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Did the Founding of the Federal Reserve Affect the Vulnerability of the Interbank System to Systemic Risk?

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As a result of legal restrictions on branch banking, an extensive interbank system developed in the United States during the 19th century to facilitate interregional payments and flows of liquidity and credit. Vast sums moved through the interbank system to meet seasonal and other demands, but the system also transmitted shocks during banking panics. The Federal Reserve was established in 1914 to reduce reliance on the interbank market and correct other defects that caused banking system instability. Drawing on recent theoretical work on interbank networks, we examine how the Fed's establishment affected the system's resilience to solvency and liquidity shocks and whether these shocks might have been contagious. We find that the interbank system became more resilient to solvency shocks but less resilient to liquidity shocks as banks sharply reduced their liquidity after the Fed's founding. The industry's response illustrates how the introduction of a lender of last resort can alter private behavior in a way that increases the likelihood that the lender will be needed.

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In the United States at the beginning of the 20th century, an extensive interbank system performed the clearing of payments and transferred money and capital from regions and sectors with surplus funds to those with deficits, all without the backstop of a central bank. Due to legal restrictions on branching, the U.S. banking system was composed largely of small, single office banks, with business relationships between banks enabling the system to function. The interbank system had a core-periphery structure. To facilitate interregional payments, invest surplus funds, and to borrow funds when needed, banks throughout the country held substantial deposits with banks in larger cities, which comprised the interbank system's regional nodes, or with major banks in the system's core cities, especially New York City.

Contemporaries viewed the interbank system as inherently fragile, though necessary for the interregional movement of funds and operation of the payments system. Seasonal pressures, marked by high demands for cash and loans in peak seasons, routinely strained the system, sometimes to the point of crisis (Kemmerer 1910). Autumn, in particular, was a period of intense economic activity when banks were called upon to provide cash and loans to facilitate the harvesting and marketing of agricultural commodities, and to make payments across long distances. Banks in agricultural regions relied on correspondent banks for additional funds to meet local demands, but a relatively fixed supply of funds in the aggregate—which contemporaries referred to as an "inelastic currency"—meant that interest rates typically rose and credit became less available in peak-demand seasons.

Contemporaries also blamed the interbank system for transmitting shocks through the banking system. The interbank network likely made the banking system more resilient to isolated liquidity disturbances by allowing those shocks to dissipate over the wider banking system. However, interconnectedness meant that local or regional banking panics could become national in scope. Strains on the system became acute when shocks drove up liquidity demand throughout the country, as in the panics of 1893 and 1907 (Calomiris and Gorton 1991; Wicker 2000). In panics, interbank networks transmitted shocks across the system and focused pressures on banks at the center of the network. A distinguishing feature of major banking panics was that banks throughout the country withdrew funds from banks at the center of the network simultaneously, rather than at the staggered times that characterized ordinary seasonal flows. Faced with considerably larger demand than usual, New York City banks would suspend cash withdrawals, which in turn caused banks in the rest of the country to suspend when they could not obtain funds from their New York correspondents.[1]

[1] Indeed, simply the possibility that the banks at the center of the system, especially the large New York City banks, might suspend could itself precipitate runs and cause them to suspend withdrawals (Vanderlip 1908; Carlson 2015). We leave aside the cause of panics, which have been studied extensively (e.g., Calomiris and

Reformers viewed disruptions to the banking system associated with suspension of the money center and other banks as having large economic costs (e.g., Sprague 1908). The Federal Reserve (Fed) was established expressly to prevent panics and their economic fallout (Owen 1919). To accomplish that objective, the Fed's founders sought to reduce the importance of interbank linkages, and in particular the role of the New York City banks at the center of the interbank network, while at the same time alleviating money market pressures caused by seasonal and other fluctuations in the demands for money and credit. A system of quasi-public Reserve Banks was set up to supplant the private network of interbank relationships that had both been the conduit for transmitting crises throughout the country and failed to fully alleviate seasonal pressures.[2]

This paper examines how the founding of the Fed affected the size of the interbank system and its vulnerability to liquidity and solvency shocks. Traditionally, the Fed has been seen as providing an elastic currency and mitigating seasonal pressures, but otherwise not greatly changing the structure of the banking system, which continued to consist largely of small, single-office banks. By contrast, we argue that the Fed's establishment profoundly affected how banks interacted with each other. We show that the Fed's founding was accompanied by a considerable reduction in the average volume of interbank deposits (scaled by total national bank assets or liabilities) and their seasonal volatility.[3] In part, the decline in the level of interbank balances reflected a shift of required reserve balances from private correspondent banks to the Reserve Banks. More importantly, the Fed's comparative advantage in meeting the seasonal demands of commercial banks for currency and reserves, and in providing interregional payments services, meant that there was less economic incentive for national banks to maintain interbank balances. The reduced volume of interbank deposits relative to total assets and liabilities in the national banking system, as well as reduced seasonal pressures on the system, in turn, affected the extent to which the interbank system was vulnerable to systemic risks. Whereas several studies have compared the prevalence and characteristics of the banking panics of the 1930s with those of the National Banking era, most

Gorton 1991). Wicker (2000) notes that, with the exception of the Panic of 1893, the major banking panics of the National Banking Era originated in New York City; the 1893 panic originated outside of New York City but heavy withdrawals by banks in the interior drained New York City banks of cash and eventually led them to suspend payments.

[2] Lowenstein (2015) explains how the Fed's decentralized structure reflected populist antipathy toward a "central bank" dominated by either Wall Street bankers or federal government officials. Jaremski and Wheelock (2016) show that the locations chosen for Federal Reserve Bank offices and Fed district borders reflected the preferences of national banks, which in turn reflected pre-existing interbank connections. Hence, the System was laid over top of the existing interbank network

[3] We cannot rule out all possible alternative explanations for the changed character of interbank deposits. However, our findings match the predicted responses and are consistent with a substantial literature on the impact of the founding of the Federal Reserve on seasonal money market pressure, including Friedman and Schwartz (1963), Miron (1986), and Bernstein, Hughson, and Weidenmier (2010).

studies focus on the Fed's performance as lender of last resort in comparison with the actions of private bank clearinghouses in the National Banking era (e.g., Friedman and Schwartz 1963; Gorton 1985; Calomiris and Gorton 1991), rather than on the vulnerability of the interbank system to contagion risks. However, the interbank system was an important conduit for the transmission of shocks across the banking system in the National Banking era, and there is evidence suggesting that it was also important during the Great Depression (e.g., Mitchener and Richardson 2014). Thus, research on how the founding of the Federal Reserve affected systemic risk in the interbank system could enhance our understanding of both the banking panics of the Great Depression and the impact of institutional changes—especially to the lender of last resort—on the vulnerability of interbank systems to contagion risk in general.

Drawing on theoretical descriptions of the functioning of interbank networks and their implications for the stability of banking systems, we construct quantitative measures of the resilience of the interbank system to solvency and liquidity shocks to gauge the impact of the Fed's founding on systemic risk in the interbank system. The insights from theoretical studies suggest that the vulnerability of interbank networks to systemic risk is related both to the extent of interconnections between members of the network and their relative sizes, as well as the size of the shocks hitting the system. Prominent in this literature is the idea that greater interconnectedness can make networks "robust-yet-fragile" (see, for example, Allen and Gale 2007; Gai, Haldane and Kapadia 2011; and Acemoglu, Ozdaglar, and Tahbaz-Salehi 2015). Specifically, greater interconnectedness makes an interbank network less fragile in the presence of relatively minor shocks, but can facilitate contagion and be destabilizing if adverse shocks are sufficiently large to eliminate the excess liquidity of the banking system. This may be especially true for core-periphery systems like the interbank system of the National Banking era, where shocks that affect the core are particularly problematic (Glasserman and Young 2015, Capponi and Chen 2015). Consistent with this description, the National Banking era system generally managed seasonal shocks well but broke down during banking panics. Other theoretical papers have considered how the existence of networks can affect bank behavior in ways that impact financial stability. For example, Castiglionesi, Feriozzi, and Lorenzoni (2012) present a model in which interbank markets move liquidity between banks located in different regions that have uncorrelated shocks. In their model, the ability to smooth idiosyncratic shocks allows banks to hold less cash and lend more than they could without interbank connections. However, lower cash balances imply that aggregate liquidity shocks result in more severe crises. This description also seems broadly consistent with the performance of the interbank system of the National Banking era.

We first examine how the Fed's founding affected solvency risk related to contagion from central reserve city banks in New York City and Chicago to reserve city and country national banks. Drawing on measures inspired by models of contagion in networks, such as Glasserman and Young (2015), we show that contagion risk declined after the Fed was established, reflecting importantly a decline in interconnectedness among national banks. However, the reduction in interconnectedness was partly offset by increased size and leverage among money center banks (as well as growth in the number and size of state-chartered banks). Overall, though, the establishment of the Fed seems to have mitigated the risk of this type of contagion.

Next, we consider how the Fed's founding affected the resilience of the banking system to liquidity stresses. The parts of bank balance sheets affected by liquidity shocks are somewhat different than those affected by solvency shocks, as are the channels through which the shocks are propagated. Again drawing on insights from network literature, we estimate the evolution of the national banking system's vulnerability to liquidity shocks associated with panic events that historically had affected the system. Following the Fed's establishment, national banks held a smaller proportion of their assets in the form of cash and other liquid assets, suggesting that they expected the Fed to provide liquidity through the rediscounting of commercial paper. Consequently, national banks were *potentially* more vulnerable to contagious liquidity shocks after the Fed was established even though interconnectedness among national banks was lower. This greater vulnerability to the sorts of liquidity shocks that called for a lender of last resort response illustrates how the introduction of a safety net alters private behavior in a way that increases the likelihood that the safety net will be needed.

The remainder of the paper is organized as follows: Section 2 examines the extent of interbank connectedness and the effect of seasonal pressures before and after the introduction of the Federal Reserve System. Section 3 discusses how banking panics were transmitted through the interbank system during the National Banking era. Section 4 focuses on how the Fed's founding affected contagion risk among national banks and presents quantitative estimates of the vulnerability of the interbank system to solvency and liquidity shocks. Section 5 concludes.

2. Regulation, Seasonal Demands and the Interbank Network

2.1 Role of the interbank system and interbank balances

In the late 1800s, the U.S. banking system consisted of a large number of small, widely dispersed, unit banks (see, e.g., Sylla 1975). However, commerce was increasingly nationwide in

scope. For instance, wheat crops were transported from many locations throughout the Plains states to cities in the Midwest and East for processing. Cotton was shipped from southern states to either New England or oversees (see Davis, Hanes, and Rhode 2009). Goods from overseas landed on the East Coast and were shipped to the interior. To facilitate this commerce, the banking system was required to move funds around the country which, given unit banking, meant that individual banks had to connect with each other through the interbank system. Rather than a complicated series of bilateral flows, transfers of funds between regions were typically routed through money center banks in New York City, Chicago, and other major cities. As described by James (1978), bank drafts and checks were the principal means for making regional and long-distance payments. Payment items were routed via the interbank network through the money center banks. Clearing and settlement was often accomplished by shifting balances from one bank's account to another within a single money center bank or through netting arrangements between members of bank clearinghouses in regional centers or New York City.[4]

The interbank system was especially important in managing seasonal fluctuations in economic activity, which were substantial as agriculture contributed a larger share of GDP than it does now (Barsky and Miron 1989; Davis, Hanes, and Rhode 2009). The harvesting, distribution and processing of agricultural crops generated considerable demand for money and credit in autumn months; a somewhat smaller increase occurred during the spring planting season (Kemmerer 1910). Banks in the interior attempted to meet heightened demands for money by drawing down their deposits in money center banks, which in turn drew funds from other banks where agricultural demands were less pressing. These regional differences in demand produced somewhat offsetting flows of currency and reserves for banks at the central nodes of the interbank market which were vital for accommodating seasonal fluctuations in money and credit demand. Since the aggregate stocks of currency and other forms of "lawful money" (gold coin, etc.) were relatively inflexible, however, interest rates would spike and money market conditions tighten at times of the year when seasonal demands peaked (Kemmerer 1910; Gendreau 1979; Miron 1986).

In addition to their use in making payments and managing seasonal fluctuations in money and credit demands, banks maintained balances with correspondents to diversify their asset portfolios and satisfy legal reserve requirements. Banks typically earned 2 percent

[4] Chang, Danilevsky, Evans, and Garcia-Swartz (2008) examine the check-clearing operations of a bank in Bloomington, Illinois in 1910 and find that processing operations were fairly efficient. Banks in a nearby regional center were used to clear nearby payments and banks in New York City used to clear checks at a greater distance.

interest on their correspondent balances, and could direct their city correspondent banks to invest a portion of those balances in the money markets (James 1978). Banks deposited excess funds with money center correspondents when the funds were not needed locally, and drew down their balances when they needed funds at home. Banks could also borrow from their correspondents. Such borrowings were typically limited to four or five times the deposit a bank held with its correspondent, which provided an extra incentive for banks to hold balances with correspondents (Conway and Patterson 1914).

The structure of legal reserve requirements provided yet another incentive for national banks to hold balances with correspondent banks. National banks were placed into one of three groups: central reserve city banks (those located in New York City, Chicago, or St. Louis), reserve city banks (banks in other selected large cities), and country banks (all other locations). Country banks were required to hold reserves equal to 15 percent of their deposits, of which two-fifths of which was required to be cash on hand while the remainder could be held as balances in either reserve city or central reserve city banks.[5] Reserve city banks were required to hold reserves equal to 25 percent of their deposits, of which half could be held as deposits in central reserve city banks. Central reserve city banks were required to hold reserves equal to 25 percent of deposits, all in the form of gold or other "lawful money."[6] Because banks usually earned interest on their correspondent balances, and because of their usefulness for making payments and managing seasonal flows, most national banks held a high percentage of their required reserves in the form of correspondent deposits, rather than as vault cash. Balances held at agent banks were generally well in excess of the amounts needed to meet reserve requirements. Country national banks could have satisfied their legal reserve requirements by holding balances with reserve agents of approximately 9 percent (three-fifths of the 15 percent requirement) of their deposit liabilities. However, their balances were roughly double that amount, suggesting that banks held deposits with reserve agents (and other national banks) for business needs beyond merely satisfying statutory reserve requirements.

