The costs and benefits of liquidity regulations: Lessons from an idle monetary policy tool

Abstract

We investigate how liquidity regulations affect banks by examining a disused monetary policy tool that functions as a liquidity regulation. Our identification strategy uses a regression kink design that relies on the variation in a marginal high-quality liquid asset (HQLA) requirement around an exogenous threshold. We show that mandated increases in HQLA cause banks to reduce credit supply. Liquidity requirements also depress banks' profitability, though some of the regulatory costs are passed on to liability holders. We document a prudential benefit of liquidity requirements by showing that banks subject to a higher requirement before the financial crisis have lower odds of failure.

JEL classification: G21, G28, E51, E52, E58

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1 Introduction

The adoption of liquidity regulations in the years after the global financial crisis has had a transformative effect on financial markets and intermediaries. Unfortunately, as noted in Diamond and Kashyap (2016), the rapid implementation of liquidity requirements has run well ahead of both theory and measurement. Research has also been hindered by the near absence of pre-crisis liquidity regulation. Consequently, researchers have offered grim assessments of policymakers' current understanding of the effects of liquidity requirements (Allen and Gale, 2014).[1]

In this paper, we address the question of how banks respond to changes in liquid assets when those changes are mandated by regulation. It is unclear whether recently introduced liquidity regulations will help banks weather a financial crisis, and what costs these regulations may otherwise impose on the economy. To assess these trade-offs, we examine the effects of a *de facto* liquidity requirement that was in place in the United States in the years before the financial crisis. A reserve requirement—nominally a tool of monetary policy—functions exactly like a rudimentary version of modern liquidity regulations insofar as it requires banks to hold high-quality liquid assets (HQLA) in proportion to designated liabilities. Such an interpretation accords with the original justification for reserve requirements, which were meant to promote sufficient liquidity in the event of rapid deposit outflows (Gray, 2011; Feinman, 1993; Carlson et al., 2015).

Liquidity requirements could have unforeseen and adverse welfare effects on the real economy if banks satisfy liquidity requirements at the expense of lending. It is *a priori* unclear how banks' response to liquidity regulation might affect loan supply. Banks could comply by reducing assets, changing the composition of assets, raising capital to hold more HQLA, or changing the composition of liabilities to lower the HQLA requirement. Even if

[1]For instance, Diamond and Kashyap (2016) note their concurrence with the closing remarks of Allen and Gale (2014), who highlight the stark knowledge gap compared with other important bank regulations, stating that, "Much more research is required in this area. With capital regulation there is a huge literature but little agreement on the optimal level of requirements. With liquidity regulation, we do not even know what to argue about."

banks adjust assets to satisfy the regulation, the adjustment need not affect lending if banks simply sell ineligible securities to meet the minimum requirement.

The potential benefits of liquidity requirements are also unclear, even though the explicit purpose of the Liquidity Coverage Ratio (LCR) is to make the financial system safer. In the long run, higher liquidity buffers could boost the resiliency of the banking sector by making it easier for banks to meet liquidity needs during a crisis. Conversely, liquidity regulations might increase fragility if bank profits are negatively affected or if banks try to offset low-yielding liquid securities with riskier assets.

We find that stronger liquidity regulations reduce lending and bank profits, but significantly decreased the likelihood of failure following the financial crisis. Loans are crowded out by both HQLA that banks are required to hold and HQLA that banks voluntarily hold as a buffer above the requirement. A one percentage point increase in the HQLA requirement causes banks to reduce their loan-to-assets ratio by between 0.25 and 0.4 percentage points. This decline is almost entirely accounted for by a reduction in more information-intensive and risky lending that is not easily securitized. Banks subject to more stringent requirements also exhibit weaker loan growth over subsequent quarters. Bank profits fall in response to liquidity regulations because the drop in interest income stemming from the rotation out of loans and into HQLA is only partially offset by banks' ability to pass on the regulatory costs to their depositors through higher fees and lower yields. Finally, we find that banks subject to a higher liquidity requirement before the crisis failed at a lower rate. Just a one percentage point increase in the HQLA requirement lowered the probability of failure by 3%. The decline in the odds of failure is driven by the reduction in risky loans, the ability to readily access HQLA to raise cash, and possibly less depositor flight.

The recent introduction of the LCR, which is widely regarded as the most important new bank regulation since the financial crisis (Gorton and Muir, 2016), has sparked substantial interest in understanding the effects of liquidity regulations on the financial sector. However, there are some key advantages of looking beyond the LCR to assess the effects of liquidity regulations. For instance, the LCR has been imposed on just a handful of multinational financial institutions for only a few years, and was implemented at the same time as other new regulations and policy developments.[2] Unfortunately, the dearth of liquidity regulations in modern history makes it difficult to otherwise estimate the effects of such regulations. We overcome this obstacle by examining a long-standing cash reserve requirement imposed by the central bank that effectively acts as a liquidity regulation.

One unique and challenging feature of estimating elasticities of HQLA regulations using reserve requirements is that reserve requirements are almost never actively used in advanced economies.[3] This disuse largely stems from central banks' transition from targeting monetary aggregates to targeting short-term interest rates. Consequently, reserve requirements exist as idle tools of monetary policy that have no meaningful connection to the stance of policy.

We address this challenge to identification by employing a regression kink design. Our design exploits a kink in the marginal required reserve ratio (RRR) that changes each year according to the rate of increase in net transaction accounts (NTAs) held by all banks. Moving from below to above the threshold subjects a bank to a marginal reserve requirement that is 7 percentage points higher. Because the annual change in the threshold for the high RRR tranche is exogenous to any bank, and because banks' NTAs are heavily affected by external factors, banks cannot precisely manipulate their NTAs. Therefore, the variation in treatment around the threshold is randomized as in an experiment (Lee and Lemieux, 2010).

We contribute most directly to the nascent literature on liquidity requirements. Most of the few existing studies on the topic focus on either a pre-crisis liquidity regulation in the Netherlands (Bonner and Eijffinger, 2016; Duijm et al., 2016) or an LCR-like requirement imposed by the U.K Financial Services Authority that was later superseded by the LCR (Banerjee and Mio, 2017). We identify adverse effects on credit supply to the nonfinancial

[2]For example, the implementation of the LCR coincided with notable economic and policy developments in many countries, including massive central bank intervention. For some evidence regarding the effects of liquidity regulation on monetary policy, see Rezende et al. (2016) and Crosignani et al. (2018).

[3]Cordella et al. (2014) report that, since 2004, no central bank in an industrial country actively used reserve requirements to adjust policy.

sector, in contrast to these earlier studies that either do not speak to the outcome (Duijm et al., 2016) or find no spillover (Banerjee and Mio, 2017; Bonner and Eijffinger, 2016). Another novel aspect of our study is our test of the effect of liquidity requirements on the likelihood of failure, which is a central question concerning regulations to promote bank liquidity. We demonstrate an economically meaningful decline in the odds of failure and identify channels through which liquidity regulations reduce failure probabilities. Lastly Gorton and Muir (2016) argue that a liquidity regulation like the LCR will prompt the private production of safe assets, which can boost financial fragility. Similar to Gorton and Muir (2016), our approach appeals to a historical scenario that mimics the essential features of the proposed policy.

We also add to the literature on the effects of the required reserve ratio. While no longer relevant to modern monetary policy implementation in advanced economies (Gray, 2011), reserve requirements have garnered renewed importance for at least three reasons. First, changes in the RRR may provide a means for the Fed to exit its post-crisis "floor-like" operating regime with ample excess reserves. As in Ihrig et al. (2015) and Kim et al. (2017), raising the level of required reserves offers an avenue for the Fed to return to a scarce reserves regime. Second, if the Fed decides to continue operating with abundant reserves, minimum requirements could be abolished.[4] Third, reserve requirements have become a hindrance in banks' efforts to comply with the LCR. Required reserves are considered encumbered assets, so they are not eligible to satisfy minimum HQLA requirements in the LCR.

Many existing studies on the effects of reserve requirements on banks focus on emerging economies. Policymakers in these countries usually resort to manipulating RRRs to influence capital flows and achieve macroprudential goals (Montoro and Moreno, 2011; Tovar Mora et al., 2012; Camors et al., 2014). Park and Van Horn (2015), a notable exception, examine the monetary actions in the U.S. in the mid-1930s. Because current and expected

[4] In fact, the Financial Services Regulatory Relief Act of 2006 includes provisions for the Fed to eliminate reserve requirements altogether (Ennis and Keister, 2008), as many view the requirement as superfluous even under the previous operating framework (Fama, 1983).

developments in financial and economic conditions elicit such policy changes, exploiting this variation makes drawing causal inference challenging. Moreover, studies on less developed economies may not be informative for advanced economies. As noted in Kashyap and Stein (2012), policymakers in emerging economies may be more activist in their use of reserve requirements *precisely because of* differences in economic and financial structure relative to advanced economies.

Our analysis does not rely on policy actions. Instead, we focus on the effects of marginal changes in the static RRR schedule on banks' balance sheets, profits, and odds of failure. Required reserves play no role in monetary control in our setting, and merely exist to establish a predictable baseline level of reserve demand. The policy irrelevance of the RRR is a feature of our approach because it rules out endogeneity issues that could arise if the HQLA requirement was adjusted to pursue policy objectives.

2 Institutional Background: Reserve Requirements in the United States

Reserve requirements were introduced in the United States in the 19th century, before the formation of a central bank, as a type of microprudential bank regulation. At that time, reserve requirements mostly took the form of specified minimums for either interbank deposits or gold and legal tender, depending on the location of the bank (Carlson et al., 2015). Reserve requirements were meant to provide liquidity cover to banks in the event of short-term liability outflows that could be particularly acute during domestic panics. The formation of the Fed and the introduction of deposit insurance weakened this rationale for reserve requirements (Feinman, 1993; Gray, 2011; Carlson et al., 2015). By the 1940s, the reserve requirement came to be seen primarily as a tool of monetary control that could be used to affect monetary aggregates and possibly influence the spread between deposit and lending rates (Gray, 2011; Federal Reserve, 1931). As modern central banking practice shifted to target short-term interest rates, reserve requirements came to serve no purpose except possibly to establish a predictable level of reserve demand.[5] Consequently, regular adjustments to reserve requirements ceased, and they have not been used as a tool of monetary policy for decades (Gray, 2011; Cordella et al., 2014).

Even though the justification for required reserves has evolved over time, the policy has to this day retained the essential feature of a liquidity regulation by compelling banks to hold HQLA against specified liabilities (Bouwman, 2014). In other words, the reserve requirement is simply a rudimentary liquidity regulation that mirrors exactly the logic of the LCR. Required reserves parallel modern liquidity regulations like the LCR in a few other important ways. First, like the LCR today, banks found the reserve requirement particularly burdensome in the pre-crisis years and incurred substantial compliance costs. Second, modern liquidity regulations typically allow banks to reduce their HQLA reserves during stress events. As we explain later, reserve requirements also permit banks some leeway in meeting the minimum threshold by allowing for modest deviations from the exact required reserves target, and by demanding only that banks meet their minimum reserve requirement on average over a two-week "maintenance period." Moreover, there is some indication in the Federal Reserve Act that required reserves are meant to be drawn upon in stress events, as it states that "balances maintained to meet the reserve requirement ... may be used to satisfy liquidity requirements." Recent theoretical work (Calomiris et al., 2015; Kashyap and Stein, 2012) offers further support for the notion that cash reserve requirements can be viewed as a liquidity regulation.[6]

The implementation of reserve requirements has remained unchanged in the United States for more than 25 years. All depository institutions are subject to a reserve require-

[5]Even this justification for maintaining reserve requirements is specious, because some level of demand for reserves would exist from interbank payment, settlement, and precautionary motives (Ennis and Keister, 2008; Kashyap and Stein, 2012).

[6]In the model of Calomiris et al. (2015), cash reserve requirements are shown to not only reduce the vulnerability of banks to exogenous liquidity risks, but also promote good risk-management practices and thereby reduce insolvency risks. Kashyap and Stein (2012) explain how reserve requirements can be used by central banks to influence financial stability.

ment that is calculated by applying the reserve ratios listed in the Federal Reserve Board's Regulation D to the institution's reservable liabilities. Reservable liabilities are composed of net transaction accounts (primarily checking accounts), nonpersonal time deposits, and eurocurrency liabilities.[7] Since 1990, the reserve ratio on all but net transaction accounts (NTAs) has been zero. Reserve requirements are calculated over a 7 or 14 day period depending on the frequency with which the bank reports its transaction accounts, other deposits, and vault cash to the Fed. Each computation period is linked to a future 14 day maintenance period during which a bank must meet its requirement on average through a combination of vault cash and reserve balances held at the Fed. A small excess or deficiency at the end of each maintenance period may carry over to following periods. Nonpermissible deficiencies in required reserves are charged a fee of 2 percentage points over the discount rate, and the Fed is also authorized to impose civil money penalties.

The reserve ratio applied to NTAs depends on the amount of NTAs at the depository institution. Since the early 1980s, a reserves "exemption amount" is declared in Regulation D on which a reserve ratio of zero is applied. The exemption amount is adjusted each year by statute such that it increases by 80% of the previous year's rate of increase in total reservable liabilities at all depository institutions. No adjustment is made in the event of a decrease in such liabilities. The exemption amount is currently $16.0 million. NTAs over the exemption amount and below the "low reserve tranche" threshold are subject to an RRR of 3%. The upper limit of the low reserve tranche is adjusted each year by 80% of the previous year's rate of increase or decrease in NTAs held by all depository institutions. The low reserve tranche is currently $122.3 million. NTAs in excess of the low reserve tranche are subject to an RRR of 10%. To clearly demonstrate the dependence of the marginal RRR on a bank's NTAs, Figure 1 depicts the required reserve schedule graphically using tranche thresholds

[7]Total transaction accounts consists of demand deposits, automatic transfer service accounts, NOW accounts, share draft accounts, telephone accounts, ineligible bankers acceptances, and obligations issued by affiliates maturing in seven days or less. Net transaction accounts are total transaction accounts less amounts due from other depository institutions and less cash items in the process of collection.

for the year 2018. Figure 2 plots the evolution of the low reserve tranche cutoff over the course of our sample, which runs from 2000 to 2007.

3 Identification and Data

3.1 Regression Kink Design

Identifying causal effects of reserve requirements is challenging. Reserve requirements are scarcely, if ever, changed in many developed countries. In countries with substantial variation in the RRR, current and expected changes in financial and economic conditions drive the policy change. Moreover, these conditions, such as destabilizing capital flows, are largely unique to emerging markets.

We sidestep these issues by using a regression kink design (RKD) to estimate elasticities of bank-level outcomes with respect to HQLA requirements. Specifically, we identify off of the previously described kink in reserve requirements that occurs when banks' NTAs cross the low tranche threshold. Banks with NTAs above the (fluctuating) threshold are subject to a 10% marginal RRR, compared with 3% for those below the threshold. The RKD treatment effect relies on the presence of a kink in the relationship between the outcome variable and assignment variable (NTAs) around the kink in the required reserves schedule depicted in Figure 1. As in Card et al. (2015), the RKD estimand is given by

$$\tau = \frac{\lim_{x_0 \to 0^+} \left. \frac{dE[Y|X=x]}{dx} \right|_{x=x_0} - \lim_{x_0 \to 0^-} \left. \frac{dE[Y|X=x]}{dx} \right|_{x=x_0}}{\lim_{x_0 \to 0^+} \left. \frac{db(x)}{dx} \right|_{x=x_0} - \lim_{x_0 \to 0^-} \left. \frac{db(x)}{dx} \right|_{x=x_0}} \tag{1}$$

for outcome Y and assignment variable X, where the kink point is normalized to 0. The RKD estimand simply divides the change in the slope of the conditional expectation function for the outcome at the threshold by the change in the slope of the RRR at the threshold. We estimate a so-called "sharp" RKD because $b(x)$ is a deterministic function that assigns a marginal reserve requirement for NTAs above and below the kink such that the denominator equals 7% (10%-3%).

Despite the irrelevance and dormancy of the RRR as a monetary policy tool, the RKD technique allows us to retrieve causal estimates of the effect of HQLA requirements on any number of bank outcomes. If we observe a precisely estimated kink in the relationship between an outcome and NTAs at the policy-induced kink in the required reserve schedule, then we can conclude that there is a causal effect of HQLA requirements on the outcome.

Importantly, though, valid identification in a sharp RKD rests on a key assumption that banks cannot *precisely* control or do not intentionally manipulate their NTAs near the low tranche threshold. There are at least three reasons that this assumption is satisfied in our setting. First, as explained in Section 2, the threshold changes regularly according to factors that are well outside the control of any individual bank. Second, NTAs are out of banks' control to some extent because they are subject to the whims of depositors who decide to make deposits to or withdrawals from their checking accounts for reasons unrelated to a bank's proximity to the low tranche threshold. Third, even if banks could precisely control their NTAs to manipulate around the threshold, other considerations—such as market share, growth, or compensation schemes—are likely to outweigh any concerns about the effect of the *marginal* RRR increase.

The key assumption that the density of NTAs is smooth for banks produces testable implications (Card et al., 2015). Specifically, we can look for evidence that there is manipulation relative to the threshold by plotting the distribution of banks against NTAs. If the distribution of banks is smooth across the low tranche threshold, then there is no evidence that the key identifying assumption is violated. The "smoothness condition" implies that the conditional distributions of predetermined bank characteristics should not exhibit a kink with respect to NTAs at the cutoff. This implication can also be tested by plotting relevant covariates against NTAs. Though the assumptions for valid RKD are relatively weak (Card et al., 2015), they are slightly stronger than the conditions required for a valid regression discontinuity design (Lee and Lemieux, 2010) because they require that the *derivatives* of the conditional expectation functions of covariates with respect to the assignment variable are continuous at the kink point. We verify that there is no evidence that these assumptions are violated in the following subsection after describing the data.

3.2 Data and Tests of Identifying Assumptions

We collect data on bank reserves from the confidential form FR2900, which commercial banks and thrifts file with the Federal Reserve. Filing institutions are required to report totals for different classes of reservable and nonreservale accounts, including transaction accounts, savings deposits, and time deposits. Required reserve ratios are applied to these totals as appropriate to calculate each institution's reserve requirement. The required reserve balance that a bank must maintain at the Federal Reserve is determined by subtracting any applied vault cash—also reported on the FR2900—from the reserve requirement. Institutions file the FR2900 at either a weekly or quarterly frequency. Some banks that fall below the exempt cutoff for required reserves (see Figure 1) and do not exceed a maximum deposits threshold are permitted to file an alternate reporting form on an annual basis. Our focus is on banks in the neighborhood of the low tranche threshold, so these annual filers are irrelevant.

We use these data to determine the NTAs for all banks for every maintenance period from 2000 through 2007. For institutions that file the FR2900 on a weekly basis, we take the quarterly average of the NTAs. Merging institutions are subject to adjustments to reserve requirements that can lead to a different required reserve ratio than that implied by the NTA value reported on the FR2900. Therefore, we drop any merging banks from our sample in the year of the merger only. Finally, we merge these data with the Call Reports and the Thrift Financial Reports to obtain quarterly information on banks' balance sheet and income items. As reported in Table 1, the median bank in a sample around the kink is larger than the median of all operating banks. However, the severe right-skew of the bank size distribution in the United States results in a notably smaller average bank size.

Nevertheless, the 75th percentile is comparable to the unrestricted sample, and the largest banks in the neighborhood of the threshold are still quite large ($25.4 and $68.5 billion in 2000 and 2007, respectively).

We first use our merged dataset to confirm that banks increase HQLA as a result of the reserve requirements. Although our interest is in the deterministic reserve requirement *per se*, it is useful to verify that banks' reserves-to-assets ratios do indeed increase around the kink in the policy rule. Figure 3 plots banks' reserves-to-assets ratios around the cutoff (normalized to zero), revealing a clear increase in banks' holdings of the regulated HQLA.

As described in subsection 3.2, the key identifying assumption for the sharp RKD is that the density of the assignment variable is sufficiently smooth for the banks in our sample. Figure 4 demonstrates that this assumption is not violated because there is no discontinuity in the density of banks near the kink in the RRR schedule. The p-value of the McCrary (2008) test statistic, reported in the inset boxes of the figures, confirms the visual result that there is no evidence of manipulation by banks.

Further, if the distribution of banks around the cutoff is indeed random, then predetermined variables should similarly be free of kinks (Card et al., 2015). Though the smooth distribution of banks in the neighborhood of the cutoff implies the continuity of predetermined characteristics, we confirm this feature of the data. Figure 5 shows that there are no discernible discontinuities in banks' age, lagged size, or lagged capital adequacy around the threshold. Moreover, the composition of bank charter types, shown in panel (d), evolves smoothly across the threshold. In all cases, we observe no evidence that banks are not randomly assigned in the neighborhood of the low tranche threshold.

Banks could conceivably manipulate their NTAs by "sweeping" customers' reservable accounts to nonreservable accounts like money market deposit accounts. However, we have already seen that there is a smooth distribution of banks around the kink point, and in fact banks' ability to precisely manipulate sweeping activity is limited for a few reasons. First, establishing sweep programs requires some minimum technical expertise and resource commitment. Banks near the threshold tend to be somewhat smaller institutions, which limits the prevalence of sweep programs. Second, there are constraints to banks' ability to fine tune their sweeping activity conditional on having a sweep program. For instance, customers must agree to sweep arrangements, which include the creation of an additional account and a specified limit on sweeping activity. In addition, rules based on depositor activity limit banks' ability to classify customer accounts, and in some cases sweep arrangements can be subject to a maximum number of "sweeps" per month.[8] However, it is possible to examine the distribution of sweeping institutions around the kink by using confidential data on sweeping activity that banks submit to the Fed. Figure 6 plots a histogram of banks near the threshold along with the number of banks that have an active sweep program during our sample. Few institutions around the threshold have a sweep program, and there is no difference in the incidence of sweep programs around the kink point. Thus, Figure 6 is also consistent with the assumption that predetermined characteristics of banks evolve smoothly around the kink.

4 The Effects of an Increase in the HQLA Requirement

4.1 Balance Sheet and Income Effects

Turning now to the effect of the required reserves policy, we estimate treatment effects, $\hat{\tau}$, as follows:

$$\hat{\tau} = \frac{\lim_{NTA \to 0^+} y'(NTA) - \lim_{NTA \to 0^-} y'(NTA)}{10 - 3}. \tag{2}$$

We use standard nonparametric local polynomial regressions to estimate the derivatives of the conditional expectation function on either side of the kink point. The kink in the required reserve ratio is normalized each quarter at $NTA = 0$. Following the findings and recommendations in Calonico et al. (2014) and Gelman and Imbens (2018), we avoid inference based on high order polynomials and estimate local polynomials of order one (local linear)

[8] See, the regulatory reporting guidance in the Board of Governors' Instructions for Preparation of Form FR-2900 and the Federal Reserve's Regulation D.

and two (local quadratic). We use the data-driven bandwidth selector proposed by Calonico et al. (2014) to obtain an appropriate sample around the kink in each regression, and we cluster errors at the bank level. The difference in the estimated slopes of the conditional expectation functions is normalized by the sharp "first stage" kink in the policy rule (10%-3%). Thus, our results can be interpreted as the change in the outcome for a 1 percentage point increase in the HQLA requirement.

Our first result, reported on the left of Table 2, shows that banks boost holdings of Treasuries and MBS backed by government agencies. Along with reserves, these assets compose the vast majority of banks' "Level 1" HQLA that is most highly valued under the LCR. This result indicates that banks do not simply exchange other liquid assets for those that satisfy the HQLA requirement even though they are close substitutes. Such behavior accords with a commonly observed "buffer stock" reaction by banks to regulations. Specifically, banks often maintain a buffer over regulatory minimums, a fact that has been well documented for capital requirements. Evidence from other settings indicates that banks aim for liquidity targets above regulatory minimums, which are viewed as a floor that should not be breached (Stein, 2013; Carlson et al., 2015; Bonner and Eijffinger, 2016), and it can also explain why banks are currently maintaining LCRs that are on average around 20% above the minimums.[9] During our sample, reserves were unremunerated by the Fed, and banks therefore faced strong pressure to avoid superfluous reserve balances. However, highly liquid securities backed by the government or a government agency earn interest and can be sold at any moment, making them as good as reserves *at a maintenance period horizon.* A bank that needs to boost reserve balances to meet a reserve requirement can easily sell these securities within the maintenance period, and in this sense, liquid securities can compose a bank's buffer stock. Therefore, as the marginal liquidity requirement increases beyond the kink point, banks' buffer liquidity stock will see a concomitant increase. Because of the institutional details of our setting, this buffer liquidity stock manifests in liquid securities even

[9]Even though the LCR regulation is written to soften in the event of a stress events, banks are evidently reluctant to ever let their LCR fall below parity.

though these assets are not directly eligible to satisfy the regulatory requirement. The point estimates imply that, for a 7 percentage point increase in the cash reserve requirement, a bank's ratio of liquid securities to assets increases by between 1 (0.14×7) and 1.3 (0.19×7) percentage points. This effect is economically meaningful, particularly when taking into consideration that the reserve requirement is calculated using *NTAs* and the outcome is measured as a percentage of *assets*.

The next key result in Table 2 concerns the loan to asset ratio. Banks' increased demand for HQLA—including reserves and cash as shown in Section 3.2 and liquid government-backed securities—evidently comes at the expense of balance sheet space devoted to lending. For every 1 percentage point increase in the HQLA requirement, banks' loan to asset ratio falls by between 0.24% and 0.40% on average, which is economically significant. The columns on the right of Table 2 decompose the reduction in lending share. Evidently, banks do not substitute out of residential real estate lending as the liquidity requirement increases. This finding may reflect the liquidity value of this category of lending, as even nonconforming single family mortgages could be sold to securitizers relatively easily during our sample period. This reasoning is consistent with the findings of Loutskina (2011), who shows that banks treat easily securitizable portfolio loans as a source of liquidity. Instead, banks substitute out of more information-intensive commercial loans, which present greater adverse selection issues.

We next test whether liquidity requirements constrain lending in a predictive sense by examining the effects of HQLA requirements on loan *growth*. We plot the RKD estimate for loan growth at increasing forward horizons in Figure 7. According to these estimates, just a 1 percentage point increase in the RRR lowers loan growth by 0.06% one quarter ahead. The full longer-run effect of roughly 0.13% that we observe at a one-year horizon appears to be fully realized after just six months. This is economically significant. For example, grossing the six month effect up using the full 7 percentage point change in the RRR implies that loan growth is 0.9% slower, which equals roughly 20% of average two-quarter loan growth.

These results accord with the prediction of the Duffie and Krishnamurthy (2016) model, in which a binding liquidity regulation leads banks to reduce demand for assets that are the least similar to those that are eligible to satisfy the requirement. As we observed, banks are prone to substitute away from assets with the least liquidity value in response to an increase in a cash requirement. The results are also consistent with Kashyap and Stein (2012), wherein reserve requirements decrease the equilibrium amount of loans.

Turning to the effect of higher liquidity requirements on bank funding, we find some evidence that banks shift to nonreservable liabilities that are treated more favorably under the regulation, as reported in Table 3. Such a result is consistent with a main finding in Duijm et al. (2016), although we notably do not observe that the adjustment to the liquidity regulation is skewed towards the liability side, as is the case in Duijm et al. (2016). Leverage ratios appear to be largely unaffected by higher reserve requirements.

One potential concern about liquidity requirements is that banks could simply pass on the costs of the regulation to depositors. Of course, such an outcome could also be a desired result of a liquidity requirement if a goal is to tax a socially costly liability (Kashyap and Stein, 2012). In Table 4, we show that the net yield that banks pay to their depositors falls as the tax on these liabilities increases. Depending on the specification, the net deposit yield—calculated as interest on deposits minus charges on deposit accounts divided by total deposits—falls between 1 and 1.65 basis points for a 1% increase in the HQLA requirement. Using the average federal funds rate of 3.45% during our sample, the marginal tax increase on deposits owing to reserve requirements is about 24 basis points. Comparing this result with our upper estimate of the pass through of 11.6 basis points ($7 \times 0.0165\%$) suggests that the pass through to depositors is far from complete.

Lastly, we examine the effect on bank profits. By forcing banks to hold more low-yielding assets, one concern is that liquidity requirements will impair profits and retained earnings. Because negative profit shocks can adversely affect loan supply (Van den Heuvel, 2002; Brunnermeier and Koby, 2018), any deleterious effect of the liquidity requirement could at least partially explain the lending results seen earlier. We report the results for banks' net interest margins (NIMs) in Table 4. We find that a 1 percentage point increase in the RRR reduces banks' NIMs by between 0.6 and 0.9 basis points on average. Given the average NIM of roughly 375 basis points, this effect is relatively modest, even when taking into account a 7 percentage point increase in the RRR. Decomposing the NIM into the interest income and interest expense components (not shown) confirms that the loss of interest income swamps banks' ability to recapture some of the increased regulatory cost from depositors. In the final columns of Table 4, we find that the effect on banks' pre-tax return on assets also points to adverse effects of liquidity requirements on profits. Here, the effects are somewhat larger than those on NIM in percentage terms, with a 7 percentage point increase in the RRR implying a 4% reduction in ROA. Taking into account the narrow liability base applied here suggests that broader liquidity regulations could substantially impair profitability. Conversely, when measured per unit of required HQLA, the profit effects observed here may be greater than those induced by a liquidity regulation that, like the LCR, can be satisfied with remunerated reserves or interest-bearing government-backed securities. In this sense, the obligation to hold unremunerated reserves in our setting magnifies the effect on interest income. Notwithstanding this qualification of the results, the evidence supports the concern that liquidity regulations squeeze bank profits.

The key results are displayed graphically in Figure 8 using binned averages for banks on either side of the cutoff, as encouraged by Lee and Lemieux (2010). For comparability across panels, we use a constant $15 million bandwidth around the kink point, and overlay the linear estimate of the relationship between each outcome and the assignment variable based on the data. All of the effects of the HQLA requirement are clear when comparing the slopes of the outcome variables to the right and left of the kink point.

In Appendix A, we examine the external validity of our results. Specifically, we use a differences-in-differences method to estimate bank-level outcomes that followed the elimination of reserve requirements on nontransaction accounts in 1990. Even though this exercise uses a much earlier sample period, considers all banks, and relies on a change in the tax on a different liability, we achieve consistent results. In particular, we find a similar effect in that banks responded to a cut in the HQLA requirement by reducing liquidity buffers and boosting credit supply, which led to an expansion of net interest margins.

In Appendix B, we perform placebo tests that use the low reserves threshold minus $30 million as a hypothetical kink in the RRR schedule. Despite the larger sample size, we observe no statistically or economically significant results when using this threshold with the exception of ROA, which has the opposite sign. Finally, we demonstrate that the results are not sensitive to the use of a different bandwidth selector.

4.2 Effects on the Probability of Failure

Because our sample ends in 2007, just before a wave of bank failures, we are able to test the effects of an HQLA requirement on banks' ability to survive the financial crisis and recession. Additionally, we can investigate possible channels through which liquidity requirements affect the probability of failure.

We begin by limiting our sample to the third quarter of 2007, which is the last quarter before the start of the recession. Our outcome variables are forward looking so that we measure banks' performance after the recession and crisis began. Otherwise, the analysis that follows uses the same RKD techniques described in the previous subsection.

To test the effect of a higher liquidity requirement on failure, we create a dummy variable that equals one if a bank failed between 2008 and 2010. During these years, 322 financial institutions failed in the U.S. For context, 322 institutions represented nearly 4% of FDIC-insured banks as of 2007Q3.

Table 5 reports the results using the failure indicator as the outcome variable. The results imply that a 1 percentage point increase in the RRR reduced the probability of failure by between 0.12 and 0.17 percentage points. These estimates imply that a 7 percentage point increase in required reserves would lower a bank's failure probability by roughly *one-fourth* of the unconditional failure rate. This outcome is consistent with the predictions in the model of Calomiris et al. (2015), in which a liquidity requirement can be used as a microprudential regulatory tool that will limit default risk.

A liquidity requirement and the concomitant buildup in liquidity buffers could lower the odds of failure via several channels. First, as explained in Section 4.1, liquidity requirements induce banks to favor more liquid assets, and we observe a shift away from riskier types of commercial lending that have been repeatedly shown to strongly predict bank failures over this period.

A second possible channel works through depositor withdrawals. A worse liquidity position could cause some depositors to flee. Such a funding loss could boost banks' funding costs or touch off other adverse scenarios. Therefore, we test the effect of higher cash requirements on the change in banks' ratio of brokered deposits to total liabilities, measured from 2007Q3 to 2008Q3.[10] As shown in the columns on the left side of Table 6, we find some evidence that banks with lower liquidity requirements saw larger declines in the flightiest deposits. Because many banks around the low tranche threshold do not solicit brokered deposits, we estimate the effects for both the full sample as well as the sub-sample of banks that witnessed any change in brokered deposits over the period. In the final row of the table, we report the average ratio for the relevant sample to provide context for the magnitudes of the point estimates (with the caveat that the treatment effects are still reported for a 1 percentage point increase in the RRR).

A final possible channel relates to the need for banks to raise liquidity during a crisis. A better liquidity position allows banks to meet liquidity needs without resorting to selling distressed securities. In fact, to the extent that banks facing a higher reserve requirement built liquidity buffers with Treasury and Agency debt, "flight to safety" dynamics could even *increase* the value of their securities portfolio. In contrast, banks in worse liquidity positions

[10] Although point estimates are somewhat smaller in most cases, extending the window to 2009Q3 generates identical conclusions. We select 2008Q3 because it corresponds to the peak of the financial crisis, and this horizon does not suffer from as much survivorship bias. Of the 322 failed institutions between 2008 and 2010, only 4% failed by the end of 2008Q3.

would possibly need to resort to drawing down on securities that witness substantial price declines because of fire sales.

To test this final channel, we measure the change in banks' ratio of privately-issued MBS and ABS as a share of total securities. As predicted, banks that face a lower cash reserve requirement experienced larger reductions in private asset backed securities during the time that these securities faced the most valuation pressures. As before, we also test this hypothesis using the sub-sample of banks that held any private ABS. Private ABS are held by even fewer banks than those that use brokered deposits, so the effective sample size is quite low. Nevertheless, statistically and economically significant effects are observed in all cases. This result is in agreement with the Cornett et al. (2011) finding that banks entering the crisis with less liquidity decreased lending and private ABS relative to HQLA in order to build cash buffers. In our case, the variation in pre-crisis liquidity stems from banks' NTA position relative to the low-tranche cutoff in mid-2007.

As before, we report the results of placebo and robustness tests in Appendix B. The only notable difference is that result for brokered deposits using an alternate bandwidth is noisier and does not achieve statistical significance. We find consistent and even statistically stronger effects in the robustness tests for the probability of failure and the change in the share of private ABS. Placebo tests using a hypothetical kink point yield null results.

In total, we find support for the notion that liquidity requirements reduce the likelihood of bank failures. The reduction in failure probabilities is evidently driven by at least three channels. First, banks subject to more stringent liquidity requirements disfavor risky loans that have little liquidity value. Second, we find some evidence that depositors are more likely to abandon a bank with a poor liquidity profile. Third, banks with a wider liquidity buffer can raise cash using HQLA rather than having to rely on distressed assets such as private asset-backed securities.

5 Conclusion

In this paper, we offer evidence on the costs and benefits of liquidity regulations by examining reserve requirements, which are a long-standing but idle monetary policy tool. Reserve requirements are functionally equivalent to liquidity requirements insofar as they compel banks to hold HQLA against specified liabilities. Because reserve requirements have fallen into disuse as a policy tool, we can be sure that we do not identify off of variation that is endogenous to current or expected economic and financial conditions. Instead, we rely on marginal increases in the reserve requirement schedule and a regression kink design to obtain causal elasticities.

We find that banks build up a buffer of HQLA over and above the regulatory requirement, and that the increase in HQLA comes at the expense of lending, with the least liquid types of loans decreasing the most. Further, we find that banks pass on some of the regulatory cost to depositors, but that this pass-through is incomplete and is swamped by the reduction in interest income owing to the rotation from loans to HQLA. Consequently, liquidity requirements cause banks' profitability, as measured by NIMs and ROA, to contract. We confirm the external validity of these results using a quasi-experimental decrease in reserve requirements a decade before our main sample period.

Although liquidity requirements restrain credit supply, we demonstrate a benefit of such regulations by documenting an economically meaningful effect on the probability of failure. We identify three channels through which liquidity regulations and the associated build-up of liquidity buffers reduce the odds of failure. First, banks subject to more stringent liquidity requirements hold fewer illiquid and possibly risky commercial loans. Second, flighty depositors are more likely to flee banks with worse liquidity positions. Third, banks that hold more HQLA are less likely to use distressed securities to raise cash, and the value of their HQLA can increase during a crisis following a flight to safety.

Thus, we are able to inform the debate surrounding liquidity requirements while avoiding some limitations and issues posed by attempting to estimate the effects of the LCR. Our results offer a unique perspective on the effects of liquidity regulations by demonstrating how mid-sized banks respond to HQLA requirements. As liquidity regulations are expanded in advanced economies, our empirical assessment sheds a new light on their effects.

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Appendix

Appendix A External Validity: Evidence from a Cut in the RRR

We now turn to the question of whether the results obtained in Section 4.1, which are local to banks around the RRR kink in the 2000s, can be generalized to other banks and other time periods. To address this question, we examine the effects of a change in the RRR that was announced at the end of 1990. Beginning with the first maintenance period of 1991, the reserve requirement on nontransaction liabilities—Eurocurrency liabilities and nonpersonal time and savings deposits—was reduced from 3% to 0%.[11] This change in reserve requirements represented the first significant change since the Monetary Control Act in 1980, when all depository institutions became subject to reserve requirements (Feinman, 1993). A key motivation for this cut in the RRR on nontransaction accounts stemmed from a recognition that an operating procedure no longer aimed at controlling the M1 money supply did not require tight management of reserves (Feinman, 1993).

The 1990 cut in reserve requirements on nontransaction accounts presents a substantially different setting to check the external validity of our main results. The reserve requirement applied to all banks rather than just those around the kink in the RRR schedule, and the sample period is well removed from our main analysis. Furthermore, the taxed liabilities are different than those in our main analysis, and sweeping was far less common during this time. Even though the effects of such a small change in the reserve requirement may be difficult to detect, the larger sample size can increase the power of our tests and potentially reveal whether banks respond in a manner similar to that identified above.

We use a differences-in-differences empirical design to estimate the effects of this policy change. Rather than sorting banks into separate "treatment" and "control" groups, we construct a continuous treatment measure that is defined as the share of reservable non-transaction accounts to total liabilities, and we specify the regression as follows:

$$y_{it} = \alpha + \gamma_i + \delta_{st} + \beta \cdot \left(\frac{non - TA_{i,1990Q3}}{Liabilities_{i,1990Q3}} \times D_{\text{Post}} \right) + \boldsymbol{\Phi}'(\boldsymbol{X_{i,1990Q3}} \cdot D_{\text{Post}}) + \varepsilon_{it}. \quad (3)$$

[11] For weekly filers, the requirement was first reduced to 1.5% for the last maintenance period in 1990.

In equation 3, we include fixed effects for each bank i and, optionally, bank characteristics ($\boldsymbol{X_{i,1990Q3}}$) just before the policy change interacted with a dummy for the post period. The bank-level controls allow for outcomes in the post period to vary according to differences between banks. We also include state-time fixed effects (δ_{st}) to account for the fact that our sample period—Q1 1989 through Q1 1992—spans a period before the liberalization of interstate branching in 1994.[12] Errors are clustered at the bank level. Summary statistics for banks above and below the median value of the treatment variable (10.9%) are reported in Table A1.

We next turn to results for the same outcome variables used in the RKD analysis beginning with Table A2. In the leftmost columns, we see that banks' liquid securities buffer is drawn down following the relaxation of the HQLA requirement. The point estimates imply that moving from the 25th to 75th percentile of the treatment variable was associated with a decrease in liquid securities as a percentage of assets of 0.3 percentage points after the policy change. As before, banks evidently expand their loan shares following the relaxation in required reserves and reduction in their liquidity buffer. Unlike in the 2000s, however, we find that residential mortgages compose some of this expansion in lending. This difference may not be surprising when considering that the liquidity characteristics of these loans were different than in the 2000s, when the MBS market was much larger and securitization activity was robust. The final two columns of Table A2 demonstrate that loan growth picked up for banks that were more exposed to the cut in reserve requirements.

Table A3 reports the results for net deposit yield, NIM, and return on assets. In contrast to the main results, we do not observe a clear relationship to net deposit yield. The coefficient estimate on NIM takes on the expected sign and achieves statistical significance. The economic significance, however, is small, as moving from the 25th to 75th percentile of the treatment variable is associated with an increase in NIM of about 1 basis point. The final two columns of Table A3 shows that the 3 percentage point reduction in reserve requirements

[12]We end the post period sample in Q1 1992 to avoid overlap with the only other significant change in reserve requirements since 1980: a change in the high tranche RRR from 12% to 10% in April 1992.

on nontransaction accounts had an effect on return on assets that is inconsistent with the other results.

Appendix B Placebo and Robustness Tests

In this appendix, we test the sensitivity of our results to the use of an alternate bandwidth selector. In the first column beneath each dependent variable in Table B1, we report the results using an alternate bandwidth selector that uses one common MSE-optimal bandwidth for the sum of the regression estimates rather than the difference (Calonico et al., 2014). The only noteworthy difference with the main results is the lack of statistical significance for the coefficient on the change in brokered deposits during the crisis. However, the point estimate remains directionally consistent with our main findings. For brevity, we only report the results using a local linear regressions, but conclusions are identical when using second-order local polynomial regressions to estimate the slopes.

In the second column beneath each dependent variable in Table B1, we report the local linear estimates of the kink around a hypothetical cutoff that is located $30 million below the low tranche threshold. We report the results for a placebo kink point to the left of the true kink point so that the effective number of observations will increase. This ensures that any lack of statistical significance in our results does not stem merely from a reduction in the sample size. Selecting an alternate kink point that is well below the low tranche threshold also helps ensure that the sample does not span the low tranche threshold. We find a null result in virtually every case. The lone exception is for ROA, which takes on an opposite sign to that reported in the main text. These conclusions are not sensitive to using a local quadratic regression to estimate the slopes or to selecting an alternate placebo kink.

Figures

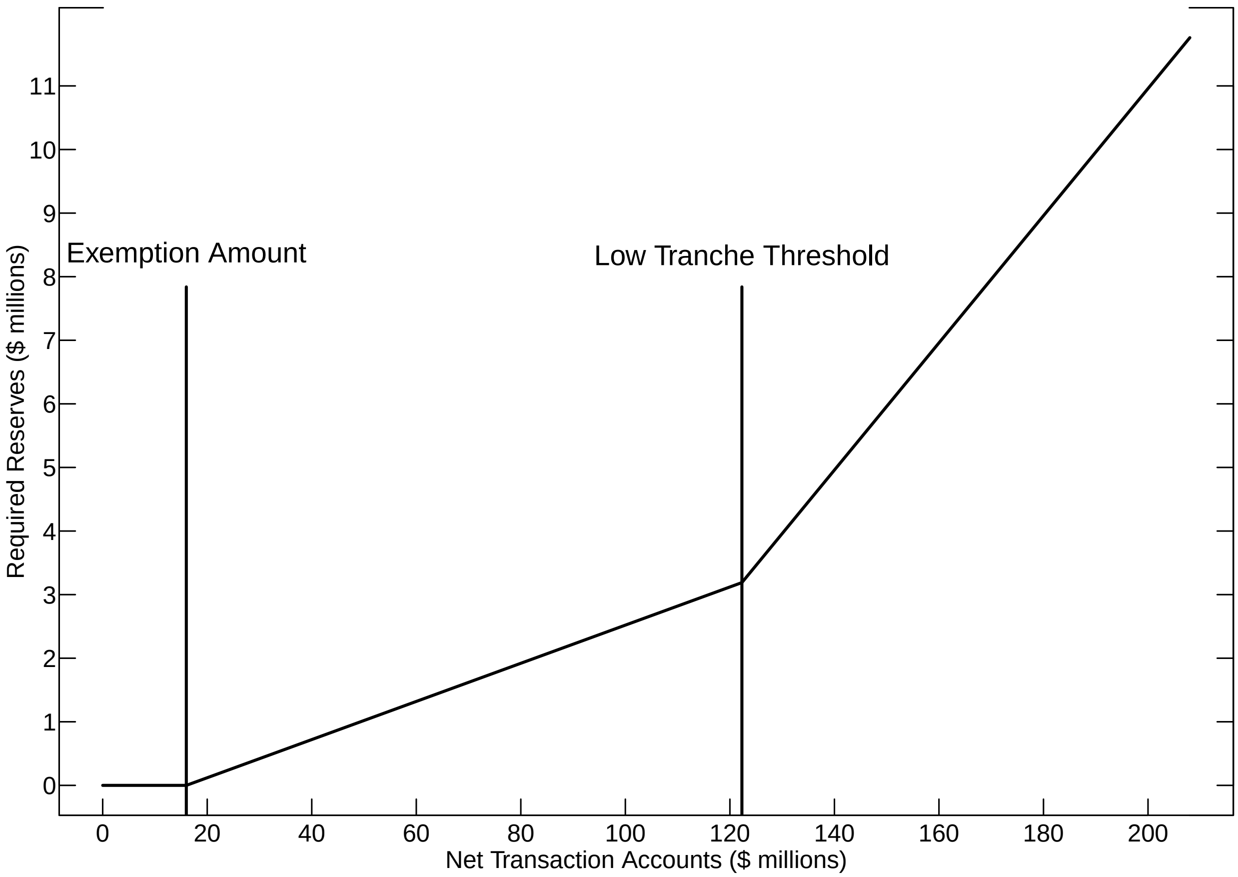


Figure 1: **Schedule of Reserve Requirements (2018 Thresholds)**
This figure shows the required reserve schedule based on 2018 threshold values. The reserve requirement on NTAs is zero up to the exemption amount, and 3% up to the low tranche threshold. The marginal required reserve ratio on NTAs beyond the low tranche threshold is 10%. Source: Federal Reserve Board of Governors.

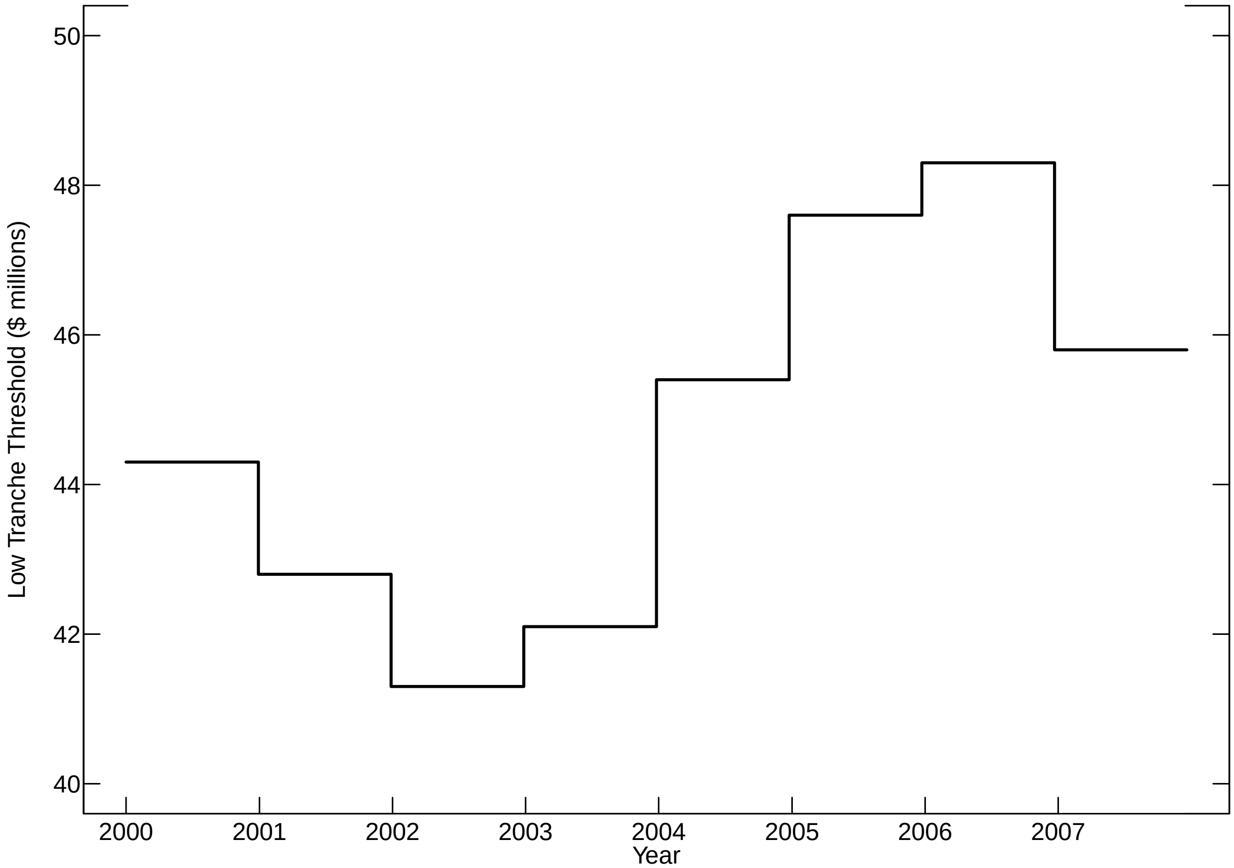


Figure 2: **Low Tranche Threshold over Time**
This figure shows the adjustments in the low tranche threshold over the course of our sample. The low tranche threshold is adjusted each year by 80% of the previous year's (June 30 to June 30) rate of increase or decrease in net transaction accounts held by all depository institutions. Source: Federal Reserve Board of Governors.

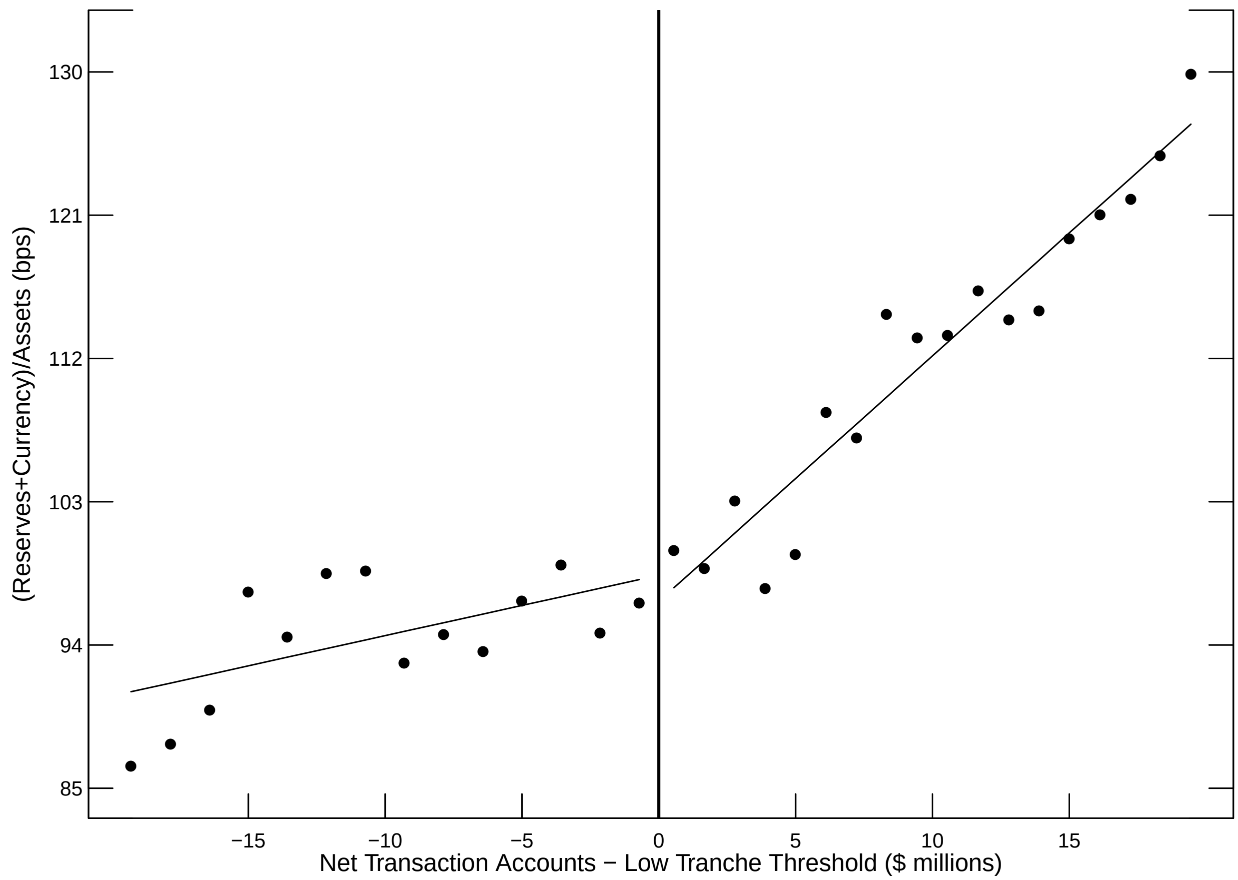
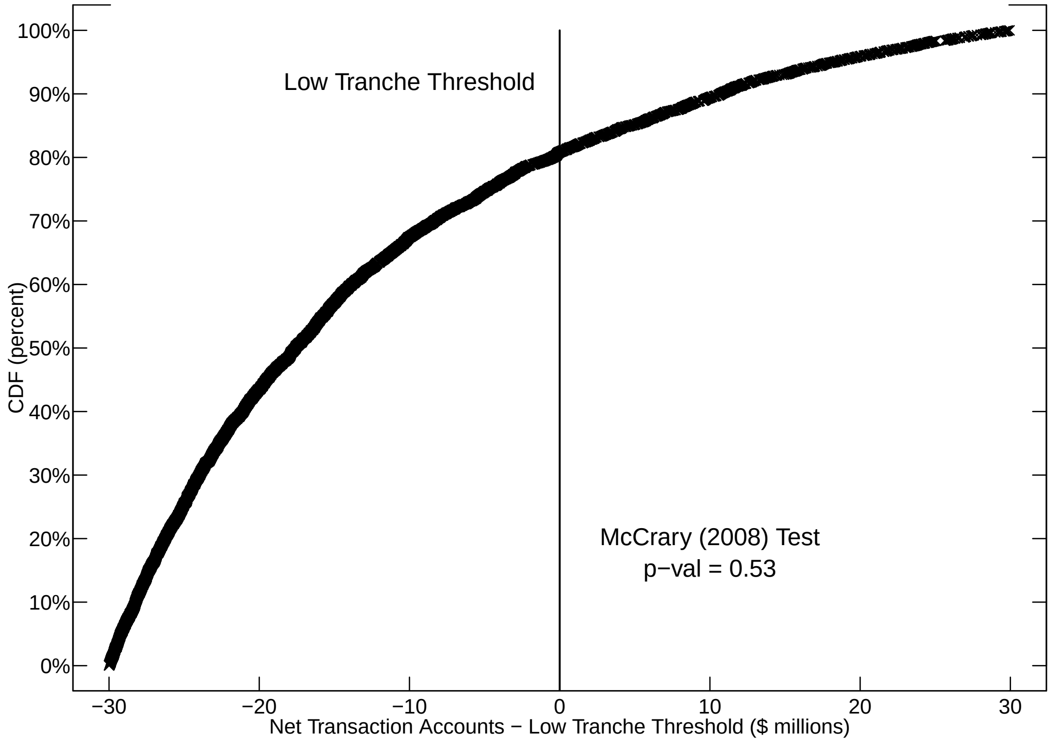
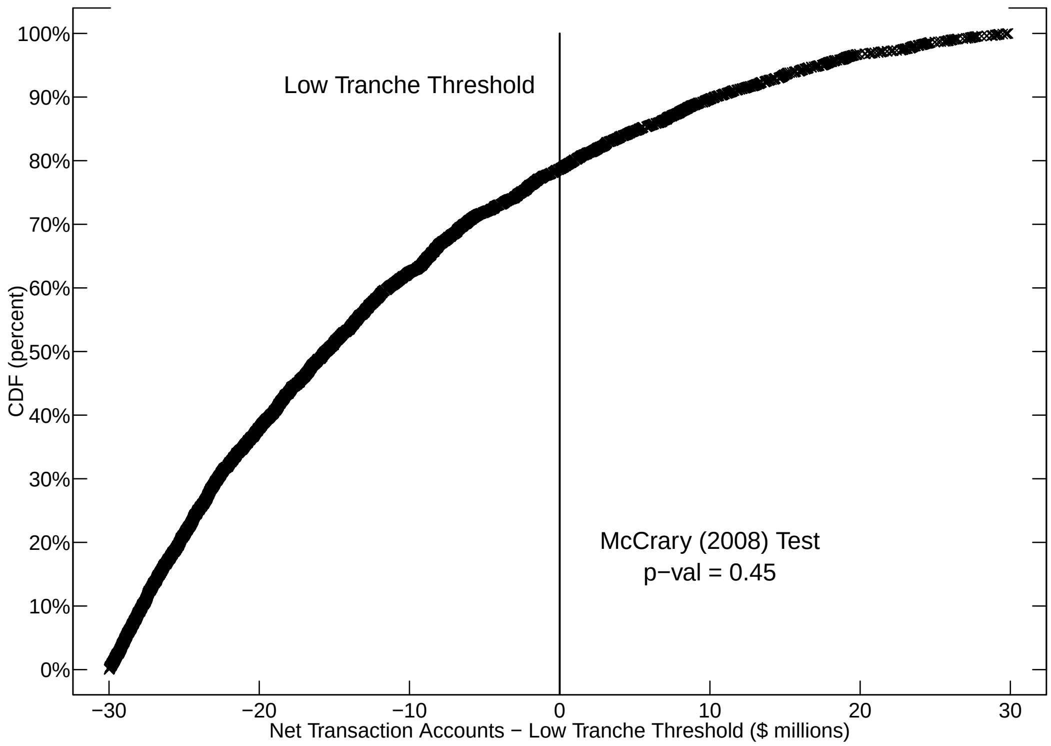


Figure 3: **Reserves and currency to total asset (2000-2007).**
This figure shows binned averages of banks' reserves and currency holdings as a share of total assets around the low tranche threshold. The low tranche threshold is normalized to zero in each time period.

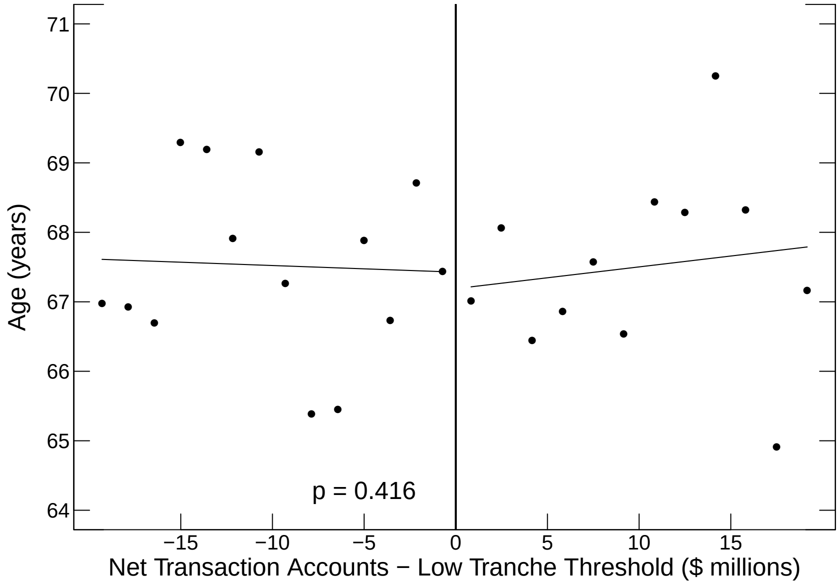


(a) 2000:Q1

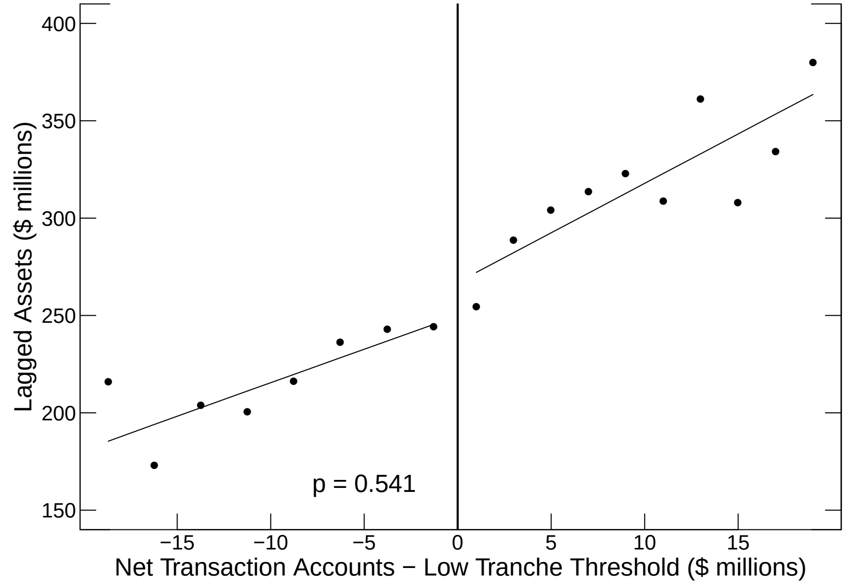


(b) 2007:Q1

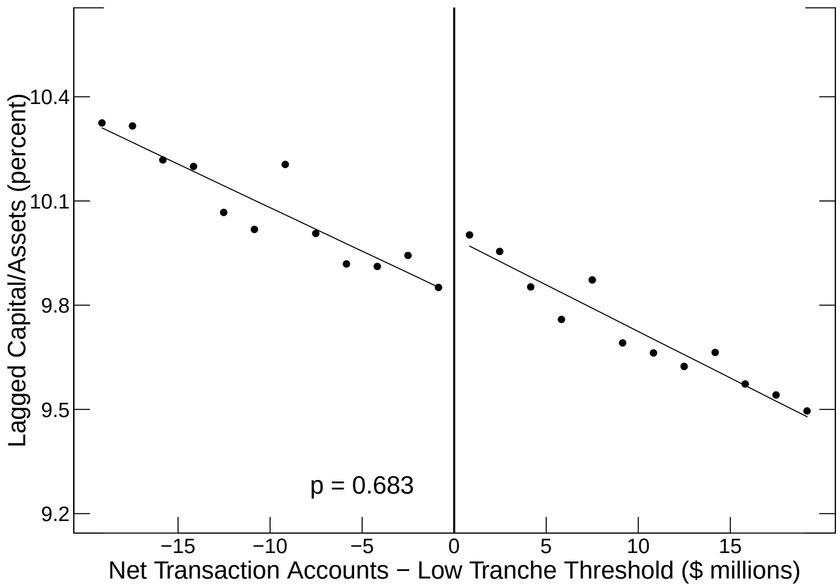
Figure 4: **Cumulative Distribution of Banks by NTA Assignment Variable.** This figure plots each bank in the sample in 2000:Q1 (panel a) and 2007:Q1 (panel b) within $30 million of the low tranche threshold. The p-value of the McCrary (2008) test statistic with a null hypothesis of no manipulation is reported in each panel.



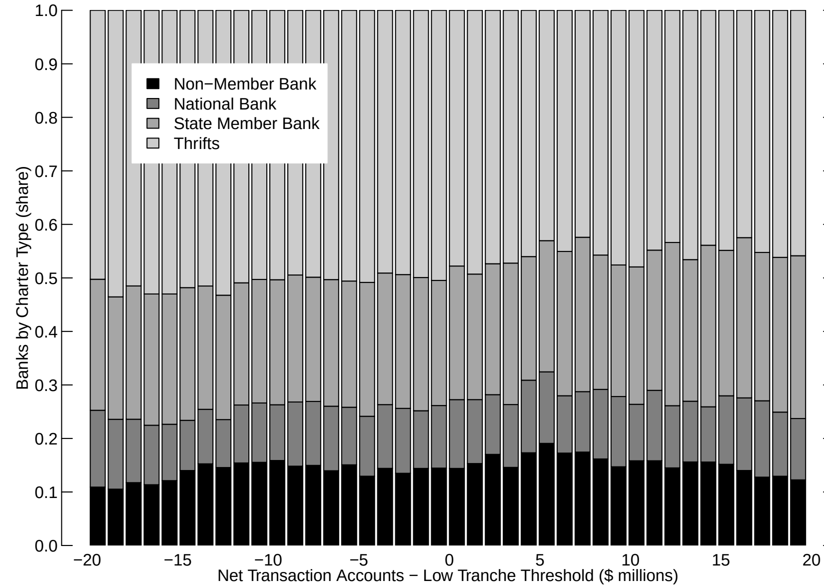
(a) Bank Age



(b) Lagged Assets

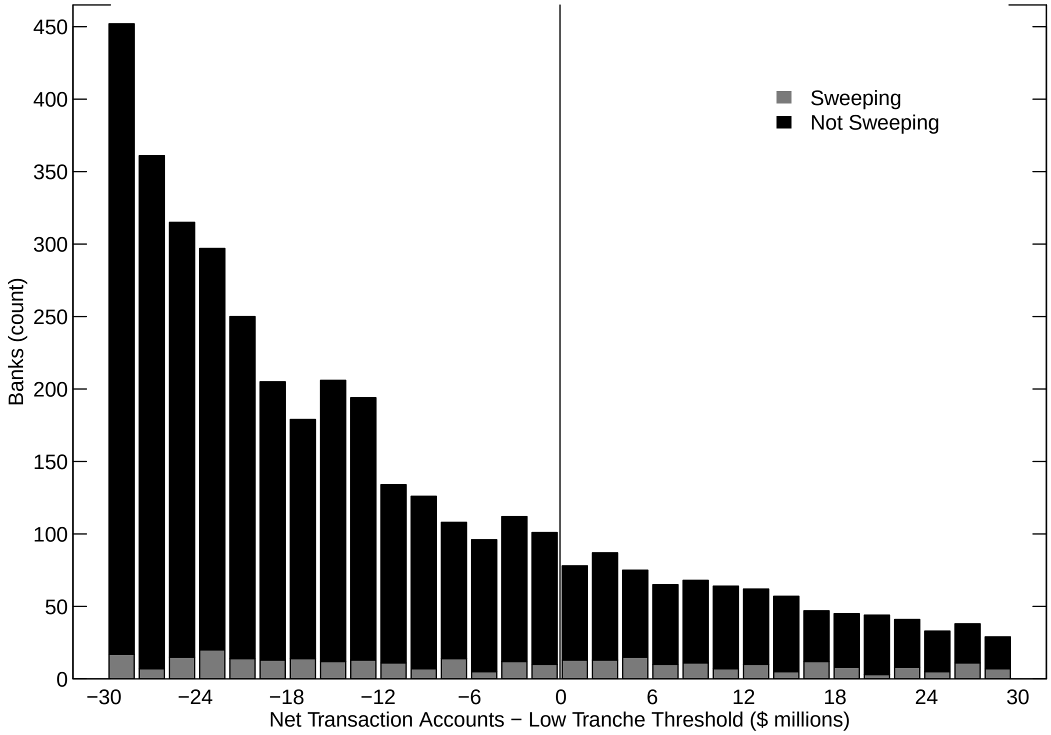


(c) Lagged Capital Ratio

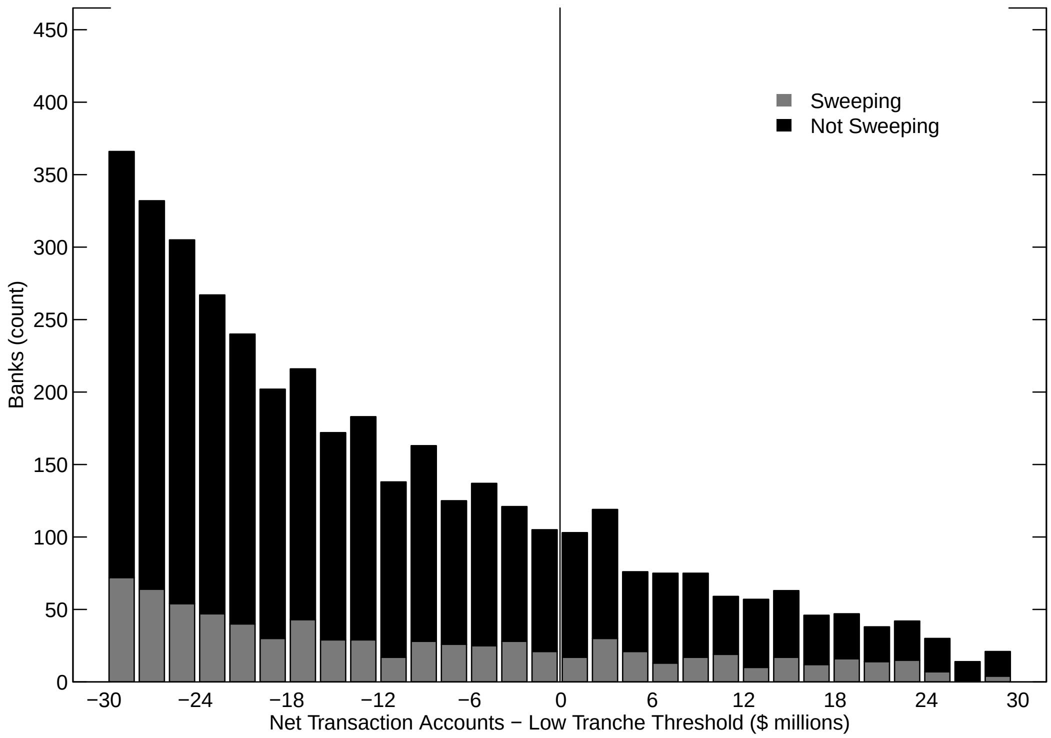


(d) Charter Shares

Figure 5: **Predetermined Variables Around the Low Tranche Threshold.**
This figure shows predetermined variables in bins around the low tranche threshold. Panels (a)-(c) plot the averages of banks in bins around the low tranche threshold. P-values of a test with a null hypothesis that the slopes are equal are listed in each chart. Panel (d) depicts the composition of charter authorization types for banks around the low tranche threshold.



(a) 2000



(b) 2007

Figure 6: **Distribution of Sweeping Banks Around the Low Tranche Threshold.** This figure shows the histogram of banks around the low tranche threshold in 2000 (panel a) and 2007 (panel b). Banks with active sweep programs are identified via confidential data reported to the Fed and are shown in light gray.

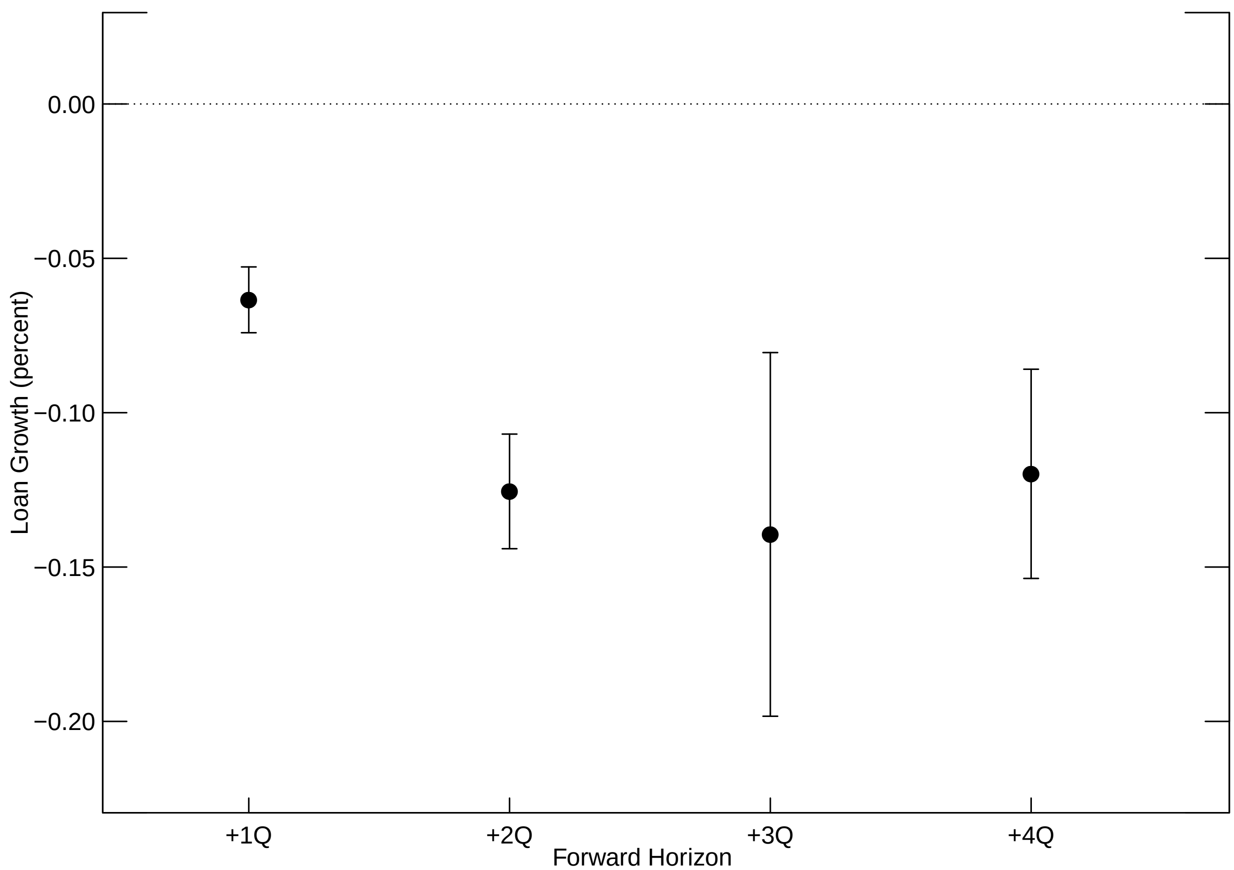
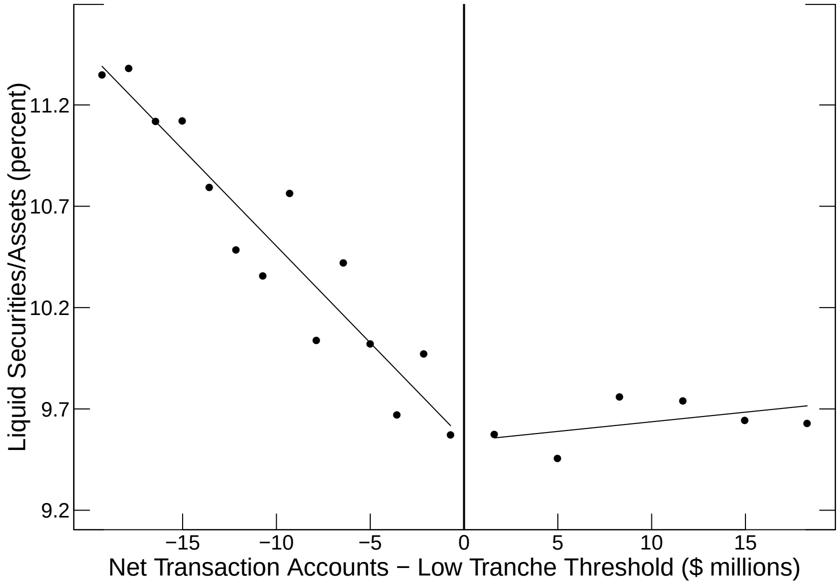
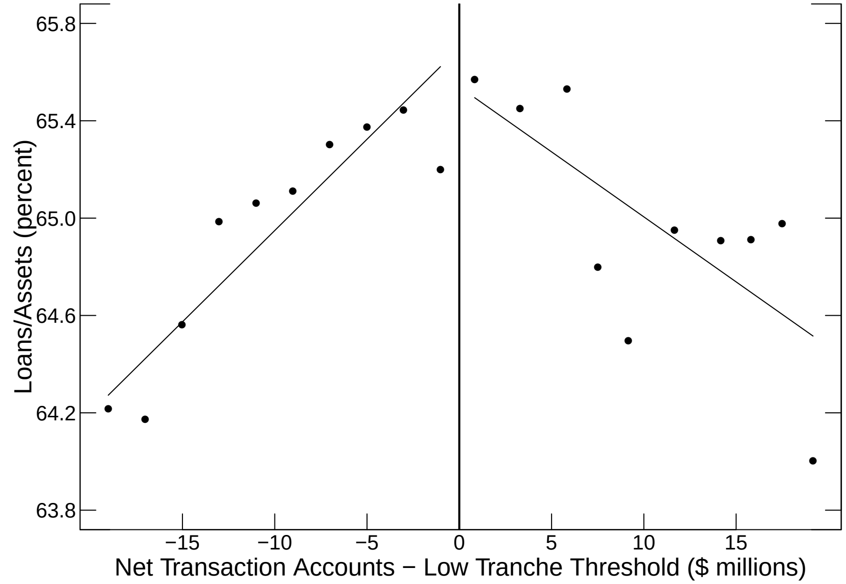


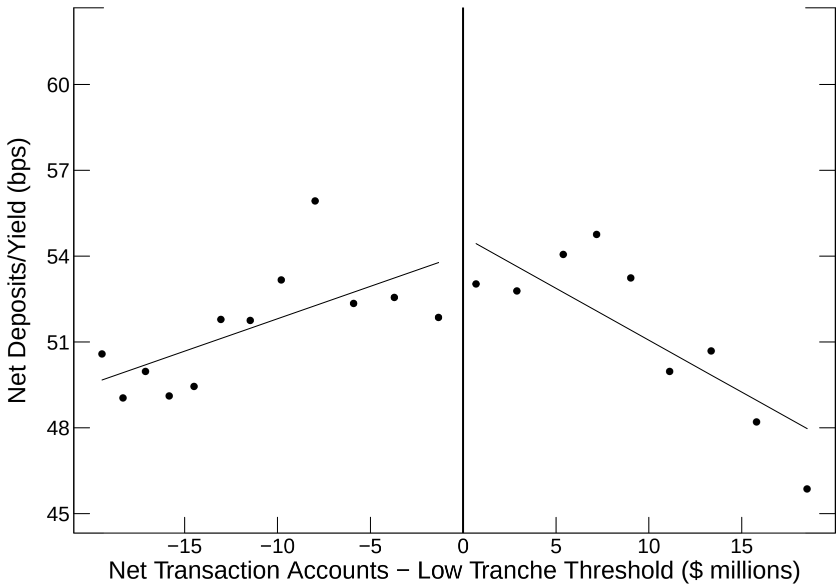
Figure 7: **Loan Growth at Future Horizons (RKD Estimate).**
This figure plots the RKD estimate of the effect of a 1 percentage point increase in the reserve requirement on future loan growth at horizons indicated on the horizontal axis. The 99% confidence interval is depicted by whiskers around each point estimate. The estimates are achieved using local linear regressions. The data-driven bandwidth selector defaults to the entire data set for the +3Q estimate, so this estimate is calculated using the optimal bandwidth for the +4Q horizon.



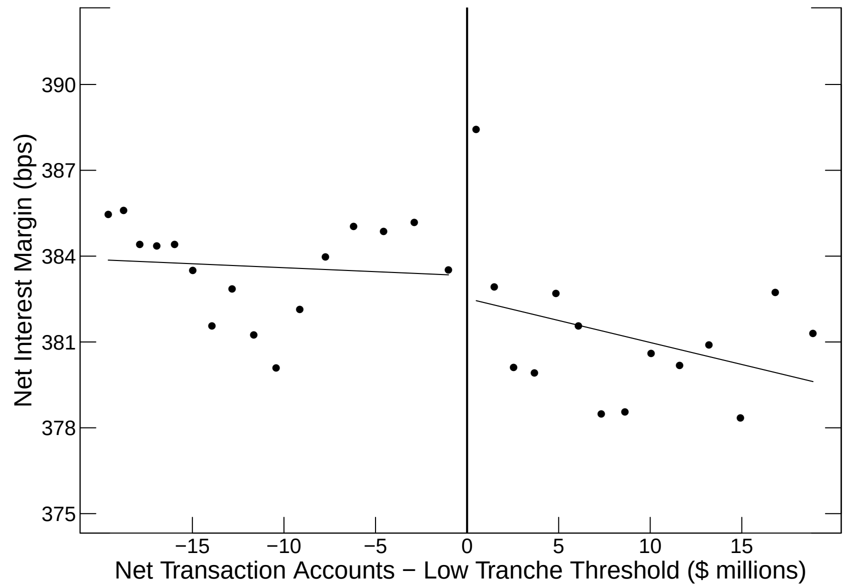
(a) Liquid Securities/Assets



(b) Total Loans/Assets



(c) Net Deposit Yield



(d) Net Interest Margin

Figure 8: **RKD Plots for Main Outcome Variables.**
These figures depict the data for bins around the low tranche threshold for the key outcome variables, as indicated. The p-value of the difference in slopes is reported in Tables 2-4.

Tables

Table 1: Size of banks around the low tranche threshold versus all banks

	Assets ($ millions)			
	2000		2007	
	Sample	All	Sample	All
Minimum	28.6	1.6	43.5	<1
25th Percentile	139.8	50.3	151.3	92.4
Median	182.0	98.4	197.9	177.2
75th Percentile	250.8	219.0	273.1	403.0
Maximum	25,412.7	522,893	68,509	1,182,833
Mean	327.9	772.3	332.0	1,784.7

Notes: This table presents descriptive statistics for the size of banks within $15 million of the low tranche threshold, compared with all banks for the years 2000 and 2007.

Table 2: Asset adjustments in response to an increase in required reserves

	Liq. Securities (% of assets)		Loans (% of assets)		Single Fam. Mtgs. (% of assets)		Nonresidential Loans (% of assets)	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
RKD Treatment Effect	0.14***	0.19***	-0.24***	-0.40**	0.01	0.05	-0.29**	-0.53***
	(0.05)	(0.07)	(0.09)	(0.16)	(0.02)	(0.05)	(0.12)	(0.18)
Local Linear	✓	–	✓	–	✓	–	✓	–
Local Quadratic	–	✓	–	✓	–	✓	–	✓
N^-	4,350	8,769	3,815	6,558	13,288	15,265	3,315	6,348
N^+	3,887	6,873	3,496	5,408	9,546	10,529	3,109	5,256
h ($ mil.)	2.94	5.55	2.63	4.25	8.13	9.13	2.33	4.18

Notes: This table reports RKD estimates calculated as the difference between estimated slopes of the CEF to the right and left of the low tranche threshold, normalized by the kink in the RRR (7 percentage points). Dependent variables and their units are listed above each column. Liquid Securities comprise Treasury and government agency-backed securities. Column (1) calculates the slopes of the CEF using a local polynomial regression of order 1, and column (2) calculates the slopes using a polynomial of order 2. Bank-level cluster robust standard errors are reported in parentheses. Bandwidths are selected using the data-driven Calonico et al. (2014) procedure. Bandwidth sizes (h) and observations to the left (N^-) and right (N^+) of the kink are reported in the bottom rows. Statistical significance: $^{***}p < 0.01$;$^{**}\, p < 0.05$;$^{*}\, p < 0.10$.

Table 3: Funding adjustments in response to an increase in required reserves

	Savings Deposits (% of liabilities)		Capital (% of assets)	
	(1)	(2)	(1)	(2)
RKD Treatment Effect	0.03***	0.01	0.00	0.02
	(0.01)	(0.03)	(0.00)	(0.02)
Local Linear	✓	–	✓	–
Local Quadratic	–	✓	–	✓
N^-	20,283	17,405	24,554	11,912
N^+	12,035	10,955	14,080	8,742
h ($ mil.)	12.51	11.08	13.26	7.44

Notes: This table reports RKD estimates calculated as the difference between estimated slopes of the CEF to the right and left of the low tranche threshold, normalized by the kink in the RRR (7 percentage points). Dependent variables and their units are listed above each column. Column (1) calculates the slopes of the CEF using a local polynomial regression of order 1, and column (2) calculates the slopes using a polynomial of order 2. Bank-level cluster robust standard errors are reported in parentheses. Bandwidths are selected using the data-driven Calonico et al. (2014) procedure. Bandwidth sizes (h) and observations to the left (N^-) and right (N^+) of the kink are reported in the bottom rows. Statistical significance: $^{***}p < 0.01$;$^{**}\, p < 0.05$;$^{*}\, p < 0.10$.

Table 4: The profit effects of an increase in required reserves

	Net deposit yield (bps)		Net interest margin (bps)		Return on assets (bps)	
	(1)	(2)	(1)	(2)	(1)	(2)
RKD Treatment Effect	-1.00**	-1.65**	-0.62***	-0.93**	-0.56**	-0.67**
	(0.49)	(0.78)	(0.20)	(0.42)	(0.24)	(0.33)
Local Linear	✓	–	✓	–	✓	–
Local Quadratic	–	✓	–	✓	–	✓
N^-	3,430	6,499	7,066	10,822	6,672	13,949
N^+	3,111	5,199	5,710	8,099	5,449	9,838
h ($ mil.)	2.63	4.64	4.71	6.96	4.44	8.59

Notes: This table reports RKD estimates calculated as the difference between estimated slopes of the CEF to the right and left of the low tranche threshold, normalized by the kink in the RRR (7 percentage points). Dependent variables and their units are listed above each column. Net deposit yield is calculated as interest on deposits minus charges on deposit accounts divided by total deposits. Net interest margin is calculated as interest income minus interest expense, divided by total earning assets. Return on assets is calculated as pre-tax net income divided by total assets. Income items are summed over the trailing four quarters. Column (1) calculates the slopes of the CEF using a local polynomial regression of order 1, and column (2) calculates the slopes using a polynomial of order 2. Bank-level cluster robust standard errors are reported in parentheses. Bandwidths are selected using the data-driven Calonico et al. (2014) procedure. Bandwidth sizes (h) and observations to the left (N^-) and right (N^+) of the kink are reported in the bottom rows. Statistical significance: $^{***}p < 0.01$;$^{**}p < 0.05$;$^{*}p < 0.10$.

Table 5: HQLA requirement's effect on failure probabilities during the crisis

	Pr(Failure)$_{2008-2010}$ (%)	
	(1)	(2)
RKD Treatment Effect	-0.12**	-0.17**
	(0.05)	(0.09)
Local Linear	✓	–
Local Quadratic	–	✓
N^-	861	1,969
N^+	419	568
h ($ mil.)	14.55	25.86

Notes: This table reports RKD estimates calculated as the difference between estimated slopes of the CEF to the right and left of the low tranche threshold, normalized by the kink in the RRR (7 percentage points). The dependent varialbe is a dummy indicator of failure between 2008 and 2010. Column (1) calculates the slopes of the CEF using a local polynomial regression of order 1, and column (2) calculates the slopes using a polynomial of order 2. Robust standard errors are reported in parentheses. Bandwidths are selected using the data-driven Calonico et al. (2014) procedure. Bandwidth sizes (h) and observations to the left (N^-) and right (N^+) of the kink are reported in the bottom rows. Statistical significance: $^{***}p < 0.01;^{**} p < 0.05;^{*} p < 0.10$.

Table 6: HQLA requirement's effect on depositor flows and asset sales during the crisis

	Δ Brokered Deposit Funding Share (%)				Δ Private ABS Share (%)			
	Full Sample		Δ > 0 Sample		Full Sample		Δ > 0 Sample	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
RKD Treatment Effect	0.04**	0.07	0.10**	0.26	0.12***	0.33***	0.76***	2.02***
	(0.02)	(0.06)	(0.04)	(0.17)	(0.04)	(0.12)	(0.23)	(0.63)
Local Linear	✓	–	✓	–	✓	–	✓	–
Local Quadratic	–	✓	–	✓	–	✓	–	✓
N^-	519	533	188	185	319	336	46	54
N^+	289	294	131	127	211	221	43	53
h ($ mil.)	9.71	9.96	8.73	8.48	6.78	7.12	5.56	6.41
Average Share (%)	3.26		7.05		1.22		5.70	

Notes: This table reports RKD estimates calculated as the difference between estimated slopes of the CEF to the right and left of the low tranche threshold, normalized by the kink in the RRR (7 percentage points). Dependent variables and their units are listed above each column. Brokered deposits are measured as a share of total deposits, and private asset-backed securities are measured as a share of total securities. The average of these ratios as of 2007Q3 are reported in the final row of the table. Column (1) calculates the slopes of the CEF using a local polynomial regression of order 1, and column (2) calculates the slopes using a polynomial of order 2. Robust standard errors are reported in parentheses. Bandwidths are selected using the data-driven Calonico et al. (2014) procedure. Bandwidth sizes (h) and observations to the left (N^-) and right (N^+) of the kink are reported in the bottom rows. Statistical significance: $^{***}p < 0.01$;$^{**}p < 0.05$;$^{*}p < 0.10$.

Table A1: Summary Statistics for External Validity Test

	Below Median (1)	Above Median (2)	Difference (3)
Nontransaction Accounts / Liabs.	0.07	0.18	-0.11***
	(0.03)	(0.09)	
ln(Assets)	10.83	10.74	0.09***
	(1.12)	(1.10)	
Capital (% of assets)	9.28	9.08	0.20***
	(3.93)	(3.79)	
Liq. Securities (% of assets)	24.13	21.72	2.41***
	(14.24)	(14.33)	
Loans (% of assets)	53.76	56.03	-2.27***
	(15.47)	(15.54)	
Non-performing Loans (% of assets)	1.12	1.23	-0.11***
	(1.37)	(1.55)	
Savings Deposits (% of liabilities)	84.68	83.98	0.70***
	(10.60)	(8.25)	
Net Deposit Yield (bps)	131.93	121.75	10.18***
	(75.21)	(69.77)	
Net Interest Margin (bps)	399.70	407.98	-8.27**
	(98.92)	(98.48)	
Observations	5,687	5,686	-

Notes: This table presents descriptive statistics for banks with low (below median) and high (above median) values of the treatment measure as of 1990Q3. We report the mean of each variable, with the standard deviations in parentheses. The final column reports the differences between the two groups with statistical significance indicated as follows: $^{***}p < 0.01$;$^{**}p < 0.05$;$^{*}p < 0.10$.

Table A2: Asset adjustments in response to a decrease in required reserves

	Liq. Securities (% of assets)		Loans (% of assets)		Single Fam. Mtgs. (% of assets)		Ln(Loans) (% of assets)	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Post × *Non-TA Share*	-3.20***	-3.91***	5.73***	6.24***	2.92***	2.50***	0.12***	0.17***
	(0.77)	(0.77)	(0.84)	(0.82)	(0.57)	(0.56)	(0.04)	(0.04)
State-Time FEs	✓	✓	✓	✓	✓	✓	✓	✓
Bank Covariates	–	✓	–	✓	–	✓	–	✓
Adj. R^2	0.90	0.90	0.92	0.92	0.96	0.96	0.99	0.99
N	146,146	146,146	146,146	146,146	146,146	146,146	146,146	146,146

Notes: This table reports the DD estimate, β, from the following specification:

$$y_{it} = \alpha + \gamma_i + \delta_{st} + \beta \cdot \left(\frac{non-TA_{i,1990Q3}}{Liabilities_{i,1990Q3}} \times D_{\text{Post}} \right) + \mathbf{\Phi'}(\boldsymbol{X_{i,1990Q3}} \cdot D_{\text{Post}}) + \varepsilon_{it}.$$

Dependent variables and their units are listed above each column. Liquid Securities comprise Treasury and government agency-backed securities. For each dependent variable, column (1) includes no bank controls beyond bank fixed effects. Column (2) reports results controlling for bank-level covariates, including the log of assets, ROA, the capital-to-asset ratio, and the nonperforming loan ratio. Standard errors clustered at the bank level are reported in parentheses. Statistical significance: $^{***}p < 0.01$;$^{**}p < 0.05$;$^{*}p < 0.10$.

Table A3: Deposit yield adjustments in response to a decrease in required reserves

	Net deposit yield (bps)		Net interest margin (bps)		Return on assets (bps)	
	(1)	(2)	(1)	(2)	(1)	(2)
Post × *Non-TA Share*	2.61	-0.55	13.02*	11.80*	-69.36***	-55.24***
	(4.05)	(4.03)	(7.03)	(6.58)	(13.63)	(13.12)
State-Time FEs	✓	–	✓	–	✓	–
Bank Covariates	–	✓	–	✓	–	✓
Adj. R^2	0.91	0.91	0.84	0.84	0.71	0.7
N	146,146	146,146	146,146	146,146	146,146	146,146

Notes: This table reports the DD estimate, β, from the following specification:

$$y_{it} = \alpha + \gamma_i + \delta_{st} + \beta \cdot \left(\frac{non - TA_{i,1990Q3}}{Liabilities_{i,1990Q3}} \times D_{\text{Post}} \right) + \boldsymbol{\Phi'}(\boldsymbol{X_{i,1990Q3}} \cdot D_{\text{Post}}) + \varepsilon_{it}.$$

Dependent variables and their units are listed above each column. Net deposit yield is calculated as interest on deposits minus charges on deposit accounts divided by total deposits. Net interest margin is calculated as interest income minus interest expense, divided by total earning assets. Return on assets is calculated as pre-tax net income divided by total assets. [All variables are calculated as the sum of the numerator over the preceding four quarters, inclusive, over the denominator value of the current quarter.] For each dependent variable, column (1) includes no bank controls beyond bank fixed effects. Column (2) reports results controlling for bank-level covariates, including the log of assets, ROA, the capital-to-asset ratio, and the nonperforming loan ratio. Standard errors clustered at the bank level are reported in parentheses. Statistical significance: $^{***}p < 0.01$;$^{**}\, p < 0.05$;$^{*}\, p < 0.10$.

Table B1: Robustness and placebo tests—the effects of an increase in required reserves

Alternate Bandwidth	✓	–	✓	–	✓	–
Alternate Kink (-$30 mil.)	–	✓	–	✓	–	✓
Panel A: Asset Adjustments						
	Liq. Securities (% of assets)		Loans (% of assets)		Nonres. Loans (% of assets)	
	(1)	(2)	(1)	(2)	(1)	(2)
RKD Treatment Effect	0.14***	0.00	-0.22***	-0.00	-0.28***	-0.00
	(0.04)	(0.01)	(0.09)	(0.02)	(0.08)	(0.01)
N^- (000s)	4.4	54.7	3.8	41.8	4.6	59.4
N^+ (000s)	3.9	40.1	3.5	30.4	4.1	51.2
h ($ mil.)	2.97	8.27	2.62	5.9	3.14	11.57
Panel B: Deposit Yield and Income						
	Net deposit yield (bps)		Net interest margin (bps)		Return on assets (bps)	
	(1)	(2)	(1)	(2)	(1)	(2)
RKD Treatment Effect	-0.83*	0.16	-0.62***	-0.04	-0.52**	0.68**
	(0.46)	(0.11)	(0.20)	(0.12)	(0.26)	(0.28)
N^- (000s)	3.6	32.5	7.1	32.0	6.2	15.9
N^+ (000s)	3.2	24.4	5.7	24.6	5.1	14.0
h ($ mil.)	2.73	5.12	4.71	4.71	4.18	2.51
Panel C: Failure Probability and Crisis Experience						
	Pr(failure) (%)		Δ Brok. Dep. Share (%)		Δ Priv. ABS Share (%)	
	(1)	(2)	(1)	(2)	(1)	(2)
RKD Treatment Effect	-0.13***	-0.03	0.02	0.07	0.39***	-0.01
	(0.05)	(0.04)	(0.02)	(0.04)	(0.01)	(0.01)
N^-	873	1,268	439	572	837	1,174
N^+	423	1,354	262	531	393	1,256
h ($ mil.)	14.71	11.09	8.38	3.73	15.66	11.09

Notes: This table reports RKD estimates calculated as the difference between estimated slopes of the CEF to the right and left of the kink point, normalized by 7 percentage points. Dependent variables and their units are listed above each column, and are all defined as in the main tables. Column (1) uses an alternate bandwidth selector to construct the sample, and column (2) uses a placebo kink point of -$30 million. Results are reported for slopes calculated using a polynomial of order 1 only. Bank-level cluster robust standard errors are reported in parentheses in Panels A and B. Robust standard errors are reported in Panel C. Bandwidth sizes (h) and observations to the left (N^-) and right (N^+) of the kink are reported in the bottom rows. Statistical significance: $^{***}p < 0.01$;$^{**}p < 0.05$;$^{*}p < 0.10$.