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9995
2022

October 2022

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CESifo

Impressum:

CESifo Working Papers
ISSN 2364-1428 (electronic version)
Publisher and distributor: Munich Society for the Promotion of Economic Research - CESifo GmbH
The international platform of Ludwigs-Maximilians University's Center for Economic Studies and the ifo Institute
Poschingerstr. 5, 81679 Munich, Germany
Telephone +49 (0)89 2180-2740, Telefax +49 (0)89 2180-17845, email office@cesifo.de
Editor: Clemens Fuest
https://www.cesifo.org/en/wp
An electronic version of the paper may be downloaded
· from the SSRN website: www.SSRN.com
· from the RePEc website: www.RePEc.org
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CESifo *Working Paper No. 9995*

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Abstract

How much deposits and equity a bank has influences how a banks' lending responds to monetary policy. While the responsiveness for the bank lending channel has been well established, this is not the case for the risk-taking channel (RTC). We show in a value-at-risk RTC model that the lending for banks with relatively more equity and non-interest-bearing deposits should respond less to monetary policy tightening. This suggests that non-interest-bearing deposits act as "pseudo capital". In a panel of US banks, we find strong evidence in support of our model for various risk measures.

JEL-Codes: E430, E520, G210.

Keywords: bank lending, deposits, value-at-risk, pseudo capital.

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August 24, 2022
We thank Pamela A. Labadie and Tomas Williams for their continuous support and advice in this project. All errors remain our own. Declaration of interest: None.

1 Introduction

Accurately determining the monetary policy transmission channels is crucial to the understanding of the effects of monetary policy. Two of the most discussed of these transmission channels are the bank lending channel (BLC) proposed by Bernanke and Blinder (1988) and risk-taking channel (RTC) emphasized by Disyatat (2011) and Jiménez et al. (2014). Under the former, monetary policy affects the reserves of a bank and tightening monetary policy decreases the deposits a bank has (e.g. an increase in the reserve requirement ratio). Because banks are not able to fully substitute between deposits and funding through the interbank or wholesale market, this reduces the amount of loans that banks can make and hence slows down the economy. Under the latter, tightening monetary policy (e.g. by increasing the Fed Funds rate) makes risky assets less attractive and reduces collateral and asset values. This again reduces the loans banks can make and hence slows down the economy.

An important aspect of these models is the different responsiveness of banks to monetary policy depending on the amount of their deposits. For the bank lending channel this is somewhat trivial. Since monetary policy directly affects deposits, banks with relatively more deposits are more affected and hence should respond more to monetary policy shocks (e.g. see Drechsler et al. (2017)). This implies that banks without deposits should only have a limited response to monetary policy through the BLC.[1] For the RTC, the role of deposits has to our knowledge not been addressed so far.

This paper addresses the role of deposits for the RTC. Specifically, we use a variation of the Hahm et al. (2013) Value-at-Risk (VaR) RTC model to obtain general relationships between bank lending, capital, and deposits. Our model shows that under monetary tightening, banks can use their non-interest-bearing (NIB) deposits and

[1] One way how non-depository banks might be affected through the BLC is that the increased demand for wholesale funds due to monetary tightening might adversely affect the funding of these non-depository institutions.

capital as a buffer and banks with less leverage or more NIB deposits should react less to a monetary policy tightening. The non-interest-bearing part of deposits thus acts as "Pseudo Capital".[2] Intuitively, non-interest-bearing deposits act like an interest free loan to the bank. The cost of this loan does not depend on the Fed Funds rate and hence bank lending financed through these deposits should not be affected by interest rate changes. This argument that at least parts of deposits are little affected by monetary policy has become even stronger since banks started to hold substantial excess reserves in 2008 as shown in Figure 2. Also, deposits and equity tend to co-move substantially over the business cycle as shown in Figure 1 which could be a further indicator that they are similar in nature.

The model in this paper thus allows for high capital banks to be less responsive to monetary policy. This is usually associated with the BLC as supported by Kishan and Opiela (2000); Jayaratne and Morgan (2000); Altunbaş et al. (2002); Gambacorta and Mistrulli (2004); Ashcraft (2006). Banks with more capital can more easily access the wholesale market and more easily use the wholesale market as a substitute for deposits.[3] For the RTC, Dell'Ariccia et al. (2014) showed that banks whose capital constraints are binding should react less to monetary policy easing. The main intuition is that the banks cannot expand lending as they are capital constrained. Subsequently, Dell'Ariccia et al. (2017) provided some evidence on this based on US data. Without a binding capital constraint, we find the opposite for the RTC, and are thus removing a key difference between the BLC and the RTC while also allowing for deposits to act as "Pseudo Capital", an additional testable implication. The key differences between these models is shown in Table 1.

[2]The "Pseudo Capital" concept here is closely related to the concepts "Deposit Productivity" and "Asset Productivity" proposed by Drechsler et al. (2021).

[3]As shown for example in Black et al. (2007), Girotti (2019), or Choi and Choi (2021), there might be additional frictions limiting the substitutability between deposits and wholesale funding.

Table 1: A Comparison of Two Channels

	Mechanism	Role of Equity	Role of Deposits
Bank Lending Channel (BLC)	Imperfect substitute between deposits and wholesale funding	More equity - less responsive	More deposits - more responsive
Risk-taking Channel (RTC)	Banks' capital and risk appetite	Undercapitalized banks react less to MP easing	No
VaR Risk-taking Channel (RCT)	Banks' capital, liability structure, and risk appetite	More equity - less responsive	More deposits - less responsive

We then apply the model to a panel of US banks shows substantial evidence in support of these two key model implications. Specifically, the risk-taking of banks with more equity or NIB deposits react less to monetary policy for a number of risk measures. When comparing different types of deposits, we find that the relationship reverses for interest bearing deposits.