In addition to maintaining balances with reserve agents, many national banks also held balances with other, non-agent national banks, presumably for making payments and as low

[5] Reserves were required against all individual deposits plus net bank deposits (i.e., deposits due to banks minus deposits due from banks). In the early part of the National Banking era, banks also were required to maintain reserves against their note issues, but that requirement was discontinued in 1874.
[6] The National Banking Act refers to "lawful money" which consisted of legal tender notes, gold and silver coin, and Treasury notes (Coffin 1890).

risk investments. Figure 1 provides a diagram illustrating some of the ways that interbank balances could be held and how those balances were classified in bank call reports.[7]

Many of the incentives for banks to hold balances with correspondents also led to a concentration of interbank deposits in the money centers, especially New York City and Chicago. The result was an interbank system with a hierarchical structure having a modest number of very well connected banks at the top that resembles the structure of many modern banking systems, including those of Germany (Craig and von Peter 2014) and the United Kingdom (Gai, Haldane, and Kapadia 2011). Haldane (2009) notes that such systems are generally more robust to shocks that hit the periphery, as the amount of contagion will be minimal, but more vulnerable to shocks at the center.

2.2 The Federal Reserve and its impact on the interbank system

Although the interbank system served to allocate liquid resources during the harvest season, it did not create additional liquidity. Consequently, interest rates exhibited wide seasonal fluctuations and "seasonal stringency" plagued money markets in autumn months (Kemmerer 1910). The Fed's founders saw a link between seasonal fluctuations in the demands for money and bank loans and banking panics. Most panics occurred at times of the year when the surplus liquidity of the banking system was at its lowest. Some attempts had been made to provide additional liquidity during crises, principally by the issuance of loan certificates by the major bank clearinghouses (Gorton 1985; Wicker 2000). However, the disruptions caused by panics, including declines in lending and suspensions of cash withdrawals, were seen as having significant macroeconomic consequences (e.g., Sprague 1913).[8] The major disruptions associated with Panics of 1893 and 1907, as well as several other panics of lesser magnitude, prompted calls for reform that led ultimately to the establishment of the Federal Reserve System in 1914.

Reformers blamed the country's "inelastic currency" stock for both seasonal money market "stringency" and for acute shortages of currency and payments suspensions during panics. They also worried about the resilience of the interbank market. The system seemed

[7] National banks were required to submit regular reports of their condition on specified dates to the Comptroller of the Currency. There were five calls in most years during the National Banking era. The frequency of calls varied considerably during the 1920s, however, from just three in 1926 to six in 1920. There were five calls in 1921 and 1922, and four in 1923, 1924, 1925, 1927, 1928, and 1929.

[8] By disrupting the normal method of clearing and settling payments, banking panics and suspensions made long-distance transactions more difficult, which depressed economic activity. With the Federal Reserve helping to clear and settle these transactions there would be considerably less risk that the payment system would be impaired, even if a panic occurred. Sprague (1908, 1913) provides a contemporary discussion. A modern, more formal analysis is provided by James, McAndrews, and Weiman (2013).

unable to supply enough funds to meet local needs (at least according to local borrowers who complained about seasonal spikes in interest rates). Further, the interbank system was vulnerable to disruptions caused by panics in the central money markets or elsewhere. Indeed, the possibility that money center banks would suspend payments made the interbank system vulnerable to self-fulfilling runs. Reformers recognized that to the extent panics were driven by runs of banks on other banks, then stopping this dynamic could help end panics entirely (e.g., Warburg 1916).

Some reformers also decried the concentration of the nation's bank reserves in reserve cities and central reserve cities, especially in New York City, and the investment of surplus funds in the call money market. Interbank deposits could be withdrawn at any time, and to the extent that a money center bank was unable to accommodate withdrawals by drawing down its excess reserves, it had to either reduce its assets or attract new deposits. Money center banks often invested surplus funds in the call loan market, which consisted of loans to financial institutions involved in trading stocks. Call loans were short-term—hence their interest rates could adjust quickly—and were secured using high quality equity shares. During normal times, ample liquidity in the call loan market meant that individual money center banks could enter or exit the market easily. However, that liquidity would vanish if all the banks sought to exit the market at once. The banking system and stock market were thus intertwined through the call loan market, and disturbances in one affected the other. Critics argued that lending in the call loan market was a source of instability for the banking system that interbank relationships amplified. Reform proponents sought to spread the distribution of the nation's bank reserves more evenly throughout the nation and to break the links between the banking system and the stock market, which were widely viewed as a source of instability.

To solve the problems stemming from ordinary seasonal fluctuations in money and credit demand as well as the acute shortages of liquidity brought about by financial disturbances, reformers sought a mechanism that would create flexible supplies of currency and bank reserves. That mechanism ultimately became the Fed's discount window, at which the System's member banks could obtain currency (Federal Reserve notes) or reserve deposits by rediscounting their agricultural or commercial loans. Congress restricted the types of collateral that banks could use to obtain funds from the Federal Reserve to short-term, "self-liquidating" commercial and agricultural loans in an effort to make the monetary and banking systems less vulnerable to disturbances from the stock market and other financial markets.

Congress also sought to lessen the concentration of the nation's bank reserves in New York City and the need for an interbank market to redistribute funds from surplus to deficit

regions. To accomplish that objective, Congress established a system of regional Federal Reserve Banks, with each Reserve Bank holding reserve deposits for its local member banks and furnishing them with currency and additional reserves as needed to accommodate local demands. Rather than having to draw down a deposit or borrow from a New York City (or other money center) correspondent, a Fed member bank could obtain funds from the discount window of its local Federal Reserve Bank. Further, only deposits with Federal Reserve Banks or vault cash satisfied a Fed member bank's reserve requirement. All national banks were required to join the Federal Reserve System, and hence they could no longer satisfy a portion of their reserve requirement by holding balances with reserve city or central reserve city banks.[9] The objective of these reforms was to provide funds locally and thereby reduce if not eliminate reliance on the interbank system to redistribute funds across the country. In the words of the Reserve Bank Organization Committee:

> The very essence of the new plan is intended to meet the condition which in the past has caused chief trouble by eliminating this necessity of interdependence between districts. The Federal Reserve Act will presumably afford a means of making each district self-supporting in a credit way so that assuming the plan to work as it is expected to work the need for mutual seasonal aid and shipments of currency will be minimized. (Reserve Bank Organization Committee 1914, p.15)

Another means by which the Fed was intended to reduce reliance on the interbank system was through the operation of the payments system. The Fed offered check clearing and settlement services for its member banks, and provided a means of interregional settlement. The requirement that member banks hold reserve balances with the Reserve Banks and other efforts by the Fed to encourage banks to use its payment services reduced the importance of the interbank system for clearing and settlement of payments (Gilbert 1998, 2000).

2.3 The size of interbank exposures before and after the founding of the Federal Reserve

Here we examine the importance of interbank balances during the National Banking era and whether the founding of the Fed was successful in reducing those balances. Figure 2 plots the share of national bank balance sheets that consisted of interbank balances before and after the establishment of the Fed. For country national banks, the figure shows the average balances due from national banks, scaled by total country bank assets. For reserve city banks, we plot both balances due from and due to national banks (again scaled by total assets) since reserve city banks were in the middle of the reserve pyramid. For central reserve city banks, which were at the top of the pyramid, we plot balances due to national banks (scaled by total assets).

[9] Membership in the Federal Reserve System was optional for state-chartered banks. Few state-chartered banks joined the System at first, however, because regulations imposed on member banks were generally heavier than those imposed on most state non-Fed member banks.

The data are as of each call report date during 1894-1914 and from 1921 to mid-1928.[10, 11] Table 1 also reports averages for the different periods.

The importance of interbank balances during the National Banking era and their reduced importance after the Fed was established are quite clear. Country banks, on average, held 13 percent of their total assets as balances with other national banks during 1894-1914 (Figure 2, top panel, black line). The share was a bit lower in the years just after the Panic of 1893, rose to around 16 percent of assets in the late 1890s, and then gradually trended lower for the rest of the period. Most but not all of these balances consisted of deposits with agent banks (shown by the grey dotted line). Following the establishment of the Federal Reserve, the share of country bank assets comprised of balances with other national banks declined sharply and averaged 7 percent during the 1920s.

Reserve city banks held a somewhat larger share of their assets in the form of balances with other national banks (middle panel, black line). Eighteen cities were designated as reserve cities from before the Panic of 1893 through1928.[12] Among these cities, the share of national bank assets that consisted of balances due from other national banks averaged almost 16 percent from 1894 to 1914, but just over 4 percent during the 1920s.

The deposits of respondent banks were an attractive source of funds for reserve city and central reserve city banks, and many of these banks relied heavily on such deposits. Balances due to other national banks averaged 14 percent of reserve city bank assets during the National Banking era (middle panel, red line). Consistent with the trends in deposits due from national banks at country banks, among reserve city banks, balances due to national banks were lower in the years just after the Panic of 1893 but rose later on. Following the Fed's establishment, respondent deposits declined in importance for reserve city banks, falling to just 7 percent of their total assets.

[10] To be precise, we plot the balances due from all national banks (reserve banks and other national banks) or balances due to national banks aggregated across all banks in a class and divided that by total assets aggregated across all banks in the same class for banks in the 48 contiguous states. We thank Warren Weber and the Federal Reserve Bank of Minneapolis for making the data for 1890-1910 available online (http://cdm16030.contentdm.oclc.org/cdm/landingpage/collection/p16030coll4).

[11] The first period starts after the Panic of 1893, which is also shortly after data become available for the 48 contiguous states and territories. It ends about the time the Fed was established. We begin the second period in April 1921 to minimize the disruption to Fed and member bank balance sheets associated with World War I and the immediate post-war period. We end the sample in June 1928 because thereafter the call reports no longer distinguish between balances due from national banks and balances due from state banks.

[12] We use data for these 18 reserve cities in throughout the paper, which allows better comparability over time. These 18 cities are: Albany, NY; Baltimore, MD; Boston, MA; Cincinnati, OH; Cleveland, OH; Detroit, MI; Kansas City, MO; Louisville, KY; Milwaukee, WI; Minneapolis, MN; New Orleans, LA; Omaha, NE; Philadelphia, PA; Pittsburgh, PA; Saint Joseph, MO; Saint Paul, MN; San Francisco, CA; and Washington, DC.

Respondent balances were an even more important funding source for central reserve city banks during the National Banking era. Shown in the bottom panel of Figure 2, during 1894-1914, deposits from other national banks averaged 23 percent of total central reserve city bank assets.[13] (We treat St. Louis as a central reserve city throughout the 1920s even though it was downgraded to reserve city status in 1922.) Like reserve city banks, central reserve city banks relied considerably less on deposits of other national banks for funding in the 1920s, when they averaged only 8 percent of total central reserve city bank assets, or about one-third the percentage that they had been before 1914.

Overall these measures point to a dramatic reduction in the level of interconnectedness of national banks at each level of the reserve pyramid following the establishment of the Fed. This drop likely reflects the changes in law by which only deposits held with a Reserve Bank could be used to satisfy reserve requirements as well as other incentives to maintain balances at the Fed.[14]

In addition to a decline in the total volume of interbank balances held across the national banks, interbank balances also were less concentrated in the central reserve cities during the 1920s. Shown in the fifth row of Table 1, as a share of all interbank balances in the three central reserve cities and 18 reserve cities, the balances held in the three central reserve cities fell from 65 percent during 1894-1914 to 58 percent in the 1920s. While the decline was modest, it is striking given that central reserve city banks held a larger share of the total combined assets of the reserve city and central reserve city banks in the 1920s (57 percent) than during 1894-1914 (55 percent).

2.4 Seasonal patterns before and after the Fed

Seasonal swings in credit and money demand were a key driver of flows of correspondent deposits through the interbank system. For many country national banks, especially in agricultural regions, seasonal peaks in loan demand and deposit withdrawals coincided, which banks typically met by drawing down their deposits with or borrowing from correspondents.[15] Facing demands from their respondent banks, the correspondent banks would either have to accept a decline in their total liabilities or attract funds from other banks in less agricultural areas (or both).

[13] If deposits of state banks are included, the share was closer to 45 percent of assets.
[14] Watkins (1929) provides a contemporary analysis of the demand for interbank balances in the 1920s.
[15] Banks could of course adjust other balance sheet items, such as their cash reserves. We also recognize that bank balance sheets are at least partly endogenously determined. However, we are more concerned with the correlation in broad balance sheet aggregates across states which are not likely to be affected by the adjustments in these other items or by the endogeneity issues.

To gauge the importance of seasonal pressures on the interbank system, we use principal components analysis to examine intra-year changes in interbank balances for the different classes of national banks. Specifically, for country banks, we calculate the principal components of changes between call report dates in balances due from national banks across the 48 states. For reserve city banks, we calculate the principal components of changes in *net* balances due from national banks (i.e., balances due from banks minus balances due to banks) across the consistent set of 18 reserve cities. Finally, for central reserve cities, we calculate the principal components of changes in balances due to national banks across the three central reserve cities. Given the growth in the size of the banking system over time, we scale changes in interbank balances by total assets.[16] So that we can observe how patterns change following the establishment of the Fed, we pool the years 1894-1914 and 1921-28.

The first principal component of changes in deposits due from national banks (scaled by total assets) for country banks is shown in the top panel of Figure 3. This principal component explains 27 percent of the variation across the 48 states, indicating that it importantly reflects nationwide trends in interbank balances. For the National Banking era, the principal component exhibits a strong seasonal pattern. For the 1920s, the seasonal pattern is decidedly dampened in amplitude. For 1894-1914, the standard deviation of the first principal component is .12, while for the 1920s it was just .04.

The interbank system allocated liquidity at harvest season not just by shifting funds between country national banks and central reserve cities, but also between country national banks in different regions of the country. The principal component analysis sheds some light on these dynamics. We find that about as many states load positively on the first principal component (25) as load negatively (23). Different signs on the loadings imply that while balances due from national banks were increasing at country banks in some states they were declining in others.

Many of the states that load positively and most heavily on the first principal component of balances due from national banks were located in the South (Alabama, Arkansas, Georgia, Louisiana, Mississippi, South Carolina, Tennessee, and Texas). The states involved suggest that the first principal component is strongly related to the cotton harvest.[17] By contrast, states with negative loadings were mainly located in the West and New England, where agriculture was less

[16] Using unscaled changes results in similar patterns that increase in amplitude over time.

[17] The links between regional crop patterns and the principal components fits with historical narratives. For example, the first principal component of due from national banks agents, which we link to cotton and the Southern states, declines one call report after the second principal component. This pattern matches the description of Kemmerer (1910), who reports that flows of funds from New York to Southern states peaked later than flows to Midwestern states (see, e.g., Kemmerer 1910, Chart XXXIII).

important. For the National Banking era, the correlation coefficient between changes in balances due from banks (scaled by total assets) between southern states and states in the West and New England is –0.21. Figure 4 shows a portion of this time series (abbreviated for visual ease). These offsetting flows reflect the movement of funds through the interbank system and illustrate the importance of the interbank system in moving liquidity between regions. In the 1920s, changes in due from banks for the same sets of states are strongly positively correlated (+0.75), which is further evidence that the interbank system was less important for meeting seasonal pressures after the Fed was established.

For reserve city banks, shown in the middle panel of Figure 3, the first principal component of changes in net balances due from banks does not show an obvious seasonal pattern. However, because reserve city banks could meet seasonal demands by drawing down their own balances at national banks, it is not obvious that net flows should be seasonal; indeed the lack of an obvious seasonal pattern may indicate that these banks simply passed any pressures from seasonal withdrawals by their respondent on to other banks—central reserve city banks in particular.[18] Nevertheless, the first principal component explains about 25 percent of the variation over time across the 18 reserve cities, indicating that it represents a fairly common driver of changes in interbank balances. It is also clear that the amplitude of this factor diminished following the establishment of the Fed. The standard deviation of this principal component declines from .06 for 1894-1914 to .03 for 1921-28.

The first principal component of changes in deposits due to national banks (scaled by total assets) for the three central reserve cities is shown in the bottom panel of Figure 3. This principal component explains 71 percent of the variation over time in changes in balances due to national banks across these three cities; while the explanatory power is expected to be higher when there is a smaller cross sectional sample, it nevertheless points to an important common component in the drivers of changes in interbank balances at banks in these cities. A seasonal pattern during the National Banking era is apparent, although there are sharp movements in this principal component at other times as well. The seasonal pattern might be present for a few years in the early 1920s, but is certainly gone by the end of that decade. The volatility of the series is also lower in the 1920s, with the standard deviation of the first principal component falling from .04 in the National Banking era to .02 in the 1920s.

[18] We also examined the patterns in gross changes in due from national banks and due to national banks separately for the reserve city banks. Similar to the net, there is not an obvious seasonal in either of these series. However, the volatility of these balances declined following the establishment of the Fed, especially in changes in balances due from national banks.

Overall we find that the interbank balances of banks at different levels of the reserve pyramid exhibited less seasonal variation after the establishment of the Fed. Since fluctuations in interbank balances reflected seasonal demands that passed through the interbank system from one group of banks to another, the Fed's founders appear to have accomplished one of their main objectives, i.e., to reduce seasonal pressures on the interbank system. The lessening of seasonal flows of interbank balances is also consistent with the well-documented declines in seasonal variation in interest rates and stock returns after the Fed's founding (Friedman and Schwartz 1963; Miron 1986; Bernstein, Hughson, and Weidenmier 2010).[19]

The Federal Reserve Banks contributed directly to reducing seasonal pressures on interbank markets by allowing their own balance sheets to expand and contract seasonally. Federal Reserve credit tended to rise during months when previously banks had withdrawn funds from correspondents to meet seasonal demands for cash and loans, and when money market conditions had tightened, and fell during months when previously banks had deposited funds with correspondents as local demands eased. Seasonal variation in the volumes of discount window loans and Fed purchases of bankers acceptances accounted for much of the seasonal variation in Federal Reserve credit. In the case of discount window lending, each Reserve Bank set a discount rate and lent currency or reserves at that rate against acceptable collateral.[20] Similarly, each Reserve Bank set a schedule of "bill buying" rates at which it would buy bankers acceptances. The Reserve Banks generally did not make seasonal adjustments to either their lending rates or terms. Thus, seasonal fluctuations in Reserve Bank lending and acceptance purchases were driven mainly by market demand for liquidity, rather than by explicit supply adjustments by the Fed (Wheelock 1992).

We estimate the seasonal patterns of discount window lending and acceptance purchases by regressing the sum of discount window loans outstanding and Fed holdings of bankers acceptances ("Federal Reserve credit") on 12 monthly dummy variables, a national index of industrial production (measured relative to January 1915) to capture the effects of the business cycle on the demand for Fed credit, and a time trend. We estimate the model using data for January 1922-August 1931.[21] As shown in Table 2, the coefficients on the monthly dummies

[19] See Carlson and Wheelock (2016) for additional discussion of the seasonal patterns of balance sheets of banks in this period.

[20] At first, the Reserve Banks extended credit by rediscounting eligible paper, which consisted primarily of short-term commercial and agricultural loans made by the member bank (such loans were usually offered on a discount basis). Later on, the Fed began to extend loans (termed "advances") directly to member banks and advances became the dominant form of discount window lending.

[21] We begin the estimation period in 1922 to avoid a large bulge in discount loans during World War I that resulted from the Fed's setting of a preferential discount rate for loans secured by U.S. Government securities. Discount loan volume declined sharply in 1921 after the Fed ended the preferential rate and increased the discount rate to a high level. Similarly, we end our estimation period with August 1931 to avoid a sharp and

indicate strong seasonal patterns with the coefficients for August-December noticeably larger than those for January-July. For ease of comparison, Figure 5 plots each monthly dummy coefficient relative to the mean of the 12 coefficients. As the figure shows, the volume of Federal Reserve credit outstanding tended to rise sharply in the fall, reflecting seasonal agricultural demands, reaching a seasonal peak in December. Local peaks in March, June, and September coincided with end-of-quarter reserve demands.[22] On average, the Federal Reserve supplied $350 million more liquidity to member banks via discount window loans and acceptance purchases in December than in April (the typical seasonal low point).[23]

Overall, the evidence in this section indicates that flows of interbank balances of national banks were less seasonal in the 1920s than they had been before the Fed was established. Further, the seasonal pattern of Federal Reserve credit suggests strongly that at least some of those seasonal fluctuations were eliminated by the new central bank, as the System's founders had intended. By varying Federal Reserve credit to meet seasonal fluctuations in money and credit demands, the Fed eliminated one of the economic rationales for interbank connections that had prevailed in the national banking era as well as the recurring seasonal pressure on the interbank system.

3. Banking Panics and Interbank Activity

Normal seasonal patterns and flows broke down during banking panics. Panics were characterized by widespread increases in liquidity demand. In such situations, interbank connections served to transmit stresses throughout the system.

To illustrate the increased demand for liquidity and withdrawals of reserve balances during panics, we compare changes in correspondent deposits for all country national banks during the panics of 1893 and 1907 with the average changes during the same months in non-panic years. We also examine the pressures faced by reserve city and central reserve city banks

unusual increase in discount window loans during a banking crisis that began after Great Britain left the gold standard in September 1931. We obtain qualitatively similar estimates of the seasonal patterns in Federal Reserve credit if we begin the estimation period prior to 1922 or terminate the period before August 1931, but specific monthly coefficients are somewhat sensitive to the estimation period. Estimation results for other periods are available from the authors upon request.

[22] Smith (1932) attributes quarterly spikes in demand to interest and dividend payments.

[23] Seasonal patterns vary somewhat across the Federal Reserve districts. Discount window loans and acceptance purchases of the Boston, New York, Philadelphia, Cleveland and Chicago Reserve Banks typically peaked in December, whereas those of most other Banks peaked in the autumn (September, October, or November). These differences likely reflected the relative importance of financial services and manufacturing in the Northeast and of agriculture in most other regions of the country. Estimation results by Federal Reserve district are available from the authors upon request.

during the panics by investigating how changes in their respondent deposits in the panic years compared with changes during other years.

The first panic occurred in the summer of 1893. Between May and September 1893, country national banks withdrew deposits from their reserve agents and other national banks totaling 1.3 percent of their total assets (average across 48 states). During the same months in non-panic years, country banks added to their balances with other national banks by an average of 0.5 percent of their total assets (Table 1, first line). Similarly, between September and December 1907, when the Panic of 1907 was at its height, country national banks withdrew funds totaling 1.1 percent of their total assets from correspondents, whereas normally in those months country banks increased their deposits at other national banks by 0.2 percent of their total assets. A similar pattern is apparent if we scale these flows by the total assets of reserve city and central reserve city banks, rather than by the total assets of country banks (line 7).

The geographic breadth of interbank withdrawals during panic periods was also unique. Normally, between May and September, country banks in the South withdrew deposits from reserve city and central reserve city banks, but country banks elsewhere added to their deposits (lines 2-6). Between September and December the pattern would reverse, with southern banks rebuilding their correspondent balances while banks in other states withdrew deposits or left them relatively unchanged. During the panics of 1893 and 1907, however, withdrawals were both large and widespread, with banks throughout the country attempting to withdraw from their city correspondents simultaneously.

The impact of panics on reserve city and central reserve city banks is shown in the bottom two lines of Table 3. During panics, withdrawals of deposits due to national banks at reserve city and central reserve city banks were much larger than normal.[24] In 1907, withdrawals by respondent banks caused deposits due to national banks to fall by an average of 2.7 percent of total assets across reserve city banks, while non-bank customer deposits fell by 2.5 percent of assets. However, at central reserve city banks, the pressure of withdrawals came almost exclusively from other banks. Across the three central reserve cities, deposits due to banks declined by an average of 2.6 percent of total assets while deposits of other customers rose by 0.5 percent. That withdrawal pressures on banks in the core of the interbank system came mainly from other banks is consistent with reports by some bankers that the panics, especially the Panic of 1907, were more panics of bankers than panics of ordinary depositors

[24] The "due to national banks" item of reserve city and central reserve city banks includes deposits of not only country national banks, but also of other reserve city and central reserve city banks. In addition to deposits due to national banks, we also examined the behavior of balances due to state banks and trust companies. These other deposits behave similarly and exhibit much steeper declines during the panics.

(Vanderlip 1908).[25] It also illustrates how the interbank market figured prominently in the financial instability of the National Banking era.

The differences in interbank deposit flows between the seasonal and panic periods provide an indication of the size of the shocks needed to shift the system from "robust" to "fragile" in the terminology of Haldane (2009). As noted by Allen and Gale (2000), networks are very good at allocating liquidity but cannot create liquidity. Seasonal demands were generally moderate and offsetting interregional flows meant that the change in the total amount of interbank claims was modest. The panic shocks, however, were characterized by widespread declines in total interbank claims (in addition to notable net decreases in the deposits of other bank customers) which resulted in declines in total liquidity. The pyramid structure of the reserve system amplified these declines. Table 3 shows that the declines in interbank claims were not massive. However, they were consequential. To meet extraordinary deposit withdrawals during panics, short of suspending withdrawals, reserve city banks drew down their reserves and, in some cases, liquidated assets. The cash reserves of money center banks declined rapidly during panics, both in absolute terms and as a share of their total assets. Banks also reduced lending. From May to October of 1893, the loans of reserve city banks contracted by an amount equal to 11 percent of initial assets (average across 18 reserve cities), compared with a typical increase of 1.4 percent over those months. Similarly, between August and December 2007, loans of reserve city banks declined by an average of 2.7 percent of initial assets whereas loans would typically increase by 1.4 percent of assets in those months. Conceivably, some of the drop in lending reflected a decline in loan demand, but it seems as likely that businesses would have been seeking credit to help weather the economic shock.

That the panic withdrawals were widespread as well as large is consistent with the sorts of stresses highlighted in models of Allen and Gale (2007) and Castiglionesi et al. (2012) in which panics are associated with aggregate liquidity shocks. In our case, customer withdrawals at country banks (the peripheral nodes) were transmitted through the interbank system to the reserve cites and central reserve cities (core nodes); in this way the panic appears similar to the aggregate shocks described in the theoretical models, and is a dynamic that we attempt to capture in counterfactual stress tests in Section 4.

[25] There are a number of potential reasons for the changes in behavior from the usual uncorrelated interbank flows to the synchronous outflows from the reserve city and central reserve city banks. It could be that there were concerns about the solvency of these institutions. However, as noted by Carlson (2015), bankers may also have been concerned that the banks in New York would suspend convertibility during a stress period and attempted to pull their funds out before any suspension would occur. This dynamic would have meant that the pressures on New York and the other reserve cities were somewhat self-fulfilling in nature.

4. The impact of the Federal Reserve on contagion risk in the interbank system

Next we examine how contagion risk among national banks changed following the establishment of the Federal Reserve. We consider contagion risk stemming, alternatively, from solvency shocks and from liquidity shocks. A solvency shock impacts the asset side of a bank's balance sheet and is potentially contagious if the equity of the affected bank is insufficient to absorb losses to the value of the bank's assets. Given the hierarchical structure of interbank claims in the network, we consider the potential impact of severe distress in central reserve city banks on the solvency of country and reserve city banks. In the National Banking era, when country national banks held large claims on reserve city and central reserve city banks, and reserve city banks held large claims on central reserve city banks, a failure of a central reserve city bank could threaten the solvency of banks throughout the system. For instance, in the Panic of 1907, the failure of trust companies raised concerns about the viability of some New York City national banks.[26] We employ a theoretically-based measure of the exposure of the system to solvency shocks. As the interconnectedness of the system decreased following the founding of the Fed, models such as Gai, Haldane, and Kapadia (2011), Glasserman and Young (2015), and Capponi and Chen (2015) suggest that a solvency shock should have had less impact on the system of the 1920s than during the National Banking era.

The dynamics of a National Banking era liquidity shock were somewhat different. In the case of a liquidity shock, deposit withdrawals cause a bank to withdraw balances due from other banks (or liquidate assets) if it does not have sufficient cash on hand to meet the withdrawals.[27] Again, the hierarchical structure of the network suggests a particular path for these withdrawals. We estimate the stress on the system resulting from withdrawals of a panic shock calibrated to match the Panic of 1893. As described by Wicker (2000), the Panic of 1893 originated outside the central money markets and the shock was transmitted via the interbank system to banks in major cities. Again, with reduced interconnectedness, one might expect that the system was more resilient to such shocks following the founding of the Fed. However, banks also held lower volumes of cash and other liquid assets in the 1920s. Part of the decline in liquid assets reflected a reduction in required reserve ratios with the enactment of the Federal Reserve Act. However, banks appear to have reduced their buffer stocks of liquid assets as well. Figure 6 plots the ratio of cash and near cash assets, including balances due from reserve agents,

[26] Gorton and Tallman (2016) document actions by the New York City clearinghouse to assist troubled national banks in the Panic of 1907 and earlier panics. A more recent example that motivates analysis of a top down solvency shock is the rescue of Continental Illinois Bank in 1984. One reason regulators cited for the rescue was that they were concerned that the failure of Continental would have seriously impacted its numerous respondent banks (Federal Deposit Insurance Corporation 1997).

