonality of rates also dropped noticeably at that time. These structural changes correspond closely with the introduction on January 7, 1908 of the Aldrich-Vreeland Emergency Currency Act, which set up the US's first national lender of last resort rules with a five-year renewable window of operation. The findings suggest that even this relatively weak commitment to a nationwide LOLR significantly altered money market behavior, such that the founding of the Federal Reserve System provided little additional effect in its first several years of operation.

1 Introduction

Call money, overnight lending to securities brokers, provides the primary source of liquidity for financial market transactions. Historically, the New York Stock Exchange requirement of daily clearing of trades, in an era well before electronic payments, created enormous demand for call loan funding–especially before the creation of a full-fledged clearing house. In addition to using call money to facilitate clearing of NYSE transactions, brokers also used the loans to finance stock purchases on margin. While banks

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could call in loans daily, in practice, most brokers could renew their call loans for weeks or even months. If a lender called his loan, a trader would need to seek out a new loan to pay off the previous loan. This process compounded the need for liquidity in the funding market.

On the supply side, call money offered short-term returns on excess bank reserves, analogous to modern-day repurchase agreements, and attracted funds from banks around the United States. Much of the funding for call money came from banks in agricultural regions of the country that experienced seasonal variations in liquidity demands revolving around their particular planting and harvesting cycles. So-called 'country banks' funneled resources into the New York call money market via their correspondent banks in the city. Seasonality in agricultural financing demand induced push and pull cycles in the flow 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. With no countervailing monetary policy, rates on call loans therefore followed a seasonal pattern during the 19th and early 20th 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, during seasons of greatest agricultural demand for funding, the New York call money market became particularly susceptible to sudden increases in demand for funds (runs) and to wild rate spikes.

Sudden rate spikes in funding markets can precipitate downward spirals in asset prices, as 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 (2018) 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."

We know that call money rates fluctuated tremendously during the National Banking Era (1863-1914). Likewise, we know that after the regulatory blitz of the mid-1930s, call loan rates dropped to extremely low and stable levels, as federal authorities more closely controlled money markets. What remains an open question is the timing of this shift, and in particular, whether rates stabilized upon the opening of the Federal Reserve System in November 1914. Most past research has started with the assumption that the Federal Reserve System reduced unpredictable interest rate spikes and seasonality, hypothesizing that the very foundation of a bona fide central bank created an expectation of rate stability. Past studies have only found weak evidence of a breakpoint in short-term interest rates at the 1914 opening of the Federal Reserve banks, and a couple of studies have actually identified apparent shifts both later–during World War I–and earlier–around the middle of 1908. Based on his finding of a May 1908 break in rates, Angelini (1994) posited that the implementation of the Aldrich-Vreeland Act, which provided for

'emergency currency' to be provided in case of crisis, as the turning point.[1]

One issue with past studies is their use of monthly average rate series and their reliance on longer maturity loans, such as 30 day commercial paper, which did not represent the key funding market used by banks at the time. Thus, in this study, I resolve past data shortcomings with a newly-gathered daily series on call loan rates, spanning from 1900 through 1933. I also employ newer Bai-Perron structural break tests developed after the first rounds of this literature. Using both the daily levels and intra-month variance measures, I find that call rate levels fell and stabilized early in January 1908, just three months after the Panic of 1907 and several months before the Aldrich-Vreeland Act passed into law and took effect (but around the time the sponsors introduced the Act in Congress). In addition, I find that seasonality declined markedly after January 1908 and dropped further after the founding of the Fed. Moreover, I show that despite the stabilization efforts 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-albeit with slightly less volatility and none of the enormous spikes of the era before the Panic of 1907.

In the next section, I provide historical background on the New York call money market structure and monetary policy regime changes over the first three decades of the 20th century. In Section 3, I discuss the methods for the current analysis and the relationship to the literature on this question and then present the newly-collected daily database of call money rates. I present the structural break results in Section 4 and the seasonality tests in Section 5. Section 6 offers some preliminary data on the volume of call money and on credit spreads and suggests avenues for future work. Section 7 concludes.

2 The Call Money Market and Monetary Policy Regimes

Overnight loans on security collateral–known as "call money," because of the ability of lenders to call in the loan on short notice–grew up as a response to the daily (overnight) clearing of transactions required by the NYSE's rules.[2] The New York call money market became the key market both for the operation of the New York Stock Exchange and for the short-term investment of funds by many banks throughout the country–not just in New York City. 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. During this same period, the US significantly altered its monetary policy regime, particularly when it introduced the Federal Reserve System in November of 1914–just 3 1/2 months into World War I. Before analyzing how monetary policy regime changes affected interest rates in overnight funding markets, it is necessary to understand the structure and function of that market and its crucial role in providing liquidity to financial markets, especially the New York Stock Exchange.

[1] Bernstein et al (2010) use a different approach but also identify mid-1908 and Aldrich-Vreeland as a turning point.

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

2.1 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.[3] 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. Commercial banks and trust companies (collectively "banks" in the following) provided the supply of call money in the New York money market, but a significant portion of their available funds actually came from the "country" banks outside of New York City with which the New York banks maintained correspondent banking relationships. Additionally, certain railroad and insurance companies also lent on stock collateral during this period. As a rule, bankers called in 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. 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. Because 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 lending of last resort to national banks in the city), the funding of the call money market carried significant risk. Therefore, 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 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

[3]Pratt (1903)

"overcertification," directly between stock brokers and their banks.[4] 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 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 NYC 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 Comptroller of the Currency still permitted the New York City Bank Clearing House Association (NYCHA) to allow overcertification because of the role it played in the NYSEs 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^{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.

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

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

rates-froze in place when the NYSE closed on July 31st, 1914. It remained in limbo for the 4 $\frac{1}{2}$ 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 24th, 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 $\frac{1}{2}$ on mixed v. industrial collateral and encouraged shorter maturity on time loans-two to four months instead of four to six months.[5]

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."[6] 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."*[7]

[5]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.

[6]Quoted in Griffiss (1923), p. 31.

[7]Quoted in Griffiss (1923), p. 33.

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.[8] 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 for the rest of the decade. The 1929 crash and ensuing financial crisis brought about a major rethinking of the country's financial structure and regulation and ushered in the modern regulatory era for financial markets with the 1933-34 regulation of corporate securities registration, issuance, trading, and market operations as well as corporate accounting and disclosure. Stringent regulation led to a virtual end to volatility and seasonality in the money market.

2.2 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 onset 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 instituted a quasi-lender of last resort (LOLR), even without a central bank or associated interest rate setting mechanism.[9] 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).

[8] See Meeker (1922).

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

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.[10] 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 conflicting views, compromise, haste, and politics"[11] -provided for a stock of extra currency available in cases of emergency, backed by deposits of railway bonds and certain approved commercial paper. 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)(of the Treasury, 1914).

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).

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 Fed 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 of 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, and Mitchell)-data re-

[10] See Fohlin et al (2016) on the impact of the liquidity freeze on the NYSE during the Panic of 1907.
[11] Laughlin (1908), p. 490.

main elusive-country banks continued to lend in the 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.[12] 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 had no 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. Notably, Griffiss, writing in 1923, explains as follows:

> *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.

3 Structural Breaks in Call Money Rates: Data and Methods

Several previous authors have weighed in on the issue of regime change in the money market, and each has produced a new statistical analysis yielding different "turning points" in the money market rate (summarized in Table 1). Griffiss (1923) provided one of the earliest thorough investigations of the New York call money market. While his work lacks an econometric model, he gathered and tabulated significant amounts of data, and he delved into the institutional structure of the market and its changes before and after the war. Griffiss considers the impact of the creation of the Federal Reserve System and emphasizes in particular the impact on out-of-town reserves, or correspondent accounts. As noted in the previous section, Griffiss argues that country banks converted only gradually and reluctantly to the discount market from the call money market, which in and of itself provides a clue to the impact of this portion of the monetary policy regime change.

Miron (1986) and Mankiw et al (1987) revived the issue of monetary regime change and started something of a strand of 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 examine the regime change embodied in the founding of the Fed and the speed of adjustment to the new regime. They find that 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 demonstrate further that the term structure of interest rates changed with the new monetary regime: long (6 month)

[12] For data on credit spreads, see Section VI.

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 in particular raised the issue of the 1908 Aldrich-Vreeland act and its impact on expectations. Angelini ran numerous robustness checks on the monthly data used by Mankiw et al and establishes May 1908 as a structural break in short-term interest rates.

Caporale and McKiernan (1998) entered the fray and, using a GARCH model, found that both Aldrich-Vreeland and the Fed turn up as turning points. After several years without further debate, Caporale (2015) raised the issue again with the application of Bai and Perron's (2003) more recent structural break tests. In order to compare most directly the results using the daily interest rate series with those for the monthly data, I use this same test.[13]

The Bai-Perron (2003) test is commonly used for the evaluation of structural shifts in linear models, which can be multiple. For the purpose of this study, I use a simple model consisting of a constant. 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. Using the Eviews application of the Bai-Perron test, 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.

Therefore, the test first evaluates the null hypothesis of zero breaks against the alternative of one structural break followed by the next test that considers the alternative of two structural breaks, and so on. For the present exercise, I consider a maximum of 3 possible breaks.

Following recommendations for empirical applications on Bai & Perron (2003) if at least one break is present the number of breaks can be decided using a sequential examination that tests the null hypothesis of l break(s) against the alternative of $l+1$ breaks. If the test rejects the null hypothesis, it determines the break date, divides the sample into two samples, and then performs a single unknown breakpoint tests in each subsample. The sequence of tests determines the number of breaks and the corresponding dates.

In evaluating the impact of monetary policy regime change, the principal variable of interest is some measure of interest rates, particularly short-term rates. 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, 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

[13]Caporale (2015) also implements a unit root test to demonstrate the lack of stationarity and support the presence of a structural break. Appendix 2 provides results of such a test in order to allow comparison with Caporale's results.

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 (Figure 1). From monthly frequency interest rates, it is possible to glean some idea of the pattern over time, but it is impossible to identify spikes properly or accurately measure volatility, particularly over the short intervals of financial panics-sometimes lasting only a day or two. Moreover, the averaging of rates within each month obfuscates brief rate spikes that nonetheless cause serious disruption to financial markets and banks.

For the period between 1900 and 1922, I used the daily money market report published in the *New York Tribune* (accessed via the Library of Congress historical newspaper website "Chronicling America"). For data from 1923 through 1933, I used the daily money market report published in the *Wall Street Journal*, via Proquest.[14] 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 on the given day. I collected all reported rates but focus the analysis on the most complete series: high, low, and ruling rates (Figure 2a-c). Descriptive statistics appear in the next section.

4 Structural Breaks

The daily series offer the most accurate means of measuring changing processes in the money market, both levels and volatility of interest rates. When assessing the impact of monetary policy regimes that changed significantly between the Panic of 1907 and the founding of the Federal Reserve System, the daily data becomes extremely useful. This high frequency data also highlights the patterns of rates during the sharp recession of 1920/1 and the boom and bust of the late 1920s.

The first step in the analysis involves simple assessment of the pattern of call money rates over the three monetary policy regimes: The National Banking era, Aldrich-Vreeland era, and the Federal Reserve era (Table 2). 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 2). That spread averaged over two percentage points during the National Banking Era, but it averaged 52 basis points

[14]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.

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.

Most of the statistical results appear clearly and in detail in the graphs of the data (Figures 2a-c). Most notably, rates dropped suddenly in January 1908 and remained low and much more stable for much of the subsequent 6-7 years before the Fed opened for business. The rate decline and stability preceded even the Aldrich-Vreeland Act's passage in May of 1908, suggesting that market forces dampened speculation and therefore volatility of money as early as January of 1908. We can only speculate about whether the mere introduction of the Aldrich-Vreeland bill in early January played a role in setting expectations that the federal government would soon create a liquidity backstop.

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.

Because the call rate spiked occasionally to extreme levels, the graphical depiction tends to dampen the visible fluctuations in rates during more normal times. When those spikes are truncated, and the range restricted to rates up to 20 percent, the episodes of smaller rate hikes come into view (Figure 3). 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.

4.1 Structural breaks in the level of rates

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), the most obvious break from visual inspection of the graph. The low and ruling rate also broke significantly in mid-January of 1908, though other breakpoints show up more prominently in both of those series. The single clearest breakpoint in the low rate appears on April 19, 1918, while that for the ruling rate came on September 1, 1917-both during critical periods of US engagement in World War I. World War I also turns up as a breakpoint for the high rate, but the turning point comes much earlier in the war, November 23, 1916, before the US entered.

The 1920-1 recession that resulted from the Fed's rapid post-WWI monetary tightening corresponded to a short-term increase in call money rates, but the test only picks up a break in the ruling rate on April 8, 1922. The high and low rates only show breaks as the stock market began its final run up in the latter part of 1928: August 28th for the high rate and November 23 for the low rate. Chow tests for known (assumed) breakpoints test individual suspected breakpoints, and the results confirm most of the expected turning points, such as the US entry into the war, the end of the war, and the formation of the Money Committee. Two notable exceptions: the opening of the Federal Reserve banks in November 1914 has no impact on the high interest rate series, and the passage of the Aldrich-Vreeland Act in May 1908 shows no effect on the ruling rate.

4.2 Structural breaks in rate volatility

Financial firms also have to manage the volatility surrounding their short term borrowing costs. The graphical evidence and basic means comparisons 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. Once again, the single most important structural break in volatility appears in January 1908, on the 14^{th} of that month (Table 4). With two breaks allowed, the BP test turns up May 11, 1904 along with January 24, 1908, while adding a third break keeps those two breaks and adds April 21, 1920. That month coincides with the sharp recession that followed the Fed's tightening, as it attempted to rein in inflation after the war.

Even allowing for four or five breaks turns up no structural break in volatility for 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 money market, and even its actions during the war show little direct effect.

Running the break tests on the intra-month variance of daily call money rates turns up statistically insignificant results.

4.3 Robustness Checks

In order to check the robustness of the results using the new data on call money rates, I next re-run the Bai Perron break tests using three alternative periods and datasets. First, I use the new data but constrain the periods to match narrower timeframes. Next, I compare against the monthly call money rate in order to match the frequency and data sources from previous analyses. Finally, I run the same tests on London call money rates to see how those results compare.

4.3.1 Sub-period tests

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 5). Other breaks appear in 1910, 1912, and January 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 of the following year.

4.3.2 Comparison with monthly call money 1890-1939

Going back to the monthly average data allows comparison of monthly average overnight call money rates and the longer maturity commercial paper rates that previous studies have analyzed. Whether we examine the longer period 1890-1941 or the shorter period that matches the daily dataset (1900 - 1933), the single most important break comes in spring or summer of 1918. January of 1908 still appears significant, especially for the

more constrained period. None of the results shows a break surrounding the opening of the Fed.

4.3.3 Comparison with London Call Money Rate Movements

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, Ugolii has collected weekly call money rates for 1881-19014 (Figure 4). Break tests for these London data indicate no significant structural break in the London call money rate up to 1914, which is the end of the available data series (Table 7).

5 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. We can use a variety of methods to assess the changing seasonal patterns over the period: comparisons of means and volatility and time series filtering methods. 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.

5.1 Comparison of means and volatility

By analyzing the daily data instead of monthly, we can get a more accurate picture of rate variations across months and among monetary regimes. Indeed, the new data indicate that, during the National Banking Era, average call money rates-high, low, and ruling-actually peaked in December (Figure 5), not October. The worst individual days often fell in October, but the daily high rate over all December days in the period from 1900 to May 1908 averaged nearly 12 percent. October days averaged slightly less than 8 percent in those years. 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 NBE and also peaked in December; averaging 6.6 percent for that month, compared to 4.5 percent for October. All of the rates remained higher in November than in September. Overall, during the National Banking Era, September ranked fourth highest for all of the average rates and the high-low rate spread.

The seasonal pattern remains, but weakens, during the Aldrich-Vreeland era (June 1908-July 1914).[15] December remained the peak month for all rates and for the high-low spread, albeit at notably lower average rates throughout the year. As expected, by now, the seasonality disappears after the founding of the Federal Reserve System, however,

[15]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.

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 8). 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' and 'ruling' rates that affected the majority of call loans. The t-tests also demonstrate the lack of significance in the seasonality of call money rates during the Fed era. At the same time, the t-test for the high-low spread shows that the autumn months had lower average spreads than the other seasons, but the difference in means is a mere six basis points.

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 the liquidity backstop. Notably, even after the founding of the Fed, the seasonality of variance remains for the low and ruling rates and for the high-low spread. Only the variance of the high rate loses its seasonality during the latter period.

5.2 Time series tests

We can also identify recurring predictable seasonal changes in the data in continuous time. Removing seasonality from the data makes it easier to observe changes in the trend of the series as well as changes in the seasonality itself over time. I filter the data for seasonality using the built-in Eviews X-12-ARIMA. This method was developed by the United States Census Bureau and allows us to decompose the series into a seasonally adjusted series, a trend-cycle, and the seasonal fluctuations.[16]

Since seasonal effects are not necessarily fixed and may evolve over time, the advantage of using X-12-ARIMA 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.

The ARIMA analysis of the seasonal factor in interest rates and the high-low rate spread on a continuous basis reinforces the previous results. Seasonality clearly diminished in 1908 and virtually disappeared after World War I. The first chart shows the continuous model covering the entire period, so it smooths transitions (Figure 6). 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.

For a closer look at the three monetary policy regimes, I break the data into the three periods (Figure 7) and run the ARIMA procedure on the sub-periods. The results highlight the striking reduction in the seasonal factor at 1908 and again after 1914. These tests indicate that the high rates 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 than most. Notably, the seasonal factor is most elevated in 1907; the year of the greatest financial panic of the era. Here again, the seasonal factor for intra-day high-low spread breaks primarily after 1907, with

[16]For a detailed discussion of X-12-ARIMA, see Findley et al. (1998).

little visible seasonality thereafter. More detailed graphs of each rate and the high-low rate spread appear in the appendix.

The seasonality graphs also show a lower level of seasonality in the first years of the century. To explore that pattern, I run the same seasonal filter on the monthly data for the NY call market and on the weekly series for the London call money market back to 1890. The results (figures 8 and 9) indicate that seasonality rose substantially over the latter 1890s and first years of the 1900s. The years just preceding the Panic of 1907 clearly experienced an unusual height of seasonality, although changes are obviously smoothed by the ARIMA procedure. London, by contrast follows a more consistent pattern of mild seasonality with little change over time and no break around 1907-08. Since that data series ends in 1914, we cannot compare that series to the NY series through the founding of the Federal Reserve.

6 A First Look at 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.[17] 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) gathered volume data for 1919-21, and the Fed reports weekly call loan volume data for 1917 onward in its 1941 compilation of monetary statistics. I have coded the printed data and present preliminary results here (Figure 10).

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 10). 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 corresponding 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 of the data. 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 11). This pattern highlights the importance of liquidity in the overnight lending market for the smooth functioning of the stock market. In ongoing work, I am gathering and analyzing a more extended series of volumes in order to provide a statistical test of the correlation. 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. In order to give a first glimpse, I have coded 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 12, two panels). From the weekly data, we can see the

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

volatility of credit spreads during the 1920-21 mini-depression and the 1929 financial crisis. The monthly data runs longer but dampens volatility. Still, we can see that credit spreads varied tremendously throughout the period until the early 1930s.

Call money commanded a premium over Fed discounts following World War I until the 1929 crash, but not during the initial few wartime years of the Fed's operation, nor following the crash. If Griffiss was correct about the failure of the Fed to elicit the development of an attractive discount market for many years, then these patterns in credit spreads make sense. Stock market speculation 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.

7 Conclusion

This paper offers a new and much more detailed view of the impact of US monetary policy regime change based on the first daily series of interest rates on call money at the New York Stock Exchange. Using this novel data set, the analysis pinpoints more precisely the structural shifts in the level and volatility of nominal interest rates, as well as the seasonality of those rates, during the first three decades of the 20^{th} century. I find that call money rates dropped suddenly and became significantly less volatile and less seasonal in the middle of January 1908, which obviously precedes the founding of the Federal Reserve System by more than six years. Past work, by contrast, has depended on pre-existing average monthly interest rate series, which drastically dampens the effects of brief, transitory shocks to the money markets. Thus, past work has struggled to identify a robust statistical measure of structural change and has tended to focus on other factors relating to US engagement in World War I.

In this paper, I return the focus to monetary policy regime change and the impact of financial crisis on the expectations of participants in money and financial markets. The newly-identified structural shift took place less than three months after the Panic of 1907, which jolted into action both the leaders of the banking and financial sector and the US Congress. This new energy for a solution to the widely-recognized problem of severe, episodic "monetary stringency" under the existing regime (the National Banking Era) led to generalized expectations of a new era of monetary policy. The New York Times, among other periodicals, began reporting on the nascent discussions in late November, 1907 and reported on key a 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. The public and financial market participants could be sure from that point that a formal, centralized liquidity backstop was imminent.

The passage of the Aldrich-Vreeland Act on May 30, 1908 surely added the final level of certainty that insured ongoing money market liquidity, however, 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, 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 cycles. The first major test of the system came with the closure of the NYSE due to the start of WWI on July 31st, 1914. The money market almost by definition 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 provided the necessary backstop to infuse the banking system with liquidity and prevent a more serious financial crisis.

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 seem to have prevented the call money market from playing its own active role in propagating or exacerbating financial panics. In light of the analysis here, the Fed foundation looks more like a continuation of the Aldrich-Vreeland liquidity backstop and less like an additional regime change of its own. The Federal Reserve System did provide alternative short-term investment opportunities for banks, but few banks adopted them until the Great Depression. The analysis here therefore supports the contemporary view that considered the transition to the new Federal Reserve system a gradual one, rather than the more recent, anachronistic interpretations that see a sudden structural change.

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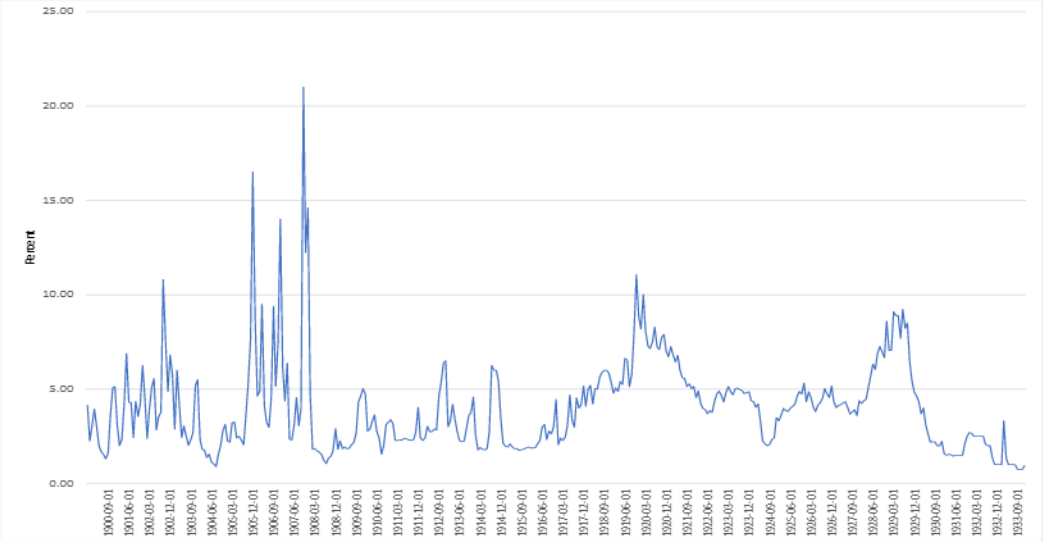
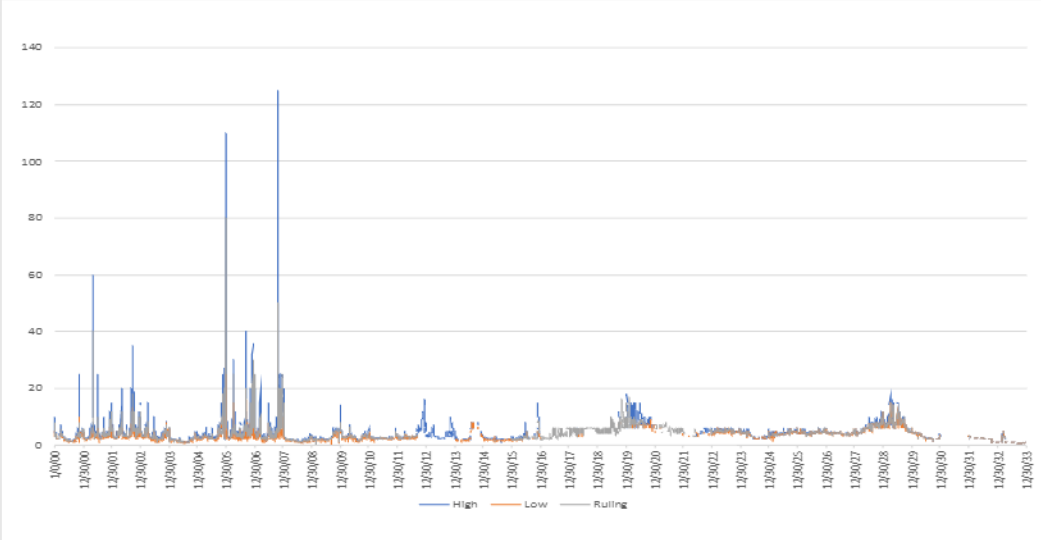
Figure 1: Call Loan Rate, Monthly 1900-1933



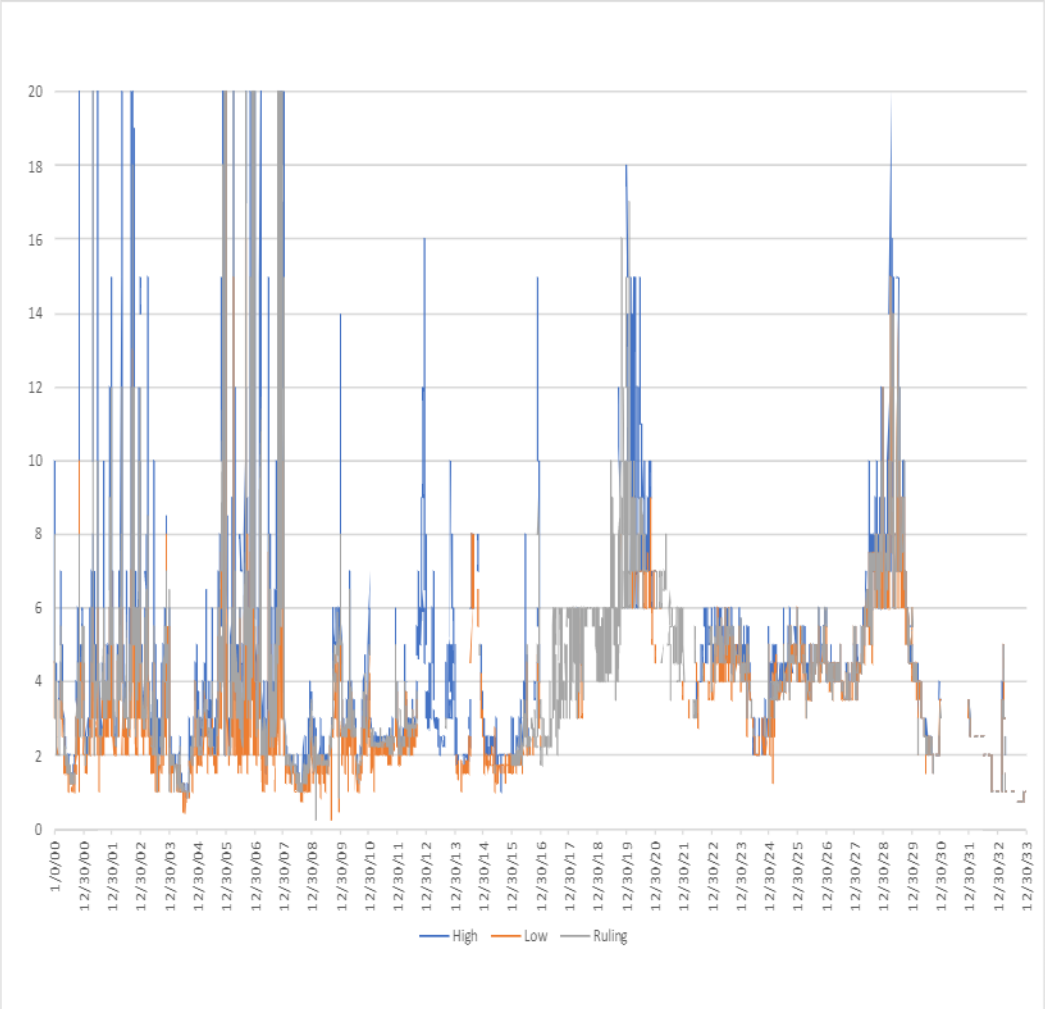
Source: NBER (via FRED)

Figure 2: Call Money Rates, Daily 1900-1933



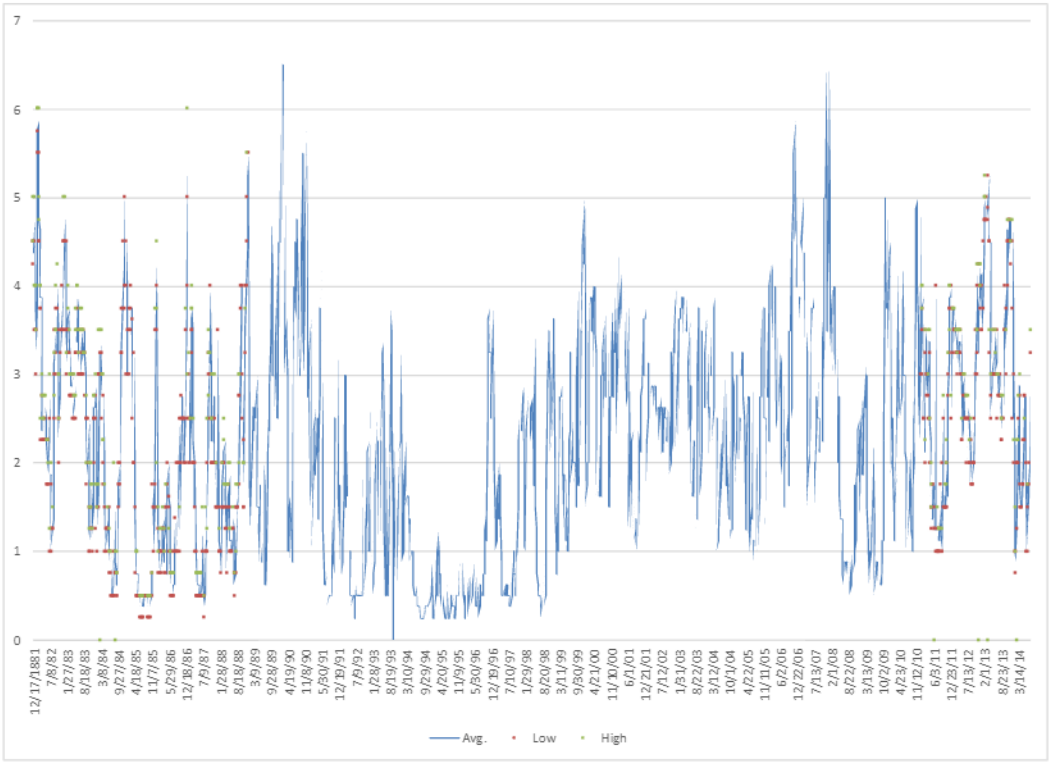
Source: data manually collected from The New York Tribune (1900-22), via Library of Congress, and The Wall Street Journal (1923-33), via Proquest. See discussion in text.

Figure 3: Call Money Rates, Daily 1900-1933



Source: data manually collected from The New York Tribune (1900-22), via Library of Congress, and The Wall Street Journal (1923-33), via Proquest.
Note: This graph depicts a truncated x-axis (20 percent max) to allow better observation of the underlying patterns over time.