The remainder of the paper is structured as follows. Section 2 presents a model that lay out the main empirical hypothesis in this paper. Section 3 will present the data and the empirical results are in section 4. Finally, section 5 concludes.

2 Model

We use the static, two-period model in Hahm et al. (2013) with some small changes. A bank makes loans in period 0 and receives repayment in period 1. The bank's balance sheet identity in period 0 is total assets or lending (L) which is equal to equity (E) plus liabilities (D). Liabilities are a mix of retail deposits and wholesale funding. Unlike Hahm et al. (2013), we do not differentiate the retail deposits and wholesale funding in the model, but we still take into account the different funding cost as shown below.

$$L = D + E \tag{1}$$

The bank holds a diversified loan portfolio. Credit risk follows the Vasicek (2002) model in line with the Basel requirements. The default risk for each individual firm is ε. Borrower j repays the loan when $Z_j > 0$, where Z_j is the random variable given by

$$Z_j = -\Phi^{-1}(\varepsilon) + \sqrt{\rho}Y + \sqrt{1-\rho}X_j \tag{2}$$

where $\Phi(.)$ is the c.d.f of the standard normal, ε is the probability of default on the loan, and Y and $\{X_j\}$ are mutually independent standard normal distribution. $\rho \in (0, 1)$ is the exposure of a loan j to the market risk Y. The loan interest rate is r so that the amount due in period 1 is $(1 + r)L$ (notional assets). A banks' expected wealth in period 1 is a random variable $w(Y)$, defined as:

$$w(Y) = (1+r)L \cdot Pr(Z_j \geq 0 \mid Y) \tag{3}$$

$$= (1+r)L \cdot Pr(\sqrt{\rho}Y + \sqrt{1-\rho}X_j \geq \Phi^{-1}(\varepsilon) \mid Y) \tag{4}$$

$$= (1+r)L \cdot \Phi\left(\frac{Y\sqrt{\rho} - \Phi^{-1}(\varepsilon)}{\sqrt{1-\rho}}\right) \tag{5}$$

The c.d.f of the realized value of the loan portfolio $w(Y)$ at date1 is given by

$$F(z) = Pr(w \leq z) \tag{6}$$

$$= Pr(Y \leq w^{-1}(z)) \tag{7}$$

$$= \Phi(w^{-1}(z)) \tag{8}$$

$$= \Phi\left(\frac{\Phi^{-1}(\varepsilon) + \sqrt{1-\rho}\,\Phi^{-1}\left(\frac{z}{(1+r)L}\right)}{\sqrt{\rho}}\right) \tag{9}$$

The bank needs to pay its lenders at date 1 (notional liabilities):

$$D(1+f)\xi \tag{10}$$

where f is the risk-free rate and $\xi \in [1/(1+f), 1]$ is the interest distribution parameter of liabilities. It is assumed that deposits have a strictly lower interest rate than the wholesale market.[4] When $\xi = 1$, the bank's liabilities are fully financed from the wholesale funding market, and it does not have any deposits. Conversely, if $\xi = (1/(1+f)$, the bank's liabilities are fully funded by non-interest-bearing deposits. Most banks are somewhere in between, and it can be motivated in a similar way as in Xiao (2020).

In order to link the lending to the liabilities we use a Value-at-Risk (VaR) constraint. Suppose a loan's default probability is less than α based on the bank's risk management requirement. So the VaR constraint becomes:

$$Pr(w < D(1+f)\xi) = \Phi\left(\frac{\Phi^{-1}(\varepsilon) + \sqrt{1-\rho}\,\Phi^{-1}\left(\frac{D(1+f)\xi}{(1+r)L}\right)}{\sqrt{\rho}}\right) = \alpha \tag{11}$$

Rearranging equation (11) , we can obtain the following equation for the ratio of

[4] In many models, deposits are assumed to be non-interest-bearing.

notional liabilities to notional assets:

$$\Phi\left(\frac{\sqrt{\rho}\Phi^{-1}(\alpha)-\Phi^{-1}(\varepsilon)}{\sqrt{1-\rho}}\right)=\frac{D(1+f)\xi}{(1+r)L} \tag{12}$$

Denote the left side of this equation φ:

$$\varphi(\alpha,\varepsilon,\rho)=\Phi\left(\frac{\sqrt{\rho}\Phi^{-1}(\alpha)-\Phi^{-1}(\varepsilon)}{\sqrt{1-\rho}}\right) \tag{13}$$

φ is a function of loan default probability ε, the value-at-risk constraint parameter α and systemic risk share ρ. Combining equations (12) and (13) with (1) leads to the loan supply equation

$$L_S=D+E=\frac{L\varphi(1+r)}{(1+f)\xi}+E \tag{14}$$

Solving for L:

$$L_S=\frac{E}{1-\frac{\varphi(1+r)}{(1+f)\xi}} \tag{15}$$

Note that for the loan supply to be well defined, it is necessary that $\frac{\varphi(1+r)}{(1+f)\xi}<1$. The market equilibrium condition is that the loan demand is equal to the loan supply. Demand is downward sloping in the loan interest rate r.

$$L_D(r)=L_S=\frac{E}{1-\frac{\varphi(1+r)}{(1+f)\xi}} \tag{16}$$

This leads us to our first proposition:

Proposition 1 bank lending decreases if ξ increases, given everything else constant. The bank lending decreases as risk-free rate f rises, given everything else constant.

