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J.E.L. Codes: G21, G28, N21
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Abstract

Looking across multiple panics of the nineteenth century, this paper treats borrowing of clearinghouse loan certificates as borrowing from a lender of last resort. We evaluate individual bank use of clearinghouse loan certificates in New York City using bank balance sheet data. Bank capital ratios do not predict positive net borrowing. Lower pre-panic reserve ratios increased the probability of positive net borrowing of loan certificates.

Introduction

Which banks borrow from a lender of last resort? With individual bank data on which banks borrow from a lender of last resort, we can evaluate questions about how to design central bank institutions. For example, banks could be reluctant to borrow from a lender of last resort (Peristiani 1998), so that weaker banks with lower capital/asset ratios fear the stigma of borrowing and are less likely to take advantage of lender of last resort facilities. In this scenario, perhaps the central bank should find ways to decrease the stigma of borrowing. Alternately, less liquid banks might borrow more from a lender of last resort during panics. In this case, perhaps the central bank should employ measures to improve bank liquidity. Do banks with stronger interbank deposit connections to other banks find themselves borrowing more from a lender of last resort? Large money center banks might feel obligated to borrow to support the needs of their customers. If so, perhaps the central bank should establish incentives such as increased capital charges for highly interconnected banks to disentangle themselves from other financial institutions.

Until the most recent financial crisis in 2008, the literature recounts only a few examples of papers on individual bank borrowing from a lender of last resort. The main examples employed data that were relatively secret and not necessarily available to private researchers, such as discount window lending. At least until the most recent financial crisis, much of the previous work considered the 1970s, 1980s, and 1990s in the U.S. and does not give special attention to panic episodes. In order to examine borrowing from a lender of last resort during a financial crisis, we could consider historical financial crises, such as the Great Depression, the financial upheaval during World War I, or crises during the National Bank Era (1863-1913), and the remainder of the episodes in the literature involve historical programs. Instead of looking at modern data, this paper focuses on a nineteenth century pre-Federal Reserve version of a lender of last resort, clearinghouse loan certificates.

This paper examines the borrowing of clearinghouse loan certificates across three crises, the panics of 1884, 1893, and 1907 in the financial center of New York City. Before the founding of the Federal Reserve, the New York Clearing House permitted member banks to borrow clearinghouse loan certificates on security collateral and substitute the loan certificates in place of reserves for payment in the daily clearings. These loan certificates resemble borrowing from a lender of last resort, and we can predict individual bank net borrowing of loan certificates using bank balance sheets.

Using a two-part or hurdle model, regression results indicate that banks with lower pre-panic reserve ratios were more likely to elect to borrow more loan certificates than they lent. The capital/asset ratio and the connectedness of the banks to correspondent networks did not influence the decision to borrow loan certificates in general, though connectedness might predict

borrowing for 1907 only. Further, the size of the bank did not influence the decision to borrow positive net amounts of clearinghouse loan certificates per dollar of assets.

Literature Review

Very few papers consider empirical evaluation of borrowing from a lender of last resort on an individual bank basis. Peristiani (1994) shows that individual bank borrowing from the discount window responded to the discount rate-federal funds spread during the 1970s and 1980s. Peristiani (1998) shows that individual banks with lower capital/asset ratios and lower S&P ratings decided to borrow from the discount window less frequently during the 1980s, meaning that banks were "reluctant to borrow" from a lender of last resort. Butkiewicz (1995) argues that the Reconstruction Finance Corporation (RFC) slowed the rate of bank failures during the Great Depresssion. Mason (2001) argues that preferred stock purchases and not loans from the RFC improved bank survival rates. Calomiris, Mason, Weidenmier and Bobruff (2013) also find that RFC preferred stock purchases improved survival rates in Michigan. Okazaki (2007) considers which banks obtained accounts with the Bank of Japan during the 1920s and 1930s and finds that larger, better performing banks were more likely to obtain special loans from the Bank of Japan. Hoag (2012a) considers borrowing from a federal program, Aldrich-Vreeland certificates during the panic of 1914, which was modeled on clearinghouse loan certificates. Banks with lower capital to asset ratios were more likely to take out Aldrich-Vreeland certificates, contrasting with the reluctance to borrow phenomenon. However, banks with lower reserve ratios before the crisis borrowed greater amounts of emergency currency.

Several previous papers consider the specific example of clearinghouse loan certificates. Hoag (2012b) examines net borrowing of clearinghouse loan certificates in New York during the panic of 1893. Pre-panic risk factors do not explain net borrowing, suggesting that moral hazard considerations did not drive loan certificate net borrowing. Tallman and Moen (2012) consider the issue of loan certificates in 1907. They argue that the six largest national banks accounted for the bulk of the borrowing, even after adjusting for bank size. Moen and Tallman (2013) describe borrowing of loan certificates at the individual bank level across all of the major panics of the National Bank Era but do not employ econometric analysis. Further, they do not control for the lending of clearinghouse loan certificates. Jacobson and Tallman (2014) compare borrowing of loan certificates and Aldrich-Vreeland Emergency currency in 1914. Following Hoag (2012b), this paper conducts econometric analysis of which banks borrowed loan certificates across panics.

History

The previous literature describes the operation of the New York Clearing House loan certificate program (Cannon 1908; Timberlake 1984; Gorton 1985, Hoag 2012b, Tallman and Moen 2012). To economize on check clearing in the city, the New York Clearing House operated a daily net clearing mechanism. Each daily check clearing created a set of creditor banks and a set of debtor banks. Ordinarily, debtor banks would discharge their obligation to the creditor banks with currency or receipts for special deposits of currency called clearinghouse certificates. In times of financial crisis, the membership could resolve to allow banks to borrow clearinghouse loan certificates. Debtor banks could submit loan certificates in place of actual

currency to fulfill their obligation to the creditor banks. The creditor banks would hold the loan certificates and earn interest at a specified rate (usually 6 or 7%), paid by the borrowing bank, and could then submit the loan certificate in place of cash in a future clearing. Banks obtained the loan certificates from a special committee of bank officers, the Loan Committee, which required the deposit of collateral by the borrowing bank. The loan certificates were overcollateralized, and in the unlikely event that the excess collateral was not enough to pay off the loan certificate, the loan certificate was backed by a joint pledge of redemption of the entire New York Clearing House membership. Borrowing banks eventually called in and presumably repaid their loan certificates with interest to the current holder of the certificate, releasing the collateral pledged to the Loan Committee.

Clearinghouse loan certificates approximate an early lender of last resort program. The loan certificates permitted banks to avoid contracting their loans during financial crises. If a bank made a loan, that loan would generally require payment to another bank when the borrower used the credit line, resulting in an unfavorable balance at the clearing house for the lending bank. By borrowing loan certificates and submitting the loan certificate to the creditor banks, the bank making a loan did not suffer a reserve outflow. Thus, the bank that borrowed the loan certificates avoided a cash outflow to the bank that held the loan certificates. The cash flows from the loan certificates replicate a loan of reserves to the bank borrowing the loan certificates from the bank holding the loan certificates. Essentially, the loan certificates permitted interbank loans among the New York Clearing House members (Hoag 2012b). Of course, during the panic the bank holding the loan certificates (the bank making the emergency loan) might change as the banks submitted them to the clearings in payment of debts on subsequent days.

Compare the loan certificates to discount window lending. In the case of discount window lending, the central bank takes eligible collateral securities in exchange for central bank deposits. The borrowing bank can then exchange these deposits for currency and pay out reserves over the counter. In contrast, loan certificates could only be used to satisfy debts incurred from the clearing mechanism at the clearing house. At least in New York, loan certificates were not a substitute for money and were not permitted to be traded outside the New York Clearing House (Cannon 1908). Smaller clearinghouses in other cities eventually did allow clearing house loan certificates to circulate in the hands of the public (a version which we might call clearing house currency certificates, to distinguish them from clearing house certificates and clearing house loan certificates), but that did not occur at least until 1893 (Andrew 1908). The Aldrich-Vreeland Act, to some extent inspired by clearinghouse currency certificates, was designed to allow associations of banks to pay out currency directly to the public.

Instead of serving as currency, clearinghouse loan certificates could be used to support loan expansion. Under suspension, suppose that member banks all increased loans by the same amount. If the funds borrowed were spent equally across all member banks, then there would be no change in each bank's reserve position after clearing (Myers 1931). However, if the spending of the borrowed funds were concentrated on depositors of certain institutions, these institutions would then obtain a creditor position in the clearings, meaning that some lending banks would experience a debtor position and would suffer a reserve outflow. The loan certificates helped to spread the loss of reserves across the banks, so that banks that increased lending and otherwise would experience a reserve outflow could effectively borrow reserves from another member. For more details about the operation of the loan certificate program, see Hoag (2015a).

We briefly review the three financial crises of 1884, 1893, and 1907, though these summaries are not meant to be comprehensive. Sprague (1910) and Wicker (2000) depict the panic of 1884, which erupted with a stock market crash in May when a leading brokerage firm failed unexpectedly, taking down a bank that provided its financing, the Marine National Bank. Concern shifted to the Metropolitan National Bank, a large interest-paying bank, when several allied brokerage houses failed. The Metropolitan suspended briefly on May 14, but reopened with support from the New York Clearing House. Overnight, bank officers certified the solvency of the bank and allowed it to borrow an extraordinary amount of loan certificates, which permitted the bank to reopen the next day, though the bank eventually closed in November (Wicker 2000, p. 37). According to both authors, the panic of 1884 was not a particularly deep or sustained financial crisis, so borrowing behavior may not be particularly evident. In particular, the panic of 1884 did not lead to a citywide suspension of bank payments, when banks would decline to pay out deposits over the counter in cash. Wicker (2000) categorizes the 1884 crisis an "incipient" panic, a panic that could have spread beyond the city of New York but did not, praising the leadership of the New York Clearing House for its swift action to prevent the crisis from spreading. Loan certificates remained outstanding for a few years after the crisis of 1884 subsided while the Metropolitan Bank paid off its loan certificates, although this length of time to repay loan certificate borrowing was highly unusual and not repeated in other crises.

Sprague (1910) and Wicker (2000) describe three phases of the panic of 1893. The failure of an important railroad inaugurated the first phase of the crisis in February 1893. In April, anxious currency speculators depleted the U.S. Treasury's gold reserve below $100 million, threatening the fixed exchange rate. The second phase, beginning in May, began with a complete rout of the stock market. In June, banks in select cities in the Midwest and West failed

at high rates. By the middle of June, the New York Clearing House was sufficiently alarmed by the financial situation that it permitted the issue of loan certificates. The third phase of the crisis began in late July when banks in the West and South experienced substantial withdrawals from their depositors, and eventually the banks in New York City at least partially suspended payments in August. All loan certificates were redeemed by November 1893.

As for the panic of 1907, Sprague (1910) describes how the trusts, a New York State banking intermediary, became substantially larger relative to national banks in New York City over the preceding decade (p. 226). When the San Francisco earthquake required substantial gold inflows to the U.S. in 1906, the Bank of England raised its discount rate and curtailed the practice of lending through American finance bills (Odell and Weidenmier 2004). Concern about the solvency of a group of copper speculators that allegedly had financial connections to particular New York banks and trusts sparked the panic in New York in October of 1907 (Wicker 2000). Hansen (2014) argues that runs on trusts were due to small individual uptown depositors. The panic ended in January 1908. Tallman (2013) also summarizes the crisis.

Data

We obtain information from bank balance sheets. We choose two balance sheets, one balance sheet before the panic representing pre-panic conditions, and one balance sheet during the panic. We choose balance sheets closest to the end of the calendar year before the crisis in question. We avoid choosing the balance sheet just before the crisis because panic narratives generally include several months of unstable conditions before the outbreak of the crisis. For example, in both 1884 and 1893, financial unrest began in the March prior to more serious

upheaval at the beginning of the panic and before the issue of clearinghouse loan certificates. This choice of a pre-panic balance sheet might not be optimal for the panic of 1907 due to the financial upheaval surrounding the San Francisco earthquake in 1906 (Odell and Weidenmier 2004), but we seek to maintain consistency with the other two years. Future editions of the paper may consider using call reports closer to the height of the panic as a benchmark for pre-panic condition. But if Hanes and Rhode (2013) are correct that macroeconomic fluctuations began with a poor cotton harvest in the previous autumn, then bank balance sheets from the December before the panic year might still represent stressed conditions of banks. Future editions of the paper may consider using call reports at least twelve months before the panic begins as a benchmark for pre-panic condition. However, note that neither of the panic narratives by Sprague or Wicker express concern about the cotton market.

The dual banking system led to two sets of banks and thus two different regulators. Federal regulators regulated national banks chartered at the federal level, while each state regulator could hold oversight over a system of state banks for that state. During the second half of the nineteenth century, bank regulators often called for balance sheet reports at irregular intervals to prevent bank window dressing (Hoag, 2015b). National and New York state regulators called for reports on different dates. For the purpose of this paper, we treat the dates from the two types of banks as simultaneous. Table 1 summarizes the different dates when both national and state banks reported their balance sheets for this paper around the crises of 1884 and 1893.

The call report dates generally occur somewhat after the height of the panic. On Saturday, June 21 1884, just after the reporting date of the national banks, only about half of the loan certificates ever issued were still outstanding ($12.93 million out of a total of $24.915

million of loan certificates issued during the panic of 1884, and of these $7.08 million had been issued to the Metropolitan National Bank). By this point the panic had already begun to subside. The balance sheets for the panic of 1893 fall closer to the height of the panic, which was more severe as partial suspensions lasted until September. We observe loan certificate borrowing on September 19, 1893 for state banks and October 3, 1893 for national banks. Again in the case of 1907, the panic balance sheet dates are in December, at least a month after the height of the panic. In particular, the state bank balance sheet falls relatively late in the panic on December 19, 1907, only a few weeks away from the resolution of the panic in January, 1908. We are confined to the balance sheet dates because the mechanics of clearinghouse loan certificates require information about lending to other banks. The presumption is that the balance sheet date of observation is representative of other periods during the panic, though borrowing behavior of clearinghouse loan certificates later in the panic may not be the same as borrowing at the height of the panic.

We make two adjustments to the dependent variable. Evaluating borrowing from a lender of last resort must take account of the specific features of the institution. First, because clearinghouse loan certificates allowed members both to borrow from a lender of last resort and to act as a lender of last resort by lending to other banks at the same time, we need to account for lending to other clearinghouse members when developing a measure of borrowing from a lender of last resort. For many applications we should avoid focusing on gross borrowing, the actual amount of borrowing. Because each bank can also be a lender, what matters is not how much each individual bank borrowed but rather the net amount of borrowing compared to lending for each bank. For example, a bank might borrow certificates from the Loan Committee by depositing the appropriate collateral but then keep the loan certificates on hand and not submit

them to the clearings. Alternately, a bank might receive loan certificates when it was a creditor in the daily clearing and other banks paid the creditor bank in loan certificates. While the fact that the bank decided to take out loan certificates may be interesting, simply taking out loan certificates from the Loan Committee does not mean the bank has actually borrowed from a lender of last resort. To see why, observe that the cash flows of clearinghouse loan certificates resemble interbank loans. When a bank tenders loan certificates to discharge a debit balance at the daily clearing, the bank receiving the loan certificate did not obtain a cash flow payment. Effectively, the creditor bank lent the reserves to the debtor bank, and in exchange the creditor holds the loan certificate and receives an interest payment. Therefore, banks that both borrow and hold loan certificates are both borrowing from other banks and lending to other banks. In the case where the bank holds its own loan certificate, the bank that borrowed loan certificates but holds them without tendering them as debt to the clearings pays no interest on net, therefore on net the bank does not borrow. Essentially, the bank lends money to itself. More generally, when a bank holds the same amount of loan certificates as it has borrowed, the interest nets out regardless of which other institutions issued the loan certificates held by the bank. In addition to the identities of the banks that borrowed loan certificates, we also know which banks held loan certificates on hand, so we can examine borrowing after controlling for lending. Controlling for holdings of loan certificates is important because several banks which borrowed loan certificates were actually net lenders to other banks. Unless we control for holdings of loan certificates, we could mischaracterize a clearinghouse member bank as borrowing from a lender of last resort when in fact it was holding a greater amount loan certificates (thus lending more money to other banks) than it was borrowing. That is, banks that borrowed might be net lenders to other member banks. In fact, about a quarter of the banks that borrowed clearinghouse loan

certificates were actually net lenders in 1884 and 1893. For additional discussion of the mechanics and importance of net borrowing, see Hoag (2012b) or Hoag (2015a).

Therefore, we need to control for holdings of loan certificates. The solution of Hoag (2012b) was to investigate borrowing minus lending. However, while we certainly need to consider holdings of loan certificates on hand to evaluate the actual amount of borrowing in this particular lender of last resort, perhaps we should treat borrowing differently than negative lending. Instead of looking at borrowing alone, this paper focuses on truncated net borrowing: the greater of zero and borrowing minus lending. Let b_i be borrowing of loan certificates for individual bank *i*. Let h_i be holdings of loan certificates for bank *i*, essentially the amount lent in loan certificates to member banks, possibly including bank *i* itself. Then define truncated net borrowing (or positive net borrowing) for bank *i* as:

$$TRUNCBORROW_i = \max(b_i - h_i, 0) \qquad (1)$$

Thus, we focus on positive net borrowing, that part of borrowing which is not netted out by lending. Because this definition yields a large number of banks that have truncated borrowing of zero either because they did not borrow or because the banks were net lenders to other clearinghouse member banks, we will have to use an econometric model to account for the large portion of zeros in the dependent variable.

Unfortunately, the additional precision about truncated borrowing and accounting for the lending of loan certificates comes at a cost: we can only investigate borrowing when we also have records of the lending of loan certificates. Very few panics have information on the holdings of loan certificates. Further, the identities of which banks lent loan certificates could

change rapidly. A balance sheet provides only a snapshot of the banks holding loan certificates. If the next day a bank decided to use the loan certificates it held as payment of a debit balance at the clearinghouse, that bank would no longer be a lender. Future work may investigate the turnover of the lending of loan certificates. For the purpose of comparison, we also present results on borrowing alone, but as described above we should not place weight on these results.

The 1884 data on loan certificate holding have consistency issues. In particular, aggregate weekly average loan certificate holding does not equal aggregate weekly average loan certificates outstanding. While we would expect that fact to be true in our data since we draw the balance sheets from different sets of banks in different weeks, aggregate weekly borrowing still does not equal aggregate weekly lending even in the same week. Other work discusses this issue with the data.

The procedure of the loan certificates may have differed in 1907 and in subsequent years. According to the *New York Times* (October 27, 1907) in 1907, the New York Clearing House used a set of accounting entries rather than allocating physical loan certificates. Balance sheets at the banks recorded labeling holdings of loan certificates as "Clearing House Account Net Balance," both as an asset and a liability, rather than recording "Loan Certificates on Hand" as an asset or "Loan Certificates Outstanding" as a liability as had been the case in previous years. In the case of 1907, loan certificate borrowing was already netted out on individual bank balance sheets: no bank that borrowed loan certificates was recorded as having lent loan certificates. At least in this panic year, we cannot distinguish between borrowing and net borrowing because in this data source borrowing has been netted out by the management of the clearinghouse. Of course, it is possible that the difference between borrowing and net borrowing was maintained in other records. According to the report in the Minutes of the New York Clearing House, loan

certificates were printed in preparation for the crisis of 1907, but it is not clear that they were actually employed, or they may have been employed only for a short while and then New York Clearing House officers enacted the accounting system. The *New York Times* (October 27, 1907) also suggests that this procedure may have been used in 1893, though we have no independent verification of that suggestion, and the balance sheets in previous years refer to actual loan certificates. However, the use of an account entry rather than physical loan certificates should not change our view about the loan certificates as representing loans among the banks (albeit mutually guaranteed by all members) rather than lending from a central clearinghouse, see Hoag (2015a).

As a second modification to the dependent variable, we adjust for the size of the bank. Larger banks will naturally borrow more dollars from a lender of last resort, so we must control for bank size. This paper divides $TRUNCBORROW_i$ by the total assets of the bank. Thus, our dependent variable for bank *i* is $TRUNCBORROW_i \,/\, TOTAL\ ASSETS_i$. According to Table 2, banks net borrowed loan certificates of about 2% of total assets on average.

Note that evaluating which banks borrowed from a lender of last resort involves selection issues. We confine attention to those banks that have the opportunity to borrow clearinghouse loan certificates. In particular, banks that are not members of the New York Clearing House are not considered for this paper because nonmembers are not eligible to borrow clearinghouse loan certificates. Similarly, banks that failed after the pre-panic balance sheet but before the panic balance sheet are not included in the analysis, because those banks do not exist to borrow during the panic. However, no banks that were members of the New York Clearing House failed during the panics of 1884, 1893, and 1907 between the time that loan certificates were first issued and the observation of the panic balance sheet. This paper also ignores the trusts, which were not

members of the New York Clearing House during this period and hence ineligible to borrow clearinghouse loan certificates.

We tabulate several balance sheet variables to investigate which banks borrow from a lender of last resort. We measure the capital to asset ratio, CAP/ASSET, as book capital plus net profits all over total assets. Peristiani (1998) observes that under reluctance to borrow, weaker banks should borrow less often from the lender of last resort. We include two variables for the reserve ratio. First, we include the reserve ratio from the balance sheet from the December before the panic began, RESRAT, which we calculate as specie plus legal tenders all over total deposits. (Future editions of this paper may consider more sophisticated or more historically accurate definitions of the reserve ratio.) Hoag (2012a) shows that banks with higher reserve ratios chose to borrow more from a lender of last resort, Aldrich-Vreeland certificates. We also consider the change in the reserve ratio, ΔRR, as banks that had paid out reserves might require more assistance. We include the natural log of total assets, LNTOT, as a measure of bank size. The variable STATE takes the value one if the bank is chartered as a state bank. Further, some New York banks, known as "interest-paying banks" (Sprague 1910, Hoag 2005), based their business on accepting deposits from banks on the agricultural interior and might have been more likely to suffer withdrawals during a crisis when country banks withdrew funds and hence be more likely to require assistance from a lender of last resort. So we include banker's balances as a fraction of deposits on the pre-panic date, BANKBAL. Tallman and Moen (2012) show that banks with large bankers' balances borrowed larger amounts of loan certificates in 1907. Finally, we tabulate the percent change in deposits, %ΔDEP, as banks with more substantial withdrawals might likewise require more assistance. (In addition, we could also control for the change in ordinary interbank borrowing from each bank over the course of the panic. While the

omitted variable is statistically significant, the results remain essentially the same. Future editions of this paper may explain this concern more carefully.) Table 2 contains summary statistics about the variables of interest.

Test

We predict positive net borrowing at the individual bank level using balance sheet variables. We can write the following regression equation which predicts borrowing from a lender of last resort as a function of the independent variables:

$$y_i = \beta_0 + \beta_1(CAP/ASSET) + \beta_2 RESRAT + \beta_3 \Delta RR + \beta_4 LNTOT + \beta_5 STATE + \beta_6 BANKBAL + \beta_7 \%\Delta DEP + \varepsilon_i \quad (2)$$

In our preferred specification, the dependent variable y_i is $TRUNCBORROW_i \,/\, ASSET_i$, or truncated borrowing of bank *i* over total assets of bank *i*. For the purpose of comparison, we also include results on borrowing where the dependent variable y_i is simply the actual amount of borrowing for bank *i* over total assets for bank *i*.

We adopt an empirical strategy that considers both which banks decide whether to borrow a net positive amount of loan certificates and then how much positive net borrowing banks elect. Some banks would choose not to borrow loan certificates at all, meaning that some banks have a dependent variable of zero. Ordinarily, this type of data would call for a tobit model. However, Hoag (2012a) argues that the marginal effects for choosing to borrow may have a different sign than the marginal effects for the amount borrowed. Therefore, we use a

two-part or hurdle model to predict truncated borrowing, which allows for the marginal effects of the different decisions to have different signs. Further, the tobit model can be considered as a special case of a two-part model (Greene 2003, p. 770). In the first stage, the choice equation, banks decide whether to become positive net borrowers (to have positive truncated borrowing) or not. We model this first stage using a probit model of equation (2). In the second stage, the outcome equation, those banks that have chosen to assume positive net borrowing decide how much to borrow. We estimate the second stage equation with a truncated regression model of equation (2), which includes a selection term for net borrowing being positive. We estimate the truncated regression only over those banks which elected to keep net borrowing positive.

Results

Table 3 displays results from the estimation of the two-step (or hurdle) model of equation (2) that includes data from all three crises. We are interested in examining which banks borrow from a lender of last resort. Following the discussion above, we focus on the dependent variable of truncated borrowing of loan certificates as a fraction of total assets. Column (1) describes the results with truncated borrowing as the dependent variable. Because the dependent variable in Hoag (2012b) is net lending rather than truncated lending, the current results may not necessarily reflect previous work.

Focus first on the choice equation which determines whether or not banks chose to have positive net borrowing of loan certificates. We see no strong evidence of a reluctance to borrow from a lender of last resort. The coefficient on the capital to asset ratio is negative and statistically insignificant ($p = 0.78$). The result suggests no reluctance to borrow on the part of

banks with lower capitalization ratios. The result contrasts with Hoag (2012a) under the Aldrich-Vreeland Act, which did find a statistically significant negative effect.

The reserve position of the bank played an important role in determining positive net borrowing of loan certificates. Banks with higher reserve ratios before the panic struck were more likely to borrow more loan certificates than they lent. The coefficient on RESRAT before the crisis was negative and statistically significant ($p = 0.03$), and a one percentage point decrease in the reserve ratio led to about a two percentage point increased probability of positive net borrowing. The result follows previous work on net lending by Hoag (2012b) for the crisis of 1893 which suggested a negative relationship between the reserve ratio and the amount of net lending. The result contrasts with the result from Hoag (2012a) under the Aldrich-Vreeland Act, where the reserve ratio did not influence the decision to borrow from a lender of last resort. But the conclusion that the reserve position of the bank matters for positive net borrowing might not be entirely unexpected, since in order to have positive net borrowing a bank could either have borrowing with little lending or a large amount of borrowing relative to lending, and some banks did fall into the latter category.

Note that per dollar of assets, large banks were not more likely than small banks to be positive net borrowers: the coefficient on LNTOT is positive but statistically insignificant ($p = 0.92$). State banks, which were possibly riskier because regulation at the state level was considered less exacting, were not more likely to have positive net borrowing from a lender of last resort ($p = 0.27$). But banks with large correspondent networks were not more likely to positive net borrow loan certificates, as the coefficient on the percentage of bankers' balances, BANKBAL, is not very large and is statistically insignificant ($p = 0.13$). In particular, highly interconnected banks were not more likely to borrow and use loan certificates in place of cash so

as to conserve on currency which could be used to fund deposit redemption, whether locally or to the agricultural interior. In general across all panics, the result contrasts with footnote 19 (p. 282) of Tallman and Moen (2012), which suggests that bankers' balances are correlated with loan certificate borrowing in 1907.

Finally, a decrease in deposits led to an increase in the probability borrowing of loan certificates. The coefficient on %ΔDEP was negative and statistically significant ($p < 0.01$), though not particularly large, with a one percentage point decrease in deposits leading to nearly a two-thirds of one percentage point increase in the probability of positive net borrowing as a fraction of total assets. Banks that suffered deposit drains were more likely to borrow from a lender of last resort. Column (2) of Table 3 presents a final model after eliminating statistically insignificant variables. We can eliminate the five variables CAP/ASSET, LNTOT, STATE, BANKBAL, and ΔRR that are jointly marginally insignificant ($p = 0.09$).

In addition to the likelihood of actually borrowing, we can also consider the amount of loan certificates borrowed. Given that net borrowing was positive, the outcome equation predicts the amount of positive net borrowing by clearinghouse member banks. Again, the truncated regression only involves those banks with positive net borrowing. The lower part of Column (1) of Table 3 records the results of the truncated regression. Unfortunately, Table 3 shows that none of the estimated coefficients are statistically significant.

To show how we can reach different conclusions by examining a less appropriate dependent variable, we also include versions of the results that consider actual borrowing as a fraction of total assets. Because the data have netted out loan certificate borrowing for 1907, we can only make this comparison across the two panics of 1884 and 1893. Table 4 presents estimation of equation (2) using only data from 1884 and 1893. These results are very similar to

the original results presented in Table 3 based on all three panics including 1907. In contrast, Table 5 presents comparable results of estimating both the choice equation and the outcome equation with ordinary borrowing, when borrowing of loan certificates is not netted out by lending of loan certificates, for the panics of 1884 and 1893. Notice that we could draw unwarranted conclusions by focusing on borrowing alone. For example in Table 5, because the coefficient on LNTOT is positive and statistically significant ($p = 0.03$), we would conclude that larger banks were more likely to borrow. Recall that the results on truncated borrowing show that large banks were not more likely to borrow, as some of these large banks that decided to borrow loan certificates were also willing to lend more than they borrowed, making these large banks net lenders. In the outcome equation, banks with higher capital/asset ratios borrowed larger amounts of loan certificates ($p = 0.03$). By looking at borrowing alone, we might imagine that a stronger capital position would lead to more borrowing. Unfortunately, focusing on borrowing alone can yield less informative results. However, some of the remaining results on the amount of borrowing alone are qualitatively similar to the results on net borrowing.

Due to the historical description of the crises, we might express concern about one large bank affecting the results. Recall that the Metropolitan National Bank borrowed about more than a quarter of the loan certificates ever outstanding during the crisis of 1884. Therefore, one might fear that this one bank might skew the results toward concluding that large banks with large correspondent networks (and hence a large fraction of bankers' balances) would be more likely to require assistance from a lender of last resort. Although the initial results do not suggest that conclusion, removing the Metropolitan bank from the sample does not affect the main results for truncated borrowing (results not reported).

If we choose, we can allow for different behavior during each crisis or by different type of bank. Historians are occasionally accused of conditioning their results on particular historical facts relevant to each episode. However, we might believe that the economic forces governing borrowing from a lender of last resort should be constant across crises, especially crises less than a generation apart. The baseline case estimated in Table 3 assumes that there are no differences in behavior by banks across the crises. Alternately, we could allow the estimated coefficients to differ across the multiple crises. For example, we allow for a different constant term for the two crises. The main results for truncated borrowing are unchanged with different constants for different years (results not reported).

In addition, we can consider separate regressions by individual crisis. Results from the individual crises of 1884 and 1893 follow the aggregate results (not reported), but the results from the crisis of 1907 appear somewhat different. Table 6 reports the results of estimating equation (2) over data from the panic of 1907 alone. In the choice equation, the coefficient on the reserve ratio is no longer statistically significant ($p = 0.68$), and while still negative, the magnitude of the coefficient fell by about half. In fact, the only variable that is even marginally statistically significant is the coefficient on bankers' balances: a one percentage point increase in bankers' balances as a fraction of total deposits leads to a moderately sizable one percentage point increase in the probability of positive net borrowing ($p = 0.07$). This result provides support for Tallman and Moen (2012), who argue that the six largest national banks, which heavily relied on bankers' balances for funding, were more closely associated with borrowing loan certificates in 1907, though that paper only considers borrowing and not positive net borrowing. Sprague (1910, p. 226) notes a substantial concentration in bankers' balances in 1907 relative to 1897 and earlier years, so the increased importance of bankers' balances might

not be surprising. But many smaller banks had similar ratios of bankers' balances to total deposits but did not choose to borrow loan certificates. Of the six large banks cited by Tallman and Moen (2012), two were substantial lenders of loan certificates by early December 1907. However, in the outcome equation, bankers' balances played no role in the amount of loan certificates borrowed among the banks that chose to borrow in 1907 ($p = 0.35$). Further, larger banks did not borrow a greater amount of loan certificates relative to their size ($p = 0.21$). Thus, any connection between bankers' balances and clearinghouse loan certificate borrowing in 1907 extends only to the likelihood of actually borrowing. The size or holdings of bankers' balances of the six large banks in 1907 did not induce them to borrow any additional loan certificates relative to their size when compared to other borrowers.

To further investigate the importance of bankers' balances, we consider an additional robustness check of the stability of the coefficients across the three crises. We allow three separate coefficients in the original equation (2) for bankers' balances, one for each panic year, while using data from all three panics simultaneously. Table 7 reports the results of estimating the choice equation with separate coefficients on bankers' balances for each panic including two year dummies. The coefficient on bankers' balances for 1907 is positive but is not statistically different from zero ($p = 0.13$). The data accept the null hypothesis that all three coefficients are equal ($p = 0.59$) and that all three coefficients are equal to zero ($p = 0.39$). In summary, the results for 1907 appear somewhat different from the results in 1884 and 1893. There is some support for the result that holding bankers' balances explains the decision to borrow of

clearinghouse loan certificates in 1907 only (though not how much to borrow), although the results for this hypothesis are not particularly robust.[1]

Conclusion

This paper econometrically evaluates which banks borrow from an historical lender of last resort program, clearinghouse loan certificates during the panics of 1884, 1893, and 1907. Although clearinghouse loan certificates allowed banks to borrow from other member banks, in contrast to the investigation of net borrowing by Hoag (2012b) we focus on banks whose net borrowing was positive. The capital/asset ratio does not predict which banks borrowed. Instead, the results suggest that the reserve position of the bank influences borrowing from this lender of last resort. Lower reserve ratios predicted which banks would be more likely to require assistance from a lender of last resort. However, this result did not hold strongly for the panic of 1907. There is some evidence that bankers' balances, representing the connectedness of the

[1] Note that in general, we should not rely upon univariate regressions to isolate the determinants of borrowing due to omitted variable bias. If we follow Tallman and Moen (2012) and regress borrowing as a fraction of total assets on bankers' balances as a fraction of total assets using heteroskedasticity robust standard errors for 1884 and 1893, we also obtain a positive coefficient that is marginally statistically significant ($p = 0.077$). That is, we would believe that holding bankers' balances was an important reason for borrowing clearinghouse loan certificates, when in fact it was not. This point emphasizes the importance of not employing a single independent variable rather than a more comprehensive suite of independent variables from the balance sheet following Hoag (2012b) or as in this paper.

balances to other banks, played a role for the probability of positive net borrowing of loan certificates, but only possibly in 1907 and not in other years.

We could draw a causal lesson where we interpret the results as suggesting that bank liquidity is an important input into the decision to borrow from a lender of last resort. Note that during the late nineteenth century, national banks in New York City were required to maintain a reserve ratio of 25%. In fact, the New York Clearing House occasionally adopted rules requiring members to hold specific minimum reserve ratios (Gorton and Mullineaux 1987). Even with such a high reserve ratio, banks were still subject to relatively frequent panic conditions, with one financial crisis roughly every decade. Modern reserve ratios in the U.S. are much lower, perhaps 10% or less, while some foreign central banks require higher reserve ratios. Of course, many institutions worldwide evade reserve requirements by temporarily investing in less regulated assets. Less optimistically, the reserve ratio has fallen out of favor in the United States as a tool to influence the banking system, especially since the reserve ratio is not binding at large financial institutions. Instead, new rules to maintain bank liquidity, such as the liquidity coverage ratio, could help to make banks less likely to require assistance. Requiring additional liquidity, though costly for bank profits, may help to prevent banks from needing to borrow from a lender of last resort. But we might not necessarily view the causal interpretation as definitive. As an alternate interpretation of the results, perhaps banks that were more conservative and chose to hold higher reserve ratios were less likely to require assistance on those occasions when panics struck. The presumption of the causal interpretation is that there is no omitted variable correlated with lower reserve ratios that helps to explain the need to borrow from a lender of last resort, such as a lower risk aversion of senior bank officers or investment by the bank in particularly volatile industries.

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Table 1: Dates of reports of condition to bank regulators

	National	State
1884 Pre-panic	12/31/83	12/22/83
1884 Panic	06/20/84	06/14/84
1893 Pre-panic	12/09/92	12/15/92
1893 Panic	10/03/93	09/19/93
1907 Pre-panic	11/12/06	11/14/06
1907 Panic	12/03/07	12/19/07

Table 2: Summary Statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
CAP/ASSET	178	0.195	0.07	0.068	0.41
RESRAT	178	0.217	0.056	0.085	0.527
DELRR	178	0.013	0.073	-0.157	0.365
LNTOT	178	15.941	1.036	13.885	19.27
STATE	178	0.315	0.466	0	1
BANKBAL	178	0.237	0.226	0	0.855
PCDEP	178	-0.101	0.202	-0.885	0.484
BORROW	178	424554.5	1196015	0	8370000
TRUCBORROW	178	357464.6	1168402	0	8370000
BORROW/ASSET	178	0.028	0.056	0	0.397
TRUNCBORROW/ASSET	178	0.021	0.051	0	0.386
Year 1884	178	0.348	0.478	0	1
Year 1893	178	0.36	0.481	0	1
Year 1907	178	0.292	0.456	0	1

Table 3: Two-part model results: Clearinghouse Loan Certificates in 1884, 1893, and 1907

1. Choice Equation: Probit Estimates
Dependent variable: 1 if TRUNCBORROW/ASSET > 0, 0 otherwise
(approximate z-scores in parentheses)

	Column (1)		Column (2)	
Variable	Coefficient	Marginal Effect	Coefficient	Marginal Effect
CAP/ASSET	-0.494	-0.163		
	(-0.29)	(-0.29)		
RESRAT	-5.421**	-1.788**	-3.808*	-1.281*
	(-2.19)	(-2.21)	(-1.88)	(-1.90)
DELRR	-1.327	-0.438		
	(-0.79)	(-0.79)		
LNTOT	0.139	0.005		
	(0.10)	(0.10)		
STATE	-0.312	-0.099**		
	(-1.10)	(-1.15)		
BANKBAL	0.981	0.323		
	(1.51)	(1.52)		
%ΔDEP	-1.948**	-0.642**	-2.246**	-0.755**
	(-3.08)	(-3.09)	(-3.89)	(-3.92)
CONSTANT	0.120		0.016	
	(0.05)		(0.04)	
Log-likelihood	-93.451		-98.326	
Number of Observations	178		178	

* = significant at the 10% level, two-tailed test
** = significant at the 5% level, two-tailed test

Table 3: Two-part model results: Clearinghouse Loan Certificates in 1884, 1893, and 1907 (continued:)

2. Outcome Equation: Truncated Regression Estimates
Dependent variable: TRUNCBORROW/ASSET (only if TRUNCBORROW/ASSET > 0)
(approximate z-scores in parentheses)

	Column (1)	
Variable	Coefficient	Marginal Effect
CAP/ASSET	-0.141	-0.014
	(-0.11)	(-0.11)
RESRAT	2.131	0.213
	(0.79)	(1.17)
DELRR	-1.875	-0.188
	(-0.87)	(-1.37)
LNTOT	-0.070	-0.007
	(-0.55)	(-0.66)
STATE	0.494	0.087
	(1.09)	(1.63)
BANKBAL	0.732	0.073
	(0.92)	(1.60)
%ΔDEP	-1.875	-0.034
	(-0.87)	(-1.24)
CONSTANT	-0.065	
	(-0.04)	
Log-likelihood	93.881	
Number of Observations	53	

* = significant at the 10% level, two-tailed test
** = significant at the 5% level, two-tailed test

Table 4: Two-part model results: Clearinghouse Loan Certificate Borrowing in 1884 and 1893

1. Choice Equation: Probit Estimates
Dependent variable: 1 if TRUNCBORROW/ASSET > 0, 0 otherwise
(approximate z-scores in parentheses)

	Column (1)		Column (2)	
Variable	Coefficient	Marginal Effect	Coefficient	Marginal Effect
CAP/ASSET	-1.418	-0.448		
	(-0.66)	(-0.66)		
RESRAT	-10.388**	-3.282**	-6.485**	-2.11**
	(-2.78)	(-2.89)	(-2.25)	(-2.28)
DELRR	-4.050*	-1.280*		
	(-1.66)	(-1.69)		
LNTOT	0.239	0.076		
	(1.07)	(1.07)		
STATE	-0.668*	-0.188**	-0.577*	-0.172**
	(-1.74)	(-1.98)	(-1.81)	(-2.01)
BANKBAL	-0.286	-0.009		
	(-0.04)	(-0.04)		
%ΔDEP	-2.743**	-0.867**	-3.090**	-1.007**
	(-2.77)	(-2.83)	(-3.52)	(-3.63)
CONSTANT	-1.736		0.649	
	(-0.52)		(0.92)	
Log-likelihood	-62.686		-64.892	
Number of Observations	126		126	

* = significant at the 10% level, two-tailed test
** = significant at the 5% level, two-tailed test

Table 4: Two-part model results: Clearinghouse Loan Certificate Borrowing in 1884 and 1893 (continued:)

2. Outcome Equation: Truncated Regression Estimates
Dependent variable: TRUNCBORROW/ASSET (only if TRUNCBORROW/ASSET > 0)
(approximate z-scores in parentheses)

	Column (1)		Column (2)	
Variable	Coefficient	Marginal Effect	Coefficient	Marginal Effect
CAP/ASSET	0.394	0.162		
	(1.25)	(1.26)		
RESRAT	0.326	0.134		
	(0.52)	(0.51)		
DELRR	-0.273	-0.112		
	(-0.50)	(-0.51)		
LNTOT	0.019	0.008		
	(0.55)	(0.55)		
STATE	0.569	0.027		
	(0.97)	(0.85)		
BANKBAL	0.005	0.002		
	(0.04)	(0.04)		
%ΔDEP	-0.400**	-0.164**	-0.492**	-0.165**
	(-3.34)	(-3.08)	(-3.36)	(-3.46)
CONSTANT	-0.525		-0.117	
	(-1.01)		(-1.42)	
Log-likelihood	74.125		72.454	
Number of Observations	38		38	

* = significant at the 10% level, two-tailed test
** = significant at the 5% level, two-tailed test

Table 5: Two-part model results: Clearinghouse Loan Certificate Borrowing in 1884 and 1893

1. Choice Equation: Probit Estimates
Dependent variable: 1 if BORROW/ASSET > 0, 0 otherwise
(approximate z-scores in parentheses)

	Column (1)	
Variable	Coefficient	Marginal Effect
CAP/ASSET	-1.532	-0.569
	(-0.76)	(-0.76)
RESRAT	-10.386**	-3.859**
	(-3.01)	(-3.07)
DELRR	-0.517	-0.192
	(-0.22)	(-0.22)
LNTOT	0.458**	0.170**
	(2.14)	(2.15)
STATE	-0.251	-0.091
	(-0.70)	(-0.72)
BANKBAL	-0.175	-0.065
	(-0.22)	(-0.22)
%ΔDEP	-2.492**	-0.926**
	(-2.68)	(-2.68)
CONSTANT	-4.986	
	(-1.58)	
Log-likelihood	-68.705	
Number of Observations	126	

* = significant at the 10% level, two-tailed test
** = significant at the 5% level, two-tailed test

Table 5: Two-part model results: Clearinghouse Loan Certificate Borrowing in 1884 and 1893 (continued:)

2. Outcome Equation: Truncated Regression Estimates
Dependent variable: BORROW/ASSET (only if BORROW/ASSET > 0)
(approximate z-scores in parentheses)

	Column (1)	
Variable	Coefficient	Marginal Effect
CAP/ASSET	0.401**	0.243**
	(2.14)	(2.11)
RESRAT	0.294	0.178
	(0.76)	(0.75)
DELRR	-0.155	-0.094
	(-0.79)	(-0.80)
LNTOT	-0.004	-0.003
	(-0.20)	(-0.20)
STATE	0.033	0.021
	(0.94)	(0.89)
BANKBAL	0.029	0.018
	(0.38)	(0.38)
%ΔDEP	-0.328**	-0.200**
	(-4.50)	(-4.44)
CONSTANT	-0.093	
	(-0.30)	
Log-likelihood	90.135	
Number of Observations	49	

* = significant at the 10% level, two-tailed test
** = significant at the 5% level, two-tailed test

Table 6: Two-part model results: Clearinghouse Loan Certificate Borrowing in 1907

1. Choice Equation: Probit Estimates
Dependent variable: 1 if TRUNCBORROW/ASSET > 0, 0 otherwise
(approximate z-scores in parentheses)

	Column (1)	
Variable	Coefficient	Marginal Effect
CAP/ASSET	1.260	0.402
	(0.27)	(0.27)
RESRAT	-2.929	-0.933
	(-0.42)	(-0.42)
DELRR	0.729	0.232
	(0.13)	(0.13)
LNTOT	-0.023	-0.007
	(-0.08)	(-0.08)
STATE	0.311	0.101
	(0.56)	(0.56)
BANKBAL	3.219*	1.026*
	(1.84)	(1.86)
%ΔDEP	-0.990	-0.315
	(-1.12)	(-1.12)
CONSTANT	-0.860	
	(-0.19)	
Log-likelihood	-25.870	
Number of Observations	52	

* = significant at the 10% level, two-tailed test
** = significant at the 5% level, two-tailed test

Table 6: Two-part model results: Clearinghouse Loan Certificate Borrowing in 1907
(continued:)

2. Outcome Equation: Truncated Regression Estimates
Dependent variable: TRUNCBORROW/ASSET (only if TRUNCBORROW/ASSET > 0)
(approximate z-scores in parentheses)

	Column (1)	
Variable	Coefficient	Marginal Effect
CAP/ASSET	-2.324*	-0.674**
	(-1.83)	(-2.58)
RESRAT	-0.527	-0.153
	(-0.37)	(-0.36)
DELRR	-1.872**	-0.543*
	(-2.43)	(-1.72)
LNTOT	-0.114	-0.033
	(-1.25)	(-1.55)
STATE	0.015	0.005
	(0.14)	(0.13)
BANKBAL	0.241	0.070
	(0.94)	(1.12)
%ΔDEP	0.085	0.025
	(1.03)	(0.83)
CONSTANT	2.246	
	(1.53)	
Log-likelihood	32.106	
Number of Observations	15	

* = significant at the 10% level, two-tailed test
** = significant at the 5% level, two-tailed test

Table 7: Two-part model results: Clearinghouse Loan Certificates in 1884, 1893, and 1907

1. Choice Equation: Probit Estimates
Dependent variable: 1 if TRUNCBORROW/ASSET > 0, 0 otherwise
(approximate z-scores in parentheses)

	Column (1)	
Variable	Coefficient	Marginal Effect
CAP/ASSET	-1.558	-0.497
	(-0.83)	(-0.84)
RESRAT	-8.112**	-2.592**
	(-2.54)	(-2.60)
DELRR	-3.539	-1.130
	(-1.58)	(-1.59)
LNTOT	0.056	0.018
	(0.32)	(0.32)
STATE	-0.320	-0.098
	(-1.07)	(-1.12)
BANKBAL1884	0.551	0.176
	(0.58)	(0.58)
BANKBAL1893	1.088	0.347
	(1.22)	(1.21)
BANKBAL1907	1.963	0.626
	(1.51)	(1.52)
%ΔDEP	-1.674**	-0.535**
	(-2.51)	(-2.51)
Year 1893	0.536	0.178
	(1.34)	(1.31)
Year 1907	-0.620	-0.179
	(-1.16)	(-1.31)
CONSTANT	0.200	
	(0.08)	
Log-likelihood	-88.079	
Number of Observations	178	

* = significant at the 10% level, two-tailed test
** = significant at the 5% level, two-tailed test