working paper

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The Transmission of the Financial Crisis in 1907: An Empirical Investigation

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FEDERAL RESERVE BANK OF CLEVELAND

Working Paper 14-09 September 2014

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Using an extensive high-frequency data set, we investigate the transmission of financial crisis specifically focusing on the Panic of 1907, the final severe panic of the National Banking Era (1863-1913). We trace the transmission of the crisis from New York City trust companies to the New York City national banks through direct and indirect interconnections. Trust companies held cash balances at national banks, and these balances were liquidated as trust companies suffered depositor runs. Secondly, trust companies and national banks were notable creditors to the New York Stock Exchange; when trusts were suffering runs, the call loan market on the stock exchange seized. The crisis spread to the interior banks after the New York Clearing House banks restricted the convertibility of deposits into cash. Bond returns were sharply negative in the two weeks following the suspension. We highlight commonalities between the Panic of 1907 and the financial crisis of 2007-2009.

JEL Codes: E44, G01, N11, N21.

Keywords: Banking panic, asset price, asset volatility, correlation risk, correspondent banking.

Suggested citation: Moen, Jon R., and Ellis W. Tallman, 2014. "The Transmission of the Financial Crisis in 1907: An Empirical Investigation," Federal Reserve Bank of Cleveland, working paper no. 14-09.

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I Introduction

The Panic of 1907 received renewed attention following the 2007-2009 financial crisis and the analysis by scholars, both financial historians as well as financial economists, draws parallels between the events despite the century that separates them. Both crises focused on New York City financial intermediaries -- the trust companies in 1907 and the investment banks in 2007-09. In each case, the stricken intermediaries had only indirect (and apparently unreliable) access to the liquidity provision services of the relevant lender of last resort -- the New York Clearing House in 1907 and the Federal Reserve System in 2007-09.

In this paper, we investigate the transmission of financial distress from the proximate trigger -- the run on deposits held at New York City trust companies --- to the banks in New York City, to wider New York financial market, then to the entire United States. The financial crisis among New York City trust companies initially affected the call loan market and New York Stock Exchange in October of 1907 and the effects spread to the larger bond market.[1] To trace the transmission of financial distress, we use data on a monthly, weekly, and daily frequency to isolate financial markets responses that reflect distress mainly from specific events. For example, we first look at the failed attempt by F. Augustus Heinze and Charles W. Morse to corner the stock of United Copper, an event closely associated with the subsequent panic. For several days, the distress appeared limited to those banks and stock brokers (and the copper stock) involved in the corner attempt. Initial efforts by the New York Clearing House limited the impact from the shock on the member financial institutions that were associated with Heinze and

[1] The subsequent spread into the broader financial markets and to the rest of the country set the stage for the global impact transmitted through large-scale imports of gold into the United States, which transmitted the crisis to financial markets throughout the world. We are presently pursuing that transmission path to global financial markets in a separate paper.

Morse. But then the panic spread beyond that limited group, leading to an extended run on trust companies in New York City, which were not members of the New York Clearing House.

We define a financial panic as a widespread run on deposits from intermediaries coupled with an increase in perceived risk across a spectrum of assets. We make the concepts operational by measuring the volatility of stock returns and of a simple bond price index. Further, we investigate the degree to which financial asset returns displayed unusual correlations during the crisis, namely, that both stock and bond returns moved notably negative. We also investigate whether there were periods other than those of crisis that displayed high correlation of returns; the empirical results indicate few non-panic periods display large negative returns to both bonds and stocks. October 1907 is the only period that displays a sequence of three consecutive weeks with substantial losses in both the bond and stock indexes over the period 1900-1908.

Our empirical focus highlights the presentation and analysis of measures of financial distress. Our results confirm the conventional view that the Banking Panic of 1907 was sparked by the suspension of the Knickerbocker Trust Company, after which trust companies throughout New York City became subject to runs on deposits. The panic focused on trust companies largely because the New York Clearing House chose to let Knickerbocker Trust suspend, in contrast to the aid provided by the Clearing House to Heinze banks in the week before the panic. The suspension of Knickerbocker Trust apparently had an immediate effect on the call money interest rate, which spiked toward 50 percent at an annual rate on the day of the suspension. Trust companies played an active and well-known role in the call loan market both by providing call loan financing and more uniquely by offering uncollateralized overnight bridge loans to purchase stock on credit before the collateral could be transferred to collateralize call loans at any financial institution. The effects of the Knickerbocker suspension on stock market and call loan market activity are therefore not surprising. But the transmission of the Banking Panic of 1907 to the financial market more generally, and the rest of the country (and rest of the world) reflected more factors than the trust company runs. Despite the initial distress on the stock market, the panic had only minor effects on the interior of the United States or on international markets until the New York Clearing House imposed a suspension of convertibility of deposits into currency on October 26.[2] Recent work by James, McAndrew, and Weiman (2013) shows that suspensions of convertibility were costly and our evidence is consistent with that view.

Our investigation using high-frequency data from the Panic of 1907 was inspired by recent inquiries into the financial crisis of 2007-2009. Specifically, we find a paper by Gorton and Metrick (2012) that investigates the transmission of recent financial crisis to be particularly useful. Gorton and Metrick examine how the co-movement of risk spreads indicated a "systemic event," one that began as a shock in the subprime mortgage market, but one that soon was transmitted throughout the financial system. Thus, in their analysis, an initial disturbance to the financial markets arising from a small sub-market can influence and eventually envelop the entire financial market. Their econometric analysis uncovers a path through which a shock to subprime mortgage asset valuations spread to other areas of financial investment through the workings of the financial market.

In our investigation, contemporary observers of the financial markets in 1907 considered the initial shock – the failed attempt to corner a copper stock -- as small. But subsequent events accumulated into a panic. The liquidity crisis in New York City was reflected in financial markets by sharp increases in the call money interest rate and the declines in the value of stocks as well as key high-quality bond issues; the crisis spread as normal market mechanisms to adjust to the stress were restricted, which magnified liquidity demands and motivated large-scale asset

[2] The New York Clearing House also agreed to issue clearing house loan certificates on this date.

sales to increase cash assets. Specifically, the suspension of convertibility generated a currency premium, a market price for the scarce good, cash.[3] The premium on currency made imports of gold from abroad highly profitable at commonly observed exchange rates.[4]

We also find that the issuance of clearing house loan certificates offered only a modest, yet crucial, reduction in financial distress. The temporary liquidity infusions from clearing house loan certificates is associated with a lowering of the call loan interest rate from its peak levels, but the rates were still largely elevated. The issues did not end the crisis; this observation is likely a reflection of legal prohibition on their passing to the public as hand-to-hand currency and the possible ineffective redistribution of legal tender and specie among the New York Clearing House member institutions.[5]

Symptoms of financial distress across markets in the United States disappeared only after the convertibility resumed, the amount of cash reserves in New York Clearing House banks was no longer in deficit (relative to required reserves), and currency premium was eliminated. At that point, the New York Clearing House banks accelerated the cancellation of their outstanding clearing house loan certificates, and financial market asset values stabilized.

II Analogies to the Financial Crisis of 2007-2009

A series of studies by Gary Gorton (2008; 2009; 2010; 2012) highlights common characteristics of the recent financial crisis and the sequence of crises that took place throughout

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[3] At that point, the exchange rate between cash and bank deposits became a market price.

[4] Rich(1987) emphasizes the culpability of the U.S. as the source of worldwide financial distress in 1907 by draining gold away from key European financial markets. The shipment of gold out of the European money centers (London, Paris and Berlin) and toward New York City in November and December 1907 transmitted the panic from the United States to Europe.

[5] Elmus Wicker (2000, 2005) emphasizes the absence of "reserve pooling" or "reserve equalization" in National Banking Era panics following 1873. In his opinion, the combination of reserve pooling and clearing house loan certificates was far more successful at alleviating crisis conditions arising from extreme liquidity demands.

the National Banking Era (1863-1913). Gorton argues that the recent crisis was, in fact, a panic similar to the financial crises in the United States a century ago. We follow up on this assertion and provide further detail highlighting institutional and financial similarities between the Panic of 1907 and the financial crisis of 2007-2009.

A. Common themes in 1907 and 2008

A key feature of the Panic of 1907 was that panic-related withdrawals centered on New York City trust companies rather than on national banks. The Mercantile National Bank, an institution that was part of the Heinze-Morse-Thomas banking chain, along with National Bank of North America, New Amsterdam National Bank, and Mechanics' and Traders' Bank (a state-chartered member of the New York Clearing House) were subject to runs by their depositors following the collapse of the Heinze copper corner attempt. But there was no widespread attempt to remove deposits from New York City national banks that were not implicated in the scheme. Reassurances from the New York Clearing House regarding the solvency of its member institutions (Mercantile National was emphasized most prominently) settled the depositors sufficiently so that the banks could operate effectively, although with notable credit support from the New York Clearing House. The support included loans from the New York Clearing House, and those loans were eventually exchanged into clearing house loan certificates, one of the benefits of membership in the clearing house association.

"Panic-related" withdrawals separates the onset of the financial panic, a widespread attempt to remove deposits from intermediaries generally, from what had been perceived as a transfer of deposits from weakened Heinze national banks toward stronger and more reliable banks. The efforts of the New York Clearing House to settle the financial situation required cooperation among its member institutions and decision-making by its executive committee. But a key element of those decisions was the information about the financial condition of its member institutions, and detailed examinations took place at those institutions prior to the decisions to aid them. That is not to say that there was no uncertainty about the outcome for the Mercantile National. The New York Sun (October 20, 1907 page 2) reported that in weekly reports, the cash balances of Mercantile National Bank were around 15 percent, far below the 25 percent minimum for central reserve city banks. Its debit balances at the New York Clearing House were reported to be $1.14 million (New York Times October 20, 1907). Perhaps in response to such numbers, the New York Clearing House had an equivocal response in its treatment of Mercantile National, when a clearing house representative expressed that the clearing house would not pay off the depositors of the Mercantile National Bank, and that the aid that was offered was temporary. However, on the following day, October 21, 1907, the New York Clearing House made a public announcement that the member banks (Mercantile National, National Bank of North America, and New Amsterdam National) were examined and deemed to be solvent.

One key difference between Mercantile National Bank and the Knickerbocker Trust Company was the relationship of each of these intermediaries to the New York Clearing House. The New York Clearing House was effectively the lender of last resort in the New York City financial market, and Knickerbocker had been intentionally isolated from it. In the same New York Times issue (October 22, 1907) that described the New York Clearing House announcement in support of member banks, another headline read "Knickerbocker Will Be Aided," and the article described clearly financial amounts allegedly committed to support it. There was public perception of a $15 million backstop fund to support Knickerbocker, but that amount turned out to be only $3 million, and it was not tapped at all prior to the suspension of the Knickerbocker Trust.[6] The distinction -- non-membership in the New York Clearing House -- likely affected how depositors treated the Knickerbocker Trust in light of uncertain funding assistance from the key liquidity providing institution.

We have not uncovered any unambiguous financial evidence to substantiate the allegations of insolvency of Knickerbocker Trust during the Panic of 1907. We have looked at the stock and bond investments of Knickerbocker Trust as of September 17, 1907 and noted three dubious investments that may be considered associated with Charles Morse's investments – American Ice (valued at nearly $600K), Consolidated Steamship ($85 K), and Mercantile National ($91K). The total value of these investments approaches 10 percent of Knickerbocker Trust's equity value, although the perceived losses were less than that total.[7]

Reasonable explanations for what spurred the depositor withdrawals from Knickerbocker Trust emphasize that the President of Knickerbocker Trust, Charles T. Barney, was associated with Charles Morse, a member of the Heinze group.[8] The run on Knickerbocker had reportedly begun as early as Friday, October 18, and the National Bank of Commerce had been extending credit to Knickerbocker Trust to cover those withdrawals. The debit balance of the National Bank of Commerce at the New York Clearing House on October 22, 1907 was reported to be $7 million, and was largely assumed to reflect its dealings for Knickerbocker.[9] For legal reasons, the National Bank of Commerce had an incentive to limit its exposure to Knickerbocker's possible suspension; as the clearing agent for Knickerbocker, the National Bank of Commerce would have no priority as a claimant to Knickerbocker assets if the trust suspended, and its assets

[6] New York Tribune, October 23, 1907, p. 1.
[7] A full examination of the value of Knickerbocker Trust during the crisis would require a separate paper.
[8] Barney was on the Board of Directors of the National Bank of North America and the Mercantile National Bank (See Bruner and Carr 2008). His involvement in any of the Heinze-Morse activities has not been proven. There were reports of Knickerbocker Trust having extensive investments in real estate (New York Sun, October 23, 1907 p. 2), although we have been so far unable to verify that claim. The irony for comparison to financial events of Fall 2008 is nonetheless worth mentioning.
[9] The New York Tribune on October 23, 1907, p. 1.

went into receivership.[10] Then, the National Bank of Commerce would have to wait in line for its payment as an ordinary depositor.[11] On October 21, 1907, the National Bank of Commerce announced that it would no longer act as clearing agent for the Knickerbocker Trust Company, and at this point, the runs on Knickerbocker took off.

The National Bank of Commerce had approached the New York Clearing House for a loan on the behalf of Knickerbocker Trust, but the request was denied and the denial noted specifically that the New York Clearing House retained its resources to aid its member institutions.[12] The Knickerbocker Trust was not aided and suspended on October 22, 1907 after depositors withdrew all its cash. Hanover National Bank presented the final check totaling $1.5 million to Knickerbocker Trust. The event spawned the full-scale financial crisis in New York City as we will examine further below.

Over a century later in March 2008, Bear Stearns faced a crisis of confidence from its over-night lenders, and the events that unfolded in the spring of 2008 eerily resembled those of 1907. Its lenders had monitored the financial condition of Bear Stearns closely for several months following the failure of two of its hedge funds, both of which invested heavily in mortgage-backed securities.[13] On March 14, 2008, the Federal Reserve System issued a $30 billion loan to JPMorgan-Chase, which could then arrange to buy Bear Stearns at $2 per share. Assets of Bear Stearns collateralized the loan. The Federal Reserve System received substantial criticism for this arrangement, which was perceived as an intervention by the Federal Reserve System in a market – investment banking – over which it has no supervisory or regulatory

[10] See Hansen (2013) and Tallman (2013) for further discussion of the change in banking law that prompted the action by the National Bank of Commerce.
[11] In a similar action, the New York Clearing House ordered the Mercantile National Bank to stop clearing for Hamilton Bank, a bank related to E.R. Thomas, to avoid potential losses from its possible suspension. The Hamilton Bank suspended October 24, 1907.
[12] Minutes of the New York Clearing House Committee, October 21, 1907.
[13] The two failed Bear Stearns hedge funds were named the High-Grade Structured Credit Fund(the "High Grade Fund") and the High-Grade Structured Credit Strategies Enhanced Leverage Fund (the "Enhanced Fund").

authority. Aside from this criticism, there were also concerns that the Federal Reserve System was engaging in fiscal action, although a letter from Secretary of the Treasury Paulson verifies that the Office of the Treasury was effectively in support of the action.

The Bear Stearns situation was stabilized by the loan from the Federal Reserve System (made through a member bank – JPMorgan-Chase). It is important to be clear that there were no private entities offering Bear Stearns credit on terms that were close to those offered by the Federal Reserve System. The Fed loan extension made when Bear Stearns was in extreme duress reflects "lender of last resort" role of the central bank, despite the fact that the investment bank was not in fact a Fed "member" institution. Despite that distinction, the actions taken with respect to Bear Stearns appears analogous to the Mercantile National Bank interactions with the New York Clearing House in October 1907. First, there was some perception that the institution under consideration had engaged in undesirable financial activities. Secondly, there was some equivocation on the part of the respective lenders of last resort (the Fed allegedly had originally planned to lend directly to Bear Stearns, but opted for an indirect loan through JPMorgan Chase). Thirdly, there was a perceived market relief that followed the announcement, giving the financial markets a short-term respite from financial distress.

The failure of Lehman Brothers in September 2008 and the suspension of Knickerbocker Trust in October 1907 share a dubious distinction – their demise marked the beginning of the most severe observations of financial crisis in their respective eras. Lehman Brothers' shaky financial condition was apparent from the time of the Bear Stearns collapse in March.[14] Although the summer had several important financial events, the announcement of the conservatorship of Fannie Mae (Federal National Mortgage Association) and Freddie Mac (Federal Home Loan Mortgage Company) on September 7, 2008 was likely the biggest shock to

[14] Wall Street Journal, "Bearish Bets Made on Lehman" March 18, 2008.

the financial market in the year up to that time. As the magnitude of the financial problems was becoming apparent, it was also perceived as unlikely that the Federal Reserve System would be able to enact an initiative with Lehman Brothers as it had with Bear Stearns; for one thing, the condition of banks and the financial market conditions in general were weaker in September and there were few candidate institutions capable of taking over Lehman Brothers, an institution much larger than Bear Stearns. Policymakers aimed at a market-based solution to the situation; Treasury Secretary Paulson was apparently unwilling to negotiate a bail out by the public sector, although there was sentiment to consider some kind of public support to facilitate a resolution.[15] Unfortunately, the negotiations for Barclays Bank to take over Lehman fell apart, and on September 15, 2008, Lehman Brothers filed for bankruptcy protection.

The similarities of the two instances highlight the dramatic effect of isolation from prospective support. As Knickerbocker Trust opened for business on October 22, 1907, it was not *known* that there was no support for it, but it was suspected and the depositors were ready to be wrong in that inference as long as their deposit funds were in their possession. For Lehman Brothers, the lack of a financial suitor forced the firm to seek bankruptcy protection, from which few observers thought that Lehman could recover. The financial losses to Lehman Brothers' creditors have been substantial, and the losses on Lehman commercial paper generated a run on money market mutual funds in general (and the failure of the Prime Reserve Fund).[16]

There were significant differences between the failures of Knickerbocker Trust in 1907 and Lehman Brothers in 2008. Among the most significant is the fact that Knickerbocker Trust was in suspension when it closed preventing depositors from any access to their deposits; it reopened in March 1908 following the infusion of $2.4 million in new capital. The capital

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[15] Stewart, James B., Eight Days, September 21, 2008, *The New Yorker*.
[16] See Dwyer and Tkac (2009) for an examination of the run on money market mutual funds.

infusion represented about 25 percent of the capital value at the time of suspension, but was about 4 percent of the total assets of the trust. In contrast, the remnants of Lehman Brothers have been purchased by a variety of firms around the world, Lehman's customers required nearly six years to receive their payments, and the net losses to Lehman creditors have not yet been accounted for completely.[17]

III What Usually Happened in National Banking Era Panics?

A familiar pattern of events took place during panics that occurred in the National Banking Era (1863-1913). The recognition of that pattern suggests that there are important similarities in the events that trigger a banking panic. Economists like Sprague (1910), Laughlin (1911), and Kemmerer (1910) attributed the financial crises or panics to the shortcomings of the existing National Banking System. The system had no reliable mechanism to expand quickly the base money supply in response to increased demand, and the inability of the system to expand credit (or ship cash) to interior banks sufficiently during the crop-moving season (autumn) was perceived as the main culprit of sparking banking panics. In more recent research, Miron (1986) describes the seasonal money movements in which country banks demand cash to the interior of the country to finance the shipment of grain during harvest season. These interior cash demands drain cash from the New York City money market.[18] The cash drain leads to a seasonal rise in New York City interest rates in the fall, which thereby attracts some of the cash that flowed to the interior back toward New York City. In a panic, those flows toward New York City do not occur, and in fact are reversed.

[17] Wall Street Journal, Financial Briefing Book, May 1, 2014.

[18] Goodhart (1969) emphasizes the balance of trade between New York City and the interior of the country, arguing that Sprague (1910), Kemmerer (1910), and Laughlin (1911) concentrate entirely on the capital flows.

A number of modern economists have focused on the panics of the National Banking Era (see, for example, Champ 2007, Calomiris and Gorton 1991, Gorton 1988, Donaldson 1992, and Wicker 2000). The analysis in Donaldson (1992) provides the closest parallels to our investigation, which arise from the close attention paid to the existing institutional structure and the use of high-frequency (weekly) data for empirical analysis.[19] Donaldson demonstrates that there appear to be different co-movements between interest rates and three key data series (bank reserves, bank deposits, and stock returns) during a panic. Donaldson's findings provide an interesting comparison with the work by Gorton (2008, 2009, 2010) on the recent financial crisis, in which the financial markets appear to behave differently as the panic ensues. Gorton (2009, 2010) argues that the conventional suspect, sub-prime mortgage backed assets, can explain the spark of the crisis but that the financial crisis widened as counter-party risk spread among financial market participants.

The seasonal pattern of money flows during the National Banking Era tended to produce upward spikes in New York City interest rates in the fall. When the interest rate spike was also accompanied by concerns about the solvency of the banking system, then the typical equilibrium response of interior banks leaving cash balances in New York City was disrupted. Muhleman (1908) emphasizes that the demands of interior (or country) banks for cash from New York City banks were largely responsible for the depletion of cash balances among New York Clearing House banks in 1907.[20] Chart 1 displays the seasonal pattern in net cash flows to New York City banks averaged over the years 1899-1908 versus the net cash flows observed in 1907. The divergence is striking -- the net cash outflow from New York City banks between late October

[19] Donaldson investigates whether panics were the result of the conventional "seasonal patterns" plus an external shock or whether they were a systematic event within the standard behavior of the economy.
[20] Sprague (1910) emphasizes similar points about the source of the cash drain.

and early December 1907 was three to four times the average outflow for those weeks from the previous eight years.

During banking panics, there was often an unusually large increase in the demand for cash, and the ratio of cash to bank deposits rose notably (cash rose and deposits fell). In the literature, it is referred to as "cash hoarding." Financial market volatility rose dramatically, and credit was typically unavailable. In the Panic of 1907, there were notable differences from earlier panics; for example, trust companies were struck with widespread runs on deposits, unlike national banks.[21] The drain of cash from New York City intermediaries and the lack of liquidity (or credit) on the call loan money market were the unambiguous signs of financial distress at the onset of the 1907 financial panic.[22] Chart 2 displays the seasonal pattern in call money interest rates averaged over the years 1899-1908 compared to the pattern observed in 1907. Again, the disruption in the financial market during 1907 is a striking divergence from a general pattern.

The New York Clearing House would typically take two actions to quell the drain of reserves from its member banks. First, it would issue clearing house loan certificates (CHLCs), which provided a temporary form of liquidity (near-reserves) because the certificates could be used to settle balances between member banks at the clearing house. The issues would be claims on the borrowing bank but the liabilities were effectively guaranteed payment by the membership of the New York Clearing House, and member acceptance of CHLCs as final payment in lieu of legal tender or specie was compulsory. Further, the New York Clearing House would manage and monitor the loans as well as intermediate the payment of interest on them. In order to take out CHLCs, a member bank would have to post collateral judged as acceptable by the Clearing House Loan Committee. In exchange, the bank posting collateral

[21] See Moen and Tallman (1992) for more analysis of how the Panic of 1907 was different.
[22] The description of a panic shares similarities with those of Wicker (2000), and Kindleberger (2005), and also fits with the general framework of asymmetric information as described by Calomiris and Gorton (1991).

would then receive certificates in the amount of no more than 75 percent of the perceived value of the collateral, although the 'haircut' varied.

The second action typically taken by the New York Clearing House was the imposition of a suspension of convertibility of deposits into cash, although there was an aversion to imposing suspension (See Sprague 1910, Wicker 2000, and Friedman and Schwartz 1963). Normally, these instances were partial suspensions, so that some currency would be available to depositors, but the idea of suspension was to limit the drain of cash reserves out of the banking system. Hence, the supply of cash would not match demand, and the standard fixed exchange rate (at par) between currency and deposits would be negated. The periods of suspension would also reflect this excess demand for cash with a currency premium. It is notable that the timing of the issuance of clearing house loan certificates and of the announcement of suspension were separate decisions in prior National Banking Era panics, while in 1907 they were made simultaneously.

IV A High Frequency Data Set for 1907

This paper employs high frequency data on clearing house loan certificate issues during the Panic of 1907 (see Appendices 1a and 1b). We have daily observations of clearing house loan certificate issues taken from the New York Clearing House designated by bank, by amount and on the specific date of issue. In addition, we have accumulated daily observations of call loan interest rates on the New York Stock Exchange (from various issues of the New York Times and the Commercial and Financial Chronicle) and we use estimates of the premium on currency in New York City as collected by Andrew (1908). As additional financial market indicators, we employ an index of daily stock returns (G. William Schwert 1990), and derive from it a measure of stock market volatility.

Some data series that are important for our inquiry are unavailable on a daily basis, as far as we have been able to determine so far.[23] As a result, we supplement our analysis of daily data with data recorded on a weekly and on a monthly frequency. For series that span several panic time periods, the series show similarities across panic observations (in some situations for some data series) and also expose some features that distinguish the Panic of 1907 from earlier National Banking Era panics. For the weekly data, we have all the series described above as daily data (clearing house loan certificate issues, stock returns, and stock volatility), along with weekly net gold inflows during the panic. We also have accumulated the data on weekly aggregates of New York Clearing House banks (deposits, loans and reserves; a subset of Donaldson 1992) and a selection of weekly bond prices (from Andrew 1910) that we form into a bond price index. We calculate a bond price volatility index from the bond price index.

IV How the Panic Spread: the Call Loan Market and clearing house loan certificates

Our evidence points toward a conventional conclusion that the Banking Panic of 1907 began in earnest with the suspension of the Knickerbocker Trust Company on October 22, 1907. Signals of stress arose in specific financial markets in New York City before this date, and such an observation is unsurprising. The failure of the Heinze-Morse banking chain in its attempt to corner the stock of United Copper on October 16, 1907 created notable unease among participants in the call loan market and the stock market.[24] But these initial reactions were, though notable relative to the previous several years of data, modest in comparison to the

[23] We refer to banking aggregates and daily transactions between banks. Some relevant data may be acquired from the ledger books of the New York Clearing House. The ledger books are available at the Columbia University Rare Manuscripts Library, and provide information regarding end of day net balances position between member banks and the New York Clearing House.

[24] Wicker (2000) provides an extensive investigation into the key events that preceded the Panic of 1907.

observations during previous financial panics and especially relative to the panic that was to unfold in the next week.

The Heinze-Morse banks – National Bank of North America, Mercantile National Bank, New Amsterdam National Bank, and Merchants and Trader's Bank – were national banks and were members of the New York Clearing House. In those cases, the New York Clearing House took pre-emptive action that prevented extensive runs on the associated banks in the week before the panic. During our examination of clearing house loan certificates issues, we found that the New York Clearing House issued loans approaching $10 million to these banks (with appropriately discounted collateral) during the week before the run on Knickerbocker Trust.[25] So it appears that even before the Federal Reserve System, the private clearing house played the role of lender of last resort, even to misbehaving (member) banks. The New York Clearing House also made public statements reaffirming the decision to support these banks. These actions prevented widespread liquidation of deposits from those banks. This observation is an important contrast to the lack of such actions in response to the problems that arose at the Knickerbocker Trust company. The rumored connection of the Knickerbocker Trust with the Heinze-Morse corner attempt led to the notorious run on Knickerbocker, which may have begun as early as Friday, October 19, 1907 (Carosso 1987: 535).

Among the first financial indicators to reveal the stress of the panic was the call loan interest rate. Chart 3 displays the daily call loan interest rate estimates that we have compiled. The slight increase in the week of October 14th would look more significant in the absence of the spike of the following week. Following the suspension of Knickerbocker Trust on Tuesday, October 22, 1907, depositor runs in New York City focused mainly on trust companies. Three

[25] Once the New York Clearing House announced clearing house loan certificate issues on October 26, 1907, the loans were accumulated among the clearing house loan certificate issues.

characteristic elements hindered the New York City financial markets as a consequence. Firstly, the runs on trust companies forced those institutions to liquidate reserve deposit balances held with New York City national banks (approved reserve depositories), which placed those important New York Clearing House banks into the cash drain. Secondly, it was widely reported that trust companies participated actively in, and in support of, the call loan market. Demandable loans like call loans were considered secondary reserves -- the reserve assets to liquidate for cash in order to satisfy extreme cash demands from depositor. Trust companies stricken with widespread depositor withdrawals (runs) would likely be forced to liquidate these loans (call loans and uncollateralized bridge loans). The apparent distress on the call loan market likely arose from these two sources of credit contraction (both arising from runs at trust companies). Thirdly, the notable contraction in credit on the call loan market produced a dramatic upward spike in the call loan interest rate observed immediately following the Knickerbocker Trust suspension.

The *New York Times* reported that the call loan rate on October 22 reached a high of 70 percent[26], with most transactions taking place at between 40 and 50 percent (*New York Times, Financial Markets*, October 23, 1907). As a gauge of financial distress on the stock market, the call loan interest rate illustrates the sharp rise in short-term loan funding costs on stock collateral, and indicates the impact of the Knickerbocker Trust suspension on anticipated credit availability in New York City. If nothing else, the spike in call loan interest rates heightened the degree of financial market unease reflecting the lack of cash liquidity on the stock exchange. *The Commercial and Financial Chronicle* published the call loan rate at which the majority of loans were contracted during the week of October 21, 1907. The call loan rate hovered at nearly 50 percent for most of that week, with repeated observations of transactions taking place at interest

[26] Annual percentage rate.

rates of 50 percent. Clearly, the drain of cash from the New York City financial market and hence liquidity from the financial system arose largely from the runs on trust companies during that week. Although the crisis was focused on trusts, the panic-driven runs were having a substantial impact on call loan market liquidity. At this point, however, the Panic of 1907 was primarily a New York City event.

The New York Clearing House actions in the case of the Heinze-Morse national banks during the week of October 14 stemmed the nascent runs on deposits, preventing noticeable financial distress. The clearing house inaction with respect towards the Knickerbocker Trust led to cash drains from interconnected New York City intermediaries, liquidity shortages on the call loan market, and distress within the stock market. The question arises whether the initial panic-based runs on trust companies and the related distress on the call loan market was sufficient to generate a liquidity shortage or heightened risk perceptions in other financial markets.

Sprague (1910) provides detailed descriptions of transactions and cash movements between trusts and banks, between New York Clearing House banks and interior banks, and between the clearing house loan committee and banks. His descriptions outline the relationships that represent the conventional explanation of the Panic of 1907. The withdrawals described in Sprague (1910), using aggregate information on weekly cash flows to and from New York City banks, suggest that the suspension of Knickerbocker may have prompted withdrawals of cash by interior banks from New York City national banks motivated in much the same way that Knickerbocker Trust depositors -- things may work out fine, but it will be better to have my cash "just in case" things do not work out. Sprague (1910, p. 258) emphasizes that requests for cash from the interior banks did not arise in response to the Heinze banking difficulties. If interior banks responded to the panic-related runs on trust companies, the suspension of Knickerbocker Trust and the related financial distress seems likely to be the proximate "source" of the crisis.

The contemporary descriptions in daily and weekly periodicals describe an anticipated drain of cash reserves from New York Clearing House banks (mainly the large national banks) and toward their depositors (sometimes banks as depositors) in the interior of the country. These reserve deposits were reportedly among the first to be liquidated in a crisis, and the news of the Knickerbocker Trust suspension and the stock market distress in New York City apparently increased concern among interior bankers. Prior experience during panics, especially the relatively recent 1893 panic, influenced the behavior of bankers in the interior of the country, especially if those bankers held a significant portion of their reserves at national banks in New York City. The New York City national banks were perceived as unresponsive to the needs of interior bankers in 1893, and the interior bankers viewed their deposits held in New York City banks as effectively unavailable to them once the New York Clearing House declared a partial suspension of payments. In that circumstance during the Panic of 1893, interior bankers were left with insufficient cash during a crisis, and one that uncharacteristically focused on interior banks. In contrast, the Panic of 1907 centered in New York City, and the crisis focused predominantly on trust companies, although as mentioned above, the ramifications of credit contraction arising from the runs on trust companies affected the key central financial market – the call loan market.

The developments on the New York Stock Exchange on Thursday, October 24, 1907 reflect the tenuous nature of credit available to stock market participants through the call loan market (see Carr and Bruner 2007, Sprague 1910, and Tallman and Moen 1990). The central fact for our purposes is that the call loan money market lacked adequate liquidity to offer credit to the New York Stock Exchange, and that the New York Clearing House members, the United States Treasury, and major industrial leaders united to address that liquidity shortage.[27] The temporary solution provided funding that would satisfy the market for a short-time was understood by the participants. Descriptions of the Friday, October 25 market conditions emphasized the fragile nature of the call loan market. In response to an eventful week, the New York Clearing House met on Saturday, October 26, 1907 and announced the formation of a clearing house loan committee that would oversee the issuance of clearing house loan certificates. At the same meeting, it was also agreed that the New York Clearing House members would impose a restriction of convertibility of deposits into cash (or "partial suspension").

With some ambiguity regarding its timing, a genuine hoarding of cash outside the banking system began following the announcement of the suspension of convertibility. On a weekly basis, there is evidence of a consistent outflow of cash and a requisite contraction of net deposits within New York Clearing House banks throughout November and December of 1907. Haugen (1932: 22) shows that an aggregate measure of New York City trust company deposits at other intermediaries (most likely, New York Clearing House member banks) contracted by $30 million from August 22 to December 19, 1907. Drains of cash from New York Clearing House national banks arising from trust company and interior bank depositor banks contributed further to the contraction of credit on the New York Stock Exchange. Chart 4 displays the reserve balance (surplus or deficit) among New York Clearing House banks versus the issuance of clearing house loan certificates. It is notable that the negative correlation between clearing house loan certificates and the reserve deficit among New York Clearing House banks is consistent

[27] See Wicker (2000) p. 94.

across the three National Banking Era panics in which there were restrictions on the convertibility of deposits into cash.[28]

Chart 5 displays the daily amount of clearing house loan certificates outstanding along with the daily call loan interest rates. The call loan interest rate falls from its steep rate of 50 percent following the accumulation of clearing house loan certificates outstanding over the first week of their issue. The call money interest rate continued to fluctuate following the issuance of CHLCs, reaching 20 percent during the first week in November. The total amount of CHLCs outstanding hovers near its maximum as early as November 14, 1907; it is notable that some disturbance in the call loan market in early December failed to prompt any additional issues of CHLCs.

Aside from the notable inverse co-movement following the initial issuance of CHLCs, there appears to be little measurable effect of CHLCs on call money interest rates. That observation supports views expressed by contemporary observers that the CHLCs may have prevented the unwanted premature liquidation of loans on call funded by New York Clearing House banks. Further, the CHLCs may have allowed the clearing house banks to take over call loans of trust companies that were struck with panic-related deposit withdrawals, preventing a massive sell-off of loans. But the CHLCs were limited in several ways; they could circulate only among clearing house members and could not be issued to the trust companies or the public. The volume of certificates was also constrained by the willingness of individual banks to take out loan certificates and the willingness of the Committee to issue them. The support provided by CHLCs to the markets reached a plateau of about $80 million outstanding in mid-November 1907. Sprague (1910) notes that by the last 5 days of October, nearly 84 percent of clearing settlements at the New York Clearing House were settled with CHLCs, suggesting that further

[28] New York Times, November 6, 1893. Exhibit follows Appendix III.

potential for releasing additional cash from the settlement balances by borrowing additional clearing house loan certificates was limited.

From our perspective, among those financial markets that experienced distress during the Panic of 1907, the distress started with the call loan market. The price declines both across bonds and within the stock market may have resulted from increased demands for cash among normally active participants on the market and spurred the initial declines in call loan liquidity. Sufficient circumstantial evidence suggests that the depositor runs on the trust companies, the credit contraction that followed, and the inability for the national banks in New York City to replace fully the credit lost in call loans from the trust company contraction all contributed to the elements that caused widespread financial distress. Despite attempts by the US Treasury, industrialists like John D. Rockefeller and the financiers like J.P. Morgan, the financial distress arising from the panic spread. Gold inflows from abroad were effectively neutralized by excessive demand for cash reserves by interior banks, which drained large amounts of cash from all three central reserve cities, but most notably from New York City.

The suspension (even if partial) likely exacerbated the demand for cash by the interior banks with deposits at national banks in New York City. The excess demand for cash resulted in a sizable cash premium relative to deposits in banks. The issuance of clearing house loan certificates enabled the clearing house banks to clear interbank payments with the exchange of clearing house loan certificates rather than specie or cash, thereby freeing up cash normally held at the clearing house to then be used to repay depositors in New York City as well as in the interior with cash (up to a point).

For 1907, the net effect of the suspension of convertibility and issuance of clearing house loan certificates was to promote the importation of gold and thereby potentially alleviate to some degree the credit contraction after sufficient inflow of gold. The currency premium (about four percent around the announcement of suspension) gave significant incentive to import gold, and the clearing house loan certificates provided the financing. Chart 6 displays the currency premium and the net gold flows for the weeks during the panic, revealing when the panic began to spread into overseas financial markets.

V How the Panic Spread: Evidence from the Stock and Bond Markets

A. The Stock Market and Financial Distress During the Panic of 1907

Chart 7 displays an estimated measure for a daily stock index from October through December 1907 derived from the daily capital gain returns for stocks on the New York Stock Exchange compiled by G. William Schwert (1990). The stock market had been mostly in decline through the first half of October 1907. We emphasize two key points from the stock index chart: first, the absence of a more precipitous decline following the suspension of Knickerbocker Trust on October 22, 1907 and, second, the steep trajectory of the decline in the stock index early in the month, even before the collapse of the Heinze-Morse attempt to corner the stock of United Copper on October 15, 1907. The trend decline in the first half of October was steeper than the declines that follow after the suspension of Knickerbocker Trust. This observation is a stark contrast with what was observed in 2008 in the aftermath of the failure of Lehman Brothers. After September 15, 2008, following the failure of Lehman Brothers, the daily decline of over 4 percent (for the Dow Jones and S&P 500 indexes) was followed by a subsequent net decline of over 35 percent by March 16, 2009.

The nadir of the constructed stock index was on November 22, 1907; however, that point was less than four percent lower than the index level of October 24, 1907, the day that the New

York Stock Exchange appealed to JP Morgan for liquidity to fund the call loan market.[29] The stock market appears to decline gradually and inconsistently after October 24, perhaps reflecting a sense of reassurance from the intervention of the Treasury, the New York Clearing House, JP Morgan, and John D. Rockefeller in the funding of the call loan market.

The absence of a continuous decline in stock values during the crisis hides some potential informative activity displayed in the daily return series. Despite a general trend decline in stock market values, the daily return observation of Monday, October 21, 1907 was among the highest observed in the year. The stock return on the New York Stock Exchange was over 2.5 percent after the New York Clearing House announced what likely appeared to market participants to be a settled solution to the Heinze banking problems. On the following day, the largest negative stock return observed from October through December 1907 took place on October 22, 1907, the day when Knickerbocker Trust suspended its financial operations.

Our investigation of the transmission of financial distress throughout the general financial market hinges on the connections between the markets. The call loan market and the stock market provide a key link for our analysis, motivated by the perception that a large proportion of stock trades are financed through credit extension.[30] It is therefore perhaps surprising that we fail to observe a more striking decline in the stock market index as a result of the obvious difficulties in maintaining credit volumes to restore the call loan interest rates to normal ranges.

B. The Value of the Bond Index and Stock Index

Railroad bond prices were an important indicator of financial conditions during the National Banking Era. By 1907, the market for railroad bonds had developed into an active and liquid market. We examine a data set that consists of the weekly price observations for 27

[29] The standard deviation of weekly stock returns for the constructed index was approximately 2.0 percent.
[30] See Pratt (1903: 188), Huebner (1922: 292-294), and Meeker (1922: 68).

railroad bonds compiled by Kemmerer (1910, pp. 413-512). Kemmerer chooses these issues based on the perceived liquidity and the depth of market for the issues, so the bond prices reflect a sample selection bias toward survivorship and toward lower than average risk. For our purposes, the bond prices indicate the degree to which even those markets and financial issues that are perceived as low risk respond to the financial crisis.

We create an equally-weighted bond price index from 26 of the 27 bond price series.[31] Chart 8 is a time series graph of the weekly bond price index (choosing January 1906 =100) in comparison to an estimated stock market index. The stock market index is estimated from the daily New York Stock Exchange return series constructed by Schwert (1990).[32] The sharp declines in both series just before and during the Panic of 1907 are striking. The nadir of the stock index occurs November 16, 1907, whereas the trough for the bond price index occurs the following week. From the standpoint of the financial crisis, these bottoms take place somewhat later than November 5, 1907, when the conventional wisdom on the crisis suggests the panic subsided.[33] Further, when we look closely at the differences in the log of the bond price index (holding period returns, abstracting from coupon payments), there is evidence that some rather sharp price breaks took place after November 5.

Table 1 displays the hypothetical one period return to the bond price index for the weeks of October and November 1907. With regard to the series, there are no observations coming close to the magnitude observed in these two months over the sample, 1900-1908.[34] Secondly, it is notable that the decline in the bond price index began as early as October 12, 1907 the week

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[31] The Long Island unified gold fours of 1949 goes into receivership in 1908, and for consistency, we leave this series out of the bond index. It could easily be accommodated, but its absence likely has little effect on our results.
[32] We look at the capital gain return only, abstracting from dividend yields, because we are only interested in detecting large negative returns.
[33] See Bruner and Carr (2008).
[34] Results and data are available upon request.

prior to the Heinze-Morse failed stock market corner. During the next week (of the failure), the bond price index fell notably by .74 percent, followed by declines of 1.63 and 1.7 percent during the weeks of October 26 (the week of the Knickerbocker Trust failure) and November 2 (the week after the New York Clearing House implemented a restriction on the convertibility of deposits into cash). These are the largest two week declines in the bond price index over the period 1900-1908.[35] The stock market index, on the other hand, experiences its largest declines in the week of October 12, 1907 and the week of October 19, 1907 (the week of the Heinze failed corner attempt). The stock market continued to rack up sizable negative returns during the next two weeks, but its decline was neither precipitous nor unprecedented (as mentioned above).

Here, we characterize an operant "correlation risk," that is, a shift from a normal small positive or zero correlation across the time series returns (between bond and stock returns) to a number of assets that then change sharply to a large positive co-movement (declines) during a panic. In the data, we find only two instances of consecutive weekly losses in excess of one standard deviation of returns for the bond index and stock index respectively -- the weeks of March 8 and March 15, 1907, referred to as the "Rich Man's Panic" in Sprague (1910) and the weeks of October 11, October 18, and October 25, 1907, just prior to and during the outbreak of the Panic of 1907. The week of November 2, 1907 does not qualify because the stock market loss was -1.66. Over the nine year sample of weekly returns, all other observations of large losses to both the stock and bond indexes are "one off" instances, some of which can be explained by historical events.[36] The surprising fact is that there are only five such observations

[35] The standard deviation of bond returns over the period 1900-1908 was 0.38 percent. We examine further the time series relationships among the bond prices by looking at differences in the yield to maturity for a subset of these bonds for which we have the coupon payment dates. Explained further in Appendix III, we estimate four principal components for a set of 18 bond yields to maturity.

[36] The observation of April 27, 1906 largely reflects the ramifications from the San Francisco earthquake of April 19, 1906.

that precede those already mentioned, and only two subsequent observations, one of which was November 15, 1907.

The evidence from these constructed indexes displays sizable losses for each asset class, equity and bonds, during the Panic of 1907, although the losses appear far more extreme and unusual for the bond index. The observations occur in October just as the markets sensed an impending liquidity crisis. The later single instance in November took place after the imposition of restrictions on the convertibility of deposits into cash by the New York Clearing House. In fact, bond price index fell to a nadir on November 23, 1907, which coincides with the largest reserve deficit among New York Clearing House banks. The "suspension of convertibility" may have exacerbated the demand for cash by interior banks from the New York Clearing House banks.

The large outlier holding period returns to the bond index throughout the Panic of 1907 highlights the extended duration of the financial distress as well as emphasizing the mechanism for transmitting it throughout the world financial system. Recent work by Rodgers and Wilson (2011) demonstrates that several railroad bond securities, some of which are represented in our bond price index, were traded on international markets, especially in London. Rodgers and Wilson explain how the trading prices of the same securities could be linked by arbitrage, based on the cost of shipping securities (and gold) abroad. Then, they estimate the percentage price deviation necessary for an arbitrage opportunity. During the Panic of 1907, the decline of railroad bond prices may have reflected local, domestic liquidity problems, and would offer an opportunity to buy a lower priced bond in New York and sell short the higher priced bond in London. The proceeds of the short sale could be exchanged for gold, which could then be sent to NYC to pay for the loan to buy the bond security. Given their evidence, Rodgers and Wilson suggest that such arbitrage opportunities existed during the weeks of October 26, November 2, and November 16, 1907. We suspect that the announcement of restrictions on convertibility of deposits into cash by the New York Clearing House, along with the associated premium on cash also could have affected the profitability of the transactions.

The existence of arbitrage profits on bonds trading in two different markets indicates that the New York City financial market was experiencing a liquidity crisis. The unusual losses on the constructed bond index are clear in Chart 8 -- the holding period losses for the weeks during the panic are the five largest weekly holding period losses during the sample. Further, there is no other observation of loss over this period that is even half the largest one period loss that took place during the 1907 panic. Chart 9 displays a bond price volatility measure calculated as the deviations of the weekly price index from a weekly average of the index over the previous six months. Chart 10 displays the weekly stock return deviation from the weekly average return over the previous six months. The most striking contrast between these graphs is the obvious distinction for the 1907 panic in the bond volatility measure, and the less distinctive pattern observed in the stock market volatility (also seen in the stock index chart).[37]

VI Conclusions

This investigation examines high-frequency data for the period around the Panic of 1907 in order to detect when the distress among trust companies in New York City spread to other parts of the financial market, and then throughout the United States. The behavior of the weekly railroad bond prices suggests that the bond market was experiencing turbulence even before the call loan money market interest rate spiked on October 22, 1907. The finding suggests that the

[37] Gorton and Tallman (2014) find more co-movement between the stock and bond volatility measures for the Panic of 1893. Further investigation into the divergence is ongoing.

transmission of the Panic of 1907 to the rest of the financial market was not entirely dependent upon the actions of the New York Clearing House. The evidence suggests that the serious financial distress started prior to the suspension of Knickerbocker Trust; the Panic of 1907 began in full force following the suspension of the trust.

We suggest that material changes in the severity of crisis and its spread throughout the interior of the United States take place later following the New York Clearing House announcements of a partial suspension of payments and the issuance of clearing house loan certificates. Our strongest empirical support comes from the large (largest in the 1900-1908 sample) negative holding period return to the bond index for the week ending November 2 and the huge net decline in New York City national banks reserves during the weeks ending November 2 and November 9.

The empirical analysis conjectures that when the Panic of 1907 took hold key interrelationships between financial data changed notably from those observed during normal times. The observations are not surprising, but the time series data suggest that the financial distress spread from the stock market and the call loan market to the foreign exchange and bond markets. The interior of the US responded to the crisis with a slight delay, but the actions of the interior banks to liquidate deposit accounts in New York City likely exacerbated the problems. The eventual resumption of normal liquidity provision to the call loan market required the return of deposits from the interior bankers into large, New York City national banks.[38]

[38] Gorton and Tallman (2014) investigate observable financial market characteristics that determine when deposits from interior bankers return to the New York City national banks.

APPENDIX 1A – DATA SOURCES

Call loan interest rates –
Daily observations are taken from the Financial Situation columns of the New York Times from September 30, 1907 through February 19, 1908. These articles describe the range of interest rates observed over the day, and occasionally describe the rate at which the bulk of trades were made. We referred to various issues of the Commercial and Financial Chronicle (Volume for further clarifications and enhancements to the interest rate observations. Overall, the interest rate observations for the call money market remain tentative and we continue to look for ways to clarify the measurement of a daily call money interest rate.
Weekly observations are taken from from Kemmerer (1910) pages 235-236.
Monthly observations are Macaulay (1937) also displays call money and commercial paper interest rates on a monthly basis.

clearing house loan certificates – Daily observations are taken from the minutes of the meetings of the clearing house Loan Committee of the New York Clearing House. These are indicated by date, by issuer (requesting bank), and by amount.

Currency Premium – measured daily, by Andrew (1908).

Stock returns – We use the daily returns data from Schwert (1990) for the daily and weekly analysis. We use Cowles Commission Stock Index for monthly, taken from Macaulay (1937)

Reserves of New York Clearing House Banks – taken from Andrew (1910),Table 31, Weekly Statement of New York Clearing House Banks, pages 75-118.

Panic of 1907 dummy variable: Daily: October 22, 1907 until January 11, 1908, =0, otherwise.
Weekly: =1 from October 26, 1907 until January 11, 1908, = 0 at all other dates.
Monthly: =1 for October, November, December 1907, January 1908; =0 otherwise.
Applies to regressions and to graphics.

APPENDIX 1B– BOND SERIES DESCRIPTIONS

Bond 1 Atchison, Topeka and Santa Fe adjustment gold fours of 1995:1896-1908.
Coupon payments: May 1, November 1; bond 109 in Macaulay (1937)
A bond included in Rodgers and Wilson (2010).

Bond 2 Atchison, Topeka and Santa Fe general gold fours of 1995:1897-1908.
Coupon payments: April 1, October 1; bond 94 in Macaulay (1937)

Bond 3 Baltimore and Ohio gold fours of 1948: 1900-1908.
Coupon payments: April 1, October 1; Bond 90 in Macaulay (1937)

Bond 4 Central Pacific first refunding gold fours of 1949: 1900-1908.
Coupon payments: February 1, August 1; bond 101 in Macaulay (1937).
A bond included in Rodgers and Wilson (2010).

Bond 5 Central Railroad of New Jersey general gold fives of 1987: 1890-1908.
Coupon payments: January 1, July 1; bond 104 in Macaulay (1937)

Bond 6 Chesapeake and Ohio general gold four-and-a-halfs of 1992: 1893-1908.
Coupon payments: March 1, September 1; bond 135 in Macaulay (1937).
A bond included in Rodgers and Wilson (2010).

Bond 7 Chicago, Burlington and Quincy (Nebraska extension) fours of 1927: 1890-1908.

Bond 8 Chicago, Milwaukee and St. Paul general gold fours of 1989: 1890-1908.
Coupon payments: January 1, July 1; bond 87 in Macaulay (1937).

Bond 9 Denver and Rio Grande first consolidated gold fours of 1936: 1890-1908.

Bond 10 Erie first consolidated gold fours prior lien of 1996: 1898-1908.
Coupon payments: January 1, July 1; bond 146 in Macaulay (1937).

Bond 11 Hocking Valley first consolidated gold four-and-a-halfs of 1999: 1900-1908.
Coupon payments: January 1, July 1; bond 105 in Macaulay (1937).

Bond 12 Iowa Central first gold fives of 1938: 1890-1908

Bond 13 Long Island unified gold fours of 1949: 1900-1908

Bond 14 Louisville and Nashville unified gold fours of 1940: 1898-1908.

Bond 15 Missouri, Kansas and Texas first gold fours of 1990: 1891-1908.
Coupon payments: June 1, December 1; bond 134 in Macaulay (1937).

Bond 16 Missouri Pacific first consolidated gold sixes of 1920: 1890-1908.

Bond 17 Missouri Pacific, St. Louis, Iron Mountain and Southern general consolidated gold fives of 1931: 1894-1908.

Bond 18 New York Central and Hudson River gold three-and-a-halfs of 1997: 1899-1908. ***Coupon payments:*** January 1, July 1; bond 95 in Macaulay (1937).

Bond 19 New York Central and Hudson River (West Shore) first fours guaranteed of 2361: 1890-1908. Coupon payments: January 1, July 1; bond 70 in Macaulay (1937).

Bond 20 New York, Ontario and Western refunding first gold fours of 1992: 1893-1908.

Bond 21 Norfolk and Western first consolidated gold fours of 1996: 1897-1908. ***Coupon payments:*** April1, October 1; bond 103 in Macaulay (1937).

Bond 22 Northern Pacific prior lien gold fours of 1997: 1897-1908. ***Coupon payments:*** January 1, April 1, July 1, October 1; bond 102 in Macaulay (1937). Included in Rodgers and Wilson (2010).

Bond 23 St. Louis and San Francisco general gold fives of 1931: 1890-1908.

Bond 24 St. Louis and Southwestern first gold fours of 1989: 1892-1908. ***Coupon payments:*** May 1, November 1; bond 133 in Macaulay (1937).

Bond 25 Southern Railway first consolidated fives of 1994: 1895-1908. ***Coupon payments:*** January 1, July 1; bond 119 in Macaulay (1937).

Bond 26 Union Pacific land grant gold fours of 1947: 1899-1908. ***Coupon payments:*** January 1, July 1; bond 91 in Macaulay (1937).

Bond 27 Wabash first gold fives of 1939: 1890-1908. ***Coupon payments:*** May 1, November 1; bond 78 in Macaulay (1937).

NOTE: All bond data series are taken from Kemmerer (1910). The price series for these selected bonds were chosen on the suggestion of investment bankers as most likely to have traded in liquid markets. Kemmerer notes (page 174) that quotations for prices were one of the following in order of preference: 1) Prices at which sales took place (on Friday or closest day), 2) Mean of “bid” and “asked” prices on Friday (or closest day), 3) “bid” quotations on Friday, 4) “Asked” quotations on Friday, and 5) if no quotations, the mean of the prices at nearest weeks.

DATA APPENDIX II: Time Series Properties of Data Series

Weekly Data From January 6, 1900 until December 26, 1908
Correlations of *Call Loan Rate*
Autocorrelations

1	2	3	4	5	6	7	8	9	10	11	12
0.58	0.46	0.28	0.22	0.18	0.24	0.22	0.21	0.14	0.07	0.05	0.06

Weekly Data From January 7, 1899 until December 26, 1908
Reserves less required reserves
Autocorrelations

Autocorrelations

1	2	3	4	5	6	7	8	9	10	11	12
0.95	0.87	0.80	0.72	0.65	0.58	0.52	0.48	0.44	0.40	0.36	0.35

Weekly Data From January 5, 1900 until December 25, 1908
Stock market index – capital gains returns only

Autocorrelations

1	2	3	4	5	6	7	8	9	10	11	12
0.07	0.10	-0.05	0.04	-0.06	-0.01	-0.03	-0.04	0.20	0.03	0.05	0.08

Weekly Data From January 5, 1900 until December 25, 1908
Bond Price index – weekly holding period returns

Autocorrelations

1	2	3	4	5	6	7	8	9	10	11	12
0.32	0.01	0.13	0.13	-0.12	-0.18	-0.03	0.00	-0.11	-0.03	0.03	0.00

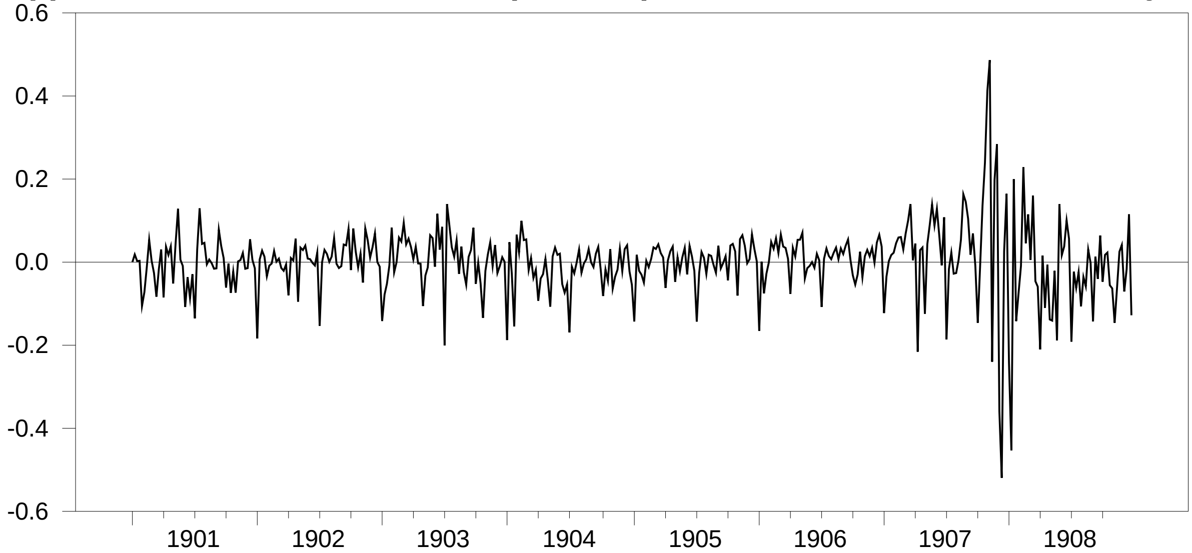
APPENDIX III – Principal Components Analysis of Bond Yields to Maturity

The bond price index aggregates the prices of a set of bonds abstracting from the payment of coupon interest. In this section, we account explicitly for the effect of coupon payments on market prices; bond market participants calculate the value of accrued interest that is paid on the coupon date to the bearer of the bond as of that date. These calculations affect the market price, which should reflect that accrued interest, and reflect the coupon payment after the fact. We calculate yields to maturity for a subset of bonds, which accounts for the timing of coupon interest payments on those bonds. However, the yield to maturity calculation introduces the variation of yields as a result of differing maturities of the bonds. The maturities of each bond under examination exceed fifteen years, and most are over 40 years to maturity.

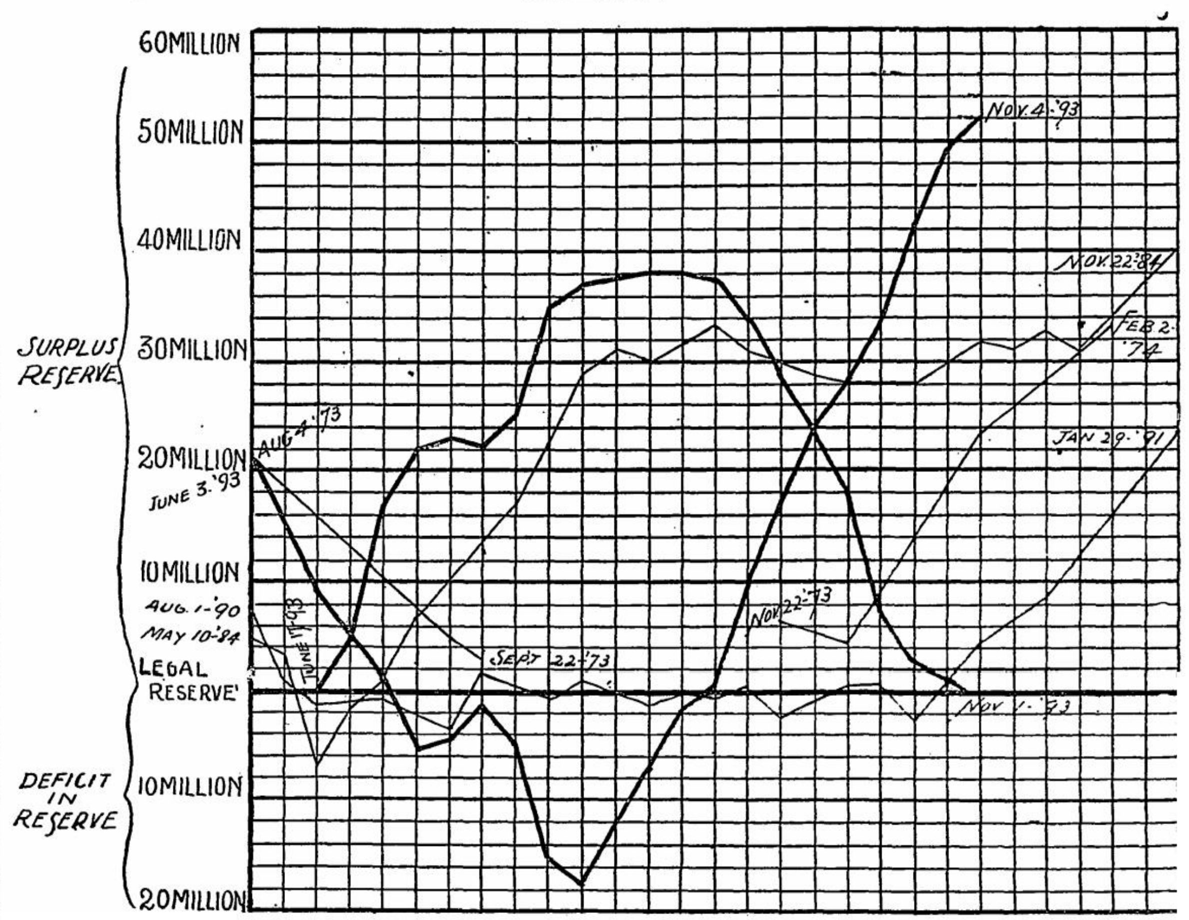
We performed principal components analysis on both holding period returns as well as on the yields to maturity (of a subsample of bonds). The results are generally similar. The estimated first principal component indicates when the variability of that component is largest. Chart III displays the first principal component time series from the set of yields to maturity.[39] Because the bond price index series along with the stock market index indicates similar findings, we keep the principal component analysis as support in an Appendix.

[39] The 18 bonds for which we calculate a yield to maturity are indicated in Appendix 1B by the presence of a coupon payment date. We cannot estimate a yield to maturity with precision for those bonds that lack a coupon payment date.

Appendix III Chart 1: First Principal Component from 18 Yields to Maturity



BANK RESERVES AND CLEARING HOUSE LOAN CERTIFICATES.



The correlation of bank reserves and of Clearing House loan certificates is pictured to the eye in an interesting manner in the above diagram. The heavy black horizontal line represents the 25 per cent. lawful reserve of the Associated Banks of New-York. Each horizontal line above or below this lawful-reserve line represents a gain or loss respectively of two million dollars, and every fifth line, printed slightly heavier, represents a change of ten millions. The vertical lines represent weeks. Starting on June 3, 1893, when the bank statement showed a total surplus reserve of $20,987,500, the line representing the reserve plunges abruptly downward until it reaches its lowest point on Aug. 12, when the bank statement showed that the reserve was $16,545,375 below the legal 25 per cent.. From this point the reserves have mounted, at first slowly, but since the middle of September by leaps and bounds, until Saturday last they had risen to $52,013,450. The surplus reserve-line serves as a datum or base for the line representing the issue of Clearing House loan certificates. These in a measure took the place of cash reserves during the silver panic; the diagram shows how closely they followed, but in reverse order, the behavior of the reserves—rising as the reserves fell, and falling as they rose. The first certificates were issued June 17; the certificate line accordingly *starts* at the second-week line from the left hand margin of the diagram—the margin line standing for June 3. From this zero point the issue rose to $38,280,000 on Aug. 26—the highest amount outstanding on any bank-statement day. Thence the line starts on its downward slide, reaching the zero point again on Nov. 1, when the last certificates were retired. The other lines in the diagram show the behavior of the bank reserves during and after the panics of 1873, 1884, and 1890, illustrating the financial law that idle money accumulates in the banks after severe financial disturbances. We append a table showing the amount of Clearing House loan certificates issued and outstanding on each successive Saturday from June 17 to Nov. 1, when the last certificate was called in:

June 24	$5,350,000
July 1	17,230,000
July 8	22,565,000
July 15	22,740,000
July 22	22,100,000
July 29	25,450,000
Aug. 5	35,050,000
Aug. 12	37,015,000
Aug. 19	37,880,000
Aug. 26	38,280,000
Sept. 2	38,015,000
Sept. 9	37,135,000
Sept. 16	34,455,000
Sept. 23	29,700,000
Sept. 30	24,745,000
Oct. 7	18,210,000
Oct. 14	9,715,000
Oct. 21	2,780,000
Oct. 28	1,515,000

Last retirement, Nov. 1.

After the panic of 1873 the first Clearing House certificates were issued on Sept. 22, and the last was retired Jan. 14, 1874. In 1884 the first was issued May 15, and the last retired Aug. 8, except $250,000 taken out by the Metropolitan Bank, which was carried until Sept. 23, 1885. In 1890 the first was issued Nov. 12, and the last retired Dec. 22. In 1893 the first was issued June 17, and the last retired Nov. 1.

REFERENCES

Andrew, A. Piatt. 1908. “Hoarding in the Panic of 1907.” *The Quarterly Journal of Economics*. Vol. 22, No. 2, 290-299.

Andrew, A. Piatt. 1910. *Statistics for the United States.* Washington: Government Printing Office.

Bruner, Robert F. and Sean Carr. (2007) *The Panic of 1907: Lessons Learned from the Market’s Perfect Storm.* New York: Wiley.

Carosso, Vincent P. 1970. *Investment Banking in America: A History*. Cambridge: Harvard University Press.

Carosso, Vincent P. 1987. *The Morgans: Private International Bankers, 1854-1913*. Cambridge: Harvard University Press.

Calomiris, Charles W., and Gary Gorton. 1991. "The Origins of Banking Panics: Models, Facts, and Bank Regulation," pp. 109-173, in R. Glenn Hubbard (ed.), *Financial Markets and Financial Crises*. Chicago: University of Chicago Press.

Champ, Bruce A. 2007. “The National Banking System: A Brief History.” Federal Reserve Bank of Cleveland Working Paper No. 07-23. Available at SSRN: http://ssrn.com/abstract=1171222

Cleveland, F.A. 1908. “Neglected Aspects of Currency and Banking.” *Annals of the American Academy of Political and Social Science*, Vol. 31, No. 2, March, 120-147.

Donaldson, R. Glen. 1992. “Sources of panics: Evidence from the weekly data.” *Journal of Monetary Economics* 30, 277-305.

Dwyer, Gerald P. and Tkac, Paula. 2009. “The financial crisis of 2008 in fixed-income markets.” *Journal of International Money and Finance*. (December) 28, 8, 1293-1316.

Friedman, Milton, and Anna J. Schwartz. 1963. *A Monetary History of the United States, 1867–1960*. Princeton, NJ: Princeton University Press for NBER.

Frissell, A. S. 1908. “Trust Companies and Reserves.” *Annals of the American Academy of Political and Social Science*, Vol. 31, No. 2, March, 163-169.

Hagen, Everett Einar. 1932. “The Panic of 1907.” Masters of Arts Thesis, University of Wisconsin-Madison.

Goodhart, Charles A.E. 1969. *The New York Money Market and the Finance of Trade, 1900-1913.* Cambridge: Harvard University Press.

Gorton, Gary B. 2010. *Slapped by the Invisible Hand: The Panic of 2007*. New York: Oxford University Press.

Gorton, Gary B. 2009. “Slapped in the Face by the Invisible Hand: Banking and the Panic of 2007.” Yale University Working Paper.
Available at SSRN: http://ssrn.com/abstract=1401882

Gorton, Gary B. and Andrew Metrick. 2012. "Securitized banking and the run on repo," Journal of Financial Economics, Elsevier, vol. 104(3), pages 425-451.

Gorton, Gary B. and Ellis W. Tallman. 2014. "What Ends Banking Panics?" unpublished manuscript.

Kemmerer, Edwin R. 1910. *Seasonal Variations in the Relative Demand for Money and Capital in the United States*, Washington: Government Printing Office.

Kindleberger, Charles. 2000. *Manias, Panics, and Crashes: A History of Financial Crises*. New York: Wiley.

Lo, Andrew W. 2008. “Hedge Funds, Systemic Risk, and the Financial Crisis of 2007–2008.” Written Testimony Prepared for the U.S. House of Representatives 49 Committee on Oversight and Government Reform. November 13, 2008. Hearing on Hedge Funds.

Macaulay, Frederick. 1938. *Some Theoretical Problems Suggested by the Movements of Interest Rates, Bond Yields and Stock Prices in the United States since 1856.* Cambridge: National Bureau of Economic Research.

Moen, Jon R. and Ellis W. Tallman. 1992. "The Bank Panic of 1907: The Role of Trust Companies," *Journal of Economic History*, (September), 52, 3, 611-30.

___________________ 2000 "Clearinghouse Membership and Deposit Contraction During the Panic of 1907" (with Jon R. Moen), *Journal of Economic History* (March), 60, 1, 145-63.

Muhleman, Maurice Louis. 1908. *Monetary and Banking Systems.* New York: Monetary Publishing Company.

Myers, Margaret G. 1970. *A Financial History of the United States*. Columbia University Press: New York.

New York Sun, New York Times, New York Tribune, various issues.

NBER Macro History Database, various series.
http://www.nber.org/databases/macrohistory/contents/

Officer, Lawrence. 2008. "Gold Standard". EH.Net Encyclopedia, edited by Robert Whaples. March 26, 2008. URL: http://eh.net/encyclopedia/article/officer.gold.standard

Pratt, Sereno (1903). *The Work of Wall Street*. D. Appleton and Company: New York.

Rodgers, Mary Tone and Berry K. Wilson. 2011 “Systemic Risk, Missing Gold Flows, and the Panic of 1907,” *Quarterly Journal of Austrian Economics* (Summer) Vol 14, No. 2, 158-187.

Schwert, G. William 1990. “Indexes of United States Stock Prices from 1802 to 1987.” *Journal of Business*, 63, July, 399-426.

Silber, William L. 2007. *When Washington Shut Down Wall Street: The Great Financial Crisis of 1914 and the Origins of America’s Monetary Supremacy*. Princeton University Press: Princeton, New Jersey.

Sprague, Oliver Mitchell Wentworth (1910) *History of Crises Under the National Banking System.* Washington: Government Printing Office.

Studentski, Paul and Herman E. Krooss. 1963. *Financial History of the United States: Fiscal, Monetary, Banking and Tariff, including Financial Administration and State and Local Finance*. McGraw-Hill: New York, Second Edition.

Tallman, Ellis W. (2013) “The Banking Panic of 1907,” Chapter 6 in *Routledge Handbook of Major Events in Economic History*, Edited by Randall E. Parker and Robert Whaples, Routledge:New York.

Tallman, Ellis W. and Jon R. Moen. 1990 "Lessons from the Panic of 1907,” Federal Reserve Bank of Atlanta *Economic Review* 75 (May/June): 2-13.

_______________. **“**Liquidity Creation without a Central Bank: Clearing House Loan Certificates in the Banking Panic of 1907,” *Journal of Financial Stability* (December 2012) Vol. 8, Issue 4: 277–291.

Wicker, Elmus R. 2005. *The Great Debate on Banking Reform: Nelson Aldrich and the Origins of the Fed.* Ohio State University Press: Columbus.

Wicker, Elmus R. 2000. *The Banking Panics of the Guilded Age.* Cambridge University Press: New York.

Table 1: Bond Price Index, Stock Price Index, and Weekly (Period) Returns: Selected Sample Taken from Sample January 13, 1900 - December 26, 1908

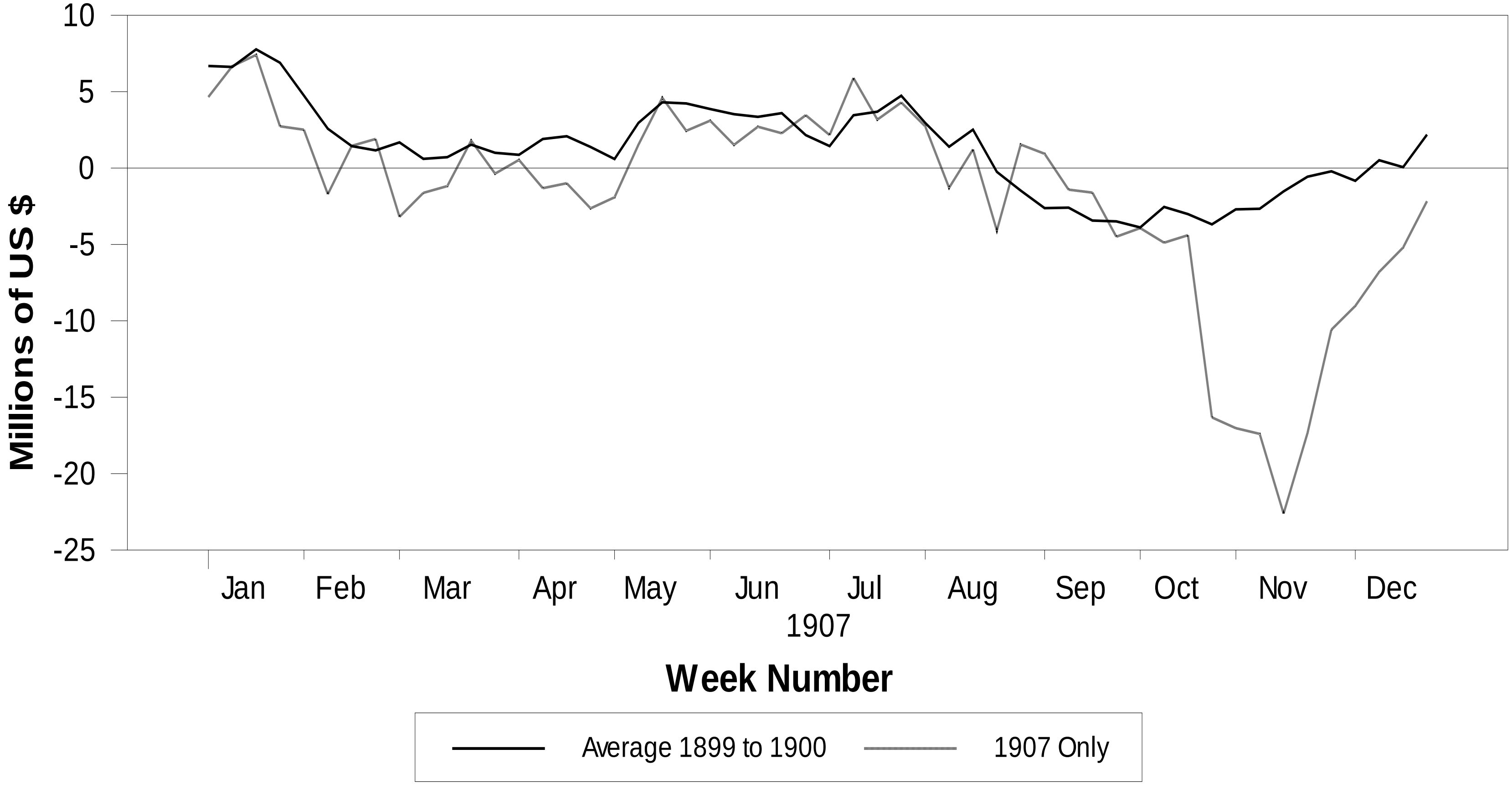
Week of Observation	***Bond Price Index***	***Stock Index***	***One-week Holding Period Return to Bond Index***	***Stock Return***
September 7, 1907	91.52	74.92	-0.06	2.24
September 14, 1907	91.33	72.34	-0.21	*-3.51*
September 21, 1907	91.47	74.35	0.15	2.74
September 28, 1907	91.87	71.35	0.44	*-4.13*
October 5, 1907	91.88	71.58	0.01	0.32
October 12, 1907	91.52	67.84	-0.39	**-5.36**
October 19, 1907	90.85	65.11	**-0.74**	*-4.10*
October 26, 1907	89.38	62.71	**-1.63**	*-3.75*
November 2, 1907	87.87	61.52	**-1.70**	-1.91
November 9, 1907	88.26	61.72	0.43	0.32
November 16, 1907	87.49	59.83	**-0.88**	*-3.12*
November 23, 1907	86.19	60.40	**-1.49**	0.96
November 30, 1907	87.36	63.39	1.35	4.83
December 7, 1907	89.31	65.75	2.20	3.66
December 14, 1907	89.24	63.38	-0.08	*-3.67*
December 21, 1907	88.72	64.87	*-0.59*	2.32
December 28, 1907	88.96	64.16	0.28	-1.11
January 4, 1908	91.16	65.84	2.43	2.59
	Full Sample Statistics			
	sample average return		0.00	0.07
	sample standard deviation		0.33	2.14
	sample maximum		2.43	8.53
	sample minimum		-1.70	-7.29

Source: Bond price index calculated from bond price series from Kemmerer (1910) pages 413-510. Stock index calculated from the daily stock return series in Schwert (1990).

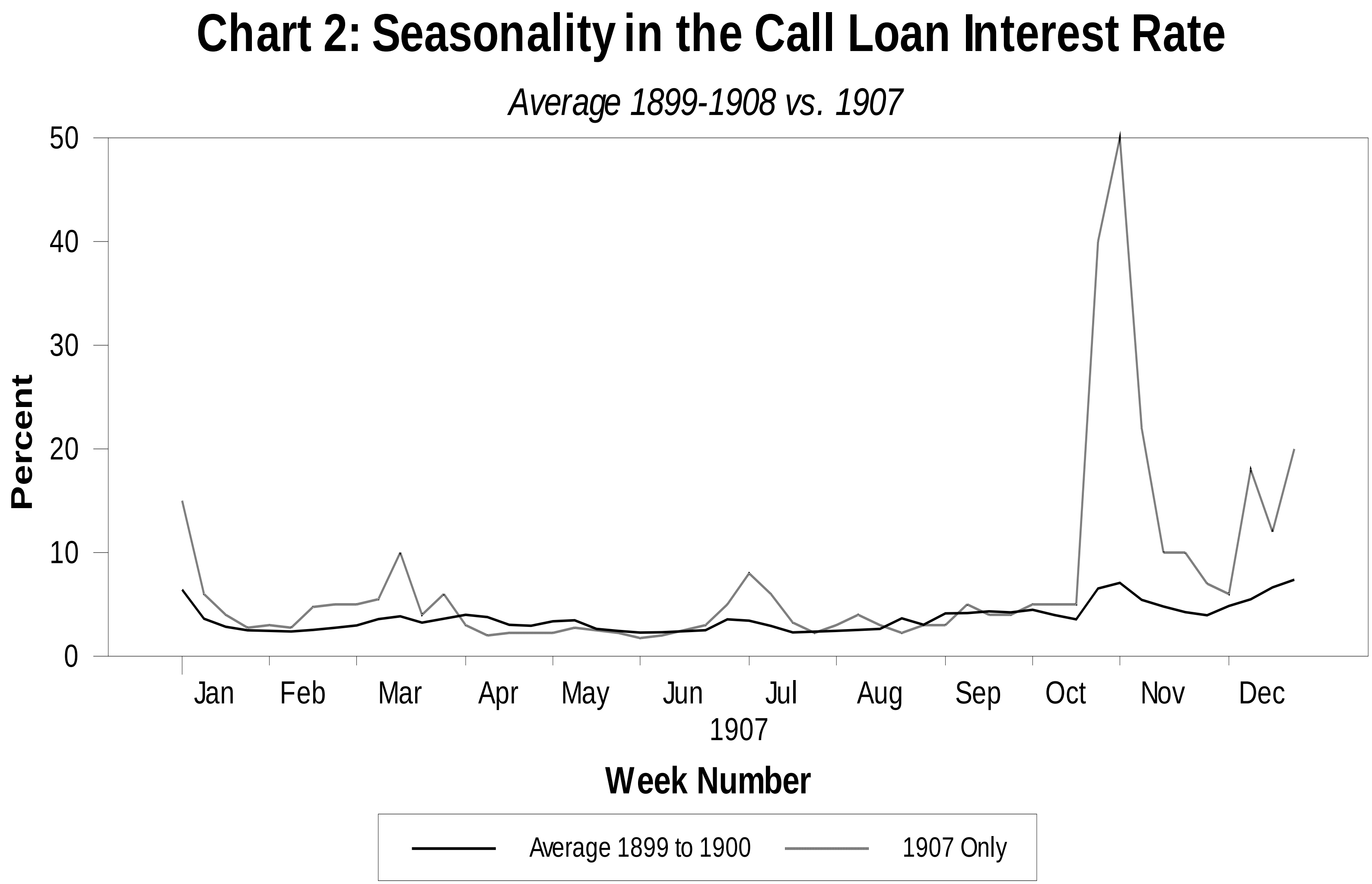
Note: Numbers in bold are below the mean by more than twice the full-sample standard deviation of the return series. Numbers in italics are

Chart 1: Seasonality in Net Cash Flows Into New York City Banks

Average 1899-1908 vs. 1907



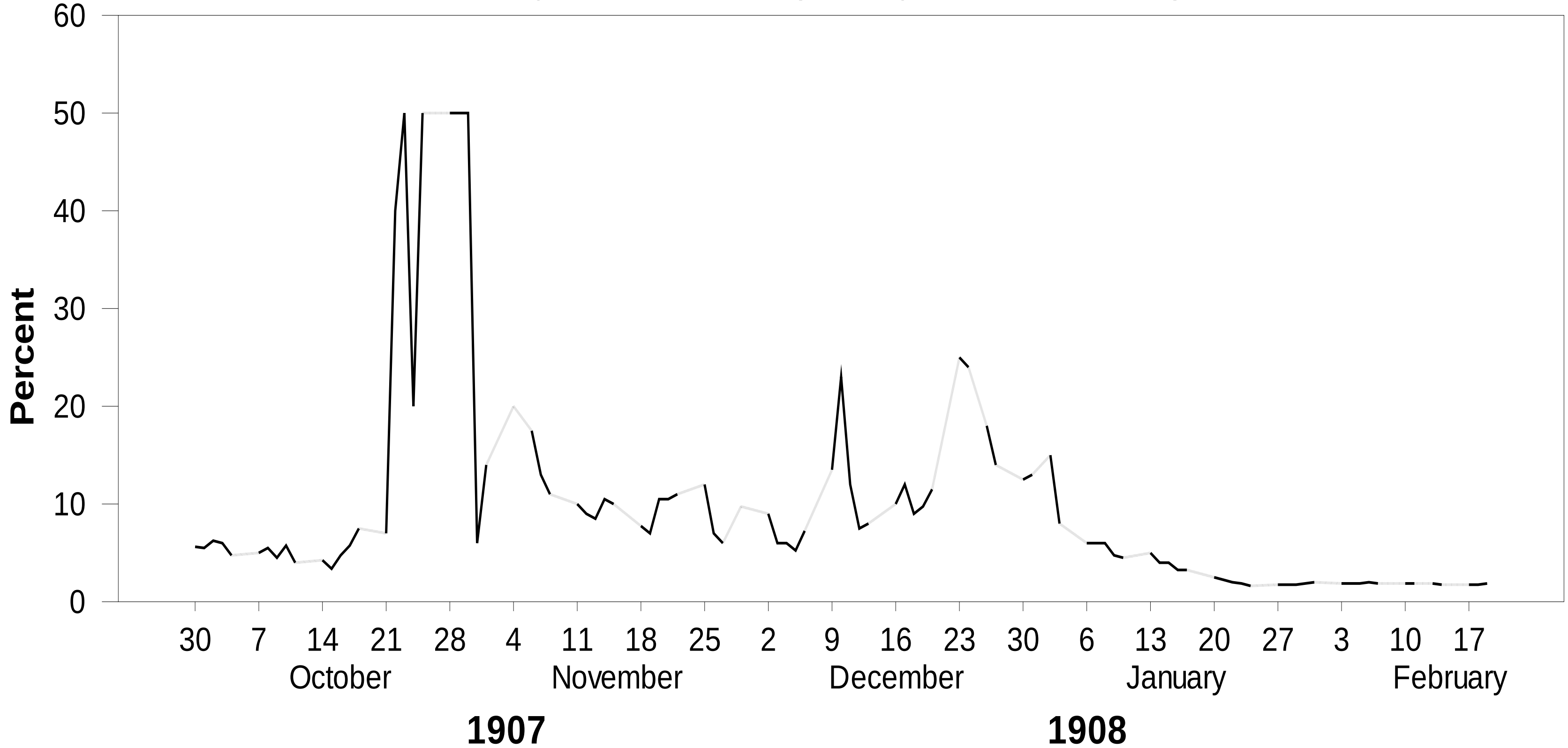
Source: Kemmerer 1910



Source: Kemmerer 1910

Chart 3: Daily Call Loan Rate in New York City

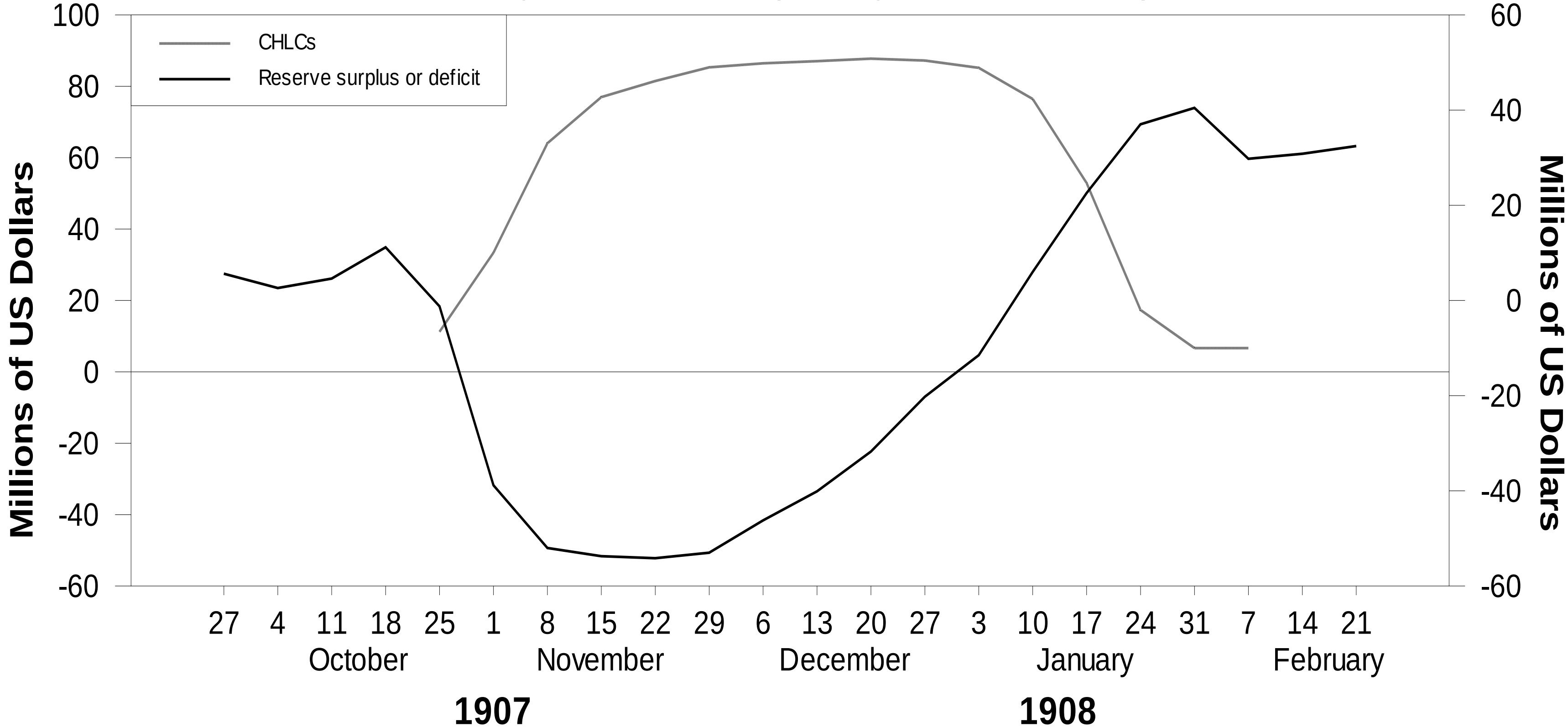
Shading indicates Panic (starting October 22, 1907)



Source: New York Times, Commercial and Financial Chronicle, Various issues

Chart 4: NYCH Bank Reserve Balance vs CHLCs

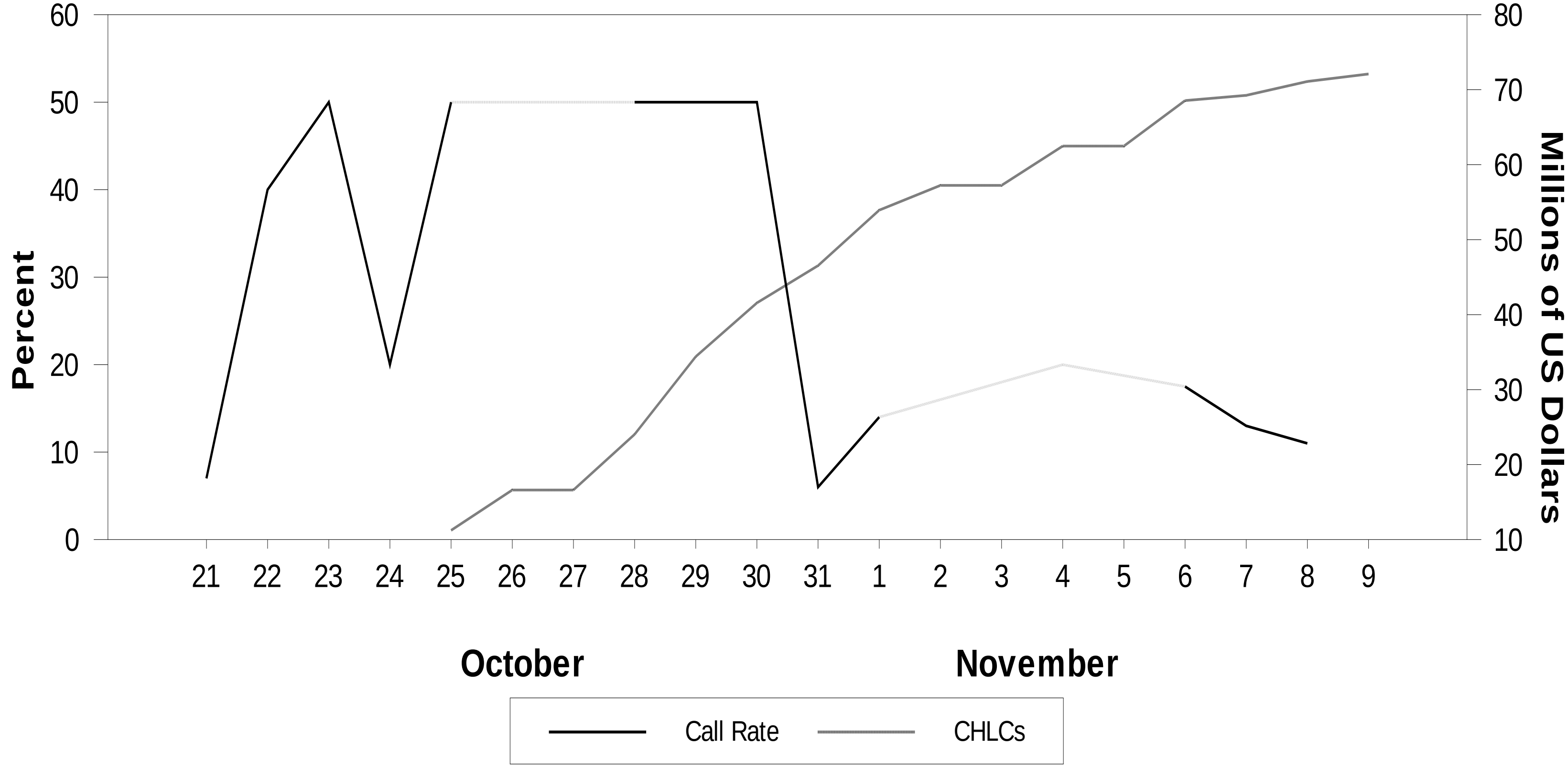
Shading indicates Panic (starting October 22, 1907)



Sources: Clearing House Loan Committee Reports and Kemmerer (1910)

Chart 5: Daily Call Loan Rate vs Clearing House Loan Certificates

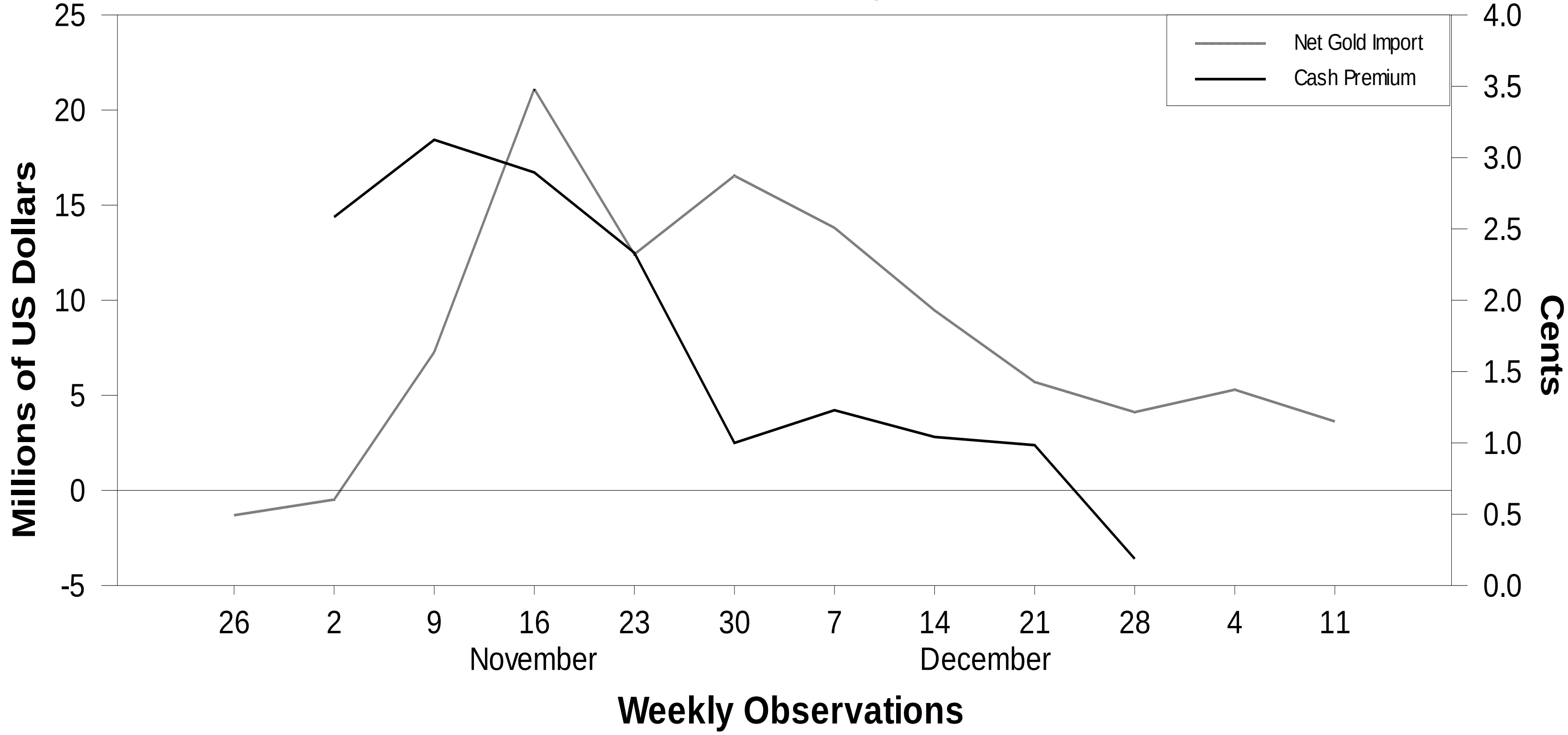
Shading indicates Panic (starting October 22, 1907)



Source for CHLC: Reports of the Clearing House Loan Committee, various issues

Chart 6: Net Imports of Gold versus Currency Premium

Shortened Sample



Sources: Andrew (1910); Andrew (1908)

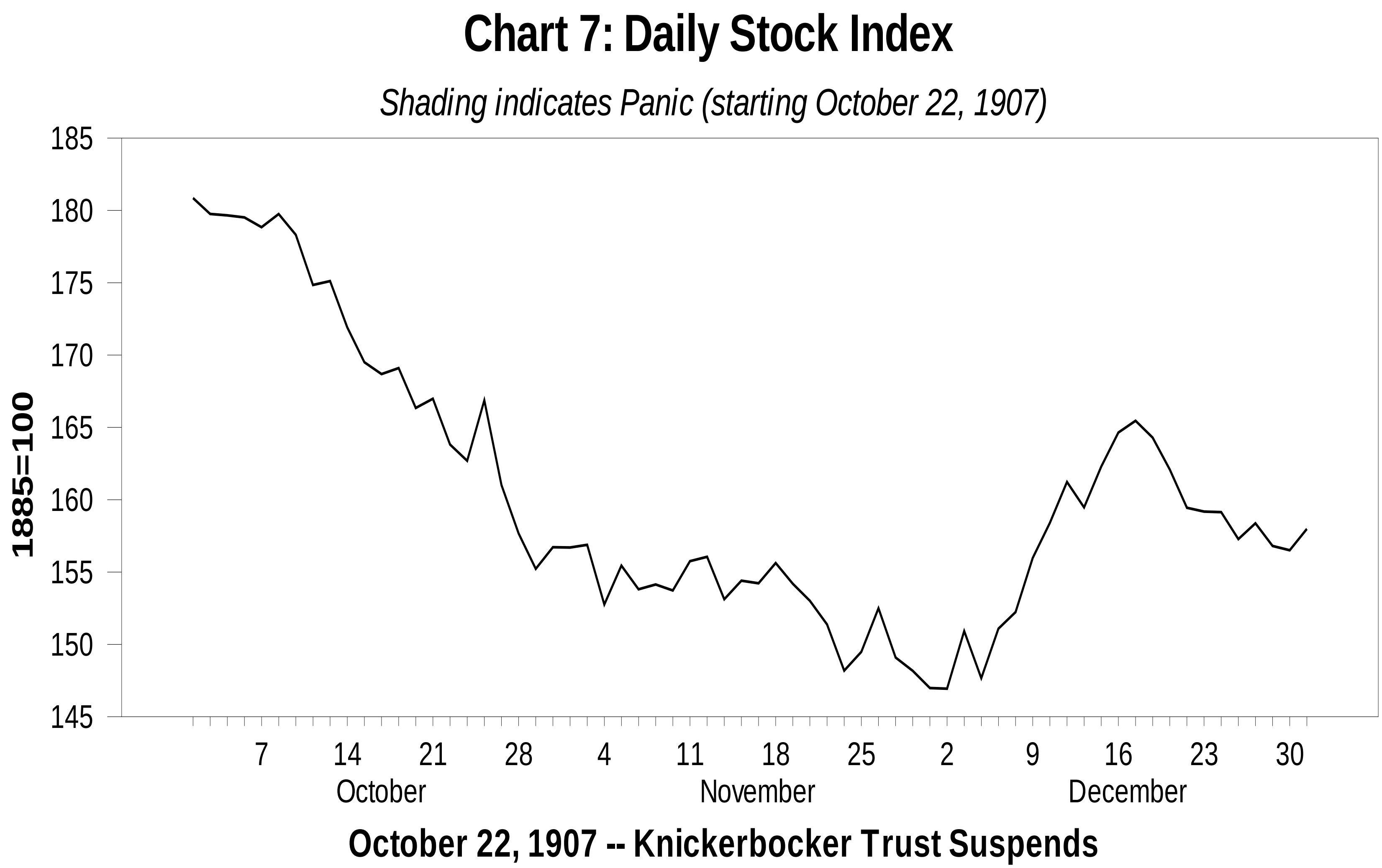
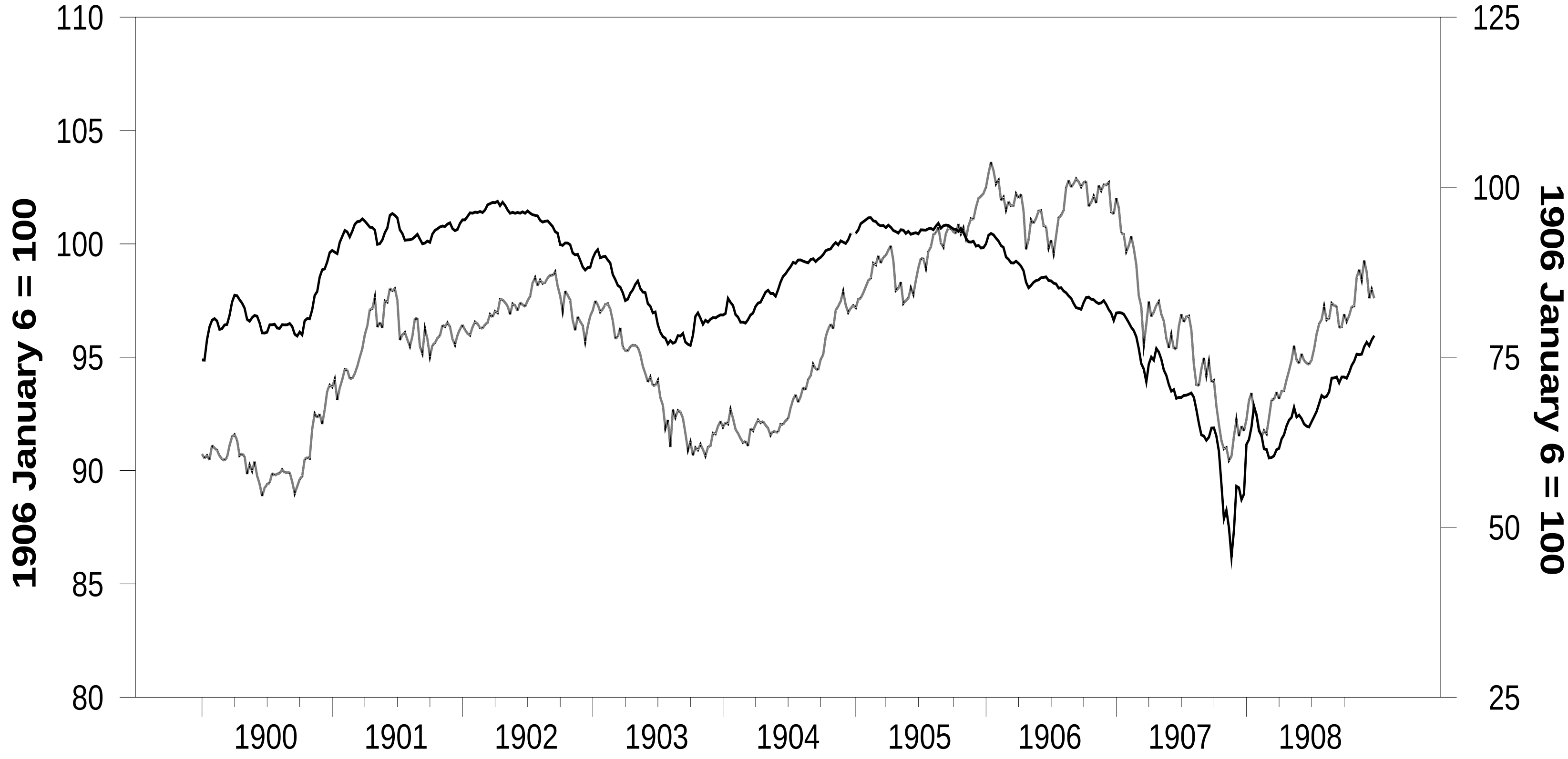


Chart 7: Daily Stock Index
Shading indicates Panic (starting October 22, 1907)
185
180
175
170
165
160
155
150
145
1885=100
7
14
21
28
4
11
18
25
2
9
16
23
30
October
November
December
October 22, 1907 -- Knickerbocker Trust Suspends

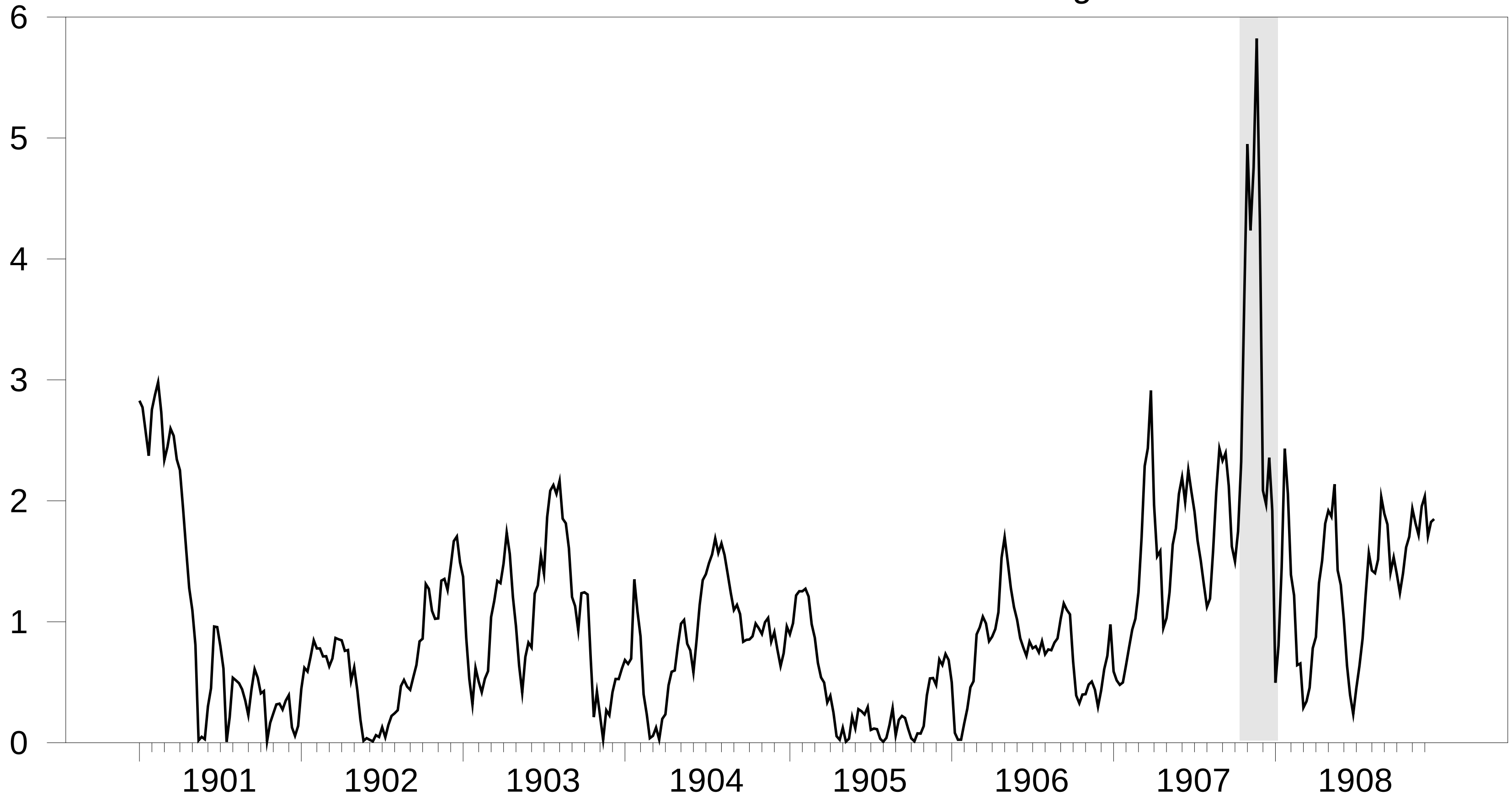
Chart 8: Equal-Weight Bond Index versus Stock Index, 1900-1908



Source: Kemmerer (1910), Schwert (1990)

Chart 9: Volatility Measure for Weekly Bond Price Index

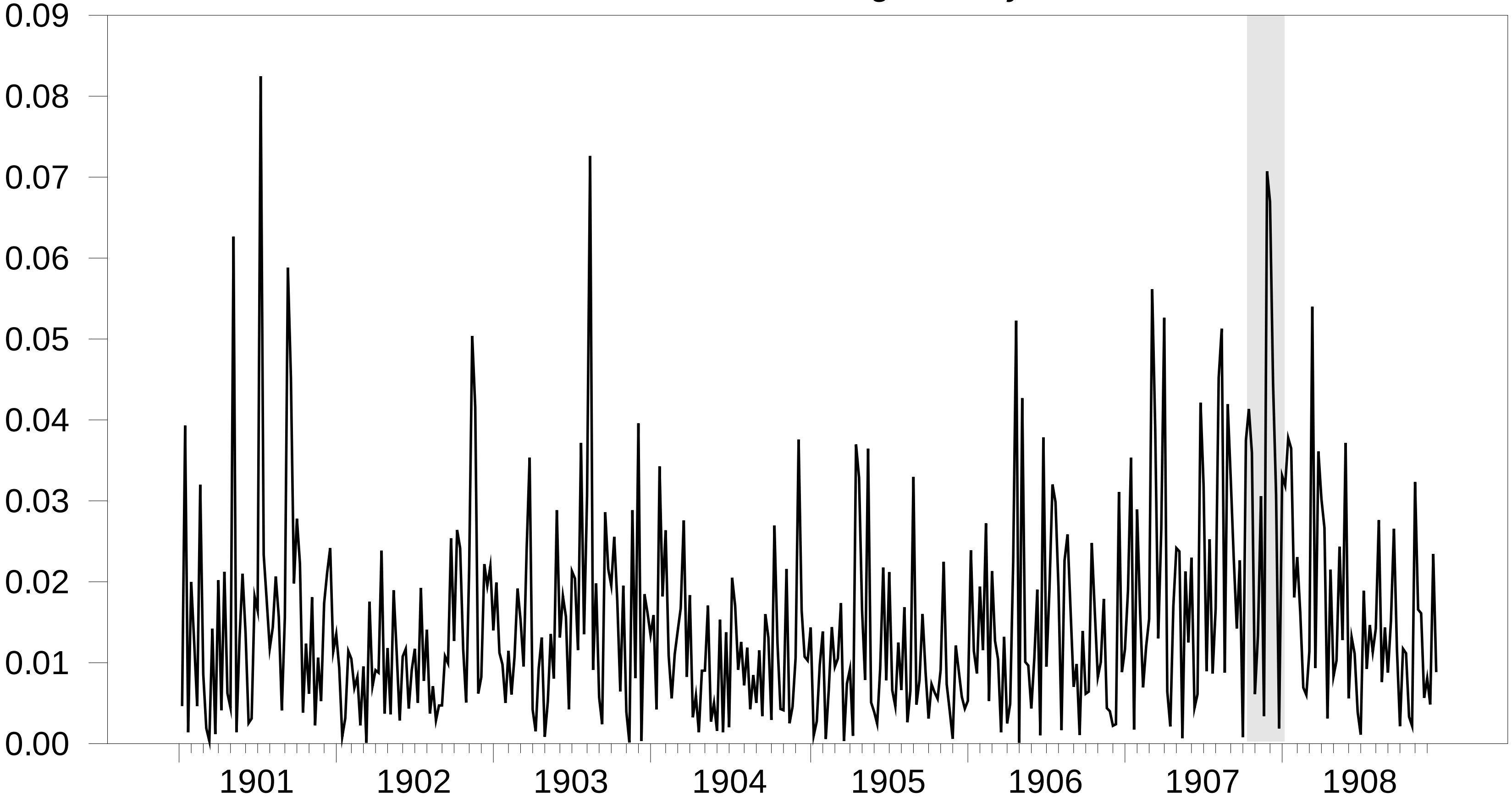
Price deviation from Six month index average



Source: Kemmerer (1910)

Chart 10: Stock Return Volatility Measure

Deviation from Six month average weekly return



Source: Schwert (1990)