Reducing ξ shifts the loan supply curve to the right and increases the risk-taking of the banking sector. Since more non-interest-bearing deposits correspond to a lower

ξ, a bank's risk-taking is elevated if non-interest-bearing deposits are high, given everything else constant. If ξ is close to the lower bound $1/(1+f)$, liabilities are essentially non-interest-bearing deposits and bank lending does not react to changes in the risk-free rate. If $\xi = 1$, the bank is fully financed by wholesale funding and its lending is most sensitive to the short-term interest rate. As a result, the lending of banks with larger non-interest-bearing deposits should be less sensitive to changes in the short-term interest rate.

For equity, a similar relationship can be found. As φ is the leverage of the bank and hence capital increases if φ becomes smaller. The lending of banks with a low φ will respond less to changes in the interest rate than the lending of banks with a high φ, meaning that banks with a higher leverage react more to changes in the interest rate.

3 Data

The main data we use is a quarterly panel of bank holding companies from Q1 1996 to Q3 2021. We retrieved the bank holding companies' financial statement through Federal Reserve Y9-C report. The monthly stock market return data is from the Center for Research in Securities Prices (CRSP). We merge banks' stock return with FR Y-9C report using the Permanent Company Number - Regulatory identification numbers (PERMCO-RSSD) link table by the Federal Reserve Bank of New York. The summary statistics for our variables are presented in Table 2.

In order to assess whether equity and other liabilities influence the risk-taking of banks, we first need to define the bank asset risk, our dependent variable. We use four measures from the existing literature. The first measure is the ratio of loan loss provisions to the total loans (see Khan et al. (2017)). This measure is also closely related to the loan level measure used in Dell'Ariccia et al. (2017). The second measure is the minus Z-score defined as

$$-Zscore = -(ROA + Equity/Assets)/(\sigma_{ROA}) \tag{17}$$

where σ_{ROA} is the standard deviation of the return on assets (ROA). The third measure is the one year rolling window standard deviation of the return on assets (ROA) (see Egan et al. (2017)). Finally, we use a market-based measure of bank asset risk, proxied by the bank holding companies' quarterly standard deviation of its stock return.

Our main independent variables are the risk-free rate for which we use the Wu and Xia (2016) shadow Fed Funds rate.[5] For the equity measure, we use the tier 1 ratio and for ξ we use the non-interest-bearing deposits over total assets.

Our main control variables are taken from (Khan et al. (2017) and Dell'Ariccia et al. (2017)) and include the natural logarithm of total assets, the return on assets (ROA), the share of total loans to total assets, the share of commercial and industrial loans to total loans and the liquid asset ratio, where liquid asset is defined as the ratio of cash and balances due from depository institutions to total assets.

For all variables, we winsorize the data at the 5% level like in Khan et al. (2017) to avoid outliers from driving our results. We also repeated the regressions with trimming at the 5% level and the results are robust to this alternative.

4 Empirical Strategy And Results

The empirical prediction from the model is that low funding cost liabilities should play a similar role as tier 1 ratio in the banks' risk-taking. For readability, we did not list the tier 1 ratio and its interaction with the shadow Fed Funds rate separately in

[5]In contrast to the effective Fed Funds rate, this shadow rate can take negative values. This could raise the concern of substantial increases in risk taking, but as shown in Claeys et al. (2021) and section 4.3, negative interest rates do not appear to accelerate risk taking.

the below equations. To this end, our baseline fixed effects panel specification is

$$BankRisk_{i,t} = \beta_1 SFFR_t + \beta_2 NIBDep_{i,t-1} * SFFR_t + \beta_3 NIBDep_{i,t-1} + X'\gamma + \nu_i + \varepsilon_{i,t} \quad (18)$$

where $BankRisk_{i,t}$ is one of the four risk measures, $SFFR_t$ is the shadow fed funds rate, $NIBDep_{i,t-1}$ is the share of non-interest-bearing deposits as a fraction of total assets in period $t-1$.[6] X are the control variables, ν_i are the bank fixed effects and $\varepsilon_{i,t}$ is the error term. Standard errors are clustered at the bank level.

Our alternative setup also includes time fixed effects μ_t which will remove the shadow fed funds rate from the regression.

$$BankRisk_{i,t} = \beta_2 NIBDep_{i,t-1} * SFFR_t + \beta_3 NIBDep_{i,t-1} + X'\gamma + \nu_i + \mu_t + \varepsilon_{i,t} \quad (19)$$

As in the previous specification, standard errors are clustered at the bank level.

4.1 Empirical Results

Columns (1) and (2) in Table 3 show that a tightening monetary policy reduce a banks' risk-taking. Across all four columns, the coefficients on equity and non-interest-bearing deposit interactions have the same sign and the sign expected from the model. That is, banks with more equity (Tier1Rat) or non-interest-bearing deposits (NIBDep) will react less to changes in the shadow Fed Funds rate (SFFR). Or put differently, if Interest rates increase, banks with high equity or NIBDep will reduce their risk by less than banks with low equity and NIB deposits.

The coefficients in column (2) suggest that if the shadow Fed Funds rate increases

[6]Note that we lag all independent variables by one quarter to reduce a reverse causality issue. Changes in the interest rate are likely to change deposits and taking the lagged deposits should reduce this issue. This is the same method used in Khan et al. (2017)

by 100 basis points and the bank previously had loan loss provisions around the mean of the distribution, the loan loss provision would decline by 7.93 percent. In terms of magnitude for interaction term in column (4), a convenient way to estimate this is to compare the impact of a 100 basis point increase in the shadow Fed Funds rate for a bank with non-interest-bearing deposits at the 25th percentile to one at the 75th percentile. Our estimates suggest that the bank at the 75th percentile for non-interest-bearing deposits and initial risk taking around the mean of the distribution reduces risk taking by 1.7 percent less than the 25th percentile using the loan loss provisions ratio.[7] This is economically meaningful as this constitutes around a fifth of 7.93 percent.