[27] Banks can also experience liquidity shocks if a large number of borrowers simultaneously draw upon lines of credit.

balances due from other national banks, and balances due from the Fed relative to total assets for central reserve city banks, reserve city banks, and country banks.[28] We illustrate the portion of these liquid assets that were required to be held to meet reserve requirements and the portion that represented "excess" liquidity. As shown in Figure 6, the amount of liquid assets that banks were required to hold to meet reserve requirements diminished following the establishment of the Fed. Excess liquidity also diminished for all three groups of banks, although the declines for central reserve city banks and reserve city banks, where average excess liquid assets to total asset ratios fell from 7.6 percent and 12.2 percent respectively in the National Banking era to 4.1 percent and 8.2 percent in the 1920s, were more notable than for country banks, where the average ratio declined from 10.5 percent to 8.5 percent. For banks to hold less cash in the presence of a central bank capable of providing liquidity is perhaps not surprising, but it does mean that the resilience of the system to liquidity shocks might depend on the central bank actually providing additional liquidity if a shock does occur.

Section 4.1 Impact of the Fed on vulnerability to contagion via solvency shocks

We illustrate the potential for the failure of central reserve city banks to impact the solvency of other groups of banks using a measure of contagion risk described by Glasserman and Young (2015). They argue that the impact a set of banks (*j*) can have on other banks in a network is reflected in a contagion index that is a function of i) the size of those banks, ii) their connectedness to the network, and iii) their leverage. Bank size is measured by total net worth. Connectedness is measured by the share of a bank's liabilities that are due to other banks in the financial system (for the purpose of this exercise we include state-chartered banks as being within the financial system).[29] Leverage is measured by the ratio of assets not involving claims on other banks in the financial system (both state and national banks) to net worth. These items are combined multiplicatively:

$$\text{Contagion index}_j = \text{size}_j * \text{interconnectedness}_j * (\text{leverage}_j - 1) \quad (1)$$

The average vulnerability of another set of banks (*i*) to shocks from banks in set (*j*), measured relative to the vulnerability of banks (*i*) to shocks hitting their other assets, depends on the average size and leverage of banks (*i*):

$$\text{Average vulnerability}_i = \text{harmonic mean of leverage}_i * \text{arithmetic mean of size}_i \quad (2)$$

[28] Here and below, cash and near cash consist of cash items, bills of other banks, fractional currency, specie, legal tender, and checks on banks in the same place. We continue to treat St. Louis as a central reserve city even though it converted to a reserve city in 1922. Reserve requirement calculations follow Coffin (1896) in the national banking era and Feinman (1993) for the period after the establishment of the Fed.

[29] This connectedness measure divides balances due to national and state-chartered banks by total liabilities rather than total assets. Nevertheless, the time series of this measure is quite similar to that shown in Figure 2.

Greater size (again measured by total net worth) clearly increases the ability of banks to withstand shocks directly. Greater leverage, measured by the ratio of assets not involving claims on other banks in the financial system to net worth (as in (1)), means that the banks in set (*i*) are more likely to be affected by shocks to their own assets than by shocks coming from banks in set (*j*).[30]

We measure the average vulnerability of country national banks across the 48 states, and vulnerability of reserve city banks in the consistent set of 18 reserve cities, at each call report date. We then construct the contagion indexes for the central reserve cities of New York and Chicago.[31]

We plot the ratio of the contagion index divided by the average vulnerability measure over time (specifically, 1894-1914 and April 1921-June 1928, which is the last month for which the requisite data are available). Constructing the ratio in this way, the higher the ratio, the more likely that shocks from the central reserve cities will be contagious, at least in comparison with the likelihood that there is a direct shock that impacts the country banks (or the reserve city banks). A decrease in the ratio implies that that the country banks (reserve city banks) have become relatively less vulnerable to a shock emanating from the central reserve cities. Glasserman and Young (2015) define contagion risk as "weak" if the banks in set (*j*) are more likely to fail from a direct shock than through contagion from (*i*); this corresponds to a situation where our ratio is less than 1. The ratio of the contagion index to average vulnerability is particularly useful in our context in that, when the ratio is less than 1, we can be sure that contagion will be weak, regardless of the structure of the rest of the network. In particular, we do not need to know how banks in set (*i*) are related to each other. In that sense the ratio is also fairly conservative in that it specifies a minimum condition before contagion is possible.

The ratios of the contagion indexes of New York City banks and Chicago banks to the average vulnerability of country banks are plotted in the upper panel of Figure 7, while similar ratios for reserves city banks are plotted in the lower panel. In general, we find that the rest of the banking system would be strongly affected by a shock emanating from New York. A shock from Chicago mattered, but was borderline "weak," especially for reserve city banks.

[30] Note that the framework allows banks in set (*i*) to be a subset of other banks in the financial system. This aspect is useful for us because it means that we do not need to know whether the claims that banks in set (*i*) are on banks in set (*j*) or on other banks in the financial system.

[31] We omit St. Louis here for ease of displaying in the charts. St. Louis was much smaller than either of the other cities so the measures constructed here indicate that failure of St. Louis banks would not have had a systemic impact.

For both country banks and reserve city banks, we find that the likelihood of contagion from either New York banks or Chicago banks was lower in the 1920s than it had been before the founding of the Fed. The reduction is particularly notable with regard to the vulnerability of country banks to a shock emanating from New York City. This fall in vulnerability stemmed importantly from the lower interconnectedness of banks in the central reserve cities.

Other changes in the banking system also affected the vulnerability of country banks and reserve city banks to solvency shocks. The leverage of the country and reserve city banks rose (Figure 8). It is important to remember that the vulnerability measure is of the relative likelihood that banks in set (i) become insolvent because of shocks to their own balance sheets versus contagious shocks. The increase in their own leverage meant that country and reserve city banks had become more vulnerable to direct shocks and thus relatively less vulnerable to contagious shocks. However, the average leverage of central reserve city banks also increased, though not as much as at the other banks. Increases in leverage at central reserve city banks would increase our vulnerability measure. While the size (net worth) of the different sets of banks also affects vulnerability, the sizes of the country banks, reserve city banks, and central reserve city banks increased by roughly similar proportions over time. Consequently, changes in size did not matter very much. On balance, these other changes contributed to the reduction in the vulnerability of the country and reserve city banks to shocks from New York and Chicago banks and added to the effect of the decline in interconnectedness.

Section 4.2 Impact of the Fed on vulnerability to contagion via liquidity shocks

The solvency shocks described above passed down the chain as banks without sufficient equity would be unable to fulfill their own obligations. Next we study the impact of liquidity shocks on the national banking system. We do so by constructing a shock that mimics the experience of the banking system during the Panic of 1893. The structure of this shock is in many ways the reverse of the solvency shock considered previously. Here we examine the capacity of the asset-side of bank balance sheets to absorb shocks to the liability-side of the balance sheet.[32] The shock is transmitted from the bottom of the system to the top as banks at the bottom draw on balances held with banks higher in the reserve pyramid. In this way, we focus on the importance of linkages as in Allen and Gale (2000); our shocks are also broadly similar to the liquidity shocks in Castiglionesi et al. (2012).

[32] We assume that only liquid assets can be used to meet the shocks. Illiquid assets, such as loans, cannot be sold or liquidated even at fire-sale prices, and we assume that banks are unable to borrow. This is consistent with the ability of the banks in this time period to suspend operations. It also focuses the exercise more directly on liquidity rather than involving concerns about solvency and the interaction of solvency and liquidity.

We view liquidity shocks as reflecting draws on national banks from outside the national banking system—in particular from individual depositors and state-chartered banks. To calibrate the shock, we calculate the percent change in individual deposits and deposits due to state-chartered banks at national banks for each state, reserve city, and central reserve city between May and October 1893. It should be noted that these observed deposit declines understate the pressures faced by national banks as suspensions of convertibility in some cities meant that some depositors (both banks and individuals) were unable to withdraw their funds. The months of May to October spanned two call report dates. Since the panic ran throughout the entire period and liabilities lost in the first part of the period were generally not replaced, we define the panic shock as the outflow of deposits from May to October, and simulate how an outflow of that size would have affected the national banking system in 1894-1914 and 1921-28. We note that the rate of decline in deposits for national banks in the 1893 panic was slightly less than the decline experienced by national banks from June 1931 to June 1932 during the panics of the Great Depression. Hence, the 1893 panic is a historically plausible benchmark for examining how the system's resilience to a large liquidity shock evolved over time.

First (step 1), we estimate the impact of the 1893 liquidity shock on country national banks at each call report date. We assume that the country banks first meet deposit outflows by running down their cash—specifically the following call report variables: cash items, bills of other banks, fractional currency, specie, and legal tender.[33] For the 1920s, we also include deposits held with the Federal Reserve.[34] For the National Banking era, we assume that country banks draw down their balances with reserve agents up to the amount that they reported holding with those agents if they do not have sufficient cash to meet withdrawals. Because call reports do not distinguish between balances at reserve city agents and central reserve city agents, we assume that one-third of country bank withdrawals are from central reserve cities and the remainder are from reserve cities.[35] This assumption affects how shocks are distributed between reserve city banks and central reserve city banks, but not the size of the shock coming

[33] During the Panic of 1893, country national banks experienced a decline in deposits of individuals totalling $190 million out of total initial deposits of $950 million, and a decline in deposits of state banks totalling $9 million out of an initial total of $25 million. To meet these withdrawals, country banks had a total of $135 million in cash, $38.5 million in balances at national banks other than reserve agents (although aggregate deposits due from non-reserve-agent national banks minus aggregate deposits due to non-reserve-agent national banks was about zero), and $121 million in balances at reserve agents in May 1893.

[34] In the 1920s we also include checks on banks in the same place and outside checks and cash items. Otherwise, we do not include "float," either in the form of clearinghouse exchange or items with the Federal Reserve in process of collection. Including these as liquid assets does not affect our general conclusions but does have an impact on the quantitative difference between the pre-Fed and post-Fed period as float was substantially higher in the 1920s.

[35] If one subtracts all balances due from agents for reserve city banks from all balances due to national banks and takes the remaining amount as due to country banks, that amount averages roughly one-third of the balance due from agent banks held by country banks during the National Banking era.

from the country banks. Further, we assume that country banks can withdraw balances due from national banks other than reserve agents in states where such balances exceed deposits due to national banks. That is, we allow country banks to draw the difference between balances due from national banks and due to national banks if that difference is positive. We assume that these withdrawals are from non-agent reserve city or central reserve city banks (rather than from other country banks).[36]

Next (step 2), we consider the impact of the liquidity shock on reserve city banks. We assume the shocks to reserve city banks consist of two parts. The first is a decline in individual deposits and deposits due to state banks equal to the rate experienced during the Panic of 1893 in the given city multiplied by the current amounts of such liabilities (the same procedure as for the country banks).[37] The second part reflects withdrawals from country national banks based on the results from step 1. Because of limitations in the data, we assume that withdrawals by country national banks from a given reserve city equal the decline in deposits due from reserve city agents in all reserve cities multiplied by that reserve city's share of all deposits due to national banks at all reserve city banks. For example, if Boston (a reserve city) had 10 percent of the deposits due to national banks at all reserve city banks then we assume that 10 percent of the withdrawals by country national banks from reserve city banks came from Boston banks. Thus, for each reserve city *k* out of the set of all reserve cities *K*:

$$withdrawals_k = indiv\ dep_k * panic\ \%\Delta_k + due\ to\ state\ banks_k * panic\ \%\Delta_k +$$
$$\Delta\ due\ from\ agents\ at\ country\ banks * .67 * \frac{due\ to\ national\ banks_j}{\sum_J due\ to\ national\ banks} \quad (3)$$

As with country banks, we assume that reserve city banks meet withdrawals first with cash (defined as before) and then by withdrawing balances due from their own agents, up to the amount they held with those agents. In the National Banking era, where balance are divided between due from agent banks and due from other national banks, we assume that the balance sheet item "due from national banks (other than reserve agents)" reflects balances with other reserve city banks; thus, from the point of view of our exercise, withdrawals of these from one

[36] This assumption may slightly upwardly bias our estimate of the impact on reserve city banks. However, it will be the same upward bias throughout the sample period. Given shifts in how interbank balances are reported following the establishment of the Fed, this assumption is useful in making the analysis consistent over time. Moreover, we expect any bias to be slight because, if the country banks did withdraw these funds from other country banks, it would simply increase the withdrawal pressures on those institutions which they would in turn pass on to their agent banks in the event that they did not have sufficient cash on hand, as was generally the case.

[37] During the Panic of 1893 individual depositors withdrew $54 million out of total deposits of $393 million, and state banks withdrew $8 million out of a total of $46 million held by national banks in the 18 reserve cities. To meet these withdrawals, reserve city banks (in May 1893) had a total of $77 million in cash, $37 million in balances at national banks other than reserve agents, and $51 million in balances at reserve agents.

reserve city would be a gain to another reserve city and thus have no net benefit or cost to the set of reserve city banks. To the extent that some of those balances were actually with central reserve city banks rather than other reserve city banks, we are understating the pressures on central reserve city banks. For the 1920s, we assume that the proportion of reserve city bank balances in central reserve cities was 65 percent, which was the average share of all reserve city bank balances with agent banks in central reserve cities before 1914.[38]

The number of reserve cities changed over time. We track individually the 18 cities that were reserve cities over the entire period. We pool the remaining reserve cities into a composite "other reserve cities" and treat this pool as a single reserve city. We assume that this pooled reserve city experiences withdrawals equal to the median experience of the 18 reserve cities.

We can create four metrics based on the results of the exercise so far: the ratio of total withdrawals from reserve city banks relative to their cash; the ratio of total withdrawals from reserve city banks relative to their cash and balances due from agents; the number of reserve cities that exhaust their cash balances; and the number of reserve cities that exhaust their cash and balances due from agents. A ratio that exceeds 100 percent indicates that the reserve city banks collectively did not have sufficient resources (cash or cash plus balances with agents) to meet withdrawal demands.

We next consider the impact on the three central reserve cities (step 3). For consistency, we treat St. Louis as a central reserve city even though it converted to a reserve city in 1922. The procedure here is similar to the one used for the reserve city banks. We assume that central reserve city banks experienced withdrawals equal to the run off rates from their own individual deposits and balances owed to state banks during the Panic of 1893, declines in deposits due to country banks from step one, and declines in deposits due to reserve city banks from step two.[39] We apportion declines in deposits due to country banks and reserve city banks based on the total deposits due to national banks at each central reserve city. Thus, for each central reserve city l of the set of all central reserve cities L, withdrawals are:

[38] Alternatively, assuming that all balances are held at central reserve city banks has only modest effects, especially once we take into account step 4 below.

[39] Individual depositors withdrew $52 million out of total deposits of $383 million, and state banks withdrew $13.5 million out of a total of $81 million from central reserve city banks during the Panic of 1893. To meet these withdrawals, central reserve city banks had a total of $134 million in cash on hand in May 1893.

$$withdrawals_l = indiv\ dep_{lk} * panic\ \%\Delta_l + due\ to\ state\ banks_l * panic\ \%\Delta_l +$$
$$\Delta\ due\ from\ agents\ at\ country\ banks * .33 * \frac{due\ to\ national\ banks_k}{\sum_l due\ to\ national\ banks} +$$
$$\Delta\ due\ from\ agents\ at\ reserve\ city\ banks * \frac{due\ to\ national\ banks_k}{\sum_l due\ to\ national\ banks} \quad (4)$$

We assume that central reserve city banks can only use cash (including reserve deposits with the Fed) to meet withdrawals. There are no other banks from which they can pull funds. We assume that any balances they hold with other national banks are with other central reserve cities and thus net out for the group as a whole. We assume that central reserve city banks suspend if they do not have sufficient cash to meet withdrawals. We then calculate the ratio of withdrawals to cash available, both at the individual central reserve cities and as a group. If this latter ratio is greater than 100 percent, then the system does not have enough cash to avoid suspension of payments.

As a final step, we account for contagion back to the reserve cities (step 4). Specifically, if the shock to the central reserve cities exceeds their combined cash holdings, we limit the amount that reserve city banks can withdraw from central reserve cities to reflect the degree by which total withdrawal demand exceeds the available cash at central reserve city banks.[40] This effectively limits the balances due from agents that reserve city banks have available to meet shocks, which could increase the number of reserve cities that exhaust their liquid resources and must suspend.

In conducting this exercise, we make several other assumptions worth noting. First, we assume that balances held at state banks cannot be used as a liquid resource. It seems unlikely that balances with state banks would be available if state banks were themselves drawing down their balances with national banks.[41] Additionally, we assume that banks cannot borrow from each other (for example by rediscounting loans). The literature (e.g., James 1978, Calomiris and Carlson 2015) suggests that banks usually borrowed from their agents in New York City and Chicago, which would mean that our exercise underestimates the amount of stress being put on the upper tiers of the reserve pyramid.

[40] Thus, we assume that reserve city banks can only obtain cash from central reserve city banks up to the lesser of 1) the deposits they have with central reserve city banks or 2) the cash that central reserve city banks have on hand. As a consistency check, we verify that estimated withdrawals by national banks are less than deposits due to national banks for both central reserve city banks and reserve city banks.

[41] For instance, Vanderlip (1908) reports heavy withdrawals by state banks from national banks during the panic of 1907. Calomiris and Gorton (1991) note that the suspension rate of state banks tended to be higher than the suspension rate of national banks; if the state banks were suspended, they would be unable to redeem interbank deposits.

As shown in Figures 9 and 10, we estimate that, throughout the national banking era, a panic shock of the order of magnitude of the 1893 shock would have been sufficient to deplete the cash resources of the reserve cities as a group (as the ratio of withdrawals to cash holdings exceeds 100%). However, by drawing down their balances held with reserve agents, banks in reserve cities usually would have had sufficient resources to avoid suspending (the ratio generally remains below 100%). Interestingly, we find that in the early 1900s, banks generally held less cash relative to the potential run off (as reflected in Figure 9 by an increase in the ratio of panic withdrawals to liquid assets), but after the panic of 1907 they increased their cash holdings relative to potential withdrawals. We also find that reserve city banks were more vulnerable to liquidity shocks in the 1920s, reflecting a reduction in their overall holdings of cash and other liquid assets. As shown in Figure 10, we estimate that, throughout the 1920s, an 1893-size shock would have exceeded the liquid assets of banks in at least 14 and as many as 17 of the 18 reserve cities.

Figures 11 and 12 illustrate the impact of the liquidity shocks on central reserve cities. During the 1890s, we find that, as a group, central reserve city banks had sufficient cash on hand that, had they been willing to deplete it almost entirely, they would have had sufficient cash to meet withdrawals of the size experienced during the Panic of 1893.[42] The amount of cash relative to potential withdrawals was lower in the early 1900s, except for a short period following the Panic of 1907. We also observe that central reserve city banks were considerably more vulnerable in the 1920s than they had been in the National Banking era. This owes to a decline in their cash holdings (which includes their balances with the Federal Reserve). Thus, while country and reserve city banks held lower balances in central reserve cities, we find that the other behavioral responses that accompanied the creation of the Fed more than offset that effect.

Our results are consistent with the idea that banks believed that the Fed would be a dependable source of liquidity in a crisis. If that were the case, then banks did not need to hold as much cash and other liquid assets as before. It also meant that the banking system was more dependent on the Fed providing liquidity in the event of a shock. We note, however, that this is not inherently a negative from a societal point of view. If banks hold less cash but make more loans then the result might be a net social gain. Policy makers simply need to be aware of the trade-offs that are incurred. Indeed, the reduction in required reserve ratios shown in Figure 6

[42] To create the figure, we pool the liquid resources of the central reserve cities. While in many cases, the central reserve city banks may have had sufficient cash in the aggregate, the cash was probably not evenly distributed among the banks. Even though they cooperated under the offices of the clearinghouse, and in a sense merged their balance sheets and issued clearinghouse certificates, they still ended up suspending. See Wicker (2000) for more details about the panic of 1893.

indicates that policymakers intended some reduction in bank holdings of liquid assets (cash, near cash, due from national banks, and due from the central bank). Warburg (1916) argued that the presence of the Fed reduced the need for banks to hold liquid assets. The reduction in excess liquid assets indicates, however, that banks reduced liquid assets by more than they were required which may have meant that the amount of liquidity insurance provided by the Fed was greater than policymakers had anticipated.

5. Conclusion

The Federal Reserve System was designed to overcome the flaws of the U.S. banking and monetary system that reformers believed were the root cause of banking panics. Of course, the design also reflected political compromises and realities. Ending unit banking was not politically feasible; nor was the creation of a truly centralized central bank with unlimited discretion to act as lender of last resort. The Fed's founders responded to their observations about the National Banking system by constructing a system to address the problems of an inelastic currency, seasonal stringency, and dependence on interbank ties that reformers viewed as contributing to an unstable banking system. They observed regional differences in the demands for currency and bank loans, particularly differences associated with the seasonal demands of agriculture and other sectors, and designed a system of self-sufficient regional Reserve Banks to respond to local demands.

Following the establishment of the Fed, the banking system appears to have changed in ways that the Fed's founders had hoped. In particular, the volume of balances that national banks maintained with each other declined, especially the share of those balances held in central reserve city banks. Importantly, this seems to have occurred in part as the underlying economic motivations for the correspondent banking system were addressed. The provision of elastic supplies of currency and bank reserves by the Federal Reserve mitigated the need of banks to draw funds from each other to meet seasonal demands. The Fed also provided payment clearing services previously provided by the money center banks and encouraged banks to use those services.

However, with the creation of the Federal Reserve new incentives also emerged. Federal Reserve member banks seemingly could rebalance their asset portfolios toward less liquid loans and securities now that a lender existed that was capable of providing emergency as well as seasonal liquidity support. However, few state banks became members of the Federal Reserve System, since membership required compliance with regulations and supervision that were often more strict than state banking laws and supervision. Non-members did not have direct access to the Fed's discount window; instead they relied on relationships with member banks to

provide them indirect access to liquidity support. Non-member banks became a more important funding source for some of the banks in the money centers. Both the reduction in cash holdings and greater dependence for funding on institutions that were likely to demand liquidity support increased the likelihood that liquidity shocks would exhaust the liquid asset of the member banks and force them to turn to the Fed for assistance. Indeed, Richardson and Mitchener (2014) argue that this latter dynamic occurred in the Great Depression as withdrawals by non-member banks drained liquidity from the member banks and forced a reduction in their lending.

An important lesson that, perhaps, the Fed's founders did not comprehend, or at least that they failed to adequately address, was the pressure on the entire banking system that can occur during a crisis. Our study of the behavior of interbank deposit flows of national banks during the Panics of 1893 and 1907 shows that the demands placed on the system during those crises swamped the normal seasonal patterns in which flows of funds out of some regions partly offset flows into other regions. By providing a means by which member banks could obtain additional currency or reserve balances by rediscounting commercial loans with the Federal Reserve Banks, Congress sought to provide an elastic currency. Thus, implicitly, if not explicitly, the Fed's discount window was intended to serve as the lender of last resort for the banking system. However, the Federal Reserve Act placed limits on discount window lending by restricting access to the window to only member banks and by defining narrowly the types of loans that could be used as collateral for discount window loans. During the Depression, bank failures and suspensions were more common among non-Fed-member banks. In addition, some Fed members were unable to borrow because they lacked acceptable collateral (Bordo and Wheelock 2013). The Fed's ability to act as lender of last resort was also constrained, at least potentially, by the gold reserve requirements imposed on the Reserve Banks. Although the Fed could suspend its requirements temporarily (under Section 11(c) of the Federal Reserve Act), in practice, the Reserve Banks were reluctant to do so, or even to lend reserves to each other. Finally, the Federal Reserve Act provided the Fed with no specific instructions on how to respond to crises. Some of the Reserve Banks took a broader view of their rights and responsibilities as lenders of last resort, whereas others took a narrow view, for example by strictly enforcing collateral requirements for discount window loans.[43]

[43] The differences in the behavior of different Reserve Banks is illustrated by Richardson and Troost (2009), who compare the performance of banks and the economy in the southern half of Mississippi, which is part of the 6th Federal Reserve District (based in Atlanta) and the northern half of the state, which is part of the 8th District (based in St. Louis). The study finds that the more liberal lending policies of the Federal Reserve Bank of Atlanta enabled banks in the southern half of Mississippi to weather the crises much better than the banks in the northern half of the state, with demonstrably better economic performance resulting in the southern half of the

Congress responded to the Fed's failure to prevent banking panics or the Great Depression by both relaxing the constraints on the Fed's ability to lend, especially in a crisis, and by reducing the autonomy of the individual Reserve Banks. The Federal Reserve Board (which was renamed as the Board of Governors of the Federal Reserve System) was given more explicit authority over Reserve Bank discount rates and policies, and monetary policy was lodged in a reconstituted Federal Open Market Committee with the Board making up a majority of its membership. The reforms made the Fed a more robust lender of last resort, and since the Depression, the Fed has demonstrated a much greater willingness to respond to financial disturbances (Carlson and Wheelock 2015).[44]

Today, national financial markets are becoming increasingly connected. The same financial institutions are major players in many different markets and are increasingly finding it possible to obtain funding in one country while making loans (or providing other financial services) in another. Moreover, over time, international banks have developed additional channels and markets through which they can borrow and lend to each other. Castiglionesi, Feriozzzi, and Lorenzoni (2012) cite this increasing connection as motivation for their network model. While this development makes these institutions more resilient to localized shocks, the financial crisis of 2008-09 shows how greater interconnections can also cause funding pressures to spread globally.

The historical experience we describe in this paper illustrates the robust-yet-fragile experience of the core-periphery system. As such, it underscores the importance of a strong liquidity response on the part of the institutions charged with maintaining the liquidity of the core. It also provides a note of caution. Having a mechanism in place for providing liquidity support may result in institutions taking actions that result in that liquidity support being required more often. Thus, policies that lean against this moral hazard are also a vital part of the regulatory response.

state. Carlson, Mitchener, and Richardson (2011) find that the 6th district was particularly active in its role as a lender of last resort in the late 1920s.

[44] Ironically, Congress tightened constraints on Federal Reserve lending after the financial crisis of 2008-09, particularly on the Fed's ability to lend to individual firms under Section 13(3) of the Federal Reserve Act, which had been added during the Great Depression.

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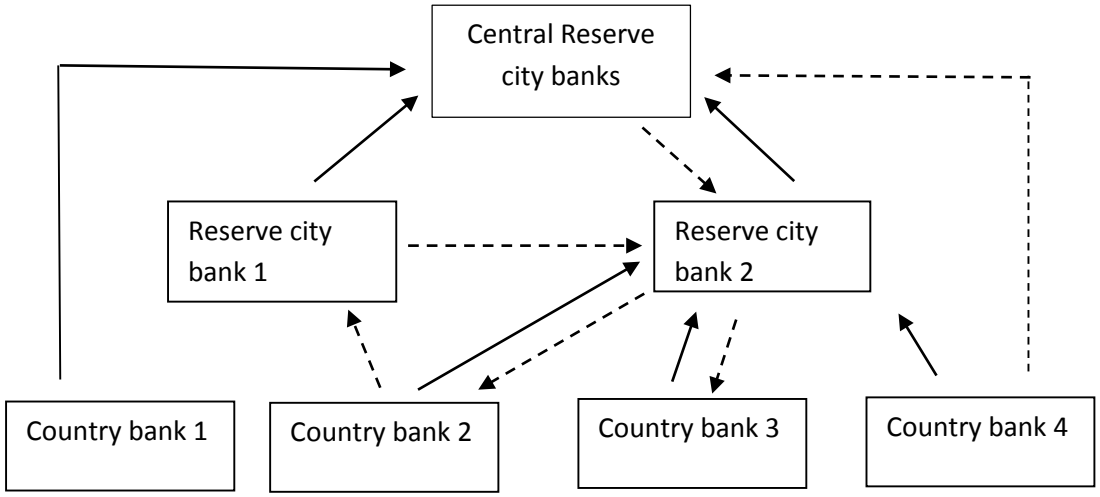
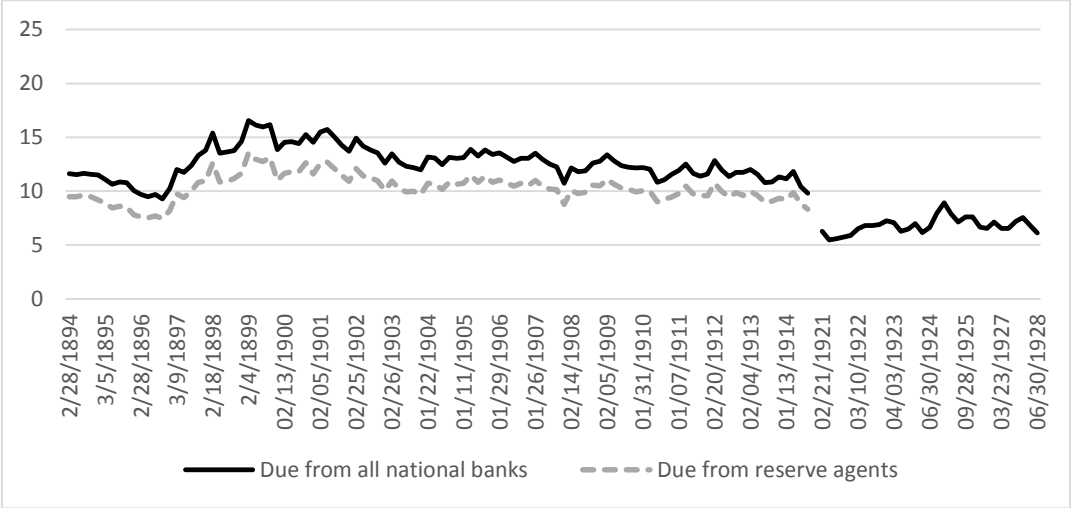
Figure 1
Illustration of how interbank balances might occur



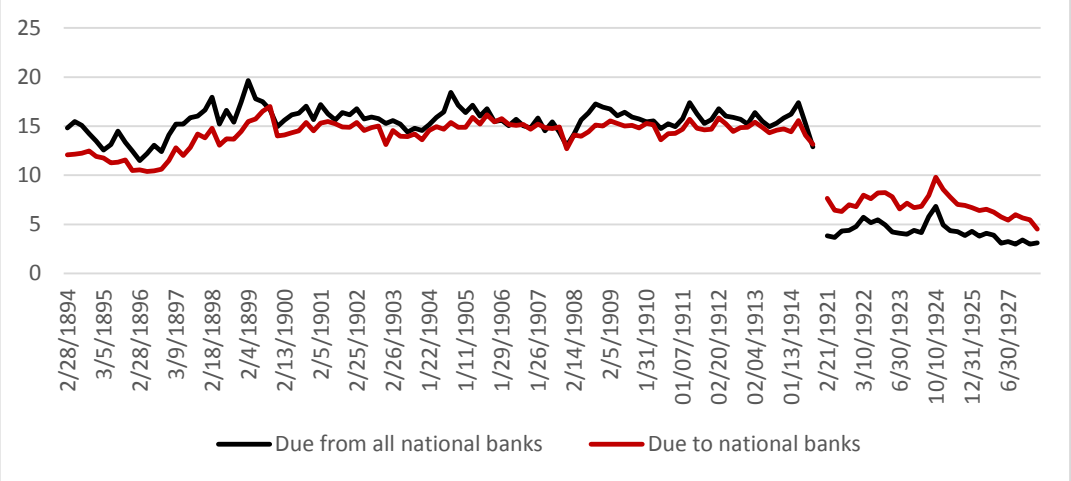
Note. Solid lines indicate balances that could be reported on the call report as "due from reserve agents." Dashed lines indicate balances that would be reported as "due from other national banks."

Figure 2
Importance of Interbank Balances by National Bank Type

Due from national banks as a share of total assets, country banks



Due from national banks and due to national banks to assets, reserve city banks



Due to national banks relative to total assets, central reserve city banks

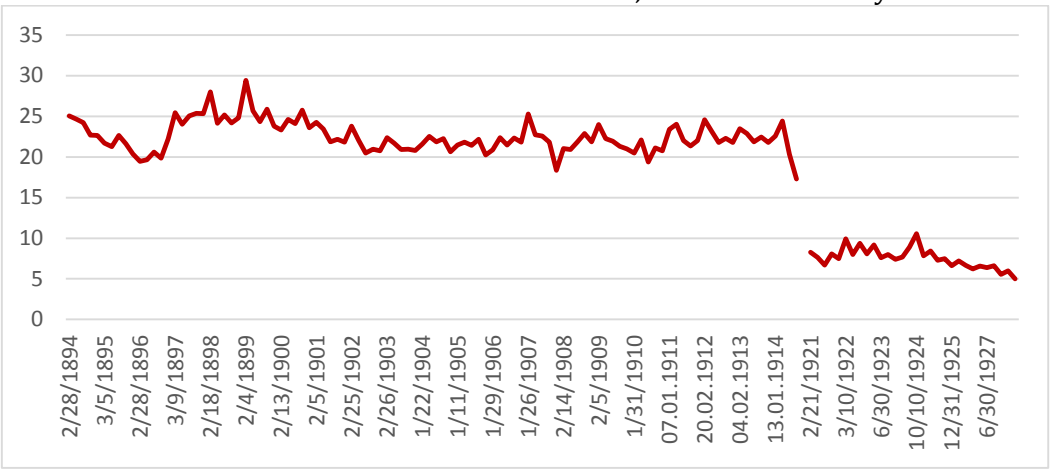
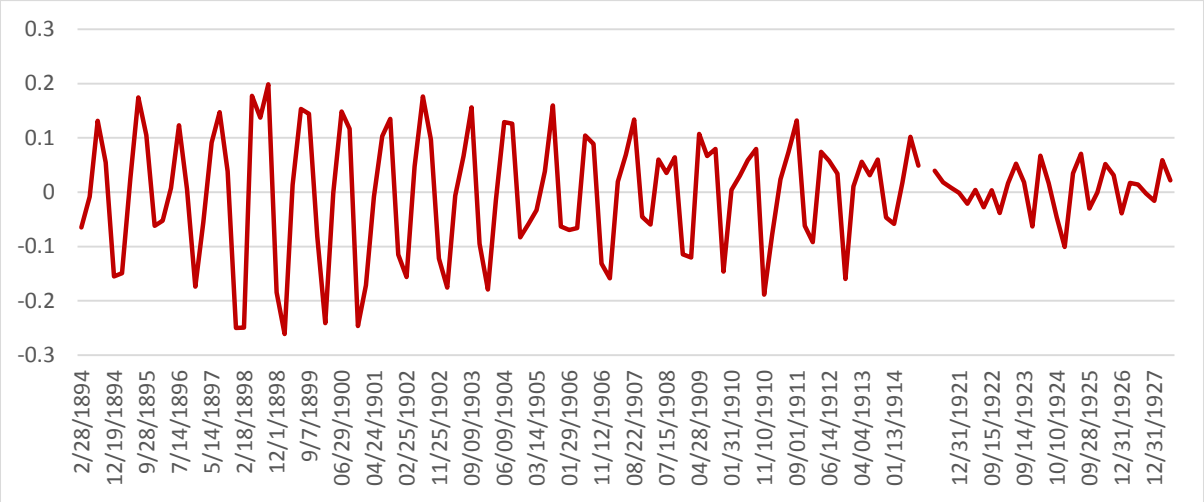
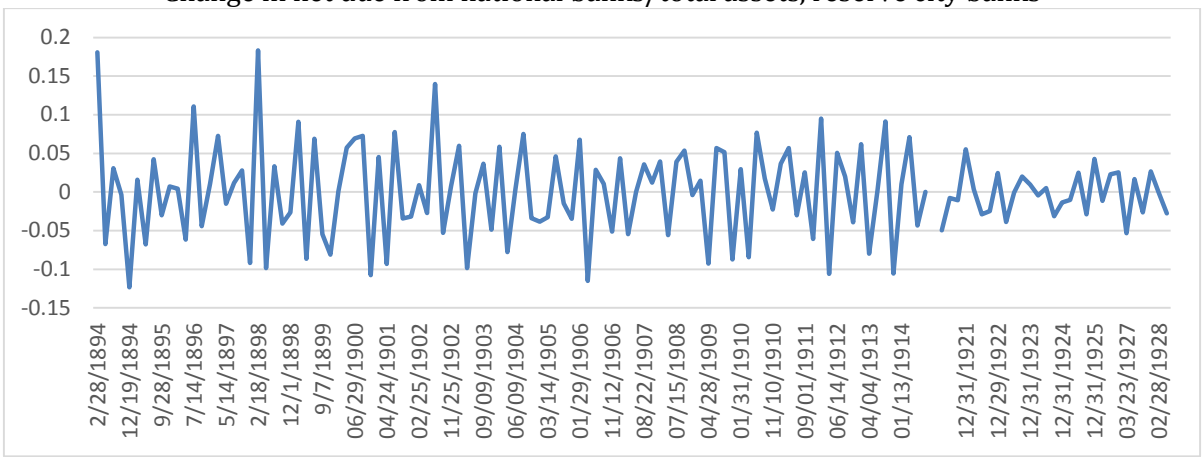


Figure 3
Principal Components of Interbank Balances, 1894-1914 & 1921-1928

Changes in due from national banks/total assets, country banks



Change in net due from national banks/total assets, reserve city banks



Change in due to national banks/total assets, central reserve city banks

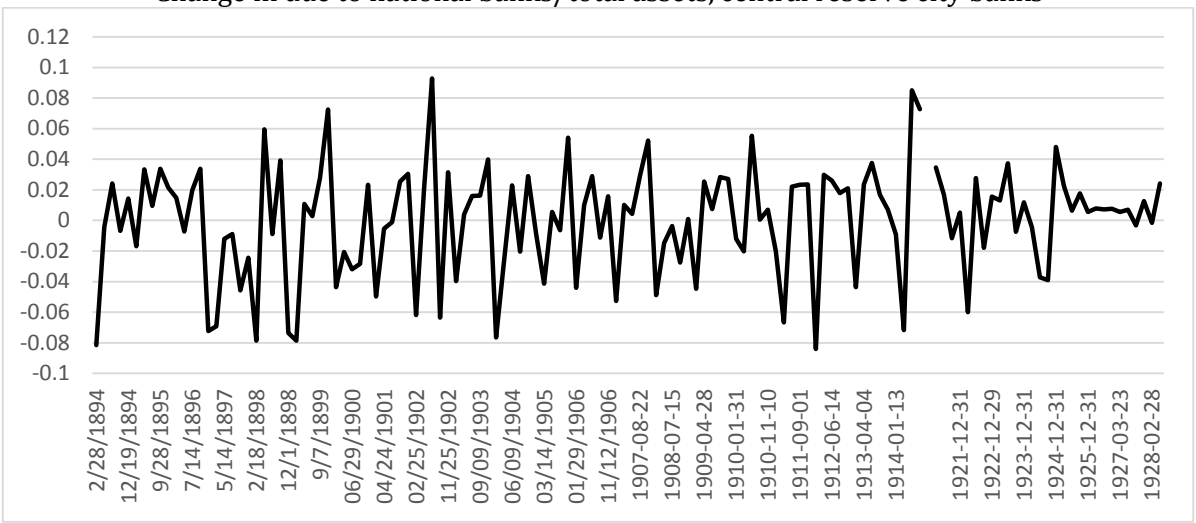


Figure 4

Changes in due from banks for different regions

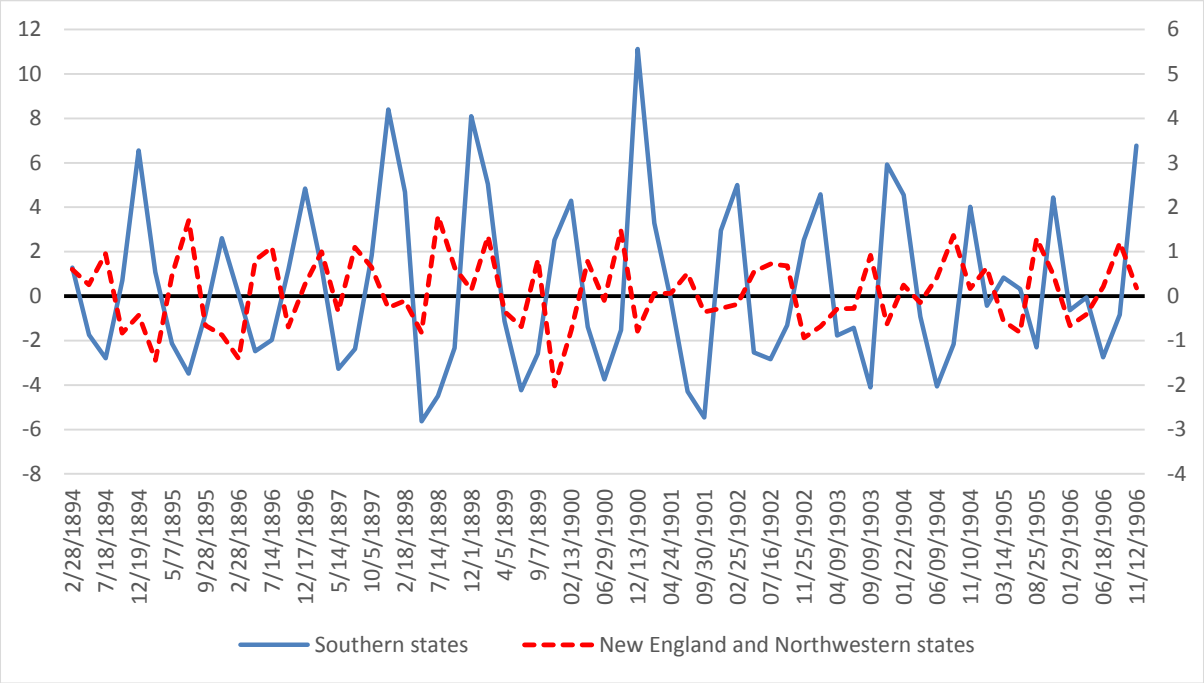


Figure 5

Seasonal Variation in Federal Reserve Credit

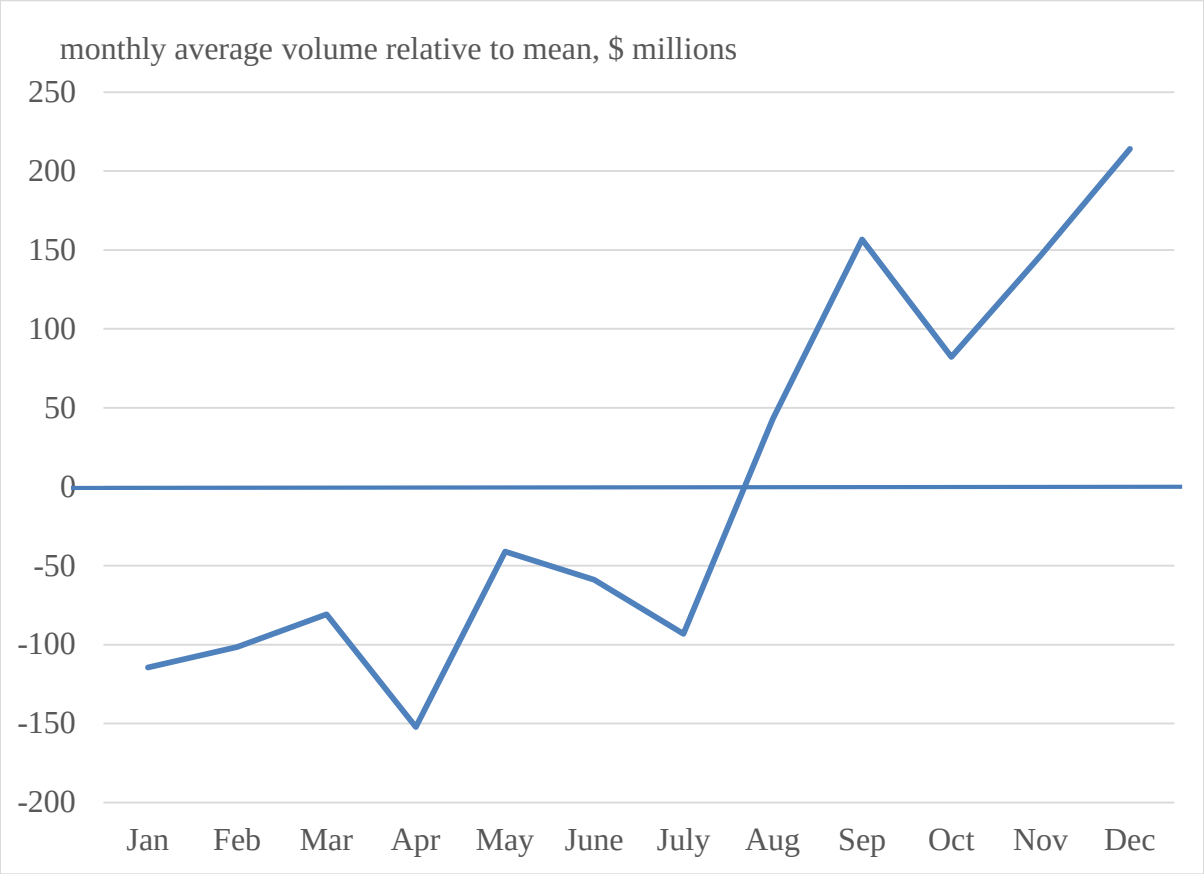
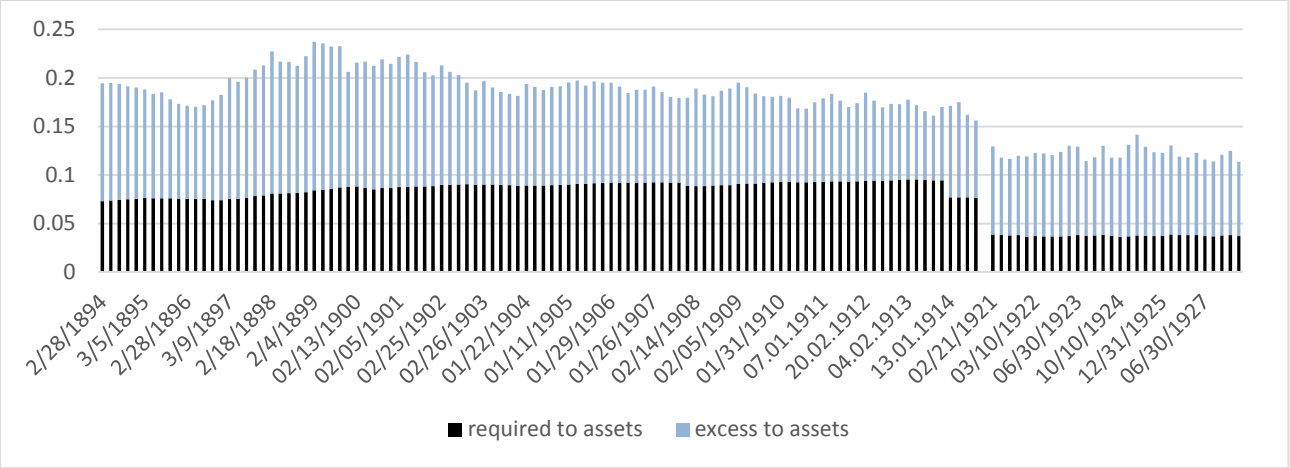
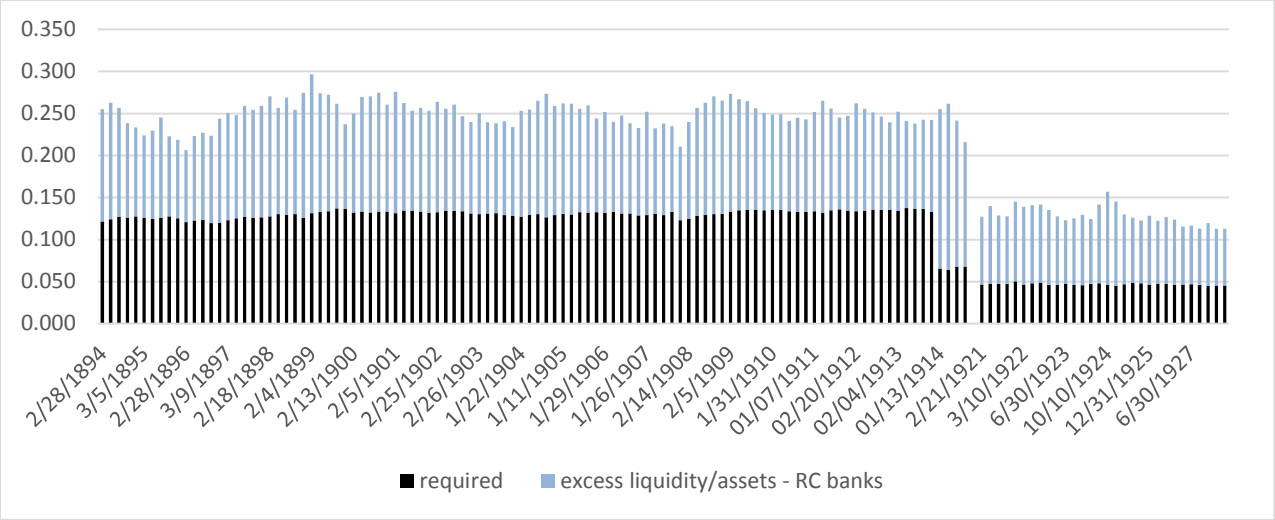


Figure 6
Required and Excess Liquid Assets as a Share of Total Assets

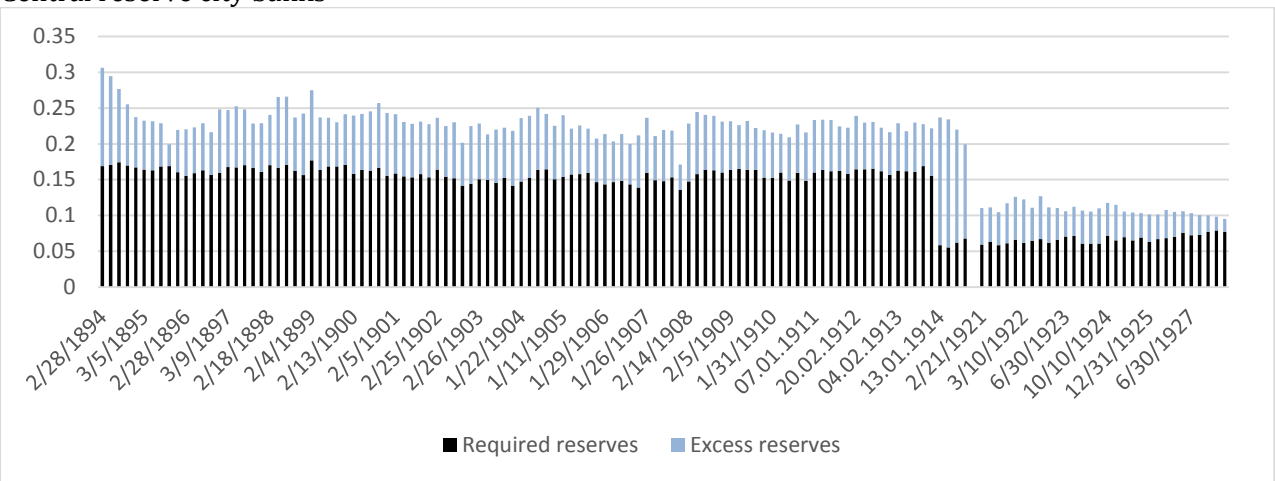
Country banks



Reserve city banks



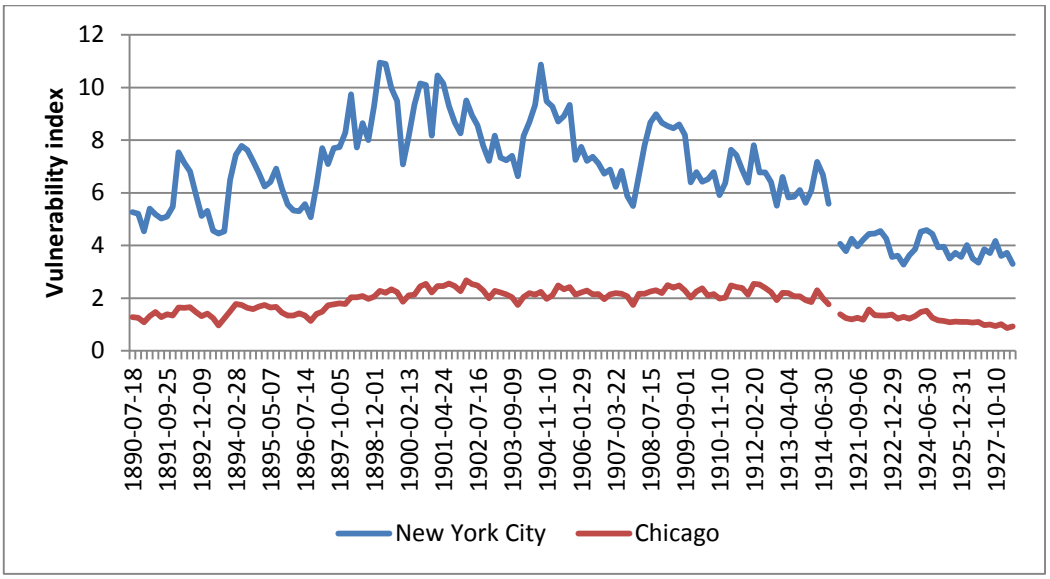
Central reserve city banks



Note. The figures plot total aggregate values for all banks in each class.

Figure 7

Vulnerability of country banks to a solvency shock originating in central reserve cities



Vulnerability of reserve city banks to a solvency shock originating in central reserve cities

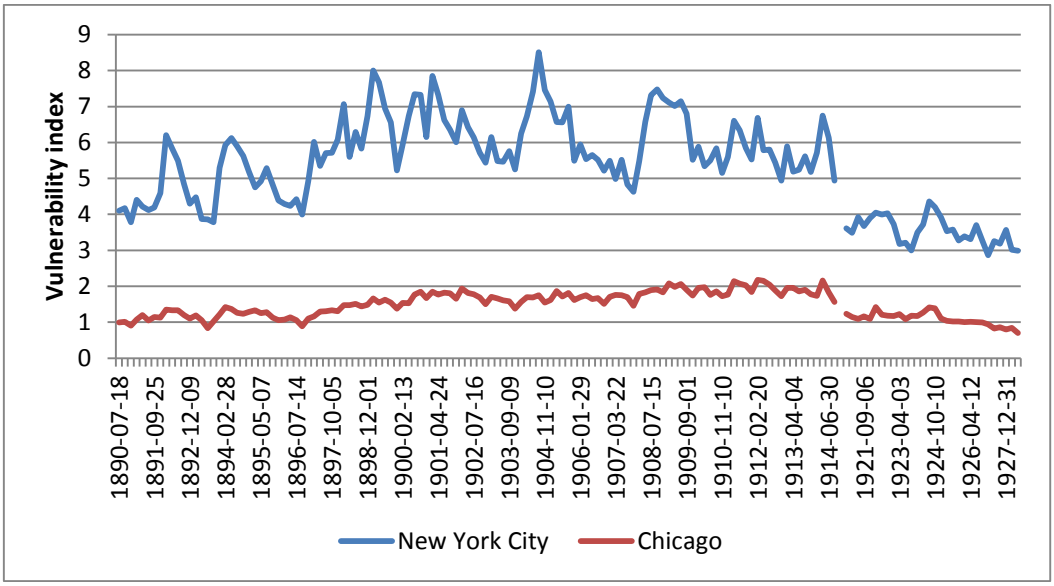
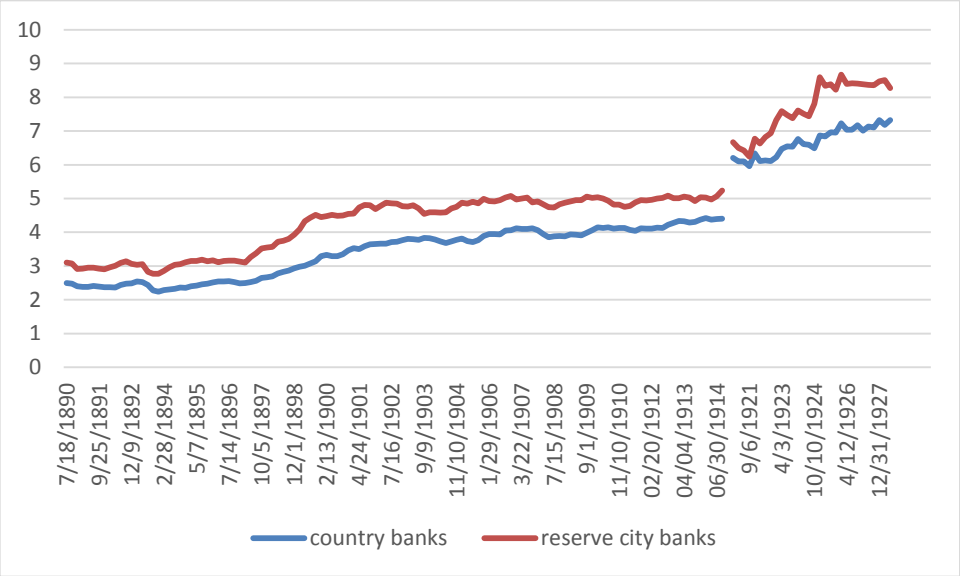


