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# The Effect of the Central Bank Liquidity Support during Pandemics: Evidence from the 1918 Influenza Pandemic

Haelim Anderson
Jin-Wook Chang
Adam Copeland

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## Abstract

The coronavirus outbreak raises the question of how central bank liquidity support affects financial stability and promotes economic recovery. Using newly assembled data on cross-county flu mortality rates and state-charter bank balance sheets in New York State, we investigate the effects of the 1918 influenza pandemic on the banking system and the role of the Federal Reserve during the pandemic. We find that banks located in more severely affected areas experienced deposit withdrawals. Banks that were members of the Federal Reserve System were able to access central bank liquidity, enabling them to continue or even expand lending. Banks that were not System members, however, did not borrow on the interbank market, but rather curtailed lending, suggesting that there was little-to-no pass-through of central bank liquidity. Further, in the counties most affected by the 1918 pandemic, even banks with direct access to the discount window did not borrow enough to offset large deposit withdrawals and so liquidated assets, suggesting limits to the effectiveness of liquidity provision by the Federal Reserve. Finally, we show that the pandemic caused only a short-term disruption in the financial sector.

Key words: 1918 influenza, pandemics, financial stability, bank lending, economic recovery

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Copeland: Federal Reserve Bank of New York (email: adam.copeland@ny.frb.org). Anderson: Federal Deposit Insurance Corporation (email: handerson@fdic.gov). Chang: Federal Reserve Board (email: jin-wook.chang@frb.gov). The views expressed in this paper are those of the authors and do not necessarily represent the position of the Federal Deposit Insurance Corporation, the Federal Reserve Bank of New York, the Board of Governors of the Federal Reserve, or the Federal Reserve System.

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## 1. Introduction

The coronavirus (COVID-19) outbreak has affected over 140 countries and prompted many of them to impose a national or partial lockdown to stem the spread of the virus. In a matter of weeks, the outbreak has pushed the global economy to the brink of a recession more severe in some respects than the 2008 financial crisis. In addition, the outbreak has created liquidity pressures in the financial sector, resulting in central banks, such as the Federal Reserve, implementing a range of facilities to improve liquidity in financial markets. These events raise several important questions: How do pandemics affect financial stability? How important is it for a central bank to provide liquidity to the financial sector? How important is it for central banks to provide liquidity to institutions without liquidity insurance?

It is important to understand the relationship between pandemics and financial stability because the health of the financial sector affects the economic recovery. The economy's ability to survive the impact of a pandemic depends in part on the availability of credit, which banks may or may not be able to extend given their ability to handle the economic fallout from the pandemic. Further, the large amount of uncertainty that arises from a pandemic can also drive a loss of confidence in the financial system, which can feed back into the real sector in an adverse way, prolonging the economy recovery from the pandemic. In the absence of financial stability measures to stop financial panics, a contraction in the flow of credit can amplify a downturn (Lagoarde-Segot and Leoni, 2013).

Central banks around the globe are using a full range of tools to respond to the economic fallout from the COVID-19 outbreak. Both the degree and the scope of the central bank liquidity support are unprecedented. In the U.S., the Federal Reserve is implementing a variety of funding, credit, liquidity, and loan facilities including the Commercial Paper Funding Facility, Primary Dealer Credit Facility, Money Market Fund Liquidity Facility, Primary Market Corporate Credit Facility, Secondary Market Corporate Credit Facility, Paycheck Protection Program Liquidity Facility, Municipal Liquidity Facility, and Main Street Lending Program, in addition to the Standing Repo Facility and traditional discount window. Many of these facilities provide liquidity to markets and entities considered not to be in the scope of a central bank prior to the current pandemic and the 2008 financial crisis. Even though many central banks share the necessity of an aggressive response to the current pandemic, there is disagreement on their

effectiveness, with many arguments both against the wide range of strong policy responses as well as for the implementation of more policies to provide even larger amounts of liquidity to a wider range of entities.

While the recent COVID-19 outbreak places more urgency on understanding the relationship between pandemics, financial stability and the provision of central bank liquidity, we are not aware of any empirical research that has been done on this specific topic. To date, most research studies the relationship between pandemics and economic outcomes (Brainerd and Siegler, 2003; J. Barro, Ursúa, and Weng, 2020; Correia, Luck, and Verner, 2020; Oscar, Singh, and Taylor, 2020), relying on data aggregated to a regional or national level. Other studies use micro level data and focus on the effect of pandemics on socioeconomic or labor market outcomes. One strand of this latter field of research examines how the 1918 Influenza affected wages, demographic composition, or mortality differences across socioeconomic classes (Noymer and Garenne, 2000; Mamelund, 2006; Garrett, 2009) or local health output (Karlsson, Nilsson, and Pichler, 2014; Clay, Lewis, and Severnini, 2018). Other strands focus on the health and economic outcomes of descendants of pandemic survivors (Keyfitz and Flieger, 1968; Almond, 2006). This paper stands apart from this existing literature because of our focus on the effect of a pandemic on financial stability, a question we are able to answer because of newly available micro-level balance sheet data around the 1918 Influenza outbreak.

The goal of this paper is to directly examine the effect of the pandemics on financial stability by comparing the deposit and lending behavior of banks in areas more affected by the 1918 Influenza to those in areas that were less affected. Although influenza outbreaks were seasonal and occurred in New York every year, these typical outbreaks had low mortality rates and affected counties across New York uniformly. In contrast, the 1918 influenza pandemic had a high mortality rate and an uneven effect across counties---some counties experienced more than four times the flu mortality rate of others.

We use this cross-county variation to examine the impact of the pandemic on the dynamics of deposit and lending growth both in the short and long term. If the pandemic lowered depositor confidence by creating uncertainty about economic growth, banks would face deposit withdrawals, which in turn reduces their ability to lend. However, if banks could mitigate deposit withdrawals by borrowing from the Federal Reserve or other banks, they would have continued to lend.

For this study, we collect and construct a new data set that combines individual bank balance-sheet data with county-level statistics on mortality due to influenza. We construct a dataset on quarterly balances sheets of all state-chartered commercial banks and trust companies in New York from 1914 to 1919. We exclude banks located in major financial centers (New York City, Albany, Buffalo, and Rochester) to arrive at a set of relatively homogenous banks whose business model is to attract deposits from local households and make loans to farmers and small businesses. We also collect data on influenza death rates across New York counties during the same period. Combining these two sources of data allows us to exploit regional mortality variation to examine the relationship between pandemics and financial stability.

We capture the impact of the pandemic on deposit stability, short-term funding, bank lending and securities holdings using a difference-in-differences approach. We compare the changes in these variables for banks in counties that were more affected by the pandemic to those banks in counties that were less affected.

We further examine whether the pandemic had a differential impact on banks that were members of the Federal Reserve System (member banks) compared to those that were not members (nonmember banks). A major difference between these two types of banks is that only the member banks were eligible to access the Federal Reserve discount window. Our analysis, then, is able to determine how effectively the Federal Reserve was able to provide liquidity to its members during a pandemic, and further, whether that liquidity was passed through to nonmember banks through the interbank market.

Our first set of results find that New York state-charter banks as a group faced deposit outflows during the pandemic. In response, these banks decreased their securities holdings. Furthermore, banks in counties that were more affected by the pandemic saw larger deposit outflows and consequently more aggressively lowered their holdings of securities.

Our second set of results focuses on differences between member and nonmember banks, and reveals stark differences in outcomes. We find that member banks were able to increase short-term borrowing from the Federal Reserve during the pandemic and so engage in lending activity, whereas nonmember banks reduced short-term borrowing and curtailed lending. In addition, our findings demonstrate that member banks did not pass-through liquidity obtained from the Federal Reserve to nonmember banks during the pandemic.

Furthermore, we find that member banks in counties most affected by the pandemic did not borrow enough to offset the large deposit outflows that they experienced. As a result, these banks reduced loans and liquidated other cash assets. Our interpretation of this result is that member banks ran out of enough good collateral to post to the Federal Reserve's discount window during the pandemic. As a consequence, the Federal Reserve was unable to provide enough liquidity to those member banks that faced the largest liquidity shocks.

Our final set of results demonstrate that the 1918 Influenza had only a short-term effect on New York banks. Over the longer term, banks experienced deposit inflows and continued to increase lending. By the end of 1919, banks were able to restore the balance sheet portfolio they had before the pandemic.

Our study has important implications for policy today. First, our study demonstrates that central bank liquidity does not necessarily pass-through to those financial institutions that are not members of the Federal Reserve. This lack of pass-through, which is important for financial stability, is especially problematic if these nonmember institutions are in need of liquidity. As such, our results provide support for the actions by the Federal Reserve both in the 2008 financial crisis and the current COVID-19 pandemic to directly provide liquidity to those financial institutions that lack discount window access.

Second, our study shows that central banks should consider implementing flexible liquidity policies that account for the varied exposure that financial institutions may have to the same aggregate shock. Our study shows that member banks in the most adversely affected counties could not borrow enough from the Federal Reserve and so curtailed lending. Most likely, the economic pain of the 1918 Influenza pandemic would have been lessened if those member banks could have borrowed more. Our results, then, suggests that central banks, in response to a large shock such as a pandemic, should consider using lending facilities that are specifically target the more severely affected localities, industries, or markets.

The remainder of this paper is organized as follows. Section 2 provides historical background. Section 3 introduces the data and provides summary statistics. Section 4 describes the empirical specifications and presents results. Section 5 concludes.

## 2. Historical Background

This section describes the banking environment around the 1918 influenza pandemic. We begin by describing how the 1918 influenza panic affected New York. Then, we describe the banking environment in New York with a focus on the trade-off state-charter banks faced with respect to becoming members of the Federal Reserve System.

### 2.1.1918 Influenza Panic

An outbreak of influenza spread across the world in 1918. The influenza was brief but severe, with about 500 million people infected globally (a quarter of the world's population) and at least 50 million people killed. The 1918 pandemic did not spare the U.S., which recorded 657,000 deaths.[1]

New York State provides a useful laboratory to study the impact of the 1918 influenza. The pandemic had a large impact on the state, with monthly influenza and pneumonia death rates spiking up in New York State from below 0.5 deaths per 1000 people to almost 3 deaths per 1000 in October 1918 (see Figure 1). Further, there was large variation in the severity of the pandemic across New York counties, with some counties experiencing almost four times the mortality rate than others (see Figure 2). For example, Seneca was the most severely affected county with the rate of 10.11 deaths per 1000 people, whereas the neighboring county of Yates was the least affected, with a mortality rate of 2.26 deaths per 1000.

To illustrate the cross-county variation more formally, we compute the mean and standard deviation in county-level mortality rates from 1914 to 1920. The time variation in the mean reflects the severe and brief effect of the pandemic. For all years except 1918, the mean mortality rate from influenza and pneumonia was below 2 deaths per 1000, whereas in 1918 this rate spiked up to 5.5 (see the first column of Table 1). The standard deviation measure reflects the variation in deaths across counties. For all years except 1918, the standard deviation in mortality rates was at or below 0.5, illustrating little differences in mortality across counties. In 1918, however, the standard deviation in death rates more than tripled to 1.6 (see the second column of Table 1).

The drivers behind the variation in mortality rates across counties is not well-understood. Although researchers have suggested possible explanations, there is little consensus on the

[1] Similar to the current COVID-19 virus, the 1918 influenza itself did not often cause death. Instead, secondary infections such as bacterial pneumonia, were typically the direct cause of death.

underlying causes (Huntington, 1923; Crosby, 1989; Kolata, 1999; Brainerd and Siegler, 2003). As a result, we will consider the cross-county distribution of the 1918 influenza to be exogenous to our object of interest, which are the balance sheet variables of New York state-charter banks.

### 2.2. New York's Banking System during the Early Years of the Federal Reserve

The 1918 Influenza Pandemic occurred during the early years of the Federal Reserve System, which was created by the passage of the Federal Reserve Act of 1913 and went into operation in 1914. The Federal Reserve was created to provide an elastic currency and prevent banking panics (Meltzer, 2003). Although national-charter banks were required to become a member of their local Federal Reserve Bank, state-charter banks were given a choice.

It was expected that discount window lending would be the principal means by which the Federal Reserve would serve as lender of last resort to the banking system. During the early years of 1914-1921, the Federal Reserve conducted monetary policy exclusively via changes in the discount rate of the discount window. The discount window, which required "good" collateral such as commercial paper, was operated as a standing facility to buffer liquidity shortages, by lending during times of stress (Chabot, 2017).[2] In contrast to later years, during the early years of the Federal Reserve, banks did not suffer from stigma when they accessed the discount window (Gorton and Metrick, 2013).

The Federal Reserve Board (1915) expressed hope that it would develop a unified system of banking where all banks would be subject to the same regulation and supervision. However, few state-charter banks chose to join the Federal Reserve System because federal regulations and supervision tended to be stricter than state counterparts. In 1917 an amendment was passed to reduce some of these burdens, after which there was a surge in membership by state-charter banks (see Figure 3). Nevertheless, many state-charter banks still did not join Federal Reserve. In New York during our sample period, the majority of state-charter banks were not Federal Reserve members.

In addition to the aforementioned costs of stricter federal regulation and supervision, there were two main reasons for state-charter banks to not join the Federal Reserve System. First,

[2] Until 1922, there were no open market operations to conduct monetary policy. Open market purchases were conducted only to support Treasury issuance or raise revenue of the Federal Reserve Banks.

state-charter banks were allowed by their state banking regulators to meet reserve requirements with interbank deposits placed at commercial banks. The Federal Reserve Act, however, prohibited its members from using interbank reserves to meet reserve requirements. Rather, member banks were required to meet reserve requirements by holding reserves at their local Federal Reserve Bank. Whereas the Federal Reserve Banks did not pay interest on reserves held on their balance sheet, during our sample period interbank deposits placed at commercial banks earned 2 percent interest on average. Becoming a member of the Federal Reserve then, foreclosed a state-charter bank's ability to earn a substantial amount of interest on required reserves.

Second, banks that were not Federal Reserve members could still enjoy the benefit of the Federal Reserve's discount window by establishing a correspondent relationship with a bank that was a member. Despite efforts to limit the pass-through of discount window benefits to banks that were not members of the Federal Reserve, the Federal Reserve was not able to prevent correspondent banks from making advances to their respondents (Congressional Quarterly, 1923).[3]

## 3. Data and Summary Statistics

To study the impact of the influenza pandemic on financial stability and bank lending, we combine information on state-charter banks and trust companies with flu mortality statistics. We collected the quarterly balance sheets of all New York state-chartered banks and trust companies from the *Annual Report of the Superintendent of Banks* for the period 1914-1919. Further, we identify which state-charter banks were members of the Federal Reserve using the *Annual Report of the Federal Reserve Board*.

Rather than use all state-charter banks in New York, we limit our focus to small country banks outside of financial centers. To that end, we drop banks located in major financial centers—the reserve cities of New York, Albany, Buffalo, and Rochester—to arrive at a set of relatively homogenous banks whose business model was to attract deposits from local households and make loans to farmers and small businesses. (Banking was a local affair during

[3] For more information on the decision by state-charter banks to join the Federal Reserve System between 1915 and 1920, see Anderson, Calomiris, Jaremski, and Richardson (2018).

our period of study because the U.S. had a unit banking system.) We do not include national-charter banks because during this period of time detailed balance sheet data are not available on a quarterly basis. After this filtering of the data, we observe about 300 state-chartered banks and trust companies every quarter from 1914 to 1919 on average. After 1917, roughly one-quarter of these depository institutions were members of the Federal Reserve System.[4] Member and nonmember banks were spread uniformly across New York, Figure 4 plots a snapshot of their locations around the state in 1918.

Table 2 displays the rich set of balance sheet variables of state-chartered banks and trust companies recorded in the *Annual Report of the Superintendent of Banks* and how we aggregate these variables for our analysis. Starting with the asset side, regulators report a fine breakdown of bank reserves which we group into two categories: vault reserves and interbank reserves. Vault reserves were composed of 'specie,' 'legal tender notes and notes of national banks,' 'Federal reserve notes,' and 'cash items.' This collection of items are currency or currency-like instruments that are held at the bank. Interbank reserves, or reserves that a bank has deposited at other banks or at a Federal Reserve bank, is the sum of 'due from trust companies, banks, and bankers' and 'due from the Federal Reserve Bank.' The structure of the banking system in the early 1900s was a tiered system whereby smaller banks placed reserves at larger banks located in reserve cities (Anderson, Paddrik and Wang, 2019). This structure was formalized in that banks that were not members of the Federal Reserve (nonmember banks) were required to meet their reserve requirements by holding deposits in these reserve-city banks. Banks that were members of the Federal Reserve (member banks) met their reserve requirements by placing cash at the Federal Reserve.[5] Nevertheless, these member banks also placed cash at reserve-city banks because these interbank deposits, which were generally considered safe assets, earned interest whereas deposits held at the Federal Reserve did not.

In our analysis, we separately examine the behavior of vault and interbank reserves for two reasons. First, as explained above, interbank deposits play a different role for nonmember versus member banks. Second, whether banks met deposit withdrawals by reducing cash

[4] As detailed in the previous section, before 1918 only a few New York state-charter banks were members of the Federal Reserve System. All the banks that were or became members of the Federal Reserve System in our data retained this status through the end of our sample period.

[5] Only banks that were members of the Federal Reserve were eligible to place cash reserves at their regional Federal Reserve Banks.

holdings or interbank deposits has financial stability implications; the large withdrawal of interbank deposits in central reserve and reserve city banks by rural banks could create liquidity problems for city banks and lead to financial contagion, as shown during the Great Depression (Richardson and Mitchener, 2019).

New York state regulators also collected detailed information on the loans made by banks, placing them into four categories. The first category is 'mortgages owned,' which are real estate loans. State banks were allowed to make mortgage loans against farmland within one hundred miles of their location (or headquarters) with several restrictions. The second category is 'loans and discounts secured by bond and mortgage, deed and other real estate collateral,' which are loans collateralized by mortgage security and deeds.[6] The third category is 'loans and discounts secured by other collateral,' which are loans collateralized by anything except for real estate security, Liberty Bonds, and securities. The fourth and final category is 'loans, discounts, and bills purchased not secured by collateral, which are promissory notes. We aggregate these four categories for our analysis, defining the sum as total loans. We also create a measure of the quality of a bank's loan that is equal to the ratio of secured loans over total loans.

The liability side of the balance sheets was mainly composed of capital, deposits, and short-term borrowing, where capital and deposits comprise over 90 percent of total liabilities. We aggregate capital and equity into one measure called equity capital, which is equal to the sum of `capital' and `surplus, including all undivided profits.' We calculate total deposits as the sum of `preferred deposits' and `due depositors, not preferred,' and define short-term borrowing as the sum of 'rediscounts' and 'bills payable.' Rediscounts are loans sold with recourse and bills payable are promissory notes issued by the bank. During our sample period, nonmember banks primarily borrowed from correspondent banks located in nearly towns. These correspondent banks were national banks that were members of the Federal Reserve.[7] In contrast, member banks borrowed directly from Federal Reserve Banks.[8]

[6] A deed was taken as a mortgage, but not an absolute transfer of ownership. Moreover, well-managed banks avoided deeds.

[7] The Federal Reserve Act made it compulsory for national banks to become members of the Federal Reserve System, while it made it voluntary for state banks to become members.

[8] For more information, see Carlson and Wheelock (2018) and Anderson, Erol, and Ordonez (2020).

Although our data include deposits from other banks, we do not focus on this liability. This interbank liability constitutes less than 1 percent of total liabilities, reflecting our focus on small country banks outside of reserve cities.[9]

In Tables 3 through 6, we provide an empirical description of the balance-sheet of the banks in our sample. In Table 3, we show the summary statistics of all banks from 1914 Q1 to 1919 Q4.[10] We divide the sample into three sub-periods: pre-pandemic, pandemic, and post-pandemic. In New York, 1918 influenza was most widespread at the end of the 1918 and the beginning of 1919 (see Section 2.1). In our analysis, we use the quarterly growth rates of balance sheet variables, and as such we define the pandemic period as the first quarter of 1919 in order to capture the effect of the flu on the banking system. As a result, the pre-pandemic, pandemic, and post-pandemic periods are defined as 1914 Q1 – 1918 Q4, 1919 Q1, and 1919 Q2 – 1919 Q4, respectively.

We start by examining the portfolio of assets held by banks, where all variables are normalized by total assets, to make for a more meaningful comparison across banks of different sizes. We find that securities and total loans are the largest asset categories, accounting for one-third and one-half percent of total assets respectively (see Table 3). The most liquid assets held by banks are vault and interbank reserves. We label the sum of both types of reserves as liquid assets and find this measure accounts for about 14 percent of total assets, implying that banks were quite conservative in their asset-management.

For financial stability purposes it is important to track where these liquid assets are held, and so we track vault reserves and the subset of interbank reserves placed at other commercial banks (as opposed to the Federal Reserve). We find that vault reserves and interbank reserves held at commercial banks account for about 3 and 10 percent of total assets, respectively. Interbank deposits held at commercial banks, then, account for roughly two-thirds of banks' liquid assets.

Turning next to the capital structure of banks, we consider equity capital, deposits, and short-term borrowings as shares of total liabilities. Not surprisingly, deposits make up the lion's

[9] Deposits 'due to' banks are deposits that other banks hold with a correspondent bank and are thus liabilities of the correspondent bank. The banks in reserve cities, which we excluded from our sample, hold large due-to banks deposits given the tiered structure of the banking system at this time.

[10] We denote quarter n of each year as Qn.

share of liabilities, at 80 percent (see Table 3). Equity capital is a distant second at around 14 percent and short-term borrowings is about 2 to 3 percent of total liabilities. Short-term borrowing has relatively high standard deviation that is about two-fold of its mean implying that there were large variation in the amount of short-term borrowings across banks.

Short-term borrowing allows us to investigate the pass-through of central bank liquidity. As mentioned above, most state banks were not members of the Federal Reserve System and did not have direct access to the Fed's discount window. These nonmember banks indirectly accessed the liquidity provided by the Federal Reserve by borrowing from banks that were members of the Federal Reserve. In our sample period, nonmember banks largely accomplished this by borrowing from the larger banks in reserve cities with which the nonmember banks placed their interbank deposits.

Given our focus on how banks reacted to the pandemic, our empirical analysis focuses on the growth rates of balance sheet items. Average growth rates for the balance sheet variables are reported in Table 4, for the pre-pandemic, pandemic, and post-pandemic periods. These summary statistics show that, as expected, banks in the pandemic period reduced their holdings of vault reserves. Further, both interbank reserves held at commercial banks and loans had anemic growth. More surprising, banks dramatically reduced short-term borrowing during the pandemic, despite the availability of liquidity from the Federal Reserve via its discount window.

To better understand if banks that were members of the Federal Reserve reacted differently to the pandemic relative to banks that were not members, we recompute these growth rates conditional on Federal Reserve membership (see Table 5).[11]

The largest differences between member and nonmember banks are observed in the growth rates of short-term borrowing and loans. During the pandemic, nonmember banks decreased short-term borrowing and loans, whereas member banks increased these balance sheet items. In the subsequent quarters following the pandemic, both types of banks increased lending.

[11] Member and nonmember banks had different reserve and capital requirements because member banks complied regulations under the Federal Reserve Act, whereas nonmember banks followed regulations imposed by the State Banking Department. In appendix table A1, we provide summary statistics for balance sheet ratios. Table A1 shows that member banks held less vault cash and interbank deposits at other commercial banks since they did not count toward reserve requirements. In contrast, nonmember banks placed large interbank deposits at other commercial banks as the state banking department allowed them to these deposits to meet reserve requirements.

To these data on banks' balance sheets, we add information on the mortality rates due to influenza and pneumonia in New York. These mortality rates, which are the ratio of deaths due to influenza and pneumonia over total deaths, are our measure of the severity of the 1918 influenza outbreak.[12] These data come from the *Annual Report of State Department of Health of New York*, from which we collect information on population and deaths from influenza and pneumonia for each county from 1914 to 1920 on a yearly basis. We also collect monthly data on deaths from influenza and pneumonia for the entire state of New York on a monthly basis.

We use the second, aggregate series to interpolate the annual county-level data to a quarterly frequency. We accomplish by assuming the pattern of flu mortality in each county resembles that observed at the state level, a reasonable assertion since flu-related deaths exhibit seasonal patterns. Finally, we merge in the mortality statistics with a lag, so that deaths from influenza and pneumonia in a particular quarter are a beginning-of-period measure, whereas our balance sheet measures are an end-of-period measure.

In the next section, we describe our empirical approach and the results of the analysis.

## 4. Empirical Approach and Results

### 4.1. Empirical Approach

To assess how the impact of the 1918 influenza pandemic affected New York state-charter banks, we adopt a difference-in-differences estimation approach that combines bank-level responses with large cross-county differences in pandemic severity. The key identifying assumption for our analysis is that regional exposure to the 1918 outbreak represents an exogenous shock and bank behavior would have been similar across counties in the absence of the pandemic. With this approach, we compare the responses of banks in more versus less affected areas before and after the pandemic.

In Table 6, we provide the summary statistics based on the quantiles of influenza mortality rates in 1918. Due to the large changes in the state banking system after the admission of new state member banks to the Federal Reserve System in late 1917, we report summary

[12] Use of mortality rates to measure severity of the pandemic is common in the literature, as in Garrett (2007) and Barro, Ursua, and Weng (2020) to name a few.

statistics for the banking system from 1914 Q1 to 1917 Q4. While these banks were exposed to different levels of pandemic severity in 1918, these banks behaved similarly prior to the pandemic. We do not find any systematic difference across banks located in regions with different levels of exposure.

We begin by examining the funding stability of banks and so focus on deposits and short-term borrowing. During this period, there were two reasons why depositors may withdraw their funds from banks. First, depositors may have withdrawn their funds in order to smooth consumption since many working age adults were infected by the flu and could not work, or temporarily unemployed due to reduced economic activity during the pandemic. Second, depositors may have withdrawn funds due to the loss of confidence in the banking sector due to the uncertainty about the economic impact of the pandemic.

The Federal Reserve System was introduced in part to help banks resolve liquidity shortages by serving as a lender of last resort. Although only banks that were members of the Federal Reserve could access the discount window, nonmember banks accessed the discount window indirectly by borrowing from member banks (Carlson and Wheelock, 2018; Anderson, Erol, and Ordonez, 2020). In our analysis, we examine whether member and nonmember banks increased short-term borrowing when they faced deposit withdrawals.

Banks can also respond to deposit withdrawals by reducing liquid assets or loans instead of borrowing on short-term from other banks. Hence, we examine how banks managed their asset portfolios. In addition, we examine whether banks reduced cash holdings or interbank deposits because a large reduction in interbank deposits could threaten financial stability through spillover effects.

The difference-in-differences estimation is implemented on both annual (Q4 of each year) and quarterly data. Conducting the analysis at the two data frequencies has a couple of benefits. First, the reports from the health department provide information about the county-level influenza and pneumonia mortality rate on a yearly basis; hence, this is the period we can use to match the frequency of the data. Second, quarterly balance sheets allow us to estimate the near-term effects of the pandemic, while annual balance sheets allow us to estimate longer lived effects and investigate whether there was a more secular change in bank behavior as a result of the pandemic.

In addition, we use different time periods to investigate how having direct access to central bank liquidity affected bank behavior during the pandemic. While we use the period from 1914 to 1919 to understand the impact of the pandemic on the banking system, we use the period from 1918 to 1919 to examine whether the pandemic had different effect on member versus nonmember banks. This is because the banking environment changed dramatically after the Federal Reserve Act was amended in 1917.[13] While the Federal Reserve System began its operation in 1914, many state banks did not join the Fed until after the amendment was made in 1917.

Our statistical analysis uses a classic fixed effects linear regression relating an indicator for the pandemic, cross-county mortality disparity, and the interaction of the three variables to various aspects of bank behavior (conditional on a set of bank-level controls). In this case, the model takes the following forms:

$$\Delta y_{i,t} = \alpha_i + \beta_1 P_t + \beta_2 x_{i,t} + \beta_3 P_t \cdot x_{i,t} + Z'_{i,t-1}\gamma + \varepsilon_{i,t}, \quad (1)$$

$$\Delta y_{i,t} = \alpha_i + \beta_1 P_t + \beta_2 M_{i,t} + \beta_3 x_{i,t} + \beta_4 P_t \cdot x_{i,t} + \beta_5 M_{i,t} \cdot x_{i,t} + \beta_6 P_t \cdot M_{i,t} + \beta_7 P_t \cdot M_{i,t} \cdot x_{i,t} + Z'_{i,t-1}\gamma + \varepsilon_{i,t}, \quad (2)$$

where $i$ and $t$ represent bank and time (whether years or quarters) respectively, $y$ is the dependent variable of interest, $\Delta y_{i,t} = \ln(y_{i,t}) - \ln(y_{i,t-1})$ is the growth rate of the dependent variable, $P$ is an indicator taking the value 1 in 1918 for the annual data, and 1919Q1 for the quarterly data. The variable *x* is the mortality rate at the beginning of the quarter in the county in which the bank is located, and $Z$ is a vector of bank-level controls. These controls are liquid assets over total assets, equity capital over total liabilities, a measure of loan quality (amount secured over total loans) and log of total assets. The variable $\varepsilon$ is a mean-zero, possibly heteroskedastic and autocorrelated within-bank error term and $\alpha_i$ is a bank-level fixed effect.

From the equation (1), the key coefficient of interest is $\beta_3$, which captures the change in the effect of flu death rates during the pandemic. The pandemic dummy represents the fundamentally different relationship during the pandemic period both in terms of average and

[13] For more information, see Anderson, Calomiris, Jaremski, and Richardson (2018).

sensitivity. In the similar manner, from the equation (2), where $M_{i,t}$ is a member bank dummy, the key coefficients of interest are $\beta_4$, $\beta_6$, and $\beta_7$. The coefficient $\beta_4$ captures the change in the effect of flu death rates during the pandemic. The coefficient $\beta_6$ captures whether member banks behaved differently on average, and $\beta_7$ captures whether pandemic severity had differential effect on nonmember versus member banks.

We capture long-term effects of the pandemic by extending our statistical analysis with distributed lags. In this case, the model takes the form:

$$\Delta y_{i,t} = \alpha_i + \sum_{k=0}^{K} \left[\beta_{1,k} P_{i,t-k} + \beta_{2,k} x_{i,t-k} + \beta_{3,k} P_{i,t-k} \cdot x_{i,t-k}\right] + Z'_{i,t-1}\gamma + \delta t + \varepsilon_{i,t}, \quad (3)$$

where $k$ is the index for the distributed lag terms (going from 0 to $K$ periods in the past). In the quarterly analysis, we take $K = 3$ as the yearly analysis covers the full year effect from the fourth quarter of each year. $\beta_{1,k}$ captures the average effect of the pandemic after $k$ periods later, $\beta_{2,k}$ captures the effect of flu death rates after $k$ periods later, and $\beta_{3,k}$ captures the change in the effect of the flu death rates during the pandemic after $k$ periods later.

We further investigate whether the pandemic had differential effect on member versus nonmember banks using the following specification:

$$\begin{aligned}\Delta y_{i,t} = \alpha_i + \sum_{k=0}^{K} \big[&\beta_{1,k} P_{i,t-k} + \beta_{2,k} M_{i,t-k} + \beta_{3,k} x_{\mathrm{i},t-k} + \beta_{4,k} P_{i,t-k} \cdot x_{\mathrm{i},t-k} + \beta_{5,k} M_{i,t-k} \\ &\cdot x_{\mathrm{i},t-k} + \beta_{6,k} P_{i,t-k} \cdot M_{i,t-k} + \beta_{7,k} P_{i,t-k} \cdot M_{i,t-k} \cdot x_{\mathrm{i},t-k}\big] + Z'_{i,t-1}\gamma \\ &+ \varepsilon_{i,t},\end{aligned} \quad (4)$$

Where the corresponding terms are analogous to (2).

### 4.2. Results

The results of the analysis at the quarterly frequency are shown in Tables 7 through 10. Tables 7 and 8 shows the results from specifications (1) and (2). Tables 9 and 10 show results from specification (3) and (4). All regressions are estimated by ordinary least squares. We cluster standard errors at the county level.

We begin by examining how the pandemic affected New York state-charter banks by looking at the capital structure and asset portfolio of these banks from 1914 to 1919. For the

capital structure, we focus on (1) deposits and (2) short-term borrowings. For the asset portfolio we focus on (3) loans, (4) securities and (5) liquid assets. Given our interest in the components of liquid assets, we also examine (6) vault reserves and (7) interbank reserves held at commercial banks. For all of our analysis, we consider the log difference of the dependent variables. We use the specification described in equation 1 and collect the results in Table 7.

The estimated coefficients imply that during the pandemic period the shift in quarterly growth rate in deposits and securities was 12.2 and 31.4 percent, respectively.[14] Conversely, banks in more severely affected areas experienced large deposit outflows, as evidenced by the estimated coefficient on -45.25 for the *Pandemic x Flu death rate* variable. Further, these banks responded to these deposit withdrawals by reducing securities. At the same time, we do not find evidence that banks increased short-term borrowing to mitigate liquidity shocks or reduced bank lending.

We now examine whether the pandemic had differential effects on member versus nonmember banks. We use the same set of dependent variables as those described above, but consider a shorter time period (1918:Q1 to 1919:Q4) given that few state banks were members of the Federal Reserve before 1918. We use the specification described in equation 2 and collect the results in Table 8.

Our main variables of interest are *Pandemic, Pandemic x Flu death rate, Member x Pandemic,* and *Member x Pandemic x Flu death rate*. The variable *Pandemic* captures the average responses of state nonmember banks during the pandemic period and the variable *Pandemic x Flu death rate* captures the changes in the responses of state banks due to the regional variations in pandemic severity. The variable *Member x Pandemic* captures the average responses of member banks during the pandemic and, lastly, the variable *Member x Pandemic x Flu death rate* captures the changes in the responses of member banks due to the regional variations in pandemic severity.

Once again, we begin with the liability side of the balance sheet. Consistent with the results above, we find that during the pandemic, member and nonmember banks in the more affected areas experienced larger deposit outflows (see the estimated coefficients on *Pandemic x*

[14] The interpretation of economic significance of coefficients for dummy variable on log dependent variable is based on Kennedy (1981).

*Flu death rate* and *Member x Pandemic x Flu death rate*, respectively, in column (1) of Table 8). Turning to short-term borrowing, we find the large positive coefficient on *Member x Pandemic x Flu death rate* implies that member banks during the pandemic period increased their short-term borrowing. In contrast, nonmember banks in counties with high flu mortality rates could not increase borrowing to meet deposit outflows. These results suggest that banks with indirect access to the discount window could not be able to obtain liquidity, even from member banks with discount window access.

We now examine the asset side of the balance sheet. We find that nonmember banks reduced lending during this period by 7.35 percent on average (see the estimated coefficient on *Pandemic* in column (3)) whereas member banks were able to increase lending (see *Member x Pandemic*) about 54.3 percent more than the usual amount, likely due to their ability to borrow directly from the discount window. The estimated coefficient on *Pandemic x Flu death rate* is not significant for loans, indicating that nonmember state banks in counties with higher mortality rates reduced their lending in-line with those in counties with lower mortality rates. In contrast, member state banks in more affected counties had significantly lower growth rates of lending compared to their peers in less-affected counties.

Moving from loans to securities, our results show the growth rate of securities held by state banks increased over the pandemic period (in line with results in Table 7), with no significant differences in growth rates across member and nonmember banks or across banks in counties with differing mortality rates.

Finally, we consider the growth rate of liquid assets (column (5)) and its components (columns (6) and (7)). Although we do not find any statistically significant evidence for changes in growth rates of liquid assets for nonmember banks, we do find results for member banks. In particular, the estimated coefficient of 139.6 on *Member x Flu death rate* implies that member banks in counties with high mortality rates have higher growth rates of liquid assets during normal times. This increase in liquid assets is broad-based, in that it is driven by increases in both vault and interbank reserves placed at commercial banks (see estimated coefficients on *Member x Flu death rate* in columns (6) and (7)).

Strikingly, this result on liquid assets and its components reverses during the pandemic period. As demonstrated by the negative estimated coefficients on *Member x Pandemic x Flu death rate* in columns (5), (6), and (7), state member banks in more affected counties during the

pandemic experienced lower growth rates of liquid assets relative to those in less affected counties. Combining the two coefficients on *Member x Flu death rate* and *Member x Pandemic x Flu death rate*, the results indicate that member banks in more affected counties during the pandemic reduced lending and liquid assets in order to meet deposit withdrawals relative to those in less-affected counties.

Table 9 shows how these responses evolved in subsequent quarters, focusing on the effects of the pandemic on all banks and how the pandemic's effect on banks varied with the differences in county mortality rates. The difference between short-term effect (1 quarter coefficients) and the long-term cumulative effect shows the trajectory of subsequent effects over time. Considering the cumulative effect over four quarters (sum of pandemic coefficients), it is clear the banking sector was not largely affected by the pandemic, thanks to higher deposits, loans, and liquid assets growth over subsequent quarters. Even though we consider regional variation in mortality severity (sum of *Pandemic x Flu death rate*), there is little evidence that the pandemic had a long-term effect on the banking sector. Short-term borrowing and securities growth show differences significant at the 5 percent confidence level, with banks in more affected regions having lower short-term borrowing and securities growth than other banks. Nonetheless, bank deposits and credit growth remain stable.

In Table 10, we examine whether differential responses of member versus nonmember banks evolved in subsequent quarters. While being a member of the Federal Reserve System helped banks to increase borrowing on short-term and increase lending during the pandemic, the difference in their behavior disappears in subsequent quarters after the panic. In addition, the difference between banks in more affected versus less affected areas disappears quickly after the pandemic as well.

Shifting to the annual frequency analysis, Tables 11 and 12 look at the impact of the pandemic as estimated under specification (1). In Table 11, the coefficients on the interaction term *Pandemic x Flu death rate* are insignificant for all regressions. In other words, there is little statistically significant evidence of year-to-year financial disruption caused by the pandemic. In Table 12, we consider whether Fed-member banks responded differently to the pandemic. Contrary to the results shown in the quarterly analysis, we find that short-term borrowing from the Fed by member banks rather decreased on average, although member banks in more severely affected areas increased borrowing than member banks in less affected areas. However, we do

find member banks increased lending, and member banks in more severely affected areas reduced lending than member banks in less affected areas consistent with the quarter frequency analysis. These results suggest that our analysis with quarter frequency enables us to capture the actual dynamics of short-term financial disruption much more accurately than the annual frequency analysis. The variation in short-term borrowing over time and across different banks in different areas provides us the importance of the central bank liquidity support, which is obscured by aggregation under yearly observation.

Overall then, the results from the analyses show that the influenza pandemic created short-term disruptions in the banking sector, but it did not have a long-term effect. The pandemic induced deposit outflows from the banking system, but banks met these withdrawals by increasing short-term borrowing from the Federal Reserve's discount window and liquidation of assets. Bank deposits returned quickly after the pandemic and banks were able to return to their normal operations. The banks' ability to maintain credit during the pandemic could have contributed to robust economic growth afterwards.

To sum, our study shows the importance of the central bank liquidity provision during the time of distress. During the pandemic, state banks faced funding shocks due to deposit withdrawals. While member banks were able to increase short-term borrowing and engage in lending activity, nonmember banks reduced short-term borrowing and curtailed lending. However, in the most affected counties, member banks were not able to fully offset the large deposit outflows with short-term borrowings. As a result, these banks responded by reducing loans as well as other cash assets. Yet, these were short-term responses. Over the longer term, banks experienced deposit inflows and increased lending. The banking system recovered within by the end of 1919.

## 5. Conclusion

The global spread of COVID-19 has triggered large disruptions in the financial markets. In order to stabilize these markets, the Federal Reserve has lowered the target rate range for federal funds to be between 0 and 0.25 percent, and implemented various emergency lending programs to provide liquidity to a range of financial intermediaries. These aggressive actions raise questions regarding the effectiveness of central bank liquidity provision on the financial system during pandemics.

To answer this question, we study the effect of the central bank liquidity provision during the 1918 influenza epidemic. We do so by comparing the behavior of member banks to nonmember banks in New York. We find that the banking system experienced deposit withdrawals during pandemic. While member banks were able to meet these deposit withdrawals by accessing the discount window and increase lending, nonmember banks had to reduce borrowing and decrease lending. However, member banks in the most affected areas could not borrow enough to fully offset their deposit outflows and so reduced their lending and liquidated certain assets. Given that member banks responded to deposit outflows aggressively by selling off their securities and reduction of cash, we interpret the result that member banks could not borrow enough to offset deposit outflows as due to a shortage of collateral that they could pledge to the discount window.

Our study has important implications for policy today. First, our study shows that the central bank liquidity support plays an important role in stabilizing the banking sector. In particular, it is important for the Federal Reserve to provide liquidity to financial intermediaries that lack access to central bank liquidity in times of distress as the Fed has been doing through various lending facility programs during the current COVID-19 pandemic. Our study provides evidence that the banks without access to central bank liquidity may not be able to raise funding through the wholesale funding market in times of distress, and so face liquidity problems. Secondly, our study shows that central banks should operate liquidity support programs flexibly since the same economic shock can create different levels of liquidity shocks to financial intermediaries. Our study shows that even member banks that were in the most severely affected areas could not borrow enough from the central bank and curtailed lending. Hence, our study suggests that lending facilities targeting more severely affected localities, industries, or markets might be important in providing appropriate liquidity to those sectors.

Table 1: Annual Mortality Rates from Influenza and Pneumonia per 1000 people, 1914-1920.

| Year | Mean | SD |
|---|---|---|
| 1914 | 1.340 | 0.378 |
| 1915 | 1.534 | 0.354 |
| 1916 | 1.643 | 0.500 |
| 1917 | 1.773 | 0.471 |
| 1918 | 5.463 | 1.645 |
| 1919 | 1.928 | 0.467 |
| 1920 | 1.869 | 0.429 |

Source: *Annual Report of State Department of Health of New York* and authors' calculations.

Table 2: Assets and Liabilities Reported, New York State Banks, 1915-1920.

| Assets | | Liabilities | |
|---|---|---|---|
| Securities | Stocks and bonds, viz.:<br>Public securities, market value | Equity capital | Capital<br>Surplus, including all undivided profits (market value) |
| | Private securities, market value | Deposits | Preferred deposits<br>Due depositors, not preferred |
| Total loans | Mortgages owned | Short-term | Bills payable |
| | Loans and discounts secured by bond and mortgage, deed or other real estate collateral | borrowings | Rediscounts |
| | Loans and discounts secured by other collateral | Other liabilities | Due to trust companies, banks, and bankers |
| | Loans, discounts, and bills purchased not secured by collateral | | Acceptances of drafts payable at a future date or authorized by commercial letters of credit |
| Interbank reserves | Due from the Federal reserve bank of New York less offsets | | Other liabilities |
| | Due from trust companies, banks, and bankers | | Add for cents |
| Vault reserves | Specie | | |
| | Legal tender notes and notes of national banks | | |
| | Federal reserve notes | | |
| | Cash Items | | |
| Other assets | Customers' liability on acceptances (per contra, see liabilities) | | |
| | Other assets | | |
| | Real estate owned | | |
| | Add for cents | | |
| | Overdrafts | | |

Source: *New York State Banking Department (1915-1920).*

Table 3: Mean and Standard Deviation of Balance Sheet Ratios in Percent, by Period.

| | Pre-Pandemic | Pandemic | Post-Pandemic |
|---|---|---|---|
| Liquid assets to assets | 15.17 | 13.35 | 13.62 |
| | (6.470) | (6.474) | (6.398) |
| Vault reserves to assets | 3.997 | 3.074 | 3.205 |
| | (1.530) | (1.330) | (1.333) |
| NonFed-interbank reserves to assets | 11.06 | 9.375 | 9.359 |
| | (6.159) | (6.030) | (5.997) |
| Securities to assets | 25.87 | 36.56 | 33.59 |
| | (15.69) | (14.21) | (13.57) |
| Loans to assets | 55.43 | 45.95 | 49.28 |
| | (15.49) | (13.22) | (13.79) |
| Capital equity to liabilities | 16.90 | 13.97 | 13.08 |
| | (7.340) | (6.954) | (5.082) |
| Deposits to liabilities | 79.95 | 81.02 | 81.72 |
| | (8.411) | (9.011) | (11.26) |
| Short-term borrowing to liabilities | 1.661 | 3.267 | 2.719 |
| | (3.983) | (5.625) | (5.461) |

Notes: Cell entries are means, with standard deviations in parenthesis. Liquid assets are vault reserves and interbank deposits (due from the Federal Reserve Bank of New York and due from other banks). The Pre-Pandemic period is from the first quarter of 1914 to the fourth quarter of 1918. The Pandemic period is the first quarter of 1919. The Post-Pandemic period is the second quarter through fourth quarter of 1919. Source: *Annual Report of the Superintendent of Banks* and Authors' calculations.

Table 4: Mean and Standard Deviation of Balance Sheet Growth Rates, 1914-1919.

| | Pre-Pandemic | Pandemic | Post-Pandemic |
|---|---|---|---|
| Asset growth | 3.233 | 1.526 | 4.631 |
| | (8.135) | (11.86) | (8.761) |
| Liquid assets growth | 1.740 | -5.583 | 6.335 |
| | (39.61) | (44.00) | (37.90) |
| Vault reserves growth | 0.427 | -4.412 | 6.404 |
| | (26.74) | (29.98) | (28.95) |
| NonFed-interbank reserves growth | 1.333 | -6.376 | 4.791 |
| | (58.97) | (66.78) | (57.02) |
| Interbank reserve growth | 2.083 | -2.411 | 6.159 |
| | (58.18) | (63.51) | (51.45) |
| Securities growth | 6.424 | 16.71 | 0.926 |
| | (23.86) | (32.73) | (20.80) |
| Loan growth | 2.310 | -2.092 | 7.366 |
| | (12.17) | (14.41) | (11.30) |
| Deposits growth | 3.436 | 3.471 | 5.594 |
| | (10.83) | (12.38) | (10.76) |
| Short-term borrowing growth | 49.87 | -104.2 | -78.52 |
| | (1435.3) | (1413.2) | (1370.0) |

Notes: Cell entries are means, with standard deviations in parenthesis. Liquid assets are vault reserves and interbank deposits (due from the Federal Reserve Bank of New York and due from other banks). The Pre-Pandemic period is from the first quarter of 1914 to the fourth quarter of 1918. The Pandemic period is the first quarter of 1919. The Post-Pandemic period is the second quarter through fourth quarter of 1919. Source: *Annual Report of the Superintendent of Banks* and authors' calculations.

Table 5: Mean and Standard Deviation of Balance Sheet Growth Rates, by Federal Reserve Membership Status, 1918-1919.

| | Member Banks | | | Nonmember Banks | | |
|---|---|---|---|---|---|---|
| | Pre-Pandemic | Pandemic | Post-Pandemic | Pre-Pandemic | Pandemic | Post-Pandemic |
| Asset Growth | 3.318 | 2.851 | 4.393 | 2.829 | 1.147 | 4.700 |
| | (8.659) | (16.41) | (8.606) | (9.390) | (10.24) | (8.814) |
| Liquid Asset Growth | -3.407 | -2.986 | 8.634 | -2.403 | -6.327 | 5.660 |
| | (34.95) | (43.86) | (37.59) | (45.77) | (44.15) | (38.00) |
| Vault reserves growth | -5.610 | -5.795 | 8.454 | -0.480 | -4.015 | 5.802 |
| | (30.17) | (30.12) | (31.21) | (29.57) | (30.03) | (28.26) |
| NonFed-interbank reserves growth | -17.58 | -12.14 | 3.359 | -2.726 | -4.723 | 5.211 |
| | (63.12) | (82.13) | (69.09) | (67.20) | (61.90) | (53.03) |
| Interbank reserve growth | -3.525 | 3.070 | 8.898 | -2.714 | -3.982 | 5.355 |
| | (49.63) | (69.50) | (49.51) | (67.20) | (61.84) | (52.02) |
| Securities growth | 8.121 | 10.24 | -2.364 | 9.992 | 18.56 | 1.892 |
| | (21.59) | (26.20) | (16.29) | (27.96) | (34.22) | (21.87) |
| Loan growth | 2.255 | 0.708 | 8.370 | 0.240 | -2.894 | 7.071 |
| | (12.29) | (20.14) | (9.916) | (10.89) | (12.25) | (11.67) |
| Deposits growth | 1.577 | 3.366 | 6.103 | 2.436 | 3.501 | 5.445 |
| | (10.10) | (15.03) | (10.44) | (12.14) | (11.57) | (10.85) |
| Short-term borrowing growth | 170.0 | 77.88 | -75.81 | 108.1 | -156.4 | -79.31 |
| | (1311.8) | (1506.6) | (1303.7) | (1578.5) | (1385.9) | (1390.2) |

Notes: Cell entries are means, with standard deviations in parenthesis. Liquid assets are vault reserves and interbank deposits (due from the Federal Reserve Bank of New York and due from other banks). The Pre-Pandemic period is from the first quarter of 1918 to the fourth quarter of 1918. The Pandemic period is the first quarter of 1919. The Post-Pandemic period is the second quarter through fourth quarter of 1919.
Source: *Annual Report of the Superintendent of Banks* and authors' calculations.

Table 6: Mean and Standard Deviation of Balance Sheet Growth Rates for 1914-1917, by Influenza Mortality Severity Quintile in 1918.

| | (0 - 20) | (21 - 40) | (41 - 60) | (61 - 80) | (81 - 100) |
|---|---|---|---|---|---|
| Asset Growth | 3.023 | 3.167 | 3.743 | 3.756 | 3.054 |
| | (7.209) | (7.776) | (8.366) | (8.581) | (7.103) |
| Liquid Asset Growth | 3.471 | 3.714 | 3.196 | 3.435 | 1.149 |
| | (35.08) | (40.42) | (37.96) | (39.10) | (39.39) |
| Cash growth | 0.544 | 1.129 | 1.001 | 2.055 | 0.527 |
| | (26.17) | (26.01) | (25.98) | (25.44) | (25.18) |
| NonFed-interbank reserves growth | 4.588 | 4.525 | 2.803 | 4.155 | 0.947 |
| | (51.42) | (55.02) | (53.59) | (64.94) | (57.13) |
| Interbank Reserve growth | 4.629 | 4.531 | 2.836 | 4.160 | 1.119 |
| | (51.40) | (55.02) | (53.61) | (64.93) | (57.18) |
| Securities growth | 4.017 | 4.997 | 5.709 | 6.169 | 7.061 |
| | (19.77) | (23.28) | (21.67) | (23.46) | (26.29) |
| Loan growth | 2.554 | 2.845 | 3.141 | 3.330 | 2.161 |
| | (9.631) | (19.26) | (10.14) | (11.73) | (7.807) |
| Deposit growth | 3.463 | 3.607 | 4.219 | 4.308 | 3.478 |
| | (10.45) | (10.12) | (10.69) | (11.89) | (9.392) |
| Short-term borrowing growth | 26.45 | 1.794 | 29.14 | 20.11 | 68.48 |
| | (1510.6) | (1335.1) | (1386.9) | (1513.2) | (1255.3) |

Note: Columns are groups of banks, categorized by the severity of influenza mortality rates in 1918. The first column includes banks located in counties that fall into the lowest quintile of 1918 mortality rates. The second column are those banks located in counties that fall into the second lowest quintile mortality rates, and so. Cell entries are means, with standard deviations in parenthesis, over the 1914 to 1917 period.
Source: *Annual Report of the Superintendent of Banks* and authors' calculations.

Table 7: The Effect of the 1918 Pandemic on State-Charter NY Banks, quarterly, 1914:Q1 to 1919:Q4.

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| | Deposits | Short-term borrowing | Loans | Securities | Liquid Assets | Vault Reserves | NonFed Interbank Reserves |
| Pandemic | 0.117** | -1.931 | 0.00401 | 0.276*** | 0.0854 | -0.00563 | 0.0710 |
| | (0.0551) | (3.549) | (0.0551) | (0.0746) | (0.134) | (0.0778) | (0.161) |
| Flu death rate | 22.90 | -4423.8** | 0.180 | 68.29* | 16.38 | 20.83 | 15.99 |
| | (17.68) | (2158.8) | (15.46) | (35.93) | (54.40) | (37.34) | (90.29) |
| Pandemic x Flu death rate | -45.25** | 4107.1* | -18.62 | -90.95** | -43.59 | -36.25 | -36.64 |
| | (20.87) | (2346.5) | (21.32) | (38.37) | (62.89) | (43.84) | (96.67) |
| Constant | 3.399*** | -26.09 | 2.027*** | 3.201*** | 7.952*** | 2.575*** | 10.89*** |
| | (0.400) | (24.82) | (0.320) | (0.701) | (1.234) | (0.501) | (1.587) |
| Observations | 4185 | 4185 | 4185 | 4185 | 4185 | 4185 | 4185 |
| Bank Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Time FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Bank FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Table 8: The Effect of the 1918 Pandemic on State-Charter Member versus Nonmember Banks, quarterly, 1918:Q1 to 1919:Q4.

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| | Deposits | Short-term borrowing | Loans | Securities | Liquid Assets | Vault Reserves | Non-Fed Interbank Reserves |
| Pandemic | 0.0665* | -0.643 | -0.076*** | 0.170** | -0.0329 | 0.0146 | -0.116 |
| | (0.0375) | (3.509) | (0.0274) | (0.0682) | (0.111) | (0.0884) | (0.160) |
| Member x Pandemic | 0.164 | -17.92* | 0.448** | 0.0884 | 0.201 | 0.217 | 0.0521 |
| | (0.119) | (9.777) | (0.169) | (0.219) | (0.238) | (0.152) | (0.449) |
| Flu death rate | 22.88 | -4349.2* | -15.22 | 57.30 | 58.24 | 42.65 | 21.88 |
| | (18.37) | (2418.8) | (21.25) | (43.47) | (71.45) | (48.00) | (113.4) |
| Member x Flu death rate | 44.21* | -6244.9* | -11.57 | 35.39 | 139.6** | 118.2** | 214.9* |
| | (24.51) | (3400.5) | (22.69) | (25.35) | (59.38) | (52.84) | (121.3) |
| Pandemic x Flu death rate | -33.72* | 3184.2 | 13.01 | -65.54 | -61.62 | -46.05 | -24.92 |
| | (17.95) | (2307.3) | (21.46) | (43.40) | (72.08) | (51.45) | (114.8) |
| Member x Pandemic x Flu death rate | -79.19** | 10456*** | -92.35** | -60.21 | -181.1* | -158.7*** | -221.3* |
| | (38.08) | (3814.6) | (44.65) | (60.45) | (90.23) | (47.89) | (131.1) |
| Constant | 3.227*** | 30.36 | 2.084*** | 4.159** | 8.059*** | 0.599 | 10.74*** |
| | (0.817) | (50.13) | (0.591) | (1.607) | (2.137) | (1.287) | (3.079) |
| Observations | 1611 | 1611 | 1611 | 1611 | 1611 | 1611 | 1611 |
| Bank Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Time FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Bank FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Table 9: The Long-Term Effect of the 1918 Pandemic on State-Charter NY Banks, quarterly, 1914:Q1 to 1919:Q4.

| | (1) Deposits | (2) Short-term borrowing | (3) Loans | (4) Securities | (5) Liquid Assets | (6) Vault Reserves | (7) Non-Fed Interbank Reserves |
|---|---|---|---|---|---|---|---|
| Cumulative Effect of Pandemic | -0.239 | 2.503 | -0.00989 | -0.72 | 0.0145 | 0.0264 | 0.29 |
| P-Value of Cumulative Effect of Pandemic | 0.0502 | 0.209 | 0.239 | 0.000712 | 0.243 | 0.231 | 0.149 |
| Cumulative Effect of Pandemic x Flu death rate | -26.27 | -8848.6 | -35.43 | -284.8 | 37.21 | 78.56 | 137.1 |
| P-Value of Cumulative Effect of Pandemic x Flu death rate | 0.15 | 0.0172 | 0.136 | 0.000223 | 0.2 | 0.0982 | 0.127 |
| Observations | 3443 | 3443 | 3443 | 3443 | 3443 | 3443 | 3443 |
| R-squared | 0.204 | 0.0187 | 0.11 | 0.101 | 0.356 | 0.0352 | 0.284 |
| Bank Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Time FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Bank FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Table 10: The Long-Term Effect of the 1918 Pandemic on State-Charter Member versus Nonmember Banks, quarterly, 1918:Q1 to 1919:Q4.

| | (1) Deposits | (2) Borrowing | (3) Loans | (4) Securities | (5) Liquid Asset | (6) Vault Reserves | (7) Non-Fed Interbank Reserves |
|---|---|---|---|---|---|---|---|
| Cumulative Effect of Pandemic | 0.247 | -12.51 | -0.114 | 0.490 | 1.247 | 0.172 | 1.503 |
| P-Value of Cumulative Effect of Pandemic | 0.0390 | 0.159 | 0.0896 | 0.0130 | 0.00359 | 0.165 | 0.0152 |
| Cumulative Effect of Pandemic x Flu death rate | 32.69 | -17078.2 | 7.719 | -231.7 | -98.36 | -0.463 | 214.4 |
| P-Value of Cumulative Effect of Pandemic x Flu death rate | 0.188 | 0.0160 | 0.237 | 0.0492 | 0.185 | 0.250 | 0.159 |
| Cumulative Effect of Flu death rate x Member | -56.29 | -11254.8 | 208.7 | 43.41 | -981.9 | -214.1 | -2234.3 |
| P-Value of Cumulative Effect of Flu death rate x Member | 0.183 | 0.157 | 0.0412 | 0.225 | 0.0158 | 0.117 | 0.00203 |
| Cumulative Effect of Pandemic x Member banks | 0.341 | -23.25 | 0.572 | 0.189 | 0.921 | 0.604 | 1.622 |
| P-Value of Cumulative Effect of Pandemic x Member banks | 0.0774 | 0.0155 | 0.0372 | 0.194 | 0.0527 | 0.0453 | 0.00676 |
| Cumulative Effect of Pandemic x Member banks x Flu death rate | -29.13 | 18162.2 | -337.2 | -117.0 | 762.7 | 176.8 | 1966.0 |
| P-Value of Cumulative Effect of Pandemic x Member banks x Flu death rate | 0.210 | 0.102 | 0.00604 | 0.177 | 0.0320 | 0.133 | 0.00453 |
| Observations | 1501 | 1501 | 1501 | 1501 | 1501 | 1501 | 1501 |
| Bank Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Time FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Bank FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

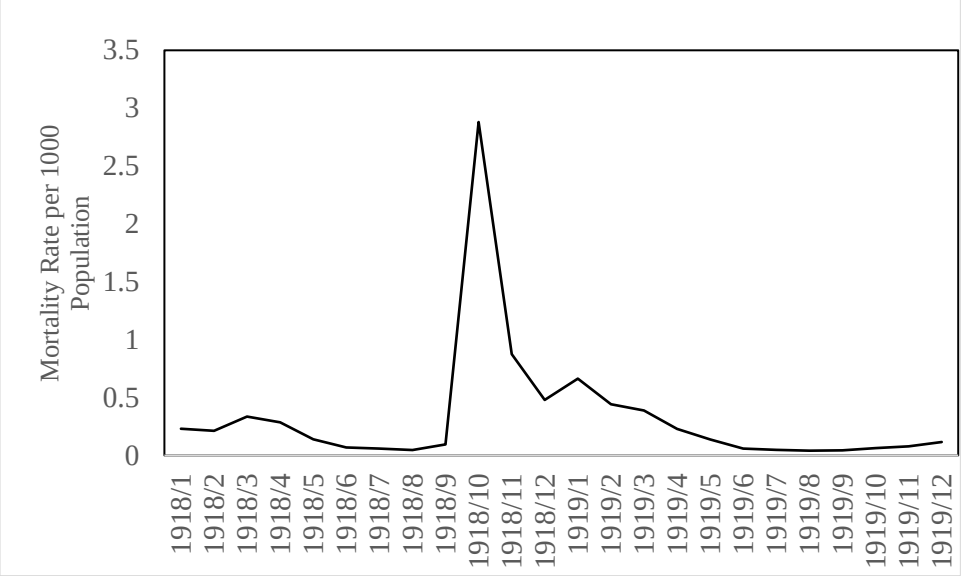
Table 11: The Effect of the 1918 Pandemic on State Banks in New York, yearly, end-1914 to end-1919.

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| | Deposits | Borrowing | Loans | Securities | Liquid Assets | Vault Reserves | Non-Fed Interbank Reserves |
| Flu death rate | -0.000940 | 1.313 | 0.0306 | -0.0574 | 0.000382 | 0.0601 | -0.0453 |
| | (0.0264) | (4.802) | (0.0380) | (0.0697) | (0.0850) | (0.0857) | (0.140) |
| Pandemic x Flu death rate | -0.0167 | -3.320 | -0.0440 | 0.0166 | -0.0233 | -0.0882 | 0.0271 |
| | (0.0227) | (4.773) | (0.0406) | (0.0628) | (0.0760) | (0.0753) | (0.125) |
| Constant | 7.455*** | 39.93 | 4.127** | 15.41*** | 7.133** | 5.943* | 10.000** |
| | (0.986) | (98.76) | (1.208) | (2.640) | (2.250) | (2.478) | (3.556) |
| Observations | 749 | 749 | 749 | 749 | 749 | 749 | 749 |
| Bank Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Time Dummies | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Bank FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Table 12: The Effect of the 1918 Pandemic on State Fed-Member Banks versus Non-member Banks, yearly, end-1918 to end-1919.

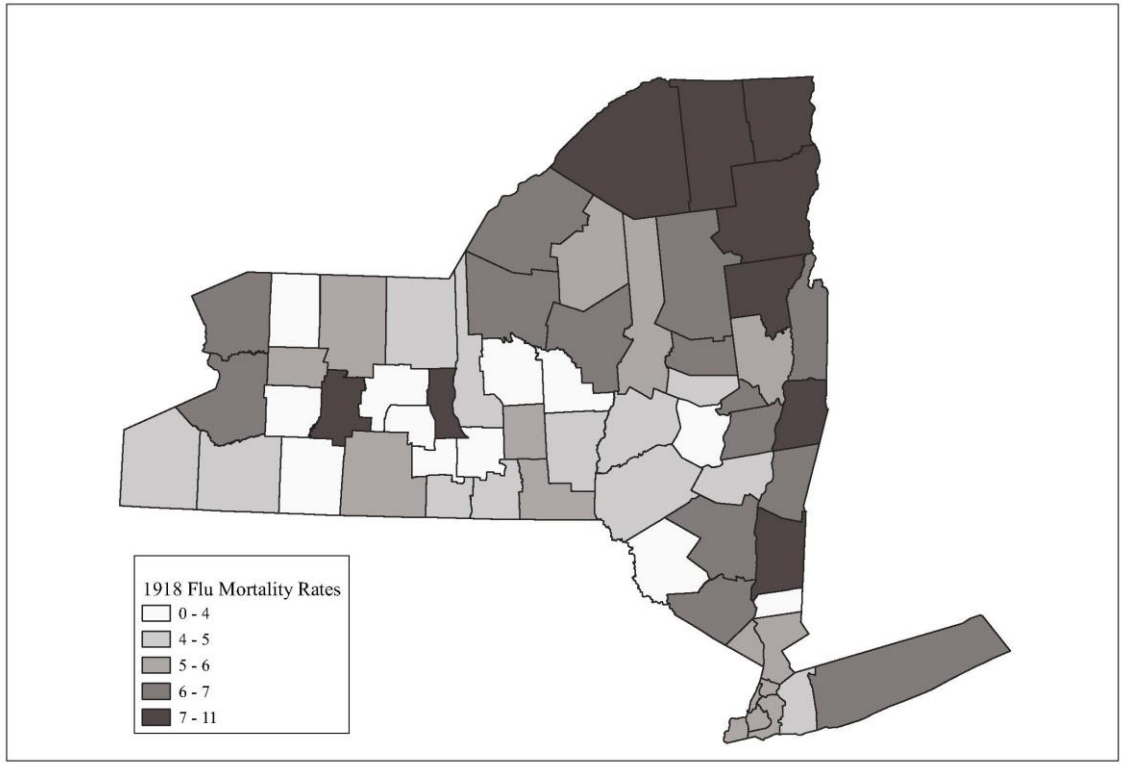
| | (1) Deposits | (2) Borrowing | (3) Loans | (4) Securities | (5) Liquid Assets | (6) Vault Reserves | (7) Non-Fed Interbank Reserves |
|---|---|---|---|---|---|---|---|
| Member | 0.129 | -21.86** | 0.484** | -0.146 | 0.116 | 0.359 | -0.486 |
| | (0.148) | (11.04) | (0.235) | (0.298) | (0.311) | (0.236) | (0.583) |
| Flu death rate | -0.0111* | -1.606** | 0.00900 | -0.0401* | -0.0346* | -0.0180 | -0.0444 |
| | (0.00603) | (0.779) | (0.00887) | (0.0211) | (0.0206) | (0.0168) | (0.0291) |
| Member x Flu death rate | -0.0221 | 4.866** | -0.0789* | 0.00764 | -0.0177 | -0.0646 | 0.0489 |
| | (0.0270) | (1.951) | (0.0441) | (0.0515) | (0.0523) | (0.0446) | (0.0929) |
| Constant | 0.239 | 28.19 | -0.178 | 1.109* | 0.924 | -0.906* | 1.609 |
| | (0.226) | (22.92) | (0.309) | (0.590) | (0.593) | (0.531) | (1.035) |
| Observations | 199 | 199 | 199 | 199 | 199 | 199 | 199 |
| Bank Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Figure 1: Monthly Influenza and Pneumonia Death Rates per 1,000 Population in New York, 1918-1919.




Source: *Annual Report of State Department of Health of New York.*

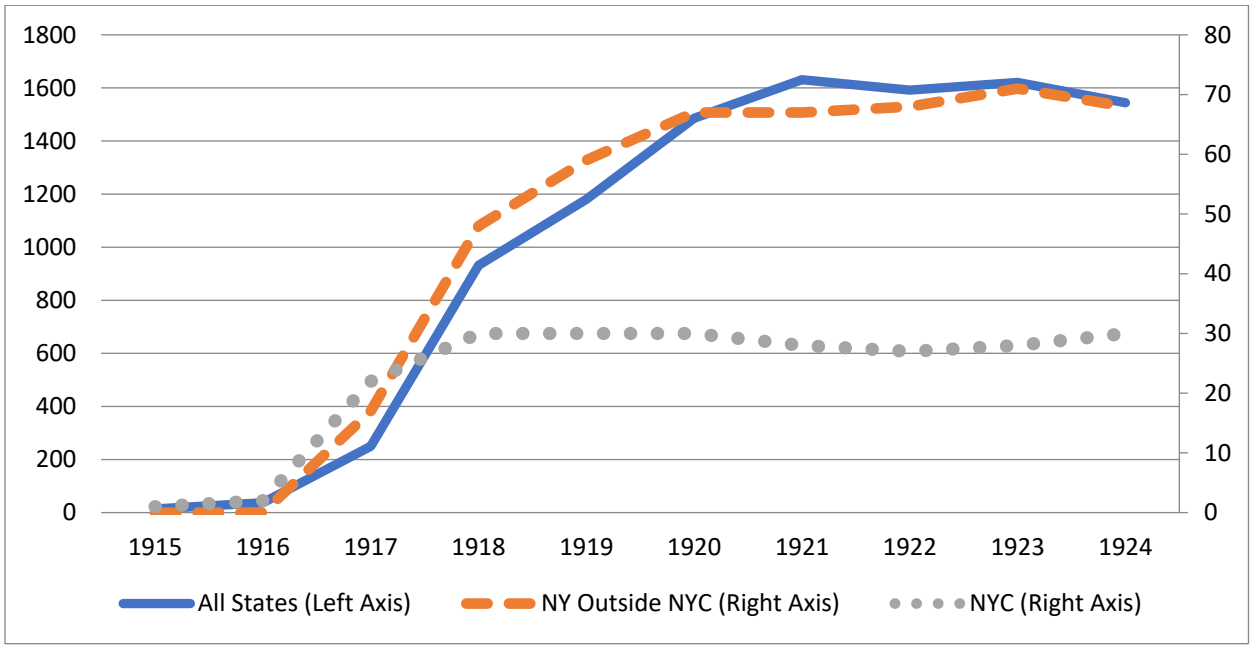
Figure 2: Pandemic Mortality Rates across New York Counties in 1918 (per 1000 population).



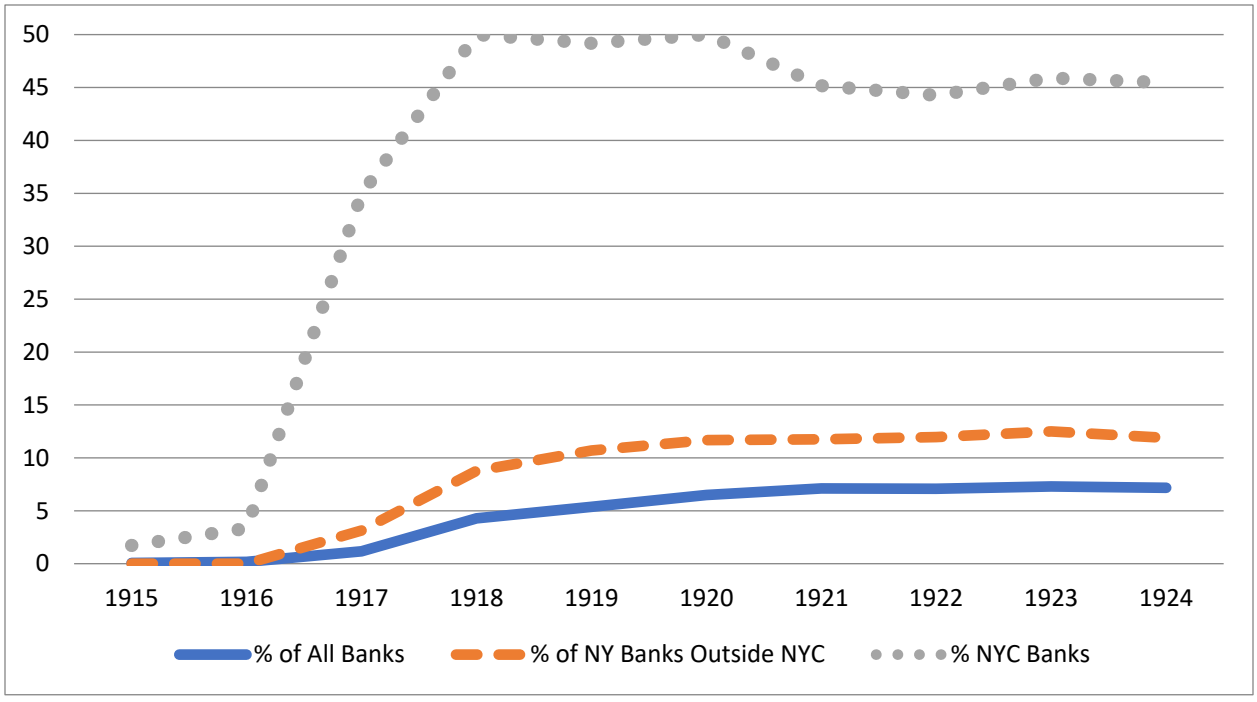

Source: *Annual Report of State Department of Health of New York.*

Figure 3: Adoption of Federal Reserve Membership by State-Charter Banks (1915-1924).

**Panel A: Number of State Bank Members**

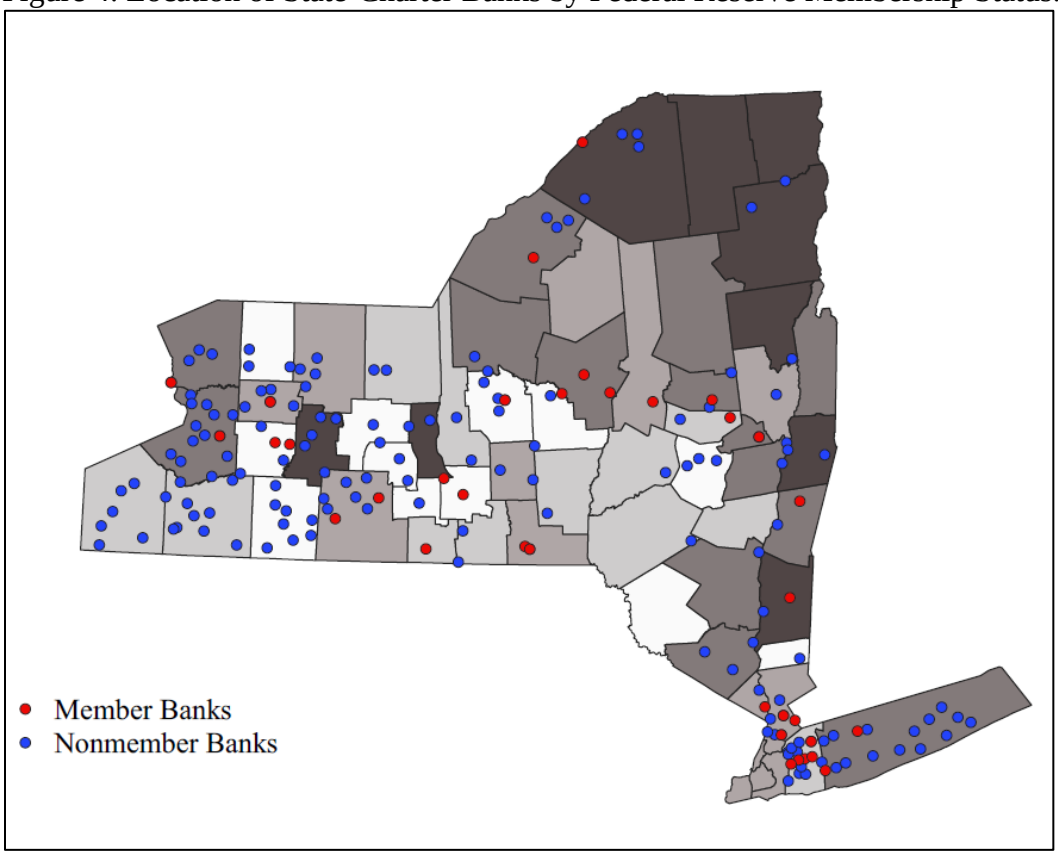



**Panel B: Percent of Banks that Are Members**




Notes: Figures display the number and fraction of Federal Reserve state members in each year. Membership rolls obtained from the *Annual Report* of the Federal Reserve Board of each year. The total numbers of banks are obtained from *All Bank Statistics* (1954).
Source: *Anderson, Calomiris, Jaremski, and Richardson* (2018).

Figure 4: Location of State-Charter Banks by Federal Reserve Membership Status.




Source: *Annual Report of the Federal Reserve Board.*

**References**


Almond, D. (2006). Is the 1918 influenza pandemic over? Long-term effects of in utero influenza exposure in the post-1940 US population. *Journal of political Economy*, *114*(4), 672-712.

Anderson, H., Calomiris, C. W., Jaremski, M., & Richardson, G. (2018). Liquidity risk, bank networks, and the value of joining the Federal Reserve System. *Journal of Money, Credit and Banking*, *50*(1), 173-201.

Anderson, H., Paddrik, M., & Wang, J. J. (2019). Bank Networks and Systemic Risk: Evidence from the National Banking Acts. *American Economic Review*, *109*(9), 3125-61.

Anderson, H., Erol, S., & Ordoñez, G. (2019). Interbank Networks in the Shadows of the Federal Reserve Act. *Available at SSRN 3367203*.

Barro, R. J., Ursúa, J. F., & Weng, J. (2020). *The coronavirus and the great influenza pandemic: Lessons from the "spanish flu" for the coronavirus's potential effects on mortality and economic activity* (No. w26866). National Bureau of Economic Research.

Bloom, D., & Mahal, A. (1997). AIDS, flu, and the Black Death: Impacts on economic growth and well-being. *The Economics of HIV and AIDS: The Case of South and South East Asia. Delhi: Oxford University Press, 1997a*, 22-52.

Brainerd, E., & Siegler, M. V. (2003). The economic effects of the 1918 influenza epidemic. Working Paper.

Carlson, M., & Wheelock, D. (2018). Furnishing an "Elastic Currency": The Founding of the Fed and the Liquidity of the US Banking System. *Federal Reserve Bank of St. Louis Review*, *100*(1), 17-44.

Chabot, B. R. (2017). The Federal Reserve's Evolving Monetary Policy Implementation Framework: 1914-1923. Federal Reserve Bank of Chicago Working Paper.

Clay, K., Lewis, J., & Severnini, E. (2018). Pollution, infectious disease, and mortality: evidence from the 1918 Spanish influenza pandemic. *The Journal of Economic History*, *78*(4), 1179-1209.

Congressional Quarterly. 1923. "Why State Banks Do Not Join the Federal Reserve System, the Effect on the System, and the Issues Involved," *Editorial Research Reports* Vol. I, Washington, D.C.: CQ Press.

Correia, S., Luck, S., & Verner, E. (1918). Pandemics depress the economy, public health interventions do not: Evidence from the 1918 flu. Federal Reserve Banking of New York Working Paper.

Crosby, A. W. (2003). *America's forgotten pandemic: the influenza of 1918*. Cambridge University Press.

Federal Reserve Bank of New York. Annual Report of the Federal Reserve Bank of New York. Various issues 1915 to 1920.

Federal Reserve Bank of New York. Federal Reserve Bank of New York Circulars. Various issues 1914 to 1924.

Garrett, T. A. (2009). War and pestilence as labor market shocks: US manufacturing wage growth 1914–1919. *Economic Inquiry*, *47*(4), 711-725.

Gorton, G., & Metrick, A. (2013). The federal reserve and panic prevention: The roles of financial regulation and lender of last resort. *Journal of Economic Perspectives*, *27*(4), 45-64.

Huntington, E. (1923). Causes of Geographical Variation in the Influenza Epidemic in the Cities of the United States. *Bull. Nat. Res. Council*, *6*, 1-36.

Jordà, Ò., Singh, S. R., & Taylor, A. M. (2020). *Longer-run economic consequences of pandemics* (No. w26934). National Bureau of Economic Research.

Karlsson, M., Nilsson, T., & Pichler, S. (2014). The impact of the 1918 Spanish flu epidemic on economic performance in Sweden: An investigation into the consequences of an extraordinary mortality shock. *Journal of health economics*, *36*, 1-19.

Keyfitz, K., & Flieger, W. (1968). World population: an analysis of vital data. *World population: an analysis of vital data.*

Kolata, G. (2001). *Flu: the story of the great influenza pandemic of 1918 and the search for the virus that caused it*. Simon and Schuster.

Lagoarde-Segot, T., & Leoni, P. L. (2013). Pandemics of the poor and banking stability. *Journal of Banking & Finance*, *37*(11), 4574-4583.

Mamelund, S. E. (2006). A socially neutral disease? Individual social class, household wealth and mortality from Spanish influenza in two socially contrasting parishes in Kristiania 1918–19. *Social science & medicine*, *62*(4), 923-940.

Mitchener, K. J., & Richardson, G. (2019). Network contagion and interbank amplification during the Great Depression. *Journal of Political Economy*, *127*(2), 465-507.

Murray, C. J., Lopez, A. D., Chin, B., Feehan, D., & Hill, K. H. (2006). Estimation of potential global pandemic influenza mortality on the basis of vital registry data from the 1918–20 pandemic: a quantitative analysis. *The Lancet*, *368*(9554), 2211-2218.

New York State Department of Health. Annual Report of the State Department of Health. Various issues 1914 to 1924.

Noymer, A., & Garenne, M. (2000). The 1918 influenza epidemic's effects on sex differentials in mortality in the United States. *Population and Development Review, 26*(3), 565-581.

Appendix Table A1: Mean and Standard Deviation of Balance Sheet Ratios, by Federal Reserve Membership Status, 1918-1919.

| | Member Banks | | | Nonmember Banks | | |
|---|---|---|---|---|---|---|
| | Pre-Pandemic | Pandemic | Post-Pandemic | Pre-Pandemic | Pandemic | Post-Pandemic |
| Liquid assets to assets | 11.80 | 10.74 | 11.61 | 14.48 | 14.10 | 14.22 |
| | (5.518) | (4.959) | (5.063) | (6.774) | (6.674) | (6.628) |
| Vault reserves to assets | 2.909 | 2.296 | 2.450 | 3.558 | 3.297 | 3.426 |
| | (1.696) | (1.252) | (1.000) | (1.430) | (1.270) | (1.338) |
| NonFed-interbank reserves to assets | 6.752 | 4.816 | 5.029 | 10.91 | 10.68 | 10.63 |
| | (4.523) | (3.655) | (4.287) | (6.386) | (5.948) | (5.835) |
| Securities to assets | 34.70 | 38.66 | 34.34 | 30.53 | 35.96 | 33.37 |
| | (12.40) | (11.12) | (11.11) | (15.62) | (14.95) | (14.22) |
| Loans to assets | 49.01 | 46.13 | 50.23 | 51.14 | 45.90 | 49.00 |
| | (12.00) | (10.84) | (11.68) | (15.08) | (13.86) | (14.35) |
| Capital equity to liabilities | 12.35 | 11.76 | 11.91 | 15.24 | 14.61 | 13.42 |
| | (4.064) | (3.973) | (4.647) | (7.147) | (7.487) | (5.157) |
| Deposits to liabilities | 78.42 | 77.66 | 79.33 | 80.12 | 81.98 | 82.41 |
| | (9.779) | (10.53) | (9.970) | (8.721) | (8.316) | (11.53) |
| Short-term borrowing to liabilities | 6.988 | 7.924 | 6.828 | 3.000 | 1.932 | 1.512 |
| | (7.702) | (8.306) | (8.608) | (5.095) | (3.641) | (3.244) |

Notes: Cell entries are means, with standard deviations in parenthesis. Liquid assets are vault reserves and interbank deposits (due from the Federal Reserve Bank of New York and due from other banks). The Pre-Pandemic period is from the first quarter of 1918 to the fourth quarter of 1918. The Pandemic period is the first quarter of 1919. The Post-Pandemic period is the second quarter through fourth quarter of 1919.
Source: *Annual Report of the Superintendent of Banks* and authors' calculations.