The sign on the equity-Fed Funds rate interaction is also in line with the findings in Gambacorta and Shin (2018) and the same relationship a bank lending channel model would imply (e.g. see Altunbaş et al. (2002) or Gambacorta and Mistrulli (2004)). However, the risk-taking channel model presented in this paper is also consistent with this empirical finding. This means that finding this positive coefficient does not imply evidence only in favor of the BLC and against the RTC but rather in support of both channels. In terms of magnitude under the NIB depotits approach in the previous paragraph, one would calculate that banks in the 75th percentile of equity would reduce risk taking by 1.5 percent less in response to a 100bp increase in the shadow Fed Funds rate, relative to banks in the 25th percentile of equity.

Given that deposits (NIBDep) and their interaction with the Fed Funds rate have the same sign as equity, this is in line with deposits acting as "Pseudo Capital". This is consistent with the RTC model presented in this paper but not necessarily consistent with the BLC. Under the BLC, one would assume that the risk-taking of banks with more deposits reacts more strongly to monetary policy than for banks with few deposits. However, Table 3 only shows the relationship for non-interest-bearing deposits

[7] In this example, it is calculated as (P75-P25)*100bp*beta/mean=(0.166-0.083)*1*0.000615/0.003 based on the summary statistics in Table 2.

and does not necessarily contradict the implications of the BLC by itself.

We conduct a first set of robustness checks in Tables 4, 5 and 6, where we use alternative measures for risk taking as our dependent variable. Specifically, we use minus Z-score, the rolling standard deviation of the ROA and the quarterly standard deviation of the stock market return. For most specifications, the interaction terms remain positive and highly significant, giving us the confidence that the results are not purely driven by a specific measure of bank risk.[8] In terms of magnitude for interaction terms and utilizing the same approach as for the loan loss provisions, our estimates suggest that the bank at the 75th percentile and initial risk taking around the mean reduces risk taking less than the 25th percentile using the minus Z-score, the standard deviation of ROA, and the quarter standard deviation of stock return by 1.2 percent, 1.6 percent, and 1.1 percent, respectively, given a 100bp increase in the shadow Fed Funds rate.

4.2 A Hierarchy of Liabilities

So far, we only looked at non-interest-bearing deposits. However, our model suggests that the relationship should also hold for other types of deposits, but the effect should be weaker, the higher interest rate on deposits. Indeed, it should be gone completely for deposits that pay the same interest rate as wholesale funding. In this section, we address this by repeating the regressions from the previous sections but using several different types of deposits and comparing them. The specification we run is the same as in equation (19) with all control variables, but the definition of the deposits is altered.

The first set of results are presented in Figure 3. All show that the interaction with non-interest-bearing (NIB) deposits have a larger coefficient than the one with

[8] Note that the sample size for Table 6 is about two thirds smaller because most banks are not listed and hence their stock market return is not available.

interest-bearing (IB) deposits. This suggests that banks with large interest-bearing deposits react more to monetary policy than banks with large non-interest-bearing deposits. Indeed, the coefficient on interest-bearing deposits is negative, suggesting that these do not act like "Pseudo Capital", but rather make bank lending respond more strongly to monetary policy.

Second, the deposits can be further divided into four groups, the demand deposits (DemDep); negotiable order of withdrawal (NOW) deposits, automatic transfer service (ATS) deposits, and other transaction accounts (NAOT); money market deposit accounts and other saving accounts (MMOS); and time deposits (TimeDep). The demand deposits typically do not carry interest due to regulation. So the funding cost for the demand deposits is lowest among these four liability types. The time deposits funding cost is the highest out of the four deposit types. And NOW, ATS, and other transaction accounts, and money market deposit account and other saving account sit somewhere in between.[9]

Figure 4 show the results for the various types of deposits across different risk measures. They clearly show that the coefficient is positive and significant for demand deposits (DemDep) and negative and significant for time deposits (TimeDep). For the other two types of deposits the coefficients are somewhere in between. These results suggest a funding hierarchy for banks. Specifically, the higher the funding cost of a bank, the more the bank reacts to changes in the Fed Funds rate. Specifically, a bank that funds itself at the Fed Funds rate through the wholesale market (or time deposits) will reduce their risk-taking much more in response to a monetary tightening by the Federal Reserve than a bank that funds itself largely by non-interest-bearing demand deposits.

[9] There is no clear ranking between NAOT and MMOS with regards to the funding cost.

4.3 Negative Interest Rates

There is some evidence that the behavior of banks changes once the lower bound has been reached (e.g. see Claeys et al. (2021)). To check whether this is the case in our sample as well, we add two more variables into our regression. Specifically, we take the interaction terms with the shadow Fed Funds rate (non-interest-bearing deposits and tier 1 capital) and multiply them by a dummy that takes value 1 if the shadow Fed Funds rate is negative and zero otherwise. These two additional variables capture any difference in the behavior of banks once the lower bound has been reached.

Table 7 reports that the interactions of the shadow Fed Funds rate with the non-interest-bearing deposits remain positive, and that banks with large non-interest-bearing deposits react even less to changes in the shadow rate if it is negative. For the interaction terms reported in rows one and three, the significant coefficients remain broadly in line with the ones that do not include the negative dummy. As the significant coefficients with the negative dummy (rows two and four) are generally positive, this suggests that the responsiveness of banks with large NIB deposits to increases in the shadow Fed Funds rate at negative interest rates is reduced further. There is however quite some variation between the different measures, variables and significance.

4.4 Alternative Monetary Policy Measures And Endogeneity

So far, our analysis focused on the shadow Fed Funds rate. An alternative measure of the Fed's monetary policy stance is the Fed Balance sheet. When interest rates reached their lower bound, the Fed has used asset purchases (initially named quantitative easing) to further stimulate the economy. Particularly for periods of lower bound interest rates, changes in the Fed balance sheet might be an alternative measure to the shadow Fed Funds rate (Wu and Zhang, 2019).

Table 8 presents the regression results where the shadow Fed Funds rate is replaced with the change of the natural log of the balance sheet of the Fed. We normalize the shock so that a positive shock is correspondent to a monetary tightening shock consistent with our benchmark interpretation. The coefficient for the interaction of non-interest-bearing deposits and the change in the balance sheet is positive across the board and significant for all but the loan loss provisions. In terms of magnitude the coefficients imply an impact of between one and two fold, relative to the impact of the shadow Fed Funds rate.[10]

Next, we want to address the potential endogeneity issue in our analysis. In particular, there might be factors that drive both the policy maker's decision as well as the bank's risk-taking decision. In order to address this issue, we use the Bu et al. (2021) monetary policy shocks. These shocks capture the unpredictable part of monetary policy decisions for both the lower bound and the non-lower bound periods. We would anticipate that factors that drive both policy maker's decisions as well as the risk taking should be mostly covered by the predictable part of monetary policy decisions. The use of the shock series instead of the shadow Fed Funds rate should thus mitigate most of the potential endogeneity issue.

Table 9 reports the regression results where the shadow Fed Funds rate is replaced with the Bu et al. (2021) monetary policy shocks. The coefficients for the interaction of non-interest-bearing deposits and the shock variable is positive across the board and significant for all but the stock return measure. In terms of magnitude the coefficients imply an impact of between 0.5 and one fold, relative to the impact of the shadow Fed Funds rate.

[10] In order to calculate a comparable impact, a 100bp increase in the shadow rate is converted into an increase as a fraction of the standard deviations and the same increase in terms of standard deviations is assumed for the balance sheet variable.

4.5 Banks Of Different Sizes

Having established that large non-interest-bearing deposits reduce the responsiveness to monetary policy, we want to assess whether large and small banks react differently to monetary policy tightening. Based on their assets, we split banks into large banks (above the 75th percentile of assets) and small banks (below the 25th percentile of assets) and repeat our baseline regressions for these two groups. We report the interaction coefficient between the shadow Fed Funds rate and non-interest-bearing deposits for these two subsets and all banks in Figure 5. As the coefficients and their respective 95 percent confidence intervals show, there is little evidence that large or small banks react differently to monetary policy tightening when compared to all banks.

5 Conclusion

This paper showed in a value-at-risk risk-taking channel model that the lending for banks with relatively more equity and non-interest-bearing deposits should respond less to monetary policy tightening. This suggests that non-interest-bearing deposits act as "pseudo capital". The implication for capital in this model is the same as in the bank lending channel; under monetary tightening, well capitalized banks should reduce their lending by less than less capitalized banks. This is not the case for deposits. The bank lending channel assumes that monetary policy mainly affects deposits and banks with substantial deposits should react strongly to monetary policy changes. Our model suggests that this is not the case for banks with substantial non-interest-bearing deposits.

Our subsequent tests of these implications using a panel of US banks find strong evidence in support of our model for a variety of risk measures. We also find that it is not general deposits that determine the reaction to monetary policy but rather there is a hierarchy. Specifically, lower interest rate deposits reduce the monetary policy reaction while higher interest rate deposits increase the monetary policy reaction. Further research might be able to address whether this hierarchy of deposits also arises in a bank lending channel model or not.

6 Declarations

Funding: None

Conflicts of interest/Competing interests: none

Availability of data and material: All data used is publicly available, cleaned data available upon request

Code availability: available upon request

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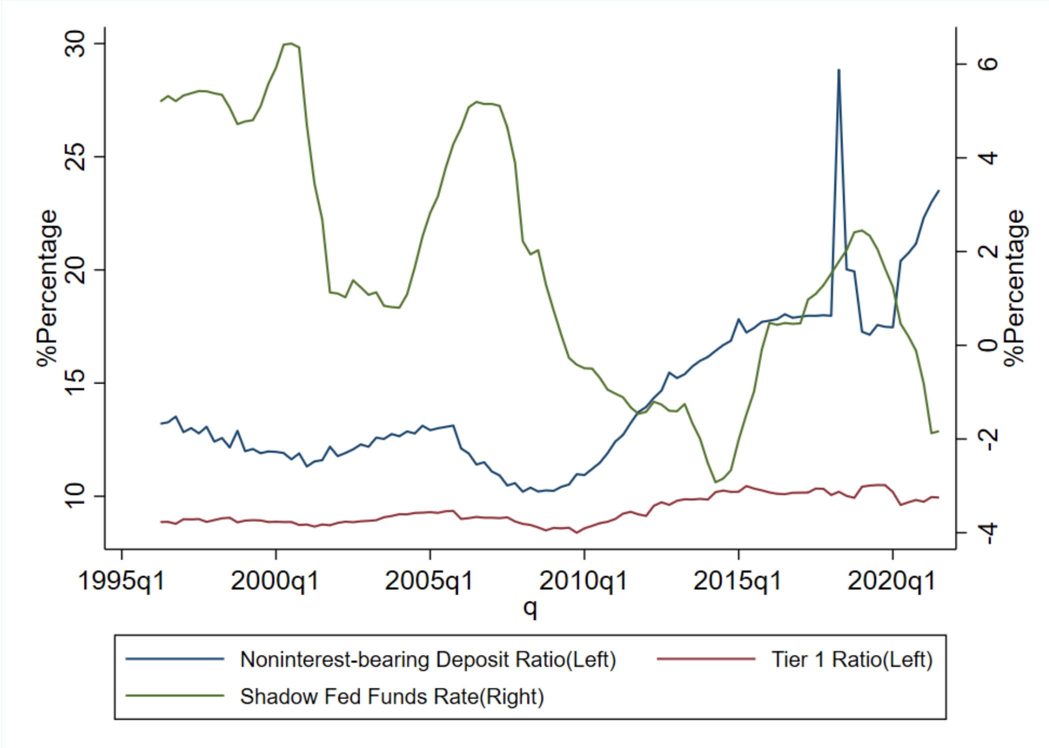

Figure 1: Non-interest-bearing Deposit Ratio and Tier 1 Ratio

Notes: This graph plots the mean of the non-interest-bearing deposit ratio and Tier 1 ratio for all the bank holding companies from 1996Q1 to 2021Q3. The Tier 1 ratio is defined as banks' Tier 1 capital divided by the banks' total assets. Source: FR Y-9C.

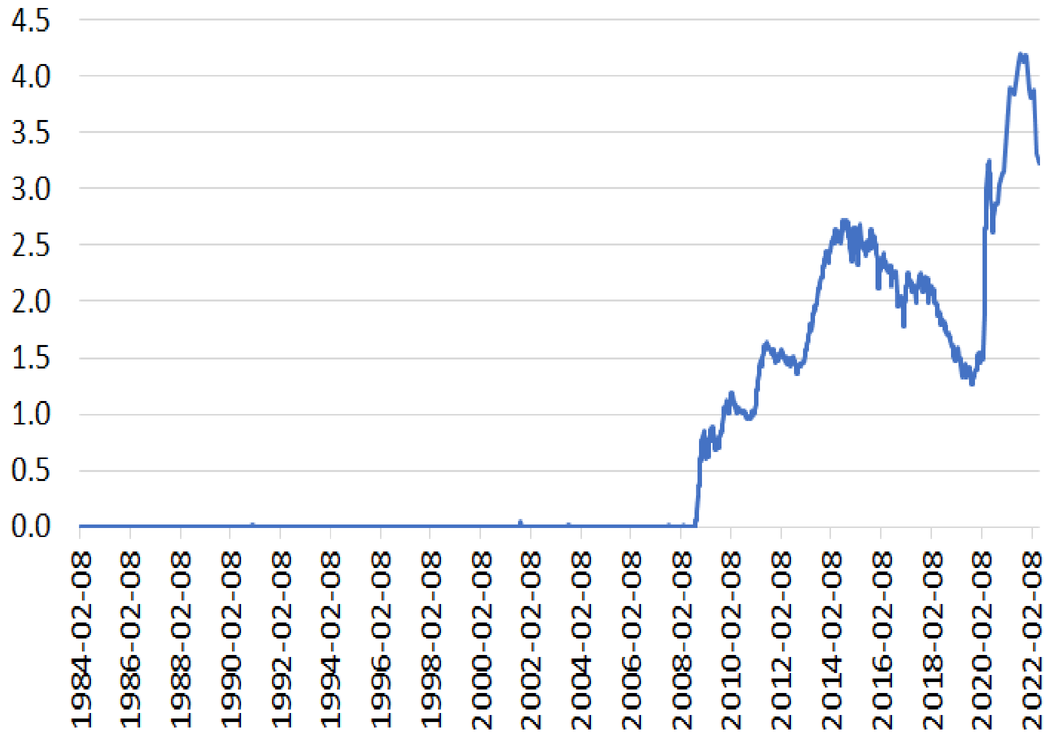

Figure 2: Excess Reserves of US Depository Institutions

Notes: This graph plots the total excess reserves at US Depository Institutions in Trillion USD. From October 2020 onwards, it shows total reserves. Source: FR H.3.

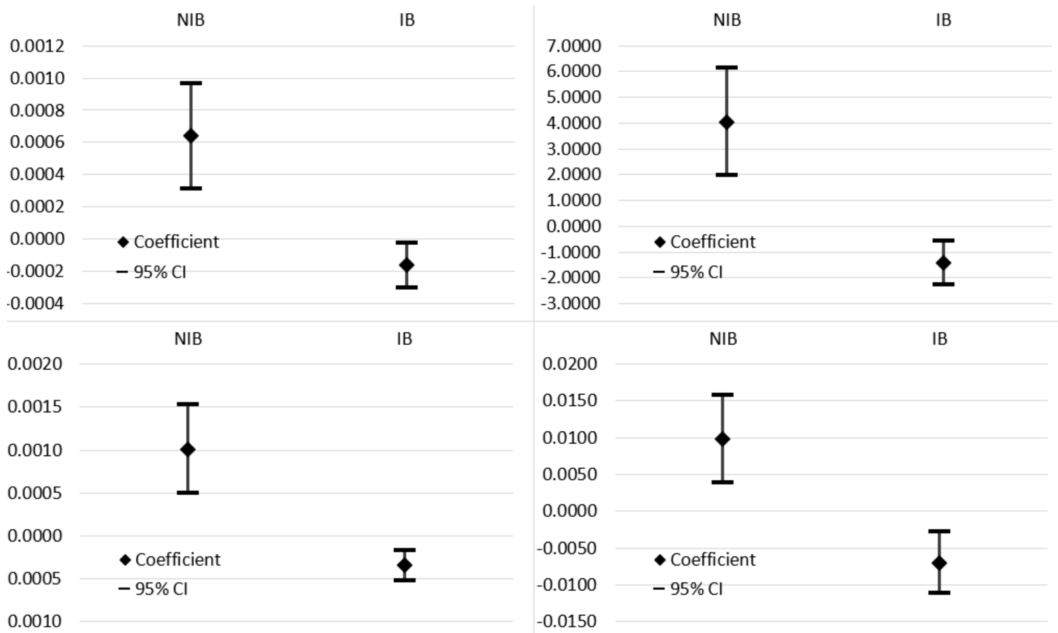

Figure 3: Interest and Non-Interest-Bearing Deposits

The graph shows the coefficients for non-interest-bearing (NIB) and interest bearing (IB) deposits interacted with the shadow fed funds rate with the four bank risk variables as the dependent variables. The regression uses the same controls as the fourth columns in Tables 3 to 6. Clock-wise starting from top left, the dependent variables are loan loss provisions, minus z-score, standard deviation of quarterly stock return and the standard deviation of the return on assets.

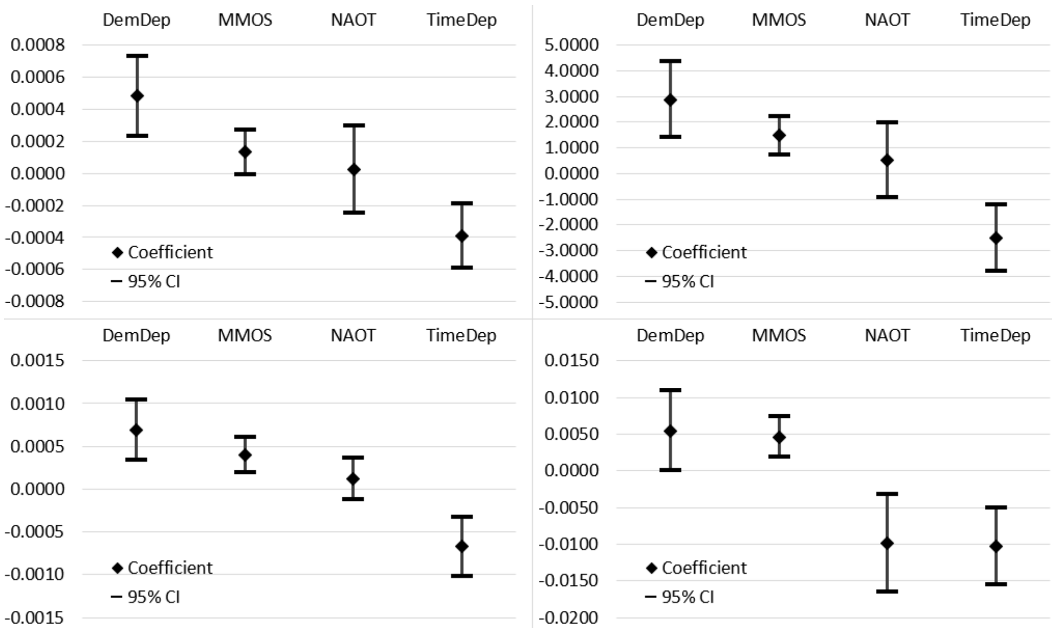

Figure 4: Hierarchy of Deposits

The graph shows the coefficients for demand deposits (DemDep), money market and other savings deposits (MMOS), NOW, ATS and other transaction accounts (NAOT) and dime deposits (TimeDep) interacted with the shadow fed funds rate with the four bank risk variables as the dependent variables. The regression uses the same controls as the fourth columns in Tables 3 to 6. Clock-wise starting from top left, the dependent variables are loan loss provisions, minus z-score, standard deviation of quarterly stock return and the standard deviation of the return on assets.

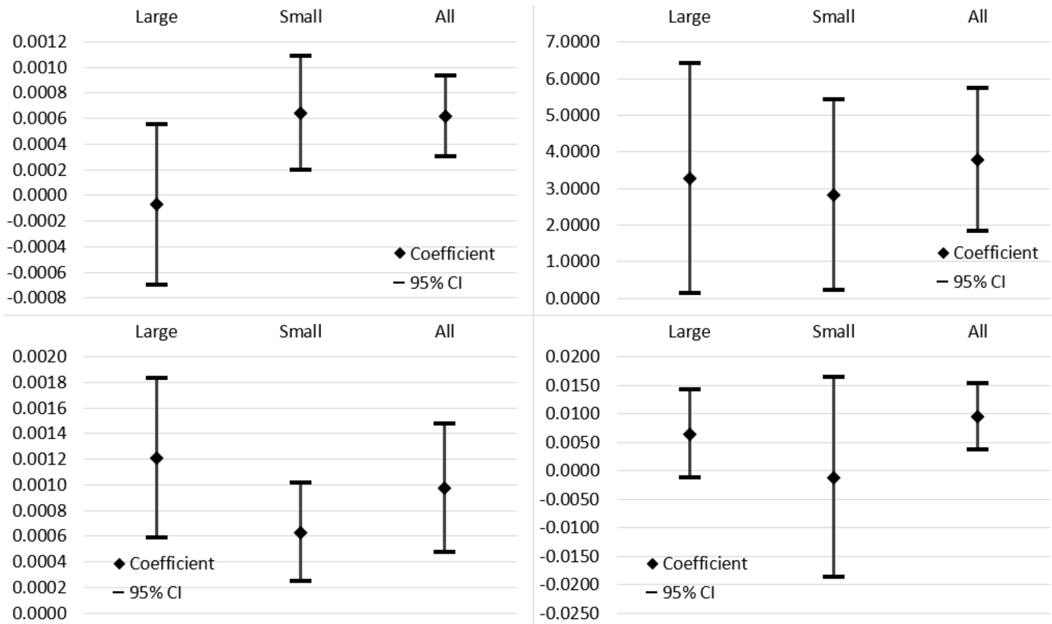

Figure 5: Large And Small Banks

The graph shows the coefficients for the interaction between the shadow fed funds rate (SFFR) and lagged non-interest-bearing deposits for different sizes of firms based on their assets. Specifically, large firms have assets large than the 75th percentile, small firms have assets smaller than the 25th percentile and all firms repeats the coefficients from the fourth columns in Tables 3 to 6. Clock-wise starting from top left, the dependent variables are loan loss provisions, minus z-score, standard deviation of quarterly stock return and the standard deviation of the return on assets.

Table 2: Summary Statistics

	Panel A: Bank Characteristics				
	p25	mean	p75	sd	count
LLPRat	.0006	.003	.003	.005	117226
MinusZscore	-29.59	-26.27	-16.76	17.86	112365
ROASD	.003	.005	.006	.003	112365
RetSD	.033	.071	.091	.057	36186
Tier1Rat	.075	.091	.102	.026	117473
NIBDepRat	.083	.131	.166	.072	117473
IBDepRat	.616	.666	.737	.108	117473
DemDepRat	.058	.109	.1424	.069	117465
MMOSRat	.169	.271	.353	.136	110138
NAOTRat	.026	.078	.117	.061	110161
TimeDepRat	.226	.318	.424	.151	117473
Ln(Assets)	12.57	13.69	14.28	1.48	117302
LoanRat	.583	.654	.745	.131	117302
ROA	.004	.008	.012	.007	117302
CILoanRat	.092	.163	.211	.103	115159
LiquidAssetRat	.026	.049	.057	.038	116418
Shadow Fed Funds Rate	-.490	1.75	4.70	2.63	103
BRW Shock	-.013	-.002	.011	.021	100
D.LnFedSec	-.047	-.034	.002	.101	74

Table 3: Baseline Regression: Loan Loss Provisions

	(1)	(2)	(3)	(4)
SFFR	-0.000280***	-0.000238***		
	(0.000)	(0.000)		
L.NIBDepRat*SFFR	0.000702***	0.000749***	0.000321**	0.000615***
	(0.000)	(0.000)	(0.018)	(0.000)
L.Tier1Rat*SFFR	-0.000348	-0.000493	0.00140***	0.00168***
	(0.340)	(0.183)	(0.000)	(0.000)
L.NIBDepRat	-0.0142***	-0.0153***	-0.00420***	-0.00206***
	(0.000)	(0.000)	(0.000)	(0.000)
L.Tier1Rat	-0.0159***	-0.0155***	-0.0137***	-0.00285**
	(0.000)	(0.000)	(0.000)	(0.045)
Bank FE	Yes	Yes	Yes	Yes
Time FE	No	No	Yes	Yes
Control	No	Yes	No	Yes
N	116487	114505	116487	114505
R^2	0.298	0.312	0.585	0.648

p-values in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: the dependent variable in this table is the ratio of loan loss provisions in the total loan holdings. The key independent variable is the interaction term of the non-interest-bearing deposits to the total assets and shadow Fed funds rate. The samples cover 1996Q1 to 2021Q3 because the risk weighted asset is available from 1996Q1 and the capital ratio is only available until 2021Q3. The control variables include the interaction of Tier 1 ratio and shadow Fed funds rate, Tier 1 ratio, non-interest-bearing deposits ratio, natural logarithm of total assets, return on assets (ROA), total loans to total assets, commercial and industrial loans to total loans and liquid asset ratio, where liquid asset is defined as the ratio of cash and balances due from depository institutions to total assets. We winsorize all observations above the 95th percentile and below the 5th percentile to exclude the effects of outliers on the estimation. Standard errors are clustered at the bank level.

Table 4: Baseline Regression: Minus Z-score

	(1)	(2)	(3)	(4)
SFFR	-1.354***	-1.420***		
	(0.000)	(0.000)		
L.NIBDepRat*SFFR	5.068***	4.773***	4.273***	3.788***
	(0.000)	(0.000)	(0.000)	(0.000)
L.Tier1Rat*SFFR	20.72***	20.42***	20.19***	19.25***
	(0.000)	(0.000)	(0.000)	(0.000)
L.NIBDepRat	-11.46***	-9.000***	-4.778	1.240
	(0.000)	(0.002)	(0.114)	(0.680)
L.Tier1Rat	-157.3***	-162.8***	-140.9***	-150.9***
	(0.000)	(0.000)	(0.000)	(0.000)
Bank FE	Yes	Yes	Yes	Yes
Time FE	No	No	Yes	Yes
Control	No	Yes	No	Yes
N	111594	109609	111594	109609
R^2	0.435	0.444	0.458	0.486

p-values in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: the dependent variable in this table is the Z-score times minus one. The key independent variable is the interaction term of the non-interest-bearing deposits to the total assets and shadow Fed funds rate. The samples cover 1996Q1 to 2021Q3 because the risk weighted asset is available from 1996Q1 and the capital ratio is only available until 2021Q3. The control variables include the interaction of Tier 1 ratio and shadow Fed funds rate, Tier 1 ratio, non-interest-bearing deposits ratio, natