Shadowy Banks and the Interbank Amplifier During the Great Depression

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Abstract

Few accounts of the Great Depression have examined how interbank networks contributed to the severity of the contraction. We assess how the reserve pyramid and deposit linkages among commercial banks amplified banking distress during the 1930s. Runs on the periphery triggered a cascade of interbank withdrawals, first in regional financial centers, and then in the central reserve cities of New York and Chicago. Fed member banks in these two central reserve cities responded by curtailing lending to businesses and households. We estimate that this banking-network effect substantially reduced lending in financial centers during the contraction from 1929 through 1933.

Keywords: Networks, Great Depression, financial crises, shadow banks, balance-sheet effects
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1. Introduction

The financial crisis of 2007-8 has drawn attention to network linkages among financial institutions and their effects on the real economy, in particular how the shadow banking system magnified the effects of the crisis and how interconnected financial institutions propagated distress and contributed to systemic risk (Allen, Babus, and Carletti, 2010; Amini and Minca, 2010; Brunnermeier, Gang, and Darius, 2012; Cohen-Cole, Patacchini, and Zenou, 2011). Despite the importance of network linkages in explaining the recent crisis, they are a lightly studied aspect of earlier banking crises. Historical accounts of networks are descriptive in nature or, where data are employed, examine banking networks to describe the process of contagion when banks fail (Carlson, Mitchener, and Richardson, 2012). Even in well-documented crises, such as the Great Depression, the role of the networks, independent of contagion, has received little attention.

Research on the banking distress of the 1930s in the United States has largely focused on how banking panics can contract the real economy through money multipliers and monetary aggregates (Friedman and Schwartz, 1963) and how bank failures can raise the cost of borrowing (Bernanke, 1986). In this paper, we demonstrate that, during the 1930s, balance sheet linkages between banks amplified the effects of banking distress on the real economy. We document that Federal Reserve member banks were linked to "shadowy," non-Federal Reserve regulated banks through the interbank deposits and that the U.S. financial system's pyramids structure of reserves, which emerged in the 19th century, persisted past the founding of the Fed and into the 1930s. We show that these network linkages exposed Fed member banks to the distress of shadowy state-chartered commercial banks through interbank deposits during the Great Depression. Bank runs in the periphery triggered reductions in interbank deposits, first in reserve city banks and then, on up the pyramid, in the central reserve cities of New York and Chicago. Distress, due to liquidity shocks, coincided with larger outflows of interbank deposits from reserve and central reserve city banks whereas solvency shocks appear to have had less of an impact on interbank flows. We then show that the reduction in interbank deposits in Chicago and New York banks triggered additional changes on the asset side of the balance sheet. Econometric tests based on a new database of call report data show that, once the Depression era banking panics began, banks in central reserve cities responded to interbank outflows by calling loans to businesses and reducing assets deposited in banks abroad and in reserve cities.

Our paper contributes to the literature showing how banking distress deepened the Great Depression. We propose a new channel, the interbank deposit network, through which banking distress worsened the contraction in real economic activity. As is the case with Friedman and Schwartz's (1963) monetary channel (1963), banks do not need to fail in order for the effects to be realized. Moreover, since we show that the interbank amplifier is most strongly associated with liquidity events, the failure of the Fed to respond to banking distress by injecting liquidity into the system appears to have magnified the effects of this channel. Our paper also contributes to the growing literature on financial networks and the real economy, showing both a mechanism for transmission (interbank deposits) as well as a source of amplification (balance-sheet effects).

The next section of the paper describes the interbank pyramid that existed before the Federal Reserve, how that network changed with the founding of the Fed, and the structure of the system on the eve of the Great Depression. Section 3 focuses on the behavior of deposits across the network during the 1920s and 1930s. Section 4 provides econometric estimates of how Fed member banks in financial centers altered their balance sheets in response to inflows and outflow of interbank deposits and other deposits during the 1930s. Section 5 separately examines the severe nationwide banking panics that occurred in the fall of 1931 and winter of

1933. Because these panics occurred between call dates, we use an additional data set that contains weekly reporting from banks to assess how the interbank deposit network affected the real economy. We conclude by showing how the interbank amplifier provides additional insight into how the restrictive policies of the Federal Reserve in the 1930s worsened the Depression.

2. The Interbank Deposit Network

As a first step in understanding the process by which the movement of interbank deposits within the banking system potentially magnified the real effects of the banking distress of the 1930s, we begin by describing the network structure that existed in 1929 and the potential role of shadowy banks in transmitting banking distress through interbank deposits.

A. The Persistence of the Pyramid

The authors of the Federal Reserve Act aimed to eliminate the banking panics of the nineteenth and early twentieth century by creating an elastic currency and a lender of last resort (Friedman and Schwartz 1963, Miron 1986). Along these lines, they sought to reduce the concentration of correspondent balances held in reserve centers and funds invested in the call loan money market, which were believed to be the source of the banking panics of the nineteenth century (James 1978, Meyers 1931, Sprague 1910).[1] The 1913 authorizing

[1] Withdrawals from non-central reserve city banks happened regularly, and if they were of sufficient magnitude, it could put pressure on call loan rates to rise and stock prices to fall, triggering panic selling of assets and inducing a financial panic that could reach well beyond New York City. The standard story for explaining why country banks and reserve city banks withdrew their interbank deposits in this era was due to the seasonal demand for money arising from planting and harvest cycles (Calomiris and Gorton, 1991). Indeed, all of the major panics of that era were marked by withdrawals of funds by the country and reserve-city banks from New York City (Bordo and Wheelock 2011).

legislation thus required that national banks and Fed member banks meet their reserve requirements by holding deposits at one of the system's reserve banks. That said, these changes did not remove the layered structure of reserves that had developed during the nineteenth century in large part because non-member commercial banks continued to meet their state-mandated reserve requirements through interbank deposits held at larger city banks.[2] These large city banks, dispersed throughout the country, in turn held deposits in banks located in Chicago and New York, and like all banks, used them as a way to manage their liquid portfolios and offer a broader variety of services to their clientele.[3]

Figure 1 shows that, although altered by the Federal Reserve Act, an inverted pyramid structure of interbank balances nevertheless remained in place on the eve of the Depression. The top of the pyramid consisted of banks in the central reserve cities of New York and Chicago. In those cities, almost all of the banks that served substantial numbers of interbank clients belonged to the Federal Reserve System. Those money-center banks held deposits from non-member country banks, non-member banks in reserve cities, and member banks in both locations. More than 90% of the interbank deposits came from non-member banks, with most of those deposits coming from country banks located in small towns and cities.

The middle layer of the pyramid consisted of the banks in the 59 reserve cities, geographically dispersed throughout the country. Table 1 displays their distribution across Federal Reserve districts. Columns 4 and 5 show the mean and standard deviation of the change in interbank deposits, between call dates, for the years 1914 to 1941. The base of the reserve pyramid consisted of country banks, located in cities and towns throughout the

[2] Correspondent networks developed as a response to the geographical growth in the nation, and its burgeoning population outside the industrial and populous Northeast. "Interior banks" sought sources for funds and investment, and correspondent networks facilitated this demand. The national banking acts further cemented the interconnected structure of U.S. banking, permitting country banks to meet their legal reserve requirements by keeping a large portion of their reserves (originally up to three fifths) with reserve-city or central reserve-city banks.
[3] By the early twentieth century, central reserve city banks in New York were holding roughly two thirds of all required reserves, much of which was then invested in the call loan market.

United States. It is particularly worth emphasizing that the majority of the bottom layer consisted of non-Fed member, state-chartered banks, which were neither regulated nor (according to Federal Reserve rules) received liquidity assistance from the Fed. Moreover, as of June of 1929, over ninety percent of all interbank deposits within the system belonged to these non-member country banks. Even though they operated outside the purview of federal bank regulation, similar to today's shadow banks they could potentially influence the behavior of Fed member banks through network linkages. For example, shocks to these non-member, shadowy banks, such as a bank runs or panics, could potentially trigger interbank withdrawals in reserve cities (especially since they did not have access to the Fed's discount window). These withdrawals, in turn, could induce further responses within the system that worked their way to the Fed member banks in Chicago and New York at the top of the pyramid. Given the existence of this network structure, it is worth considering whether this type of chain reaction may have influenced the balance sheets of central reserve city banks. In light of very limited liquidity assistance by the Federal Reserve to any banks during the early 1930s (Friedman and Schwartz, 1963), the buck ultimately stopped with central reserve city banks – a fact that was little understood by Fed officials at that time.

B. The Changing Nature of Interbank Deposit Flows in the 1920s and 1930s

To understand how the interbank network reacted to financial distress, we created a new, panel database for each call date between 1914 and 1941, which roughly corresponds to quarterly observations. It contains information on interbank deposits and other balance sheet characteristics for the three tiers of the banking system (country banks, reserve city banks, and central reserve city banks) and is aggregated at the level of the 12 Federal Reserve districts. Balance sheet data are also collected for the two central reserve cities. These data are supplemented with information on banking distress and economic activity. Additional details on the sources and construction of the database are described in the data appendix.

Summary statistics indicate that interbank deposits exceeded 20% of all demand deposits and 60% of aggregate reserves in reserve and central reserve cities. Since laws required banks to retain minimum legal reserves, the quantities above these minima, which banks could access without triggering regulatory intervention, were termed "excess reserves." On the eve of the Great Contraction, excess reserves were low, and interbank balances them by a substantial multiple. The implication is that member banks could satisfy unexpected declines in interbank balances only by liquidating investments or borrowing reserves from the Fed.

Figure 2 depicts interbank deposit flows during the 1920s and 30s for each layer of the pyramid. In the 1920s, interbank deposits fluctuated seasonally around a rising trend. After the stock market crash of October 1929, interbank deposits rose rapidly. Once banking panics began in the fall of 1930, they declined sharply in reserve and central reserve cities and became increasingly volatile in these locations. Comparing 1924-29 with 1930-32, the standard deviation of interbank deposits rose from around 3.2 to 5.6 million dollars per day.

Figures 3 and 4 illuminate patterns in the data. The figures illustrate an example: the relationship between distress among country banks in the 9^{th} and 10^{th} Federal Reserve Districts and interbank deposits in Chicago. For 1923-28, scatter plots show little or no correlation between changes in the numbers of banks in outlying regions and interbank deposit flows to central reserve cities. For 1929-32, however, a positive correlation exists between banking distress and interbank deposit flows of reserve city banks. As illustrated in Figure 5, the relationship was especially pronounced in the central reserve cities of Chicago and New York.

Looking at just the middle layer of the pyramid, interbank inflows and outflows seem to be driven by regional economic conditions and localized banking distress. As columns 4 and 5 of Table 1 show, there is considerable variation in interbank deposit inflows across districts. Reserve city banks located in the fourth district (Cleveland) exhibit the most variance while reserve city banks in the second district (New York) appear somewhat different from other districts, showing a negative mean (and valueless) variance. The growing concentration of reserve balances in New York City accounts for this difference.[4] In addition, interbank deposit flows are only weakly correlated with flows of demand and time deposits, which reserve banks typically received from depositors residing within or near their municipality. From 1922 to 1928, the correlation coefficient between interbank deposits and the sum of time and demand deposits was 0.16. From 1929 through 1933, the correlation was 0.19. From 1934 through 1941, the correlation was 0.2.

3. Bank Distress and Interbank Flows

Our analysis begins by estimating how distress among country banks influenced deposits in financial centers, particularly the reserve cities in each Federal Reserve District and the central reserve cities of New York and Chicago.

Our estimation strategy incorporates the structure of the pyramid system, described in the previous section, which we model statistically with the following assumptions. First, interbank liabilities on the balance sheets of reserve city member banks come from their country, non-member clients. Second, interbank assets on the balance sheets of reserve city member banks were deposited in central reserve city banks. Third, reserve city banks allocated their assets between central reserve cities in proportion to the fraction of aggregate

[4] All of our statistical work checks to see if the unique experience of New York's reserve cities influences our conclusions. In general, it does not. We indicate the few instances where excluding New York from the regression generates minor changes in statistical coefficients and significance levels.

interbank balances held in the central reserve cities.[5] Member banks in central reserve cities received interbank deposits from four sources: (i) member banks in reserve cities, (ii) member banks in country locations, (iii) non-member banks in reserve cities, and (iv) non-member banks in country locations. Fourth, flows of interbank deposits to and from reserve cities reflected distress among country banks in that district, and not in other districts. Fifth, flows of interbank deposits to and from central reserve cities reflect distress among all banks in the United States, both member and non-member banks located in both reserve cities and country locations.

Given the structure of the financial pyramid, distress among country banks could influence interbank deposits in New York and Chicago through two channels. In the direct channel, distress induced country banks to reduce their own interbank balances in New York and Chicago. In the indirect channel, distress induced country banks to reduce their balances in reserve cities. Distress might also induce outflows of regular deposits from reserve cities. Reserves city banks would, in turn, withdraw funds that they had deposited in the central reserve cities. Our estimation strategy enables us to determine the size of both channels, and to compare the impact of interbank outflows to outflows of regular deposits which, of course, may also be influenced by depositors' impressions of the safety and soundness of the financial system.

Scholars have also noted that bank distress due to illiquidity may have different implications for the financial system – particularly interbank relationships – than bank failures due to insolvency. Our estimation strategy accounts for differences in types of bank distress (solvency versus illiquidity), types of institutions (Fed versus non-Fed member

[5] In other words, in a year when Chicago's member banks held $1 of interbank deposits and New York member banks held $2 in interbank deposits, we assume that all reserve city member banks placed 1/3 of their interbank assets in Chicago and 2/3 in New York.

banks), or reasons for a bank's disappearance, factors that may help us identify a causal relationship between shadow banks, lending, and economic activity.

These observations yield an approach for estimating the relationship between bank distress and interbank deposits in our 14 units of observation (12 aggregations of all banks in all reserve cities in each district, and 2 aggregations of all banks in each central reserve city). This approach involves a panel regression of the following form:

(1) $D_{it} = \alpha_i + \sum_k \beta_k F_{kit} + \varepsilon_{it}$

In this equation, D_{it} indicates deposits in district i in period t. F_{it} represents bank distress in district i in period t. D is either defined as interbank deposits or deposits of individuals and firms (other than banks), which we refer to as deposits from the public or "public deposits." For New York and Chicago, F is the sum of bank distress across all 12 districts. The coefficient, β, indicates the average deposit outflow in a district due to the distress of a bank in that district. The constant term, α_i, has a subscript to indicate that we control for district fixed effects, or in other words, we include an indicator variable for each district. The period, t, corresponds to call report dates, roughly quarterly. Distress among country banks is divided into two types, insolvency and illiquidity, as defined in the previous section. We indicate the different types of bank distress with the subscript k. We define k={1,2}={insolvency, illiquidity}. The coefficient, β_k, enables us to separately estimate the impact of these two types of bank distress.

Table 2 reports fixed effects estimates of Equation (1). Since district fixed effects are included, we thus identify only off the variation over time within each district. The estimates reveal a substantial and statistically significant correlation between distress due to illiquidity and interbank flows. A run on country banks that triggered its suspension (either temporary or permanent) resulted in an outflow of about $100,000 dollars from the reserve city banks within its district. Consistent with our hypothesis, illiquidity events appear to lead to outflows of deposits. Solvency shocks are also associated with interbank deposit outflows, but the size of the effect is half of liquidity shocks and not precisely measured (i.e., statistically insignificant). Consistent with Friedman and Schwartz's view that liquidity shocks and bank runs induced depositors to withdraw funds from banks, the third and fourth columns of Table 2 shows that the public's deposits in reserve city banks (time deposits plus demand deposits) are negatively associated with liquidity shocks.

A plausible explanation exists for the patterns that we find during the 1920s and 1930s. The nature of banking distress differed in these two decades. In the 1920s, more than 5,400 banks suspended operations. With the exception of a few famous panics such as the Florida panic of 1929, most of the failures from this decade appear to have been due to solvency shocks. Many small, country banks failed as a result of lending to farmers who had expanded production and capacity when prices were rising during World War I, but then defaulted on loans when agricultural prices declined in the 1920s. Insolvencies of small banks spread across space and over time seldom triggered large flows of liquid funds from financial centers. In the 1930s, banks failed for different reasons. Panics afflicted peripheral regions of the financial system in the fall of 1930 and winter of 1931. These panics began with the counterparty cascade following the failure of Caldwell and Company. As the contraction continued, panics afflicted other regions of the United States. Panics on a national scale occurred during the fall of 1931 and winter of 1933. During these panics, depositors' withdrawals forced country banks in turn to withdraw funds from correspondents in financial centers.

4. Deposit Flows and Asset Allocation

This section examines how reserve and central reserve city banks responded to inflows and outflows of deposits. We differentiate inflows from outflows, because scholars have shown that banks responded asymmetrically to deposit flows during the financial turmoil of the 1920s and 1930s (Park 2013).[6] This asymmetry arises as banks rebalance their portfolios. When deposits decline, a bank may choose to liquidate one type of investment, such as government bonds. When deposits increase, a bank might choose to invest those funds in a different type of assets, such as commercial loans. We also differentiate reserve from central reserve cities, because financial institutions in these cities occupied different niches in the financial hierarchy and faced different economic imperatives. Finally, we distinguish reactions to flows of interbank deposits from reactions to flows of time and demand deposits (other than bank and government), which we label public deposits.

In response to deposit flows, banks changed their investment decisions. To examine these decisions, we divide banks' assets into seven comprehensive and mutually exclusive categories:

(1) loans to the private sector
(2) government bonds
(3) corporate bonds
(4) cash and reserves held at the Federal Reserve
(5) interbank assets (your deposits in another commercial bank)
(6) fixed assets such as the value of the bank building plus furniture and fixtures
(7) all other assets

For each asset category, we regress the change in the asset on the four types of deposit flows, plus indicator variables for the Federal Reserve Districts and central reserve cities. The coefficients from these regressions reveal on average how the number of dollars invested in a type of asset changed when a dollar of interbank (or public) deposits flowed in (or out) of banks.

[6] To account for these asymmetries, we extend Park's method of distinguishing the impact of inflows and outflows to two flows of two types of deposits: interbank and public

The error terms for the seven equations corresponding to the seven asset categories may be correlated. To account for this correlation and improve the efficiency of estimates, we simultaneously estimate the seven equations using Zellner's (1962) method of seemingly unrelated regressions (SUR). Equation (2) summarizes this set of regressions.

(2) $y_A = X_A \delta_A + \varepsilon_A,$

In (2), y, δ, and ε are vectors. The vectors indicate the dependent variables, coefficients, and error terms respectively. X is a matrix. The subscript, *A*, indexes these vectors. A = {1, …, 7}, where the numbers indicate the categories of assets in the list above. Each regression has the form in (3):

(3) $y_{it} = \propto + \sum_z \delta_z X_{it_z} + \varepsilon_{it}$

In (3), y_{it} indicates the dependent variable (i.e. changes in dollar values of one of the asset classes listed above), and z indicates the set of four deposit flow variables: (1) interbank inflows; (2) interbank outflows; (3) public inflows; and (4) public outflows.

All of our regression include all seven categories of assets, but for clarity, we present only results for categories (1) through (5), since the coefficients for categories (6) and (7) were uniformly statistically and economically insignificant. In the results table, each column shown in a table represents a single regression. The columns collectively represent a system of equations that we estimate simultaneously (with two equations unreported in the tables). The rows represent the independent variables. Rows with prose labels, like "public deposit inflows," indicate the correlation between deposit flows and asset allocations in reserve cities. Rows with abbreviated labels, like PI*CR, indicate the difference between the correlation of deposit flows and asset allocations in central reserve and reserve cities. To determine how central reserve city banks behaved (in an absolute sense), one needs to sum the coefficient from the two rows. We also report the standard error of each estimate and F-statistic for the test of the joint significance of all of the coefficients in each equation. In all cases, the joints tests are statistically significant, usually at the 1% level. This result validates the veracity of our research design.[7]

Table 3 reveals how reserve city banks reacted to deposit flows from 1922 to 1928. The first column indicates that one dollar of public deposits that flowed into these banks resulted, on average, in 44 cents of new lending, whereas a one dollar flowing out resulted in 34 cents less of lending. Every dollar of interbank deposits that flowed into reserve city banks resulted in 17 cents of new lending; outflows had little effect on lending. (Recall from our prior discussion that there were few liquidity shocks during this period.) The other columns reveal how reserve city banks adjusted the other assets on their balance sheets in response to deposit inflows and outflows. When deposits from the public came into reserve city banks, they utilized them to purchase government bonds and corporate bonds and to increase cash and reserves. Reserve city banks reacted to inflows of interbank deposits by purchasing government bonds and increasing their own deposits at central reserve city banks. Column (5) highlights how reserve city banks acted as conduits for the banking system. For every dollar of deposits they received from a country bank (a liability), on average they deposited 51 cents of it in central reserve city banks. For every dollar country banks took out of reserve city banks, they moved 32 cents out of central reserve city banks. Inflows and outflows of deposits from the public triggered much smaller changes in deposits in central reserve cities.

[7] In some cases, however, t-tests on individual coefficients fall below the 10% threshold. The difference from the tests stems from multicollinearity and micronumerosity. Interbank and public deposit flows tended to be closely correlated. Splitting deposit movements into two correlated flows occasionally leads to insignificant statistics on the individual components, while the sum of the two remains statistically clearly identified. In our case, like all cases, multicollinearity is compounded by low numbers of observations, particularly when we divide the sample into time periods with flows focused in one direction.

Table 3 reveals how central reserve city banks reacted to the same types of inflows and outflows. Consider their reactions to flows of interbank deposits. On average, central reserve city banks converted each dollar of interbank deposits into 88 cents of loans (0.17 plus 0.81) and 9 cents of corporate bonds (0.03 plus 0.06). Outflows of interbank deposits resulted in reductions in those same categories of roughly similar magnitudes.

Table 4 displays estimates for 1929 and 1930. These were the first two years of the contraction, prior to the start of widespread banking panics. With respect to public deposits, bank lending followed a similar pattern as to what was observed in the pre-Depression era. Reserve city banks accommodated deposit flows by expanding and contracting their lending, cash holdings, and reserves deposited at the Fed, but the pattern began to change, and banks began to accommodate these flows in part by altering interbank balances and holdings of corporate bonds. The treatment of interbank balances mirrored that of early years. Reserve city banks increased holdings in central reserve city banks by about 50 cents for every dollar of interbank deposit that flowed in and recued their holdings in central reserve cities by about 40 cents for each dollar that flowed out. Reserve city banks thus appear to be largely conduits for the system's interbank deposits.

Central reserve city banks' balance-sheet response also began to change in these two years. Interbank outflows resulted in pronounced contractions in lending. The outflow of an interbank dollar coincided with a decline in lending of $1.47 (1.65 minus 0.18) and an increase in holdings of government bonds of 39 cents (-0.67 plus 0.28).

Table 5 focuses on the period of banking distress, 1931-33, when banking panics and suspensions due to liquidity shocks became widespread. We can see some changes in the way reserve city banks handled flows of public deposits. Inflows no longer led to new loans, while outflows reduced lending by roughly 53 cents for every dollar taken out of reserve city banks. We find similar results for corporate bonds, with inflows not adding to balances, but outflows reducing holdings of bonds by roughly 7 cents for every dollar flowing out. Reserve city banks also altered their reactions to interbank inflows and outflows. Interbank flows no longer appear correlated with lending to firms and individuals, but were increasingly correlated with holdings in central reserve cities. For every dollar that country banks withdrew from reserve city banks, they reduced their holdings in central reserve cities by 58 cents – an effect that is almost half again as large as the effect during the 1920s.

Interbank outflows had a different impact on the balance sheets of banks in central reserve cities. In New York and Chicago, banks met the outflow of interbank deposits by reducing lending and selling bonds. For each dollar that flowed out, banks reduced lending to businesses and households by 37 cents, cut their holdings of corporate bonds by 41 cents, and shed 26 cents worth of government bonds.

These results suggest that once widespread liquidity events began in 1931 and country banks faced runs, they pulled their deposits out of reserve city banks. These banks in the middle layer of the pyramid responded by drawing down their deposits at central reserve cities. Since the buck stopped in Chicago and New York, central reserve city banks had to make other adjustments on their balance sheets, and they did so by reducing lending.

Having explored the effects of deposit flows on both reserve and central reserve city banks, we are now in a position to combine their impact to measure how the pyramided system of reserves transmitted liquidity shocks from the periphery to the center via shadowy banks. To calculate the aggregate impact of the banking panics on lending in reserve and central reserve cities, we need to examine flows at all levels of the pyramid. Table 5 shows the impact of interbank deposit outflows on lending to businesses in reserve and central reserve cities from 1931 through 1933, when banking panics repeatedly wracked the financial system and interbank deposits flowed on average out of financial centers. When $100 of interbank deposits flowed out, reserve city banks reduced lending to businesses by $20 ($14 in corporate bonds and $6 in loans to businesses). Reserve city banks also reduced their interbank deposits in central reserve cities by $58. That flow triggered a reaction by banks in the central reserve cities. This $58 outflow reduced lending in New York by $54.29 and in Chicago by $14.62.[8] Thus, when country banks pulled $100 in deposits out of reserve cities, the net result was a decline in lending of about $89, with roughly a quarter of that decline occurring in reserve cities and three-quarters occurring in central reserve cities.

Section 5: Magnitude of the Interbank Amplifier

Overall, how important were the balance sheet responses of central reserve city banks to the deposit outflows associated with banking distress? To calculate an aggregate macroeconomic interbank amplifier requires several types of information. The first is knowledge of the interbank network (from Section 2). The second is knowledge of how distress among country banks triggered deposits outflows from reserve and central reserve cities (Section 3). The third is knowledge of how those deposit outflows influenced credit allocation (Section 4). This section begins by combing this structural and behavioral information. Then, it adds the final piece of information, counts of the number of banks that failed for liquidity reasons (primarily runs), which enables us to calculate an aggregate estimate.

The calculation begins with coefficients from Equation (1), which reveal the correlation between failures of county banks and levels of deposits in reserve and central reserve cities. These coefficients appear in Table 2. We repeat the key coefficients in the first

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[8] The New York result comes from multiplying $54.29 = $58 * 0.8 * 1.17, where 0.8 is roughly New York's share of interbank deposits and 1.17 is the coefficient relating interbank flows to lending changes in New York City during 1931 and 1932. The Chicago result comes from multiplying $14.62 = $58 * 0.2 * 1.26, where 0.2 and 1.26 are the analogous numbers for Chicago. In 1929, interbank deposits in New York equaled $1,478 million. Interbank deposits in Chicago equaled $355 million.

row of Table 6. The suspension for liquidity reasons of one country bank coincided, on average, with a decline in public deposits in financial centers of $481,000, and a decline in interbank deposits in reserve cities of $119,000 and in central reserve cities of $183,000. The decline for central reserve cities was larger, because it includes the direct outflow from country clients of $119,000 and an indirect outflow when reserve city banks reallocate assets in response to outflows of deposits from country clients and local customers. The indirect outflow appears in line 6. The total outflow from central reserve cities of $183,000 equals $119,000 plus $69,000 minus $5,000.

In Table 6, the second through sixth rows indicate how banks in reserve and central reserve cities reacted to outflows of interbank and public deposits. These estimates arise by multiplying the outflow indicated in the first line by the corresponding coefficients from our estimate of Equation (2). We estimate this equation for three different time periods. Those estimates appear in Tables 3, 4, and 5. Table 6 presents calculation based upon Table 5. We do not report analogous tables for the other time periods.[9]

Table 6 has a straightforward interpretation. The suspension of a country bank due to a liquidity shock (typically a run) coincided with outflows of deposits from reserve and central reserve cities. Those outflows amounted to $302,000 in interbank deposits and $962,000 in regular deposits. Those outflows coincided with changes (typically reductions) in lending. The total decline in credit amounted to $1,064,000.[10]

Table 7 refines our estimates and reports them for the time periods (January 1929 through March 1933) for which we have detailed microdata on the causes of suspension and size of suspended banks. We aggregate our estimates into two categories. Lending to business

[9] To elucidate the calculation, we provide an example. Table 5 shows that an interbank outflow of $1,000 of interbank deposits coincided with a reduction of lending of $60 (1000*0.06), where 0.06 is the seventh coefficient in the first column. We multiply 119 and 60, and then round to the nearest thousand, to get the second row of the first column.

[10] This aggregate calculation is the sum of all the estimates indicated by rows 2 through 6 for columns 1 through 4 times $1,000.

is the sum of loans and corporate bonds. Lending to government is the sum of government bonds. We also aggregate the estimates for reserve and central reserve cities. Table 7 has a straightforward interpretation. It indicates how lending from banks in reserve and central reserve cities changed when country banks suspended operations due to liquidity shocks. Money center banks changed lending in part because of outflows of interbank deposits. Money center banks also changed lending because of withdrawals by their own depositors.

Table 8 provides the last type of information that we need to calculate the aggregate effect. Column (7) the number of banks that failed due to liquidity shocks (typically runs) during each quarter. Note that this figure includes both terminal and temporary suspensions, which are distinguished in columns (8) and (9) respectively. The remaining columns of the table indicate failures due to bank distress of other types. Of particular interest is the total number of terminal suspensions shown in the first column.

Table 9 presents our aggregate estimates. The estimate sums the decline in lending to businesses and governments into a single number. We need to do this to make our estimates comparable, because the data which we compare it to – loans and investments in suspended banks – is the sum of both of these categories. In the first column, the "interbank amplifier" effect is the aggregate decline in lending in reserve and central reserve cities due to the outflow of interbank deposits. In the second column, the "public response to country distress" is the decline in lending due to the outflow of public deposits in reserve and central reserve cities that coincided with distress among country banks. In the third through fifth columns, the table presents data on total loans and investments trapped in suspended banks. These data comes from the Federal Reserve' compilation of examiners' reports for suspended banks.[11] Banks that suspended terminally closed their doors, never reopened, and in almost all cases, liquidated through a court supervised process. Banks that suspended temporarily closed their

[11] Richardson 2008 provides details.

doors for at least one day (and on average about 90 days), reopened to depositors, and in almost all cases, survived the depression. The terminal suspensions for “liquidity” reasons are banks for which the examiner’s report indicated the cause of failure to be heavy withdrawals or closure of correspondents.

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Table 1: Reserve Pyramid System and Interbank Flows

Federal Reserve District		Number of: Central Reserve Cities	Number of: Reserve Cities	Changes between call dates (Millions of Dollars): Mean	SD	Max	Min
1	Boston		1	2.85	15.70	41	-50
2	New York	1	2	-0.15	4.70	13	-13
3	Philadelphia		2	3.89	25.42	91	-81
4	Cleveland		4	4.20	35.95	135	-117
5	Richmond		3	3.09	13.22	36	-26
6	Atlanta		7	3.91	19.16	49	-40
7	Chicago	1	8	3.01	14.81	44	-33
8	St. Louis		4	4.48	19.11	54	-37
9	Minneapolis		6	1.23	11.48	47	-25
10	Kansas City		5	3.67	25.19	102	-57
11	Dallas		9	3.20	22.49	70	-41
12	San Francisco		9	3.57	25.57	89	-68
	United States	2	59	3.08	20.85	135	-117

Sources: See text.
Note: Reserve city interbank deposit data are aggregated to Federal Reserve District.

Table 2: Deposit Flows and Bank Distress, January 1929 to December 1932

	(Interbank)	(FE Interbank)	(D + T)	(FE D + T)
Liquidity Shocks	-0.103	-0.119	-0.399	-0.481
	(0.047)**	(0.056)**	(0.117)***	(0.138)***
Solvency Failure	-0.033	-0.065	-0.171	-0.326
	(0.081)	(0.101)	(0.199)	(0.246)
Constant	1.723	2.529	-4.562	-0.513
	(2.621)	(3.060)	(6.486)	(7.480)
R^2	0.03	0.03	0.06	0.07
N	180	180	180	180

* p<0.1; ** p<0.05; *** p<0.01

Table 3: Deposit Flows and Asset Allocation, 1922 to 1928

	Loan	Bond-Govt	Bond-Corp	Reserve	Interbank
Public Inflow	0.44	0.17	0.12	0.66	0.03
	(0.12)***	(0.06)***	(0.04)***	(0.19)***	(0.03)
CR*PI	-0.28	-0.15	-0.10	0.15	-0.01
	(0.12)**	(0.06)**	(0.04)**	(0.20)	(0.03)
Public Outflow	0.34	-0.07	0.03	0.53	0.16
	(0.28)	(0.15)	(0.10)	(0.47)	(0.08)**
CR*PO	-0.36	0.10	-0.06	0.32	-0.12
	(0.29)	(0.15)	(0.10)	(0.47)	(0.08)
Interbank Inflow	0.17	0.23	0.03	0.01	0.51
	(0.24)	(0.13)*	(0.08)	(0.40)	(0.07)***
CR*II	0.81	-0.25	0.06	-0.20	-0.47
	(0.27)***	(0.14)*	(0.09)	(0.45)	(0.07)***
Interbank Outflow	-0.03	0.00	-0.11	0.07	0.32
	(0.33)	(0.17)	(0.11)	(0.54)	(0.09)***
CR*IO	1.30	-0.08	0.29	-0.39	-0.36
	(0.36)***	(0.19)	(0.13)**	(0.60)	(0.10)***
CR	15.72	13.70	1.57	-14.30	1.85
	(11.06)	(5.71)**	(3.81)	(18.22)	(3.01)
Constant	0.40	-2.32	-0.79	-7.76	-0.74
	(5.25)	(2.71)	(1.80)	(8.64)	(1.43)
F-statistic	77.9	2.5	7.8	128.1	20.6
R^2	0.66	0.06	0.16	0.76	0.34
N	364	364	364	364	364

* p<0.1; ** p<0.05; *** p<0.01

Table 4: Deposit Flows and Asset Allocation, 1929 and 1930

	Loan	Bond-Govt	Bond-Corp	Reserve	Interbank
Public Inflow	0.33	-0.07	0.14	0.34	0.13
	(0.20)*	(0.06)	(0.05)***	(0.12)***	(0.04)***
CR*PI	-0.44	0.02	-0.10	0.83	-0.12
	(0.22)**	(0.07)	(0.05)*	(0.13)***	(0.05)**
Public Outflow	0.29	-0.13	0.07	0.51	0.20
	(0.24)	(0.08)*	(0.06)	(0.14)***	(0.05)***
CR*PO	-0.46	0.26	-0.05	0.40	-0.15
	(0.25)*	(0.08)***	(0.06)	(0.15)***	(0.05)***
Interbank Inflow	-0.27	0.21	0.32	0.11	0.49
	(0.47)	(0.15)	(0.11)***	(0.28)	(0.10)***
CR*II	1.26	0.03	-0.07	-0.89	-0.47
	(0.53)**	(0.17)	(0.13)	(0.32)***	(0.12)***
Interbank Outflow	-0.18	0.28	-0.02	-0.00	0.40
	(0.63)	(0.20)	(0.15)	(0.38)	(0.14)***
CR*IO	1.65	-0.67	0.02	0.04	-0.38
	(0.67)**	(0.21)***	(0.16)	(0.40)	(0.15)***
CR	-18.87	17.12	2.61	-1.54	9.78
	(28.89)	(9.21)*	(6.98)	(17.34)	(6.35)
Constant	-5.06	-2.57	-1.40	-0.60	2.21
	(10.79)	(3.44)	(2.61)	(6.47)	(2.37)
F-statistic	15.0	8.9	23.3	425.8	16.3
R^2	0.55	0.42	0.65	0.97	0.57
N	112	112	112	112	112

* p<0.1; ** p<0.05; *** p<0.01

Table 5: Deposit Flows and Asset Allocation in Reserve Cities, 1931 through 1933

	Loan	Bond-Govt	Bond-Corp	Reserve	Interbank
Public Inflow	-0.17	0.01	0.03	-0.07	-0.04
	(0.24)	(0.23)	(0.06)	(0.15)	(0.07)
CR*PI	-0.22	0.36	-0.03	0.98	0.07
	(0.28)	(0.26)	(0.07)	(0.18)***	(0.08)
Public Outflow	0.53	0.05	0.07	0.09	-0.01
	(0.11)***	(0.10)	(0.03)**	(0.07)	(0.03)
CR*PO	0.01	-0.35	-0.16	0.77	0.01
	(0.13)	(0.12)***	(0.04)***	(0.08)***	(0.04)
Interbank Inflow	-0.11	0.92	0.00	-0.34	0.61
	(0.47)	(0.45)**	(0.13)	(0.30)	(0.14)***
CR*II	-0.03	0.16	0.25	0.20	-0.80
	(0.53)	(0.50)	(0.14)*	(0.34)	(0.15)***
Interbank Outflow	0.06	0.01	0.14	0.05	0.58
	(0.43)	(0.41)	(0.12)	(0.28)	(0.13)***
CR*IO	0.31	0.25	0.27	-0.10	-0.52
	(0.46)	(0.44)	(0.12)**	(0.29)	(0.13)***
CR	-4.37	-39.01	5.06	27.54	6.97
	(31.27)	(29.54)	(8.45)	(19.91)	(9.11)
Constant	-7.58	6.27	-0.50	4.55	0.29
	(10.02)	(9.47)	(2.71)	(6.38)	(2.92)
F-statistic	17.6	6.4	16.4	83.9	7.6
R^2	0.53	0.29	0.51	0.84	0.33
N	140	140	140	140	140

* p<0.1; ** p<0.05; *** p<0.01

Table 6: Liquidity Suspensions Impact on Bank Assets ($ Thousand) through Changes in Interbank and Public Deposits, Reserve and Central Reserve Cities, 1931 through 1933

	Reserve		Central Reserve	
	Interbank	Public	Interbank	Public
1. Deposit Outflows	-119	-481	-183	-481
2. Loans	-7	-255	-68	-260
3. Bonds – Corporate	-1	-24	-48	144
4. Bonds – Government	-17	-34	-8	43
5. Reserves	-6	-43	9	-414
6. Interbank	-69	5	-11	0

Note: Calculations combine coefficients from Tables 2 and 4 as described in text. Calculations reveal average aggregate change in assets of each type among Federal Reserve member banks in reserve and central reserve cities for each liquidity suspension among country banks from 1931 through 1933. Calculations for other time periods use analogous method.

Table 7: Liquidity Suspensions Impact on Lending ($ Thousand)

Response to Outflows of ..	Interbank		Public	
Change in Lending to …	Business	Govt.	Business	Govt.
1929 through 1930	-40.1	-10.0	-500.2	9.6
1931 through 1933	-123.8	-24.2	-394.4	9.6

Note: Calculations based upon estimates in Table 6 and an analogous (unreported) table for 1929 and 1930. Lending to business is the sum of loans and corporate bonds held on banks' balance sheets. Lending to government is the sum of government bonds. The estimates indicate the average change in lending in reserve and central reserve cities in response to the suspension (for liquidity reasons) of one country bank. Columns (1) and (2) indicate changes in lending due to outflows of interbank deposits. Columns (3) and (4) indicate changes in lending due to outflows of deposits from the public.

Table 8
Number of Banks in Distress, by Category and Quarter
Winter 1929 through Winter 1933

		Suspensions, Terminal	Voluntary Liquidations	Consolidations due to Financial Difficulties	Total, Distressed Departures	Suspensions, Temporary	Total, Banks in Distress	Liquidity Suspensions	Terminal	Temporary
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1929	Winter	102	1	2	105	9	114	21	20	1
	Spring	92	1	3	96	17	113	19	16	3
	Summer	96	14	19	129	25	154	54	41	13
	Fall	141	23	29	193	20	213	46	36	10
1930	Winter	229	30	38	297	32	329	76	58	18
	Spring	174	17	19	210	34	244	83	64	19
	Summer	185	19	15	219	21	240	65	56	9
	Fall	489	21	52	562	190	752	310	199	111
1931	Winter	316	34	65	415	63	478	146	114	32
	Spring	306	12	57	375	13	388	165	158	7
	Summer	496	23	58	577	53	630	213	185	28
	Fall	844	42	119	1,005	189	1,194	543	432	111
1932	Winter	435	45	67	547	81	628	268	221	47
	Spring	282	20	36	338	23	361	119	111	8
	Summer	244	12	21	277	38	315	99	83	16
	Fall	340	22	25	387	21	408	108	98	10
1933	Winter	420	38	34	492	48	540	212	189	23
Total		5,191	374	659	6,224	877	7,101	2,740	2,081	659

Notes: Statistics for Winter 1933 include suspensions in January, February, and March preceding state banking moratoria and the national banking holiday. Statistics do NOT include banks suspended during federal and state moratoria in February and March 1933.
Source: Richardson (2008) and authors' calculations for columns (7) to (10).

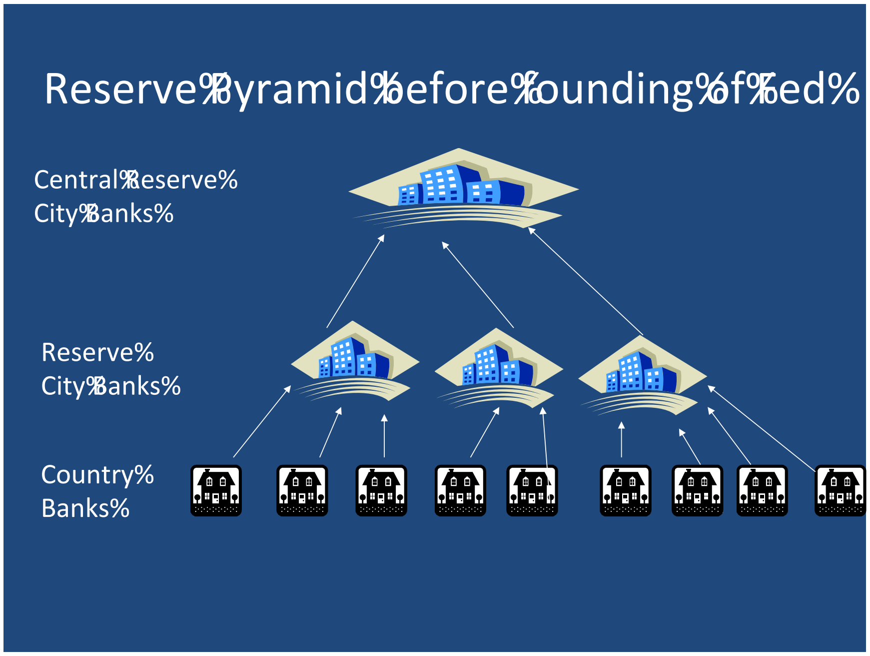
Table 9: Aggregate Impact of Interbank Amplifier Compared to Loans and Investments in Suspended Banks (all figures in $ millions)

				Loans and Investments in Suspended Banks		
				Terminal		
		Interbank Amplifier	Public Response to Country Distress	All	Liquidity	Temporary
Year	Quarter					
1929	Winter	1	10	11	3	2
	Spring	1	9	11	3	2
	Summer	3	26	40	21	3
	Fall	2	23	37	9	6
1930	Winter	4	37	78	18	13
	Spring	4	41	93	28	16
	Summer	3	32	72	33	10
	Fall	16	152	558	196	100
1931	Winter	22	56	147	62	23
	Spring	24	63	311	228	5
	Summer	32	82	496	251	41
	Fall	80	209	699	439	291
1932	Winter	40	103	297	145	39
	Spring	18	46	230	138	11
	Summer	15	38	99	45	18
	Fall	16	42	178	65	10
1933	Winter	31	82	234	148	21
Total		311	1,051	3,590	1,833	607

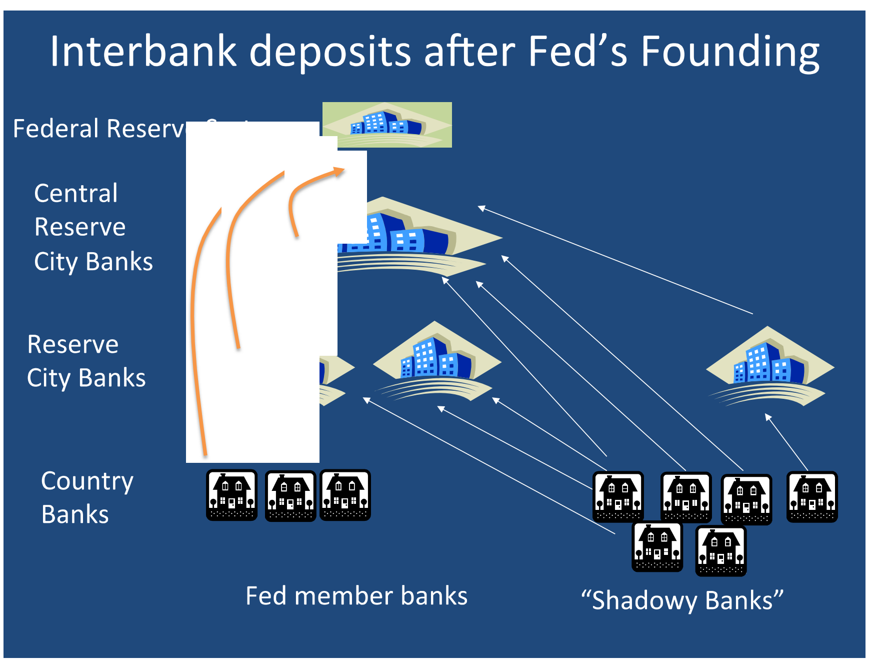
Notes: Loans and investments of suspended banks from Richardson (2008). Interbank amplifier aggregate for each quarter calculated by multiplying the Table 8, Column 7 with coefficients in Table 7, as described in the text

Figure 1. Reserve Pyramid Structure

Panel A



Panel B



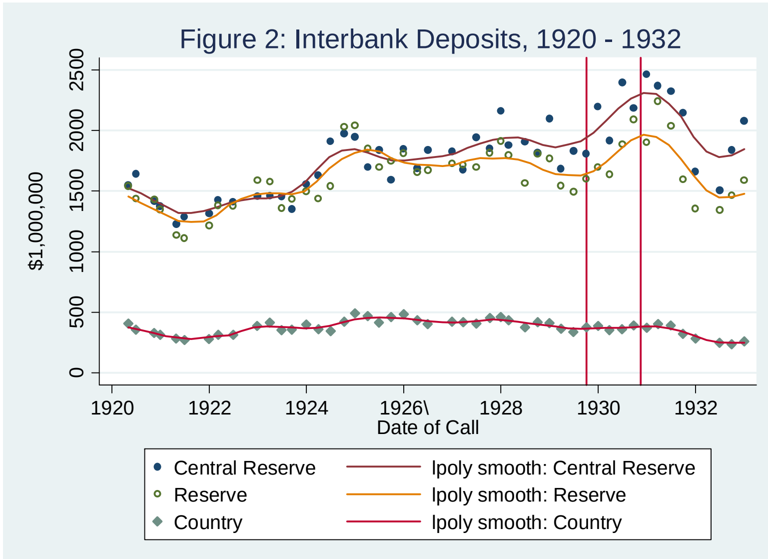


Figure 2: Interbank Deposits, 1920 - 1932

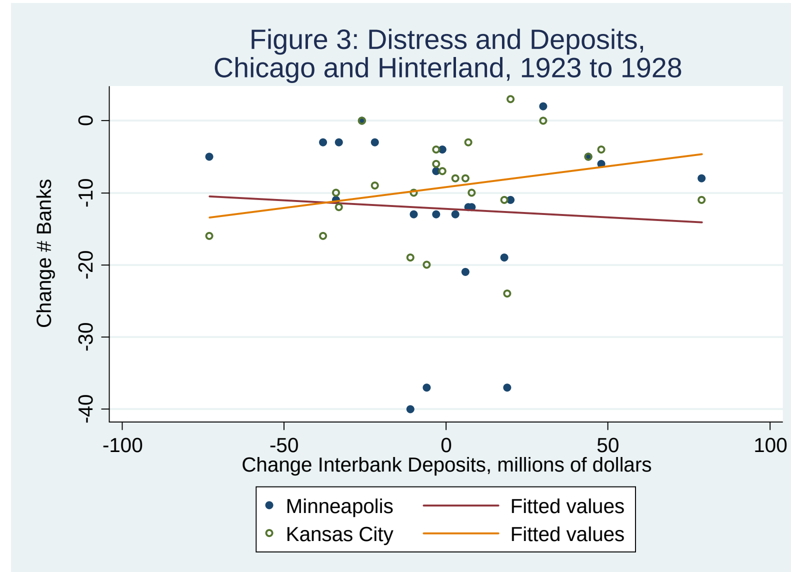


Figure 3: Distress and Deposits, Chicago and Hinterland, 1923 to 1928

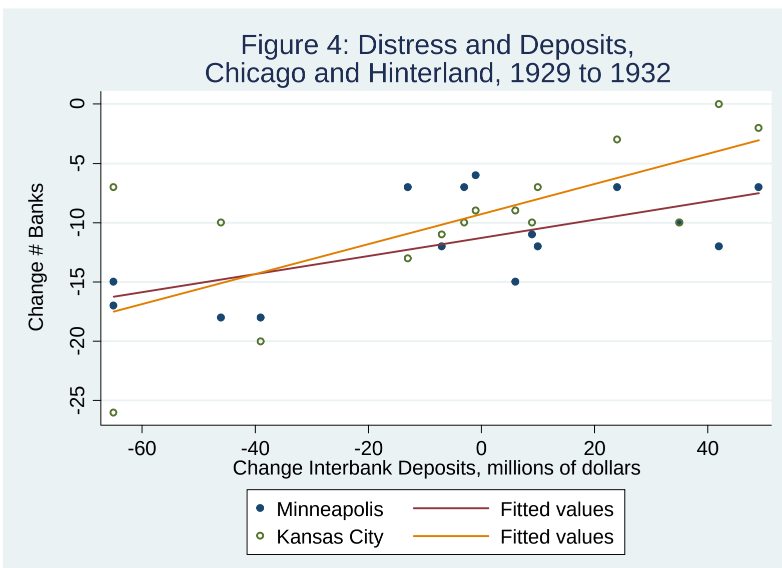


Figure 4: Distress and Deposits, Chicago and Hinterland, 1929 to 1932

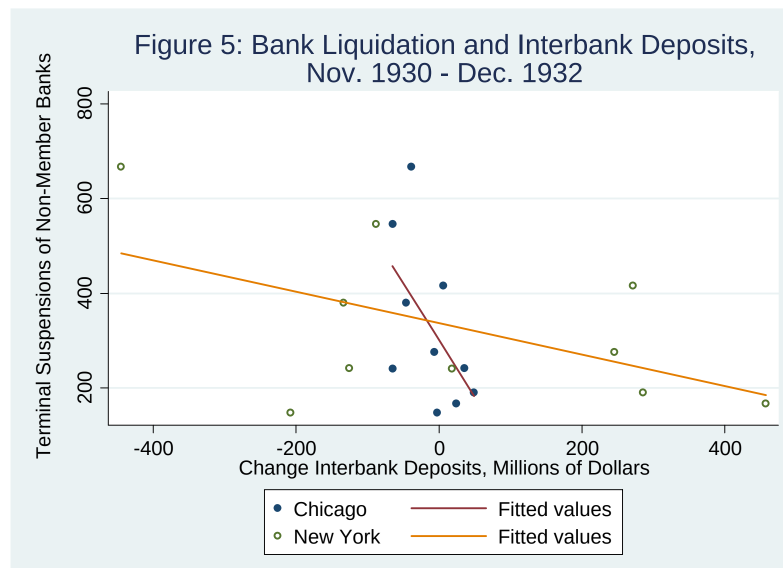


Figure 5: Bank Liquidation and Interbank Deposits, Nov. 1930 - Dec. 1932