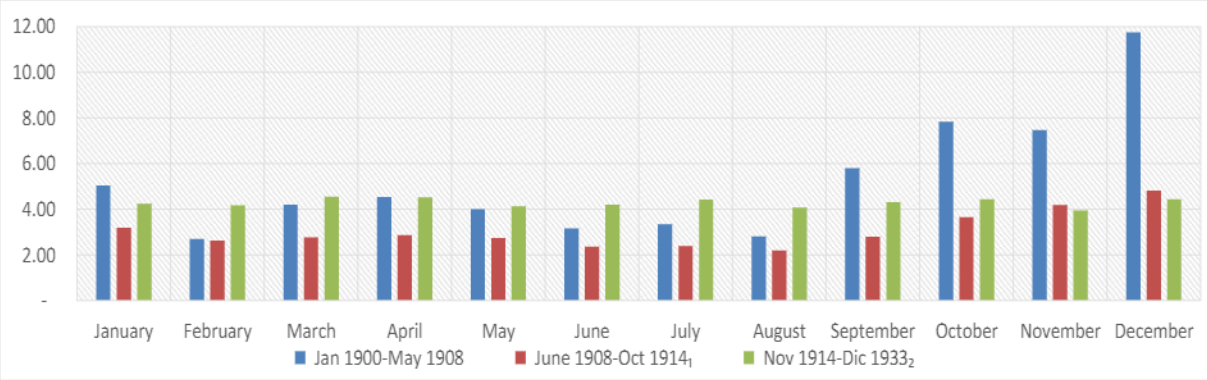
Figure 4: London Call Money Rate (weekly, 1881-1914)



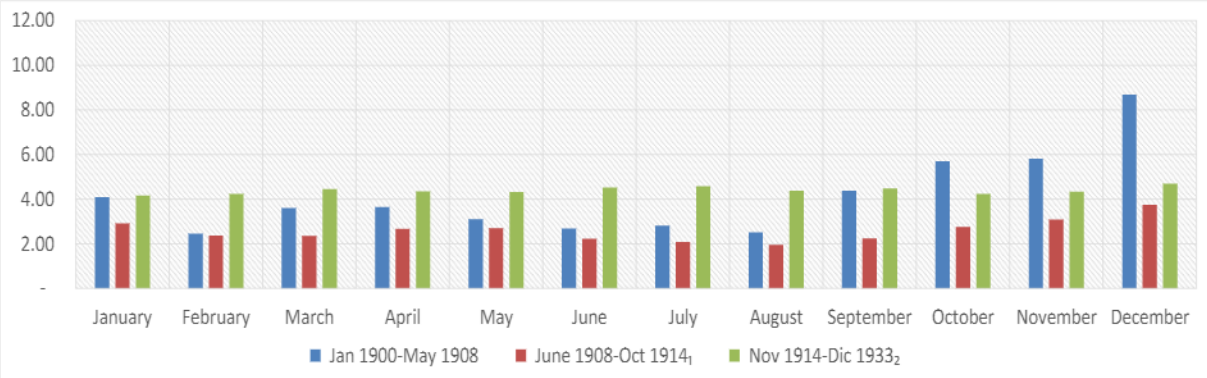
Source: Ugolini

Figure 5: Call Rates By Month

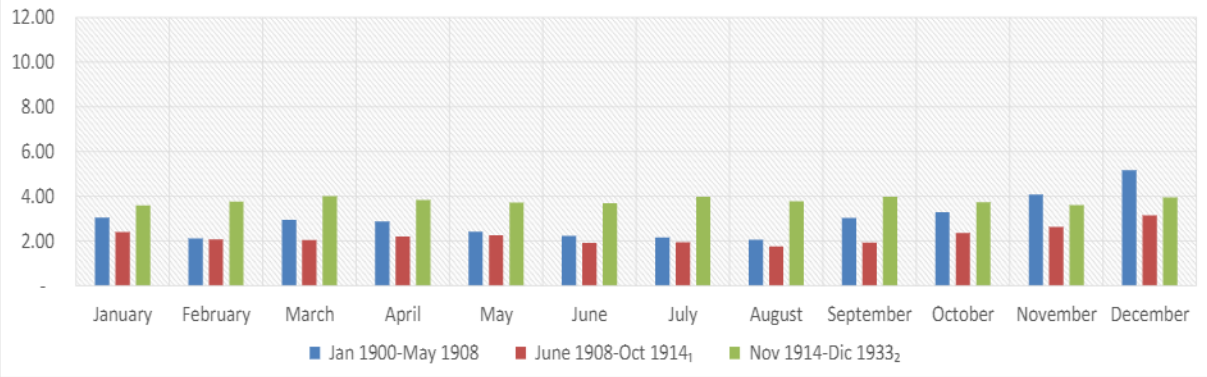
(a) Mean High Rate



(b) Mean Low Rate



(c) Mean Ruling Rate



(d) Mean High-Low

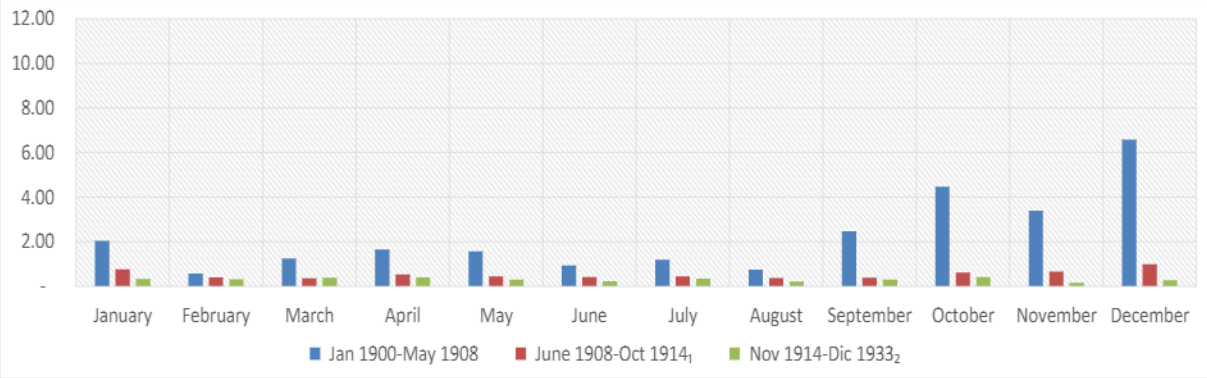


Figure 6: Seasonal Factor in High, Low, and Ruling Rates on New York Call Money, 1900-1933 (continuous)

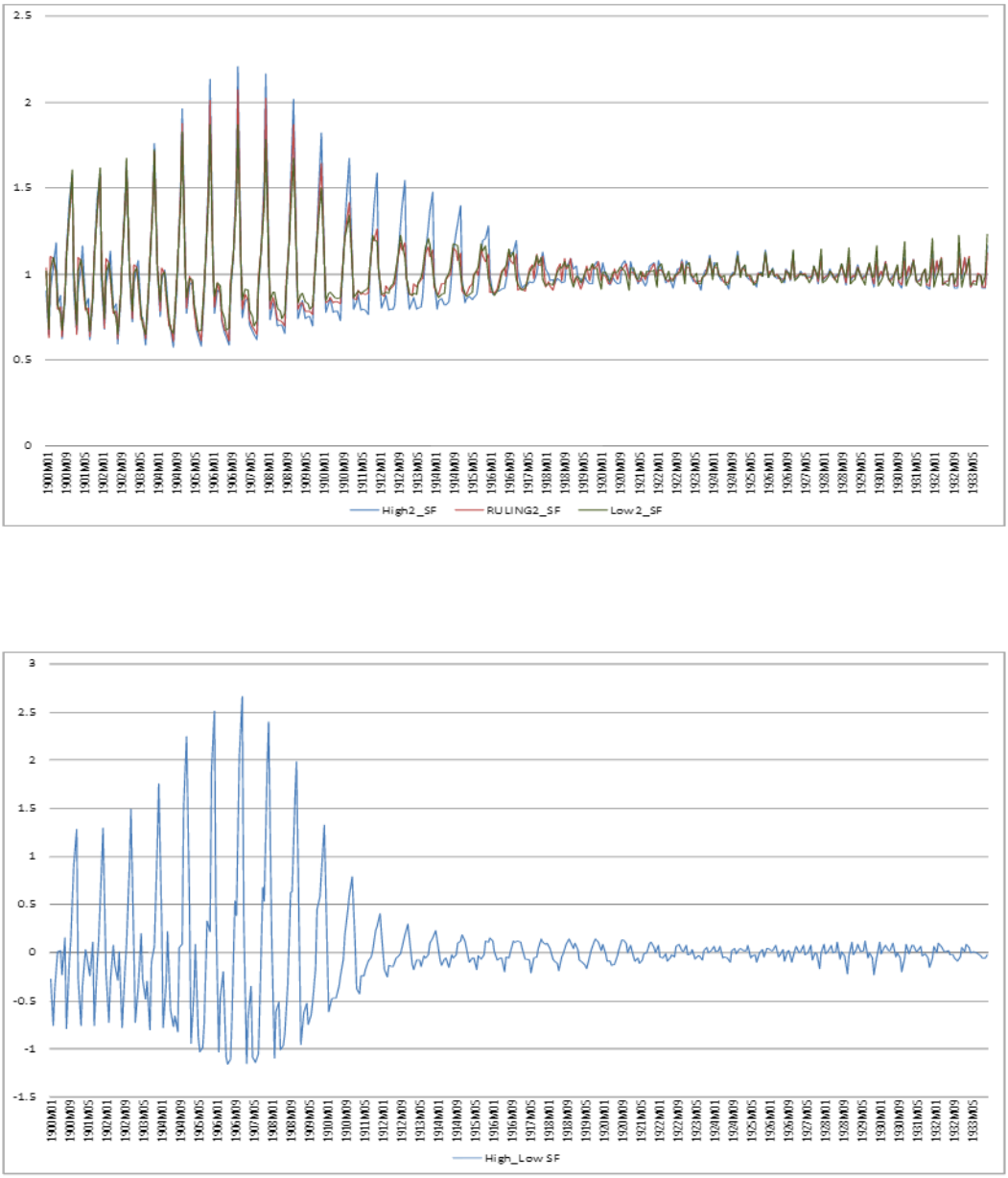
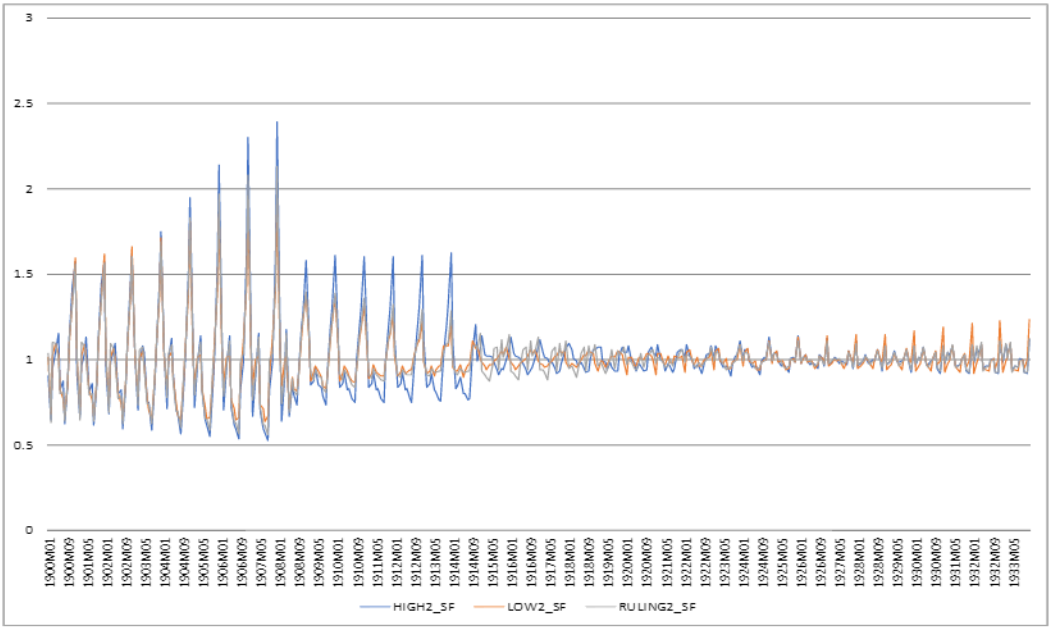


Figure 7: Seasonal Factor in High, Low, and Ruling Rates on New York Call Money, 1900-1933 (by sub-period)

(a)



(b)

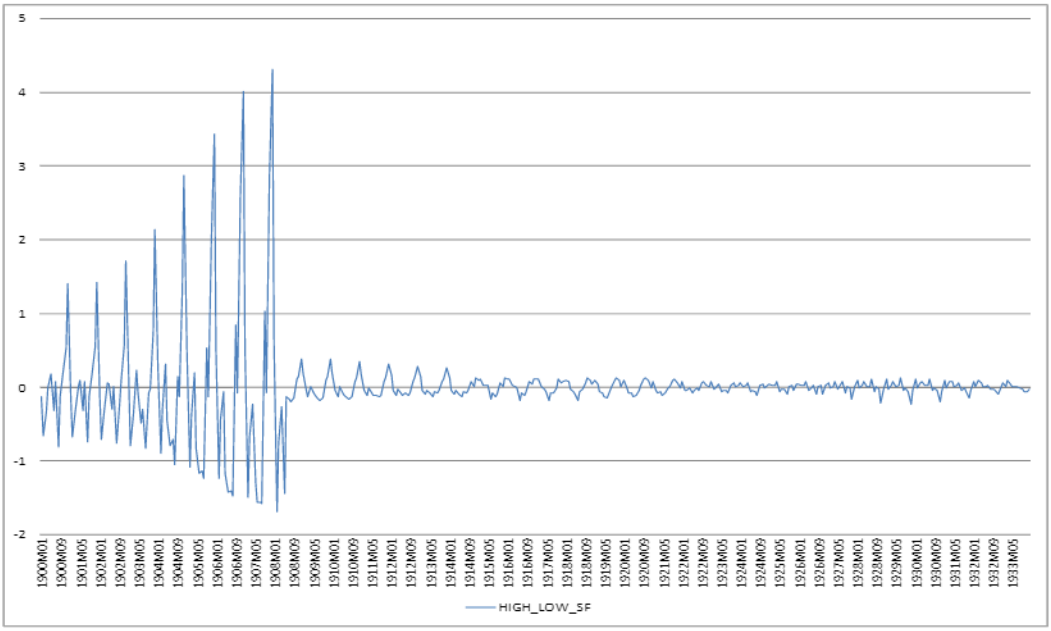
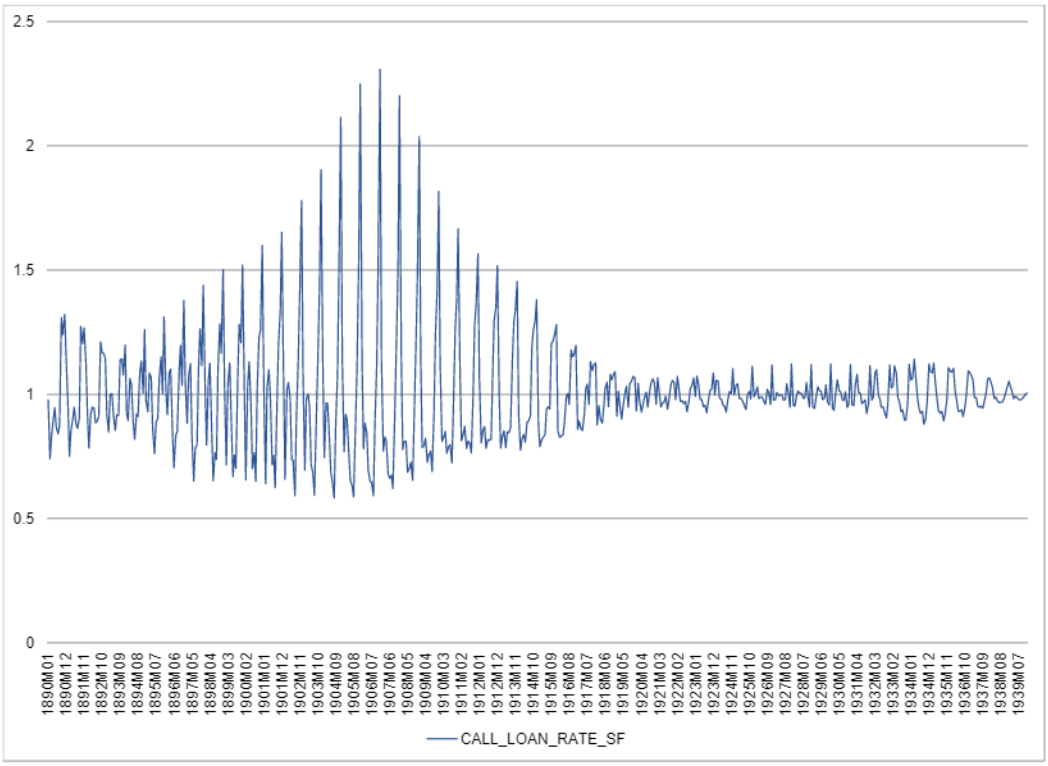
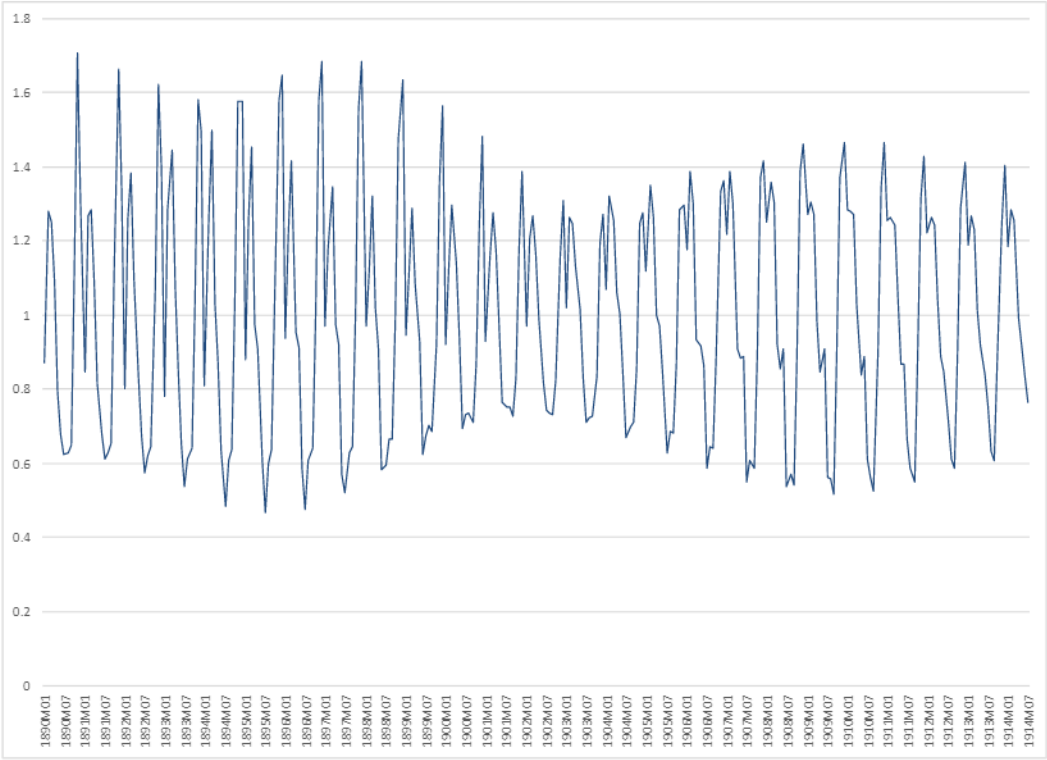


Figure 8: Call Loan Rate Seasonality (monthly, New York, 1890-1939)



Source: Banking and Monetary Statistics

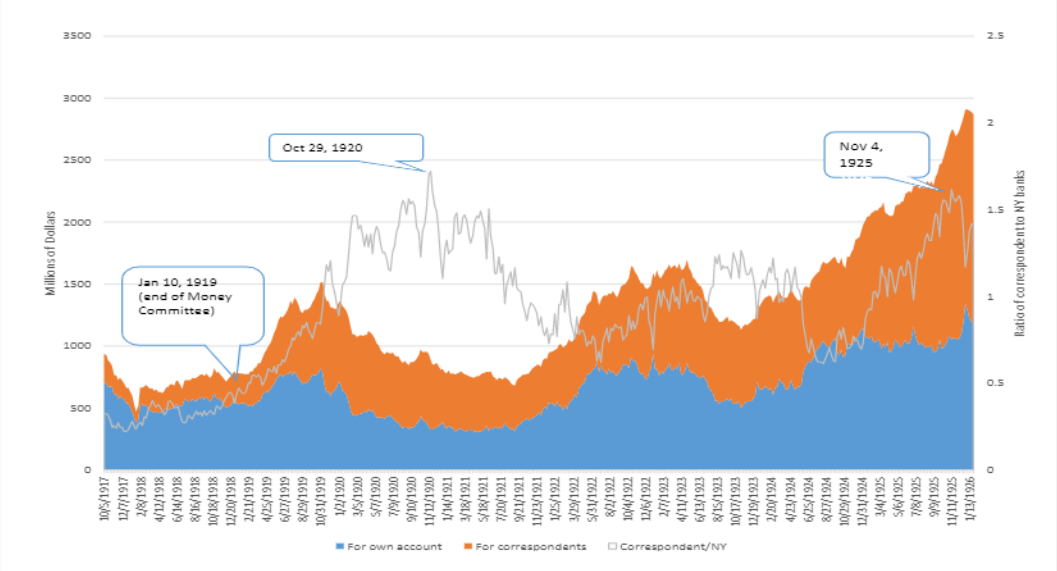
Figure 9: Call loan Seasonality (London, 1890-1914)



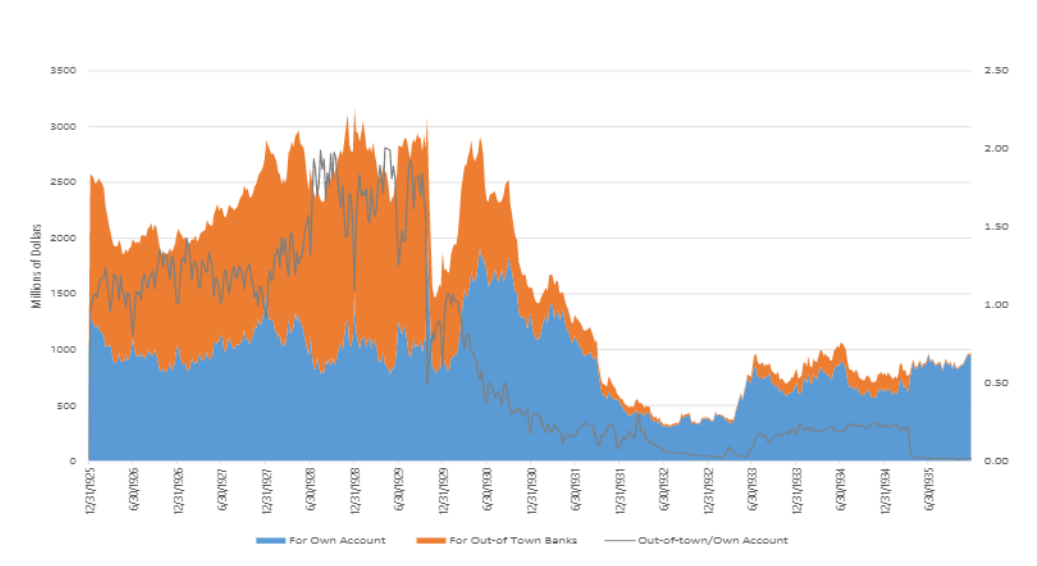
Source: Ugolini

Figure 10

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

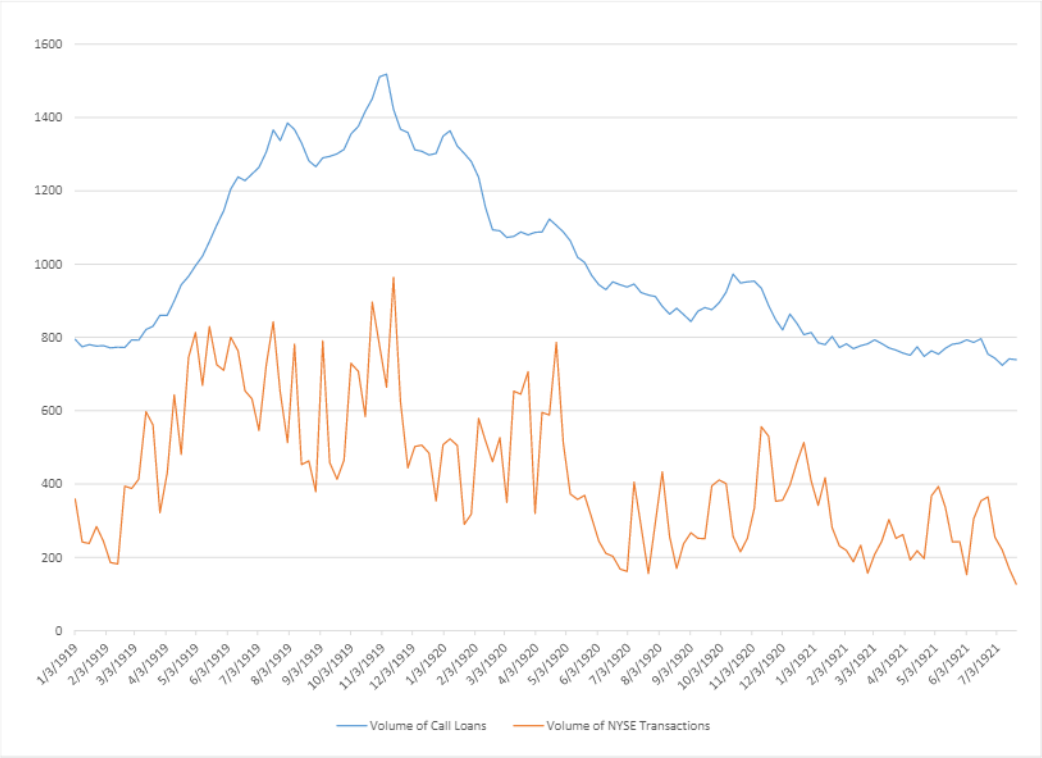


(b) Broker (Call) Loan Volume, 1926-35



Source: 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

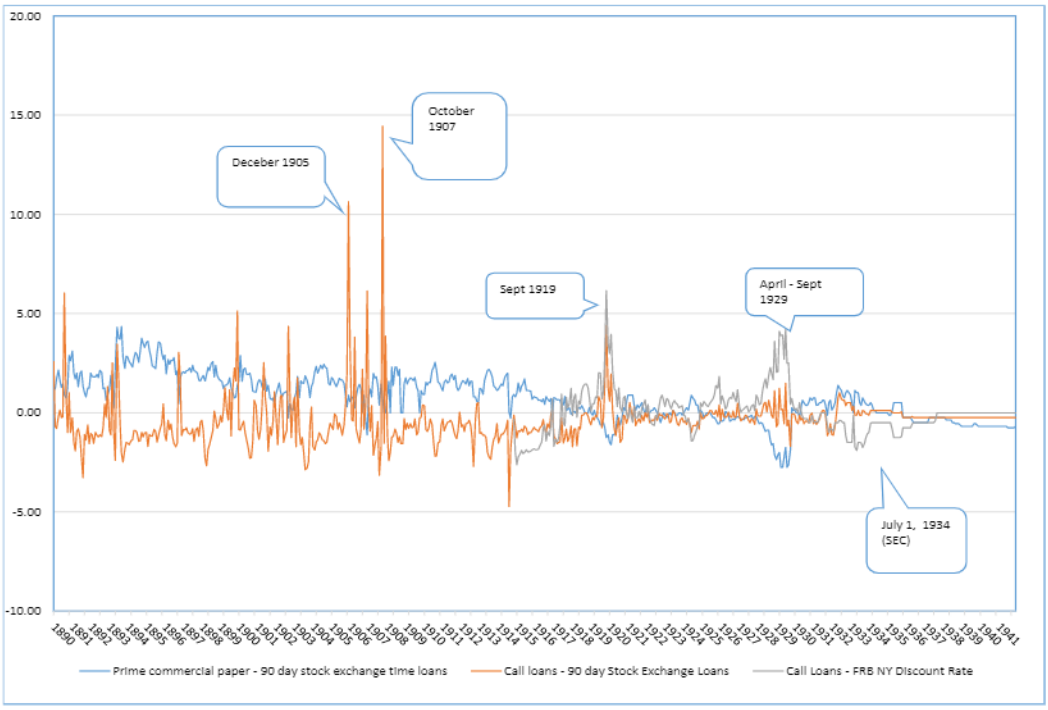
Figure 11: Call Loan and NYSE Trading Volumes 1919-1921



Source: Griffiss (1923)

Figure 12: Credit Spreads

(a) Monthly, 1890-1941



(b) Weekly, 1919-38

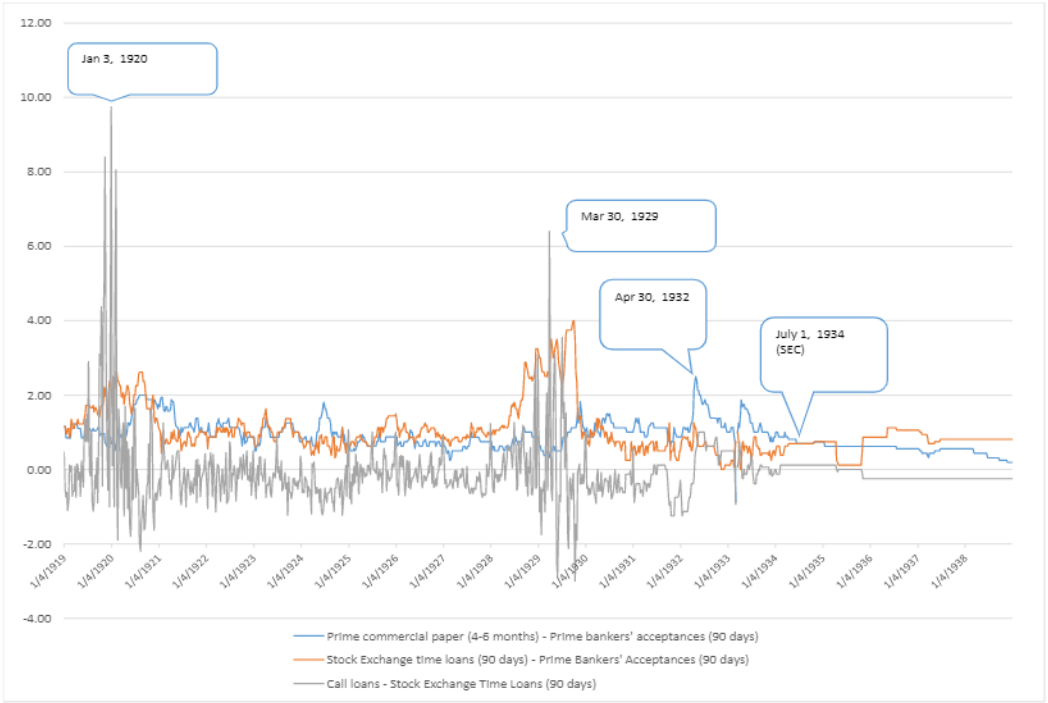


Figure 12a-Table 120
Figure 12b-Table 121

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)
Fisher 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)	Aldrich-Vreeland Act (May 1908).
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 2: Descriptive Statistics for New York Call Money Rates, 1900-33 (Daily)

	National Banking Era	Aldrich-Vreeland Era	Market closure	Fed Era Excluding Money Committee	Money Committee
	Jan 1900 - May 1908	Jun 1908 - Jul 1914	Aug 1914 - 11 Dec 1914	12 Dec 1914 - Dec 1933	5 Sep 1917 - 10 Jan 1919
High Rates					
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
Low Rates					
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
Ruling Rates					
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	0.88
Highest	80.00	8.00	5.00	17.00	6.00
Lowest	0.88	0.25	4.63	0.75	3.00
High-Low Rates					
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	0.00	0.00	0.00	0.00	0.50

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

Table 2 (cont.)

Panel B: Equality of Means and Variance Tests (Excluding market closure and Money Committee periods)

	National Banking Era	Aldrich-Vreeland Era	Means T-Test	Variance F-Test	P-Value
High					
Mean	5.18	3.02	-11.18		0
Variance	7.45	1.47		25.62	0
Low					
Mean	2.93	2.18	-13.51		0
Variance	1.82	0.77		5.58	0
Ruling					
Mean	4.06	2.56	-11.35		0
Variance	4.42	0.97		20.86	0
High-Low					
Mean	2.22	0.52	-9.07		0
Variance	6.44	0.49		170.13	0
High					
Mean	4.29	3.02	18.12		0
Variance	2.54	1.47		2.98	0
Low					
Mean	3.80	2.18	27.32		0
Variance	1.98	0.77		6.61	0
Ruling					
Mean	4.39	2.56	26.39		0
Variance	2.28	0.97		5.59	0
High-Low					
Mean	0.33	0.52	-9.09		0
Variance	0.64	0.49		1.71	0
High					
Mean	4.29	5.18	-6.09		0
Variance	2.54	7.45		8.59	0
Low					
Mean	3.80	2.93	15.8		0
Variance	1.98	1.82		1.18	0
Ruling					
Mean	4.39	4.06	3.76		0.0002
Variance	2.28	4.42		3.73	0
High-Low					
Mean	0.33	2.22	-15.79		0
Variance	0.64	6.44		99.23	0

Note: P-value greater than 0.05, averages or variance of two groups are significantly similar.

Table 3: Estimated Bai-Perron Structural Breaks in Call Money Rates

Estimated Bai-Perron (2003) Structural Breaks in Call Money Rates 1900-1933
(Without closure and without money committee)

Part A. Globally determined breaks test results

High		
Breaks	SupF	Dates
1	6.26	1/14/1908
2*	24.24	1/16/1908, 11/22/1916
3*	24.35	3/14/1904, 3/05/1908, 11/22/1916
Udmax*	24.34703	
Wdmax*	38.21074	
Obs	6,655	
Low		
Breaks	SupF	Dates
1*	64.99	10/06/1919
2*	39.47	10/06/1919, 12/12/1928
3*	72.92	1/16/1908, 10/06/1919, 12/12/1928
Udmax*	72.92	
Wdmax*	104.98	
Obs	6,265	
Ruling		
Breaks	SupF	Dates
1	5.08	8/31/1917
2*	27.67	1/18/1908, 6/01/1917
3*	31.88	1/18/1908, 6/06/1917, 4/03/1924
Udmax*	31.88	
Wdmax*	56.27	
Obs	6,820	

Part B. Sequential Breaks Test results

Low		
Breaks	SupF	Dates
0 vs 1*	64.99	10/6/1919
1 vs 2*	121.32	1/16/1908
2 vs 3	8.23	
Obs	6,265	

* Significant at the 0.05 level.

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.

Table 4: Estimated Bai-Perron (2003) Structural Breaks in High - Low Rates Spread Period 1900-1933

(Without NYSE closure and without money committee)

Part A. Globally determined breaks test results		
High - Low		
Breaks	SupF	Dates
1*	16.17	1/14/1908
2*	26.54	5/11/1904, 1/24/1908
3*	37.58	5/11/1904, 1/24/1908, 4/21/1920
Udmax*	53.96	
Wdmax*	99.42	
Obs	6,180	

Part B. Sequential breaks Test results		
High-Low		
Breaks	SupF	Dates
0 vs 1*	16.17	1/14/1908
1 vs 2*	66.00	4/21/1920
2 vs 3	3.14	
Obs	6,180	

* Significant at the 0.05 level.

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.

Table 5: Estimated Bai-Perron (2003) Structural Breaks in Call Money Rates, 1908-1917

(Without closure and without money committee)

Part A. Globally determined breaks test results		
High		
Breaks	SupF	Dates
1*	77.48	9/14/1909
2*	48.05	9/14/1909, 1/08/1914
3*	32.42	9/14/1909, 9/04/1912, 1/07/1914
Udmax*	77.48164	
Wdmax*	77.48164	
Obs	1,952	
Low		
Breaks	SupF	Dates
1*	128.21	8/10/1909
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	1,606	
Ruling		
Breaks	SupF	Dates
1*	61.69	9/1/1909
2*	40.09	9/08/1909, 7/14/1910
3*	28.43	9/09/1909, 7/15/1910, 6/06/1916
Udmax*	61.69	
Wdmax*	61.69	
Obs	1,642	

* Significant at the 0.05 level.

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.

Table 5 (Cont.)

Part B. Sequential breaks Test results

High		
Breaks	SupF	Dates
0 vs 1*	77.48	9/14/1909
1 vs 2*	72.06	1/8/1914
2 vs 3*	14.42	9/4/1912
3 vs 4	0.34	
Obs	1,952	
Low		
Breaks	SupF	Dates
0 vs 1*	128.21	8/10/1909
1 vs 2*	46.54	8/1/1910
2 vs 3*	21.39	1/20/1914
3 vs 4	4.85	
Obs	1,606	
Ruling		
Breaks	SupF	Dates
0 vs 1*	61.69	9/1/1909
1 vs 2*	14.51	7/7/1910
2 vs 3	5.75	
Obs	1,642	

* Significant at the 0.05 level.

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.

Table 6: Estimated Bai-Perron (2003) Structural Breaks in New York prime commercial, call loan, 1890-1941

Part A. Globally determined breaks test results		
Long Period 1890M01 1941M12		
Breaks	SupF	Dates
1*	71.12	1918M05
2*	54.42	1898M09, 1918M07
3*	48.16	1899M01, 1908M01, 1918M05
Udmax*	71.12366	
Wdmax*	71.77424	
Obs	618	
Short Period 1900M01 1933M12		
Breaks	SupF	Dates
1*	30.17993	1918M07
2*	28.32924	1908M01, 1918M05
3*	17.44783	1905M01, 1910M07, 1918M05
Udmax*	30.17993	
Wdmax*	33.66549	
Obs	402	

Part B. Sequential breaks Test results		
Long Period 1890M01 1941M12		
Breaks	SupF	Dates
0 vs 1*	71.12	1918M05
1 vs 2	10.10	
Obs	618	
Short Period 1900M01 1933M12		
Breaks	SupF	Dates
0 vs 1*	30.18	1918M07
1 vs 2	1.53	
Obs	402	

* Significant at the 0.05 level.

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.

Table 7: Estimated Bai-Perron (2003) Structural Breaks in London Call Money Rates, 1899-1914

Part A. Globally determined breaks test results		
Sample: 12/30/1899 8/01/1914		
Breaks	SupF	Dates
1	1.59	12/02/1911
2	4.40	4/04/1908,11/25/1911
3	5.60	1/20/1906, 4/04/1908, 11/25/1911
Udmax*	6.98	
Wdmax*	12.00	
Obs	762	

Part B. Sequential breaks Test results		
Sample 12/30/1899 8/01/1914		
Breaks	SupF	Dates
0 vs. 1	1.59	12/02/1911
Obs	762	

* Significant at the 0.05 level.

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.

Table 8: Seasonality and Monetary Policy Regimes

Periods	**Jan 1900-May 1908**		**June 1908-July 1914**		**Dec 1914-Dec 1933**	
	Sep - Dec	Jan - Aug	Sep - Dec	Jan - Aug	Sep - Dec	Jan - Aug
High						
Mean	8.22	3.79	3.86	2.64	4.25	4.29
P-value	0.00		0.00		0.65	
Ratio of Variance	9.42		4.36		0.96	
P-Value	0.00		0.00		0.45	
Low						
Mean	3.88	2.51	2.51	2.06	3.81	3.79
P-value	0.00		0.00		0.83	
Ratio of Variance	3.03		2.46		1.18	
P-Value	0.00		0.00		0.00	
Ruling						
Mean	6.13	3.14	2.92	2.38	4.34	4.28
P-value	0.00		0.00		0.48	
Ratio of Variance	9.21		2.24		1.13	
P-Value	0.00		0.00		0.02	
High-Low						
Mean	4.27	1.28	0.67	0.46	0.26	0.32
P-value	0.00		0.00		0.01	
Ratio of Variance	13.41		1.32		0.49	
P-Value	0.00		0.00		0.00	

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).

Table 9: Structural Breaks in Credit Spread (Call loans - Prime Commercial Papers)

Part A. Globally determined breaks test results		
Long Period 1890M01 1941M12		
Breaks	SupF	Dates
1*	71.12	1918M05
2*	54.42	1898M09, 1918M07
3*	48.16	1899M01, 1908M01, 1918M05
Udmax*	71.1237	
Wdmax*	71.7742	
Obs	618	
Short Period 1900M01 1933M12		
Breaks	SupF	Dates
1*	30.1799	1918M07
2*	28.3292	1908M01, 1918M05
3*	17.4478	1905M01, 1910M07, 1918M05
Udmax*	30.1799	
Wdmax*	33.6655	
Obs	402	

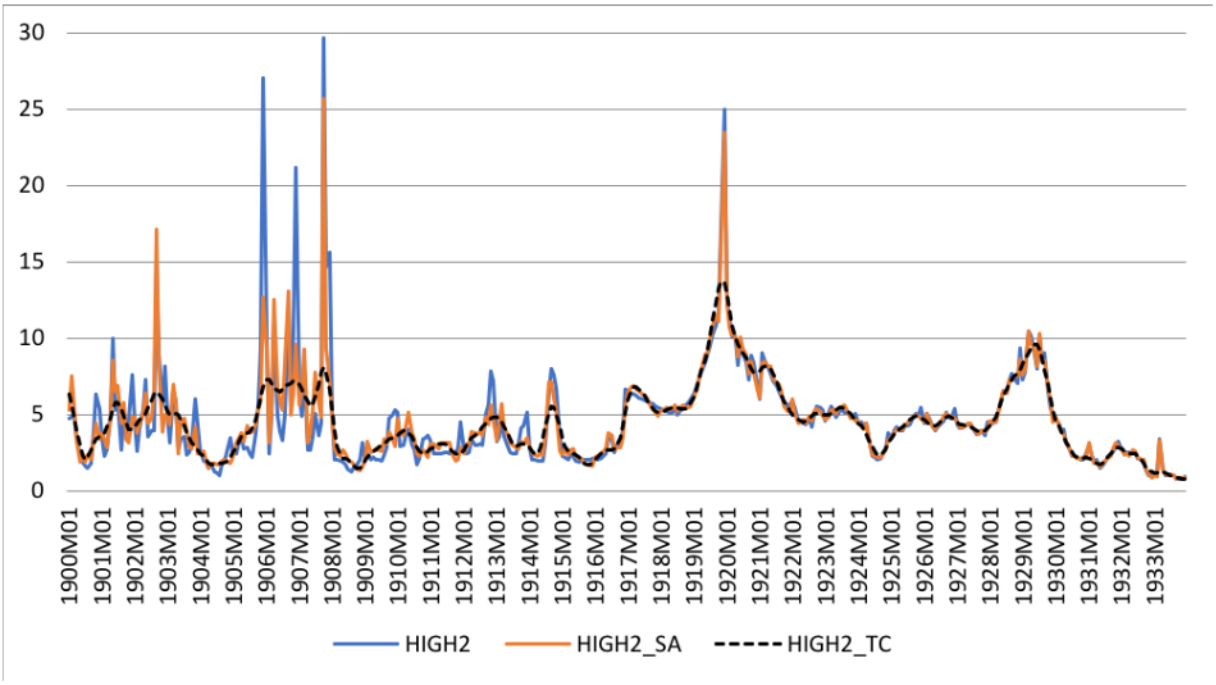
Part B. Sequential breaks Test results		
Long Period 1890M01 1941M12		
Breaks	SupF	Dates
0 vs 1*	71.12	1918M05
1 vs 2	10.10	
Obs	618	
Short Period 1900M01 1933M12		
Breaks	SupF	Dates
0 vs 1*	30.18	1918M07
1 vs 2	1.53	
Obs	402	

* Significant at the 0.05 level.

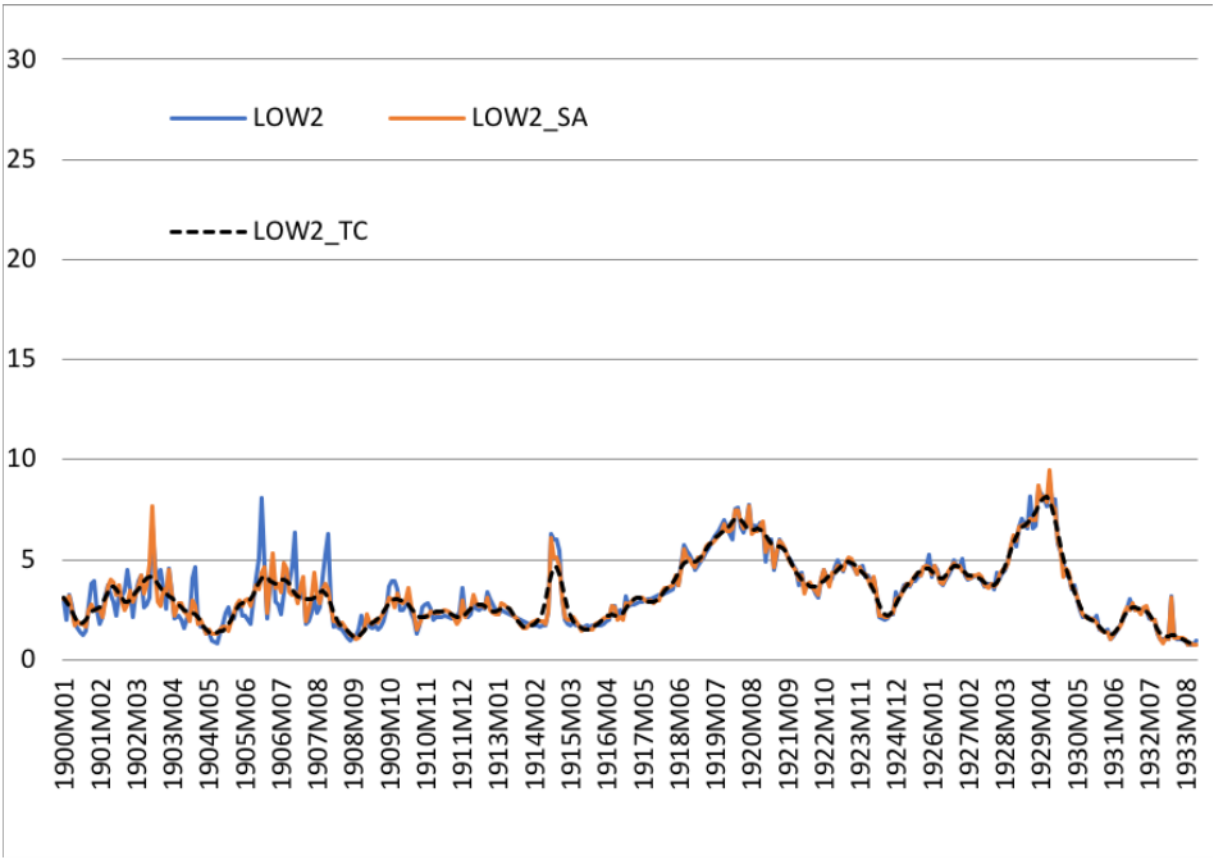
Note: Test uses trimming of 15%. Test statistics employ HAC covariances constructed with Prewhitening with 1 lag g, Quadratic-Spectral kernel and Andrews bandwidth, following Bai-Perron (2003). The test assumes common data distribution.

Appendix A: Supplemental Tables and Figures

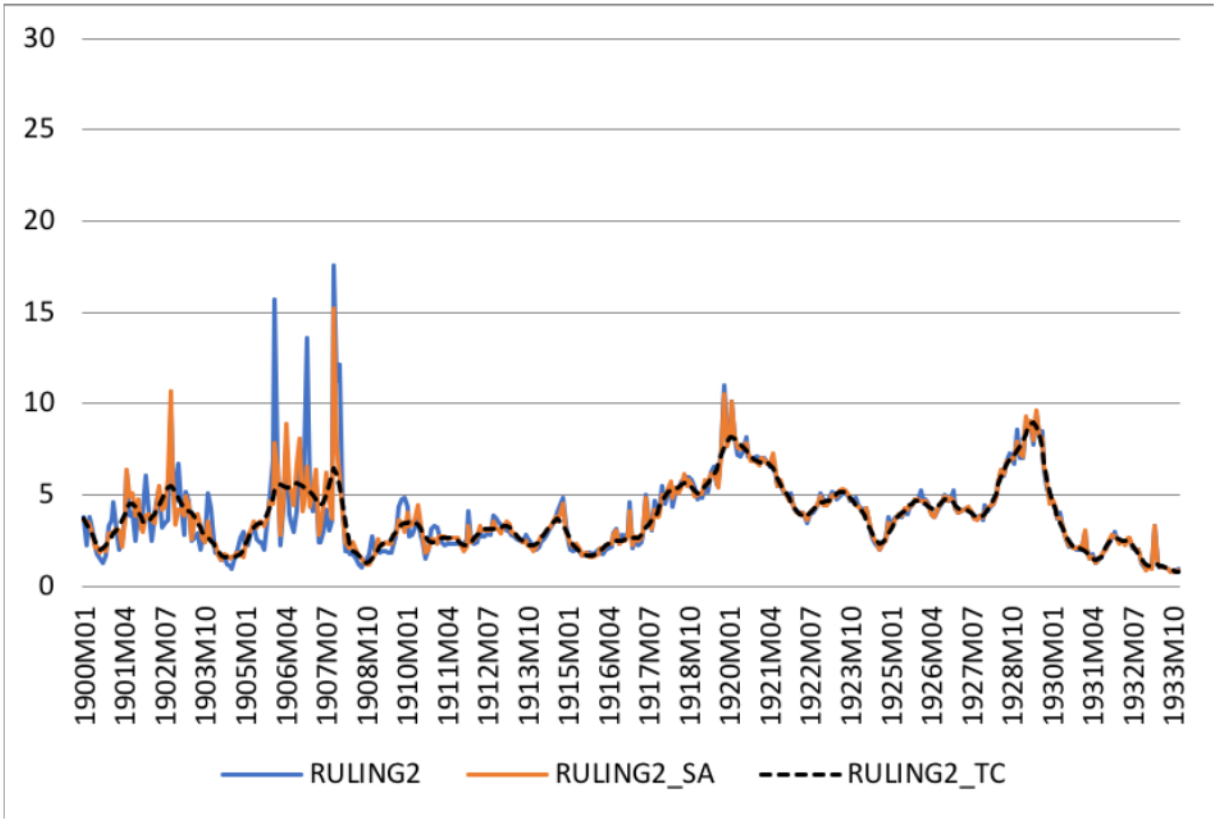
Trend and Seasonal Factors in Call Money High Rate, 1900-33



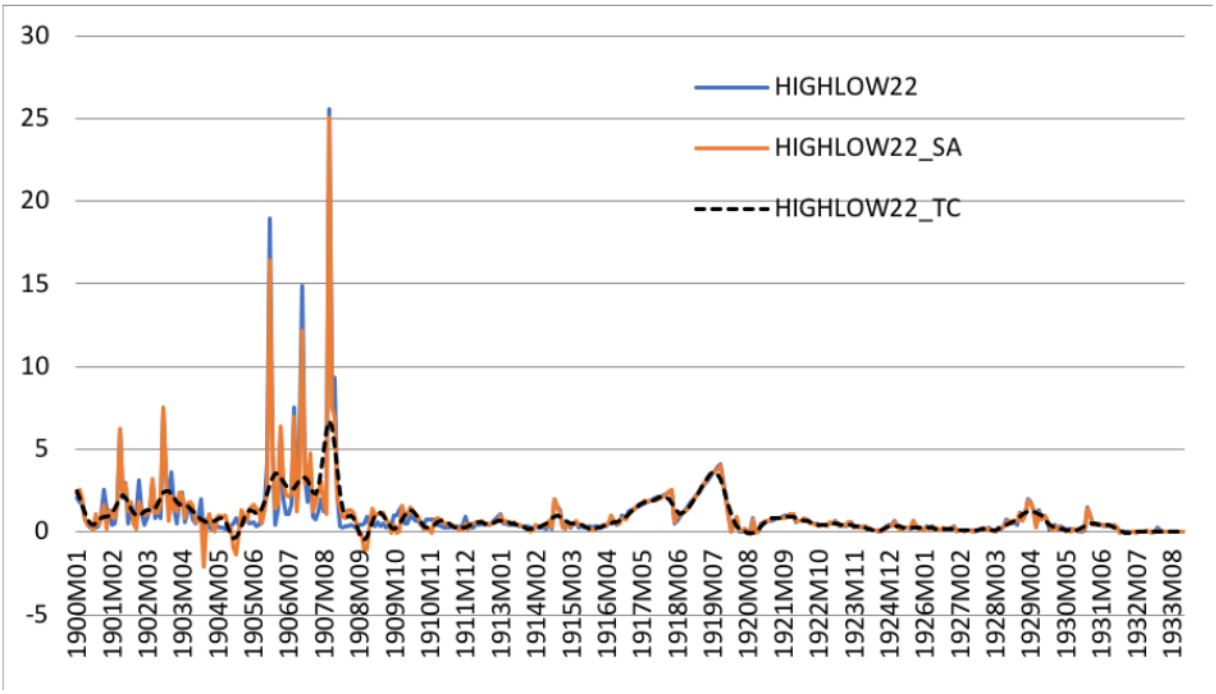
Trend and Seasonal Factors in Call Money Low Rate, 1900-33



Trend and Seasonal Factors in Call Money Ruling Rate, 1900-33



Trend and Seasonal Factors in Call Money High-Low Spread, 1900-33



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)		

Appendix B: Unit Root Test for Structural Break

Following Caporale (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, we use 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.