Figure 8
Leverage

Harmonic average of leverage of country and reserve city banks



Leverage of Chicago and New York City banks

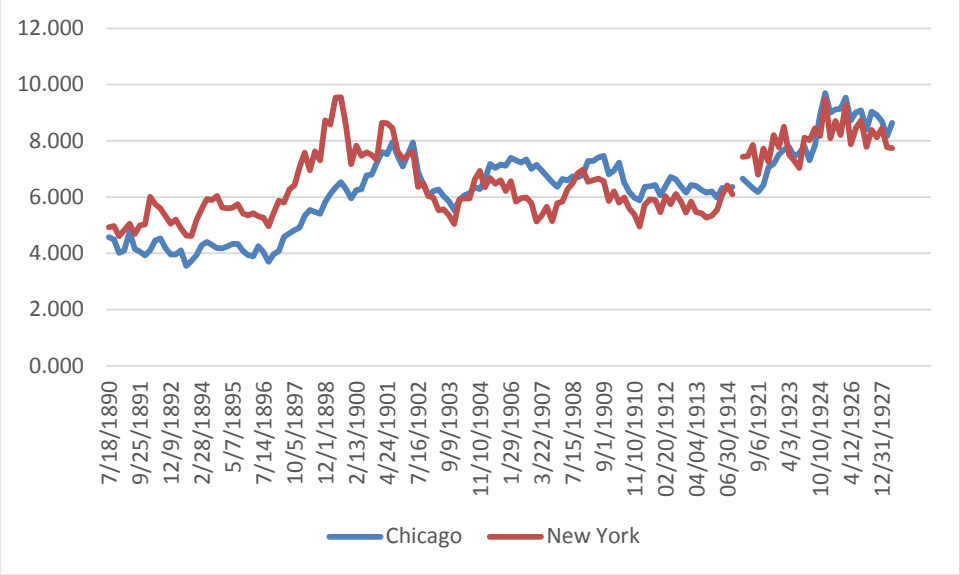


Figure 9
Size of panic withdrawals at reserve city banks

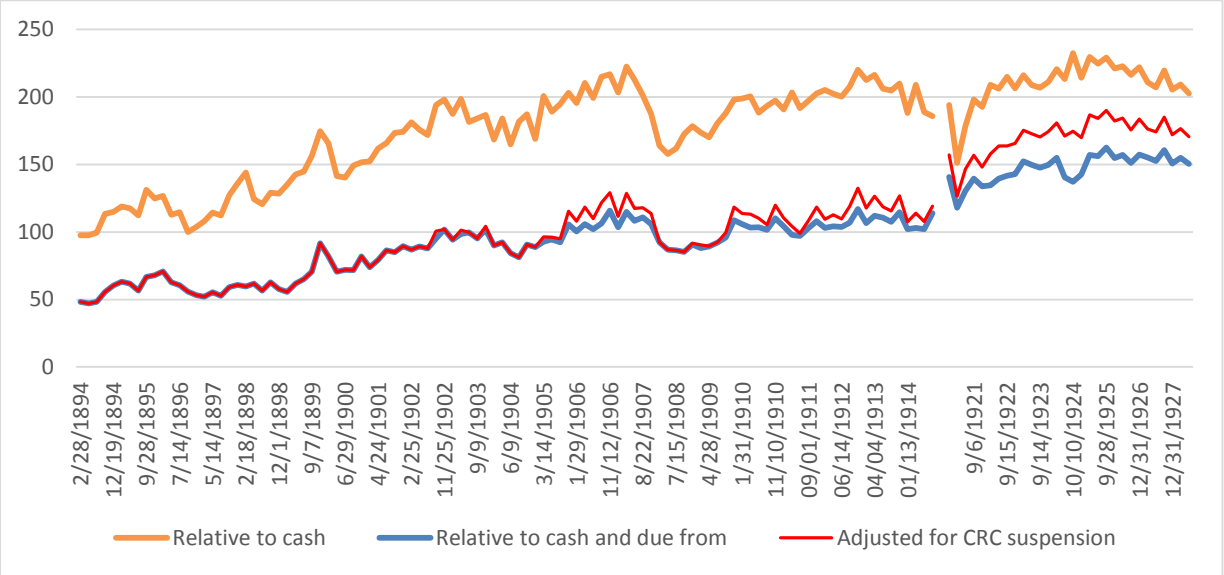


Figure 10
Number of reserve cities that exhaust liquid resources

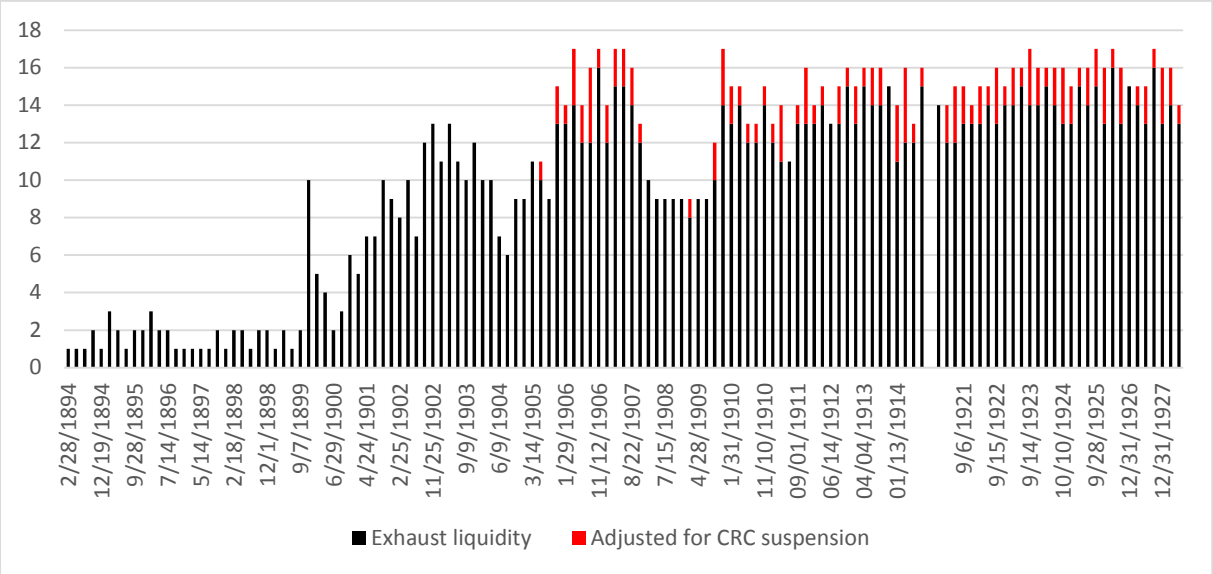


Figure 11
Size of withdrawals at central reserve city banks relative to cash holdings

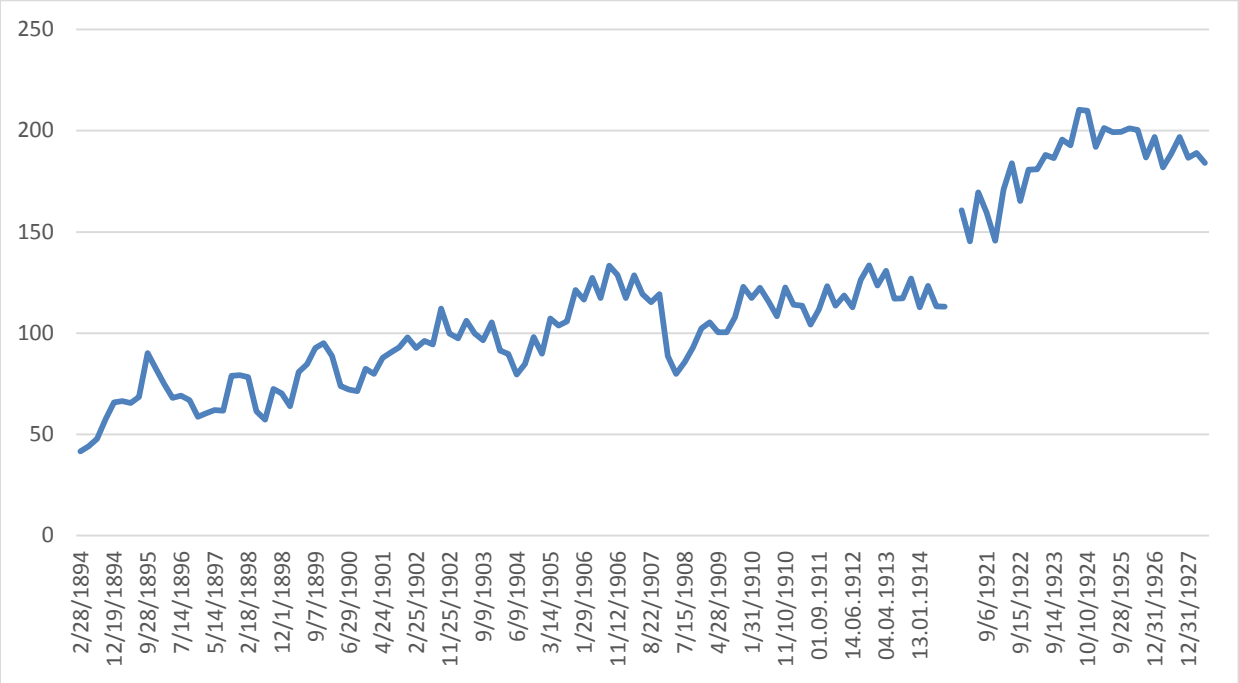


Figure 12
Number of central reserve cities exhausting cash in response to liquidity shock

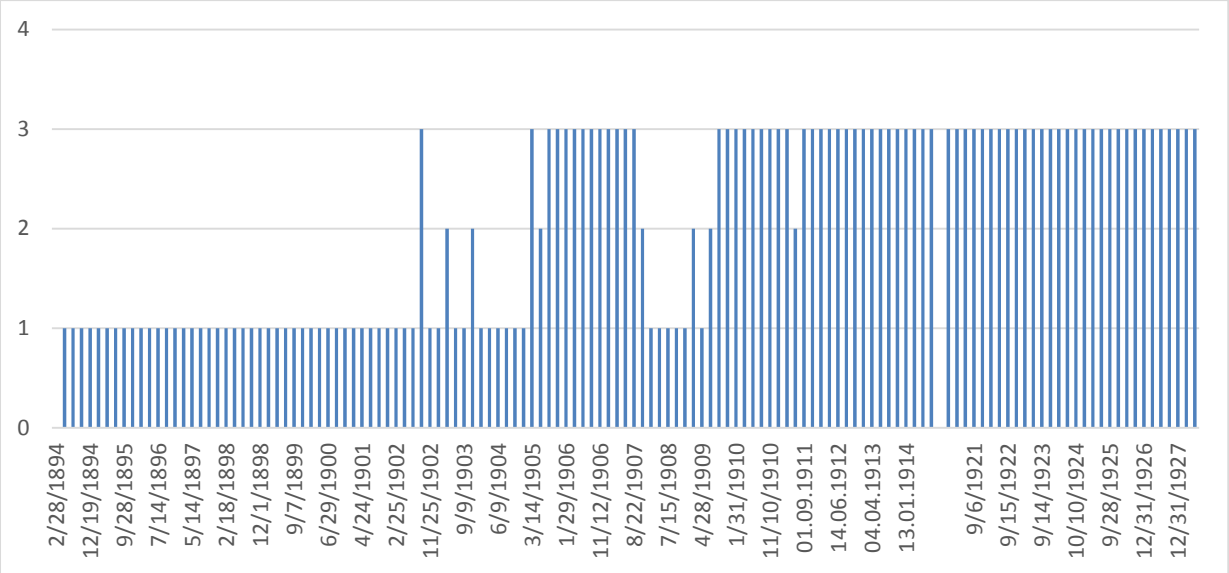


Table 1
Average Interbank Deposit Volumes

	Pre-Federal Reserve (1894-1914)	1920s (April 1921- June 1928)
Due from national banks as a share of assets, country banks	12.6 (1.6)	6.8 (0.8)
Due from national banks as a share of assets at banks in 18 reserve cities	15.6 (1.4)	4.3 (0.9)
Due to national banks as a scaled by total assets at banks in 18 reserve cities	14.2 (1.4)	6.9 (1.1)
Due to national banks scaled by total assets of banks in Chicago, New York, and St. Louis	22.5 (1.9)	7.5 (1.3)
Portion of due to national banks in these 18 reserve city and Chicago, New York City, and St. Louis banks held at the central reserve cities	65.3 (2.2)	58.1 (1.7)
Portion of assets at banks in the 18 reserve cities and banks in the central reserve cities held by banks in Chicago, New York, and St. Louis	54.9 (1.9)	57.3 (1.7)
Number of call reports	*104*	*28*

Note. Aggregate due from banks or due to banks across all banks in each city class divided by aggregate assets of all banks in each class. Averages the mean ratios over time. Standard deviations, also over time, are in parentheses.

Table 2
Seasonal patterns in Federal Reserve Credit

Dependent variable: Federal Reserve Credit

	Coefficient	SE
January	179.6	(131.1)
February	192.6	(132.1)
March	213.3	(129.5)
April	141.9	(131.0)
May	253.0**	(121.4)
June	235.1*	(122.5)
July	200.9*	(120.6)
August	337.0***	(113.4)
September	450.7***	(115.0)
October	376.4***	(126.3)
November	440.7***	(125.5)
December	508.1***	(129.2)
Industrial Production	6.6***	(1.1)
Time trend	-3.0***	(0.8)
Observations	116	
Adjusted R^2	.91	

Note. Federal Reserve credit is defined here as the sum of Federal Reserve discount window loans outstanding and holdings of bankers acceptances. The symbols ***, **, and * indicate statistical significance at the 1, 5, and 10 percent levels respectively. The analysis uses data for January 1922 – August 1931. Industrial production is the level of the Miron and Romer (1990) index of industrial production minus its January 1915 value.

Table 3

Changes in Interbank Deposits in Normal and Panic Periods
(In percentage points)

		Average change May to Sept. 1894-1906	Change from May to Oct. 1893	Average change Aug. to Dec. 1894-1906	Change from Aug. to Dec. 1907
Country banks, due from national banks scaled by own total assets					
1	All country banks	0.5	-1.3	0.2	-1.1
2	New England & Mid-Atlantic	1.3	0.5	-0.6	-0.2
3	Upper Midwest	1.2	-1.7	-0.8	-2.9
4	Southern	-4.1	-4.6	3.5	0.9
5	Plains	2.5	-2.0	-0.05	-1.3
6	Western	3.1	-5.0	0.1	-3.8
Country banks, due from national banks scaled by total assets of banks in reserve cities and central reserve cities					
7	All county banks	0.4	-1.7	-0.01	-1.7
Reserve city banks, due from national banks scaled by total assets of banks central reserve cities					
8	Reserve city banks	0.5	-1.0	-0.1	-1.6
Reserve city and central reserve city banks, due to national banks scaled by own total assets					
9	Reserve city banks	1.0	-2.5	-0.2	-2.7
10	Central Reserve city banks	-0.2	-3.3	-0.4	-2.6

Notes. Figures are the change in interbank deposits over the interval scaled by total assets at the start of the period. The averages for "normal periods" are calculated by first averaging across states or reserve cities and then over time. Averages during panic periods are averages across states or reserve cities for the indicated months only.

State groupings:
New England & Mid-Atlantic states: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Vermont, Virginia.
Upper Midwest: Illinois, Indiana, Kentucky, Michigan, Missouri, Ohio, West Virginia, Wisconsin
Southern: Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas.
Plains: Colorado, Iowa, Kansas, Minnesota, Nebraska, North Dakota, South Dakota, Wyoming.
Western: Arizona, California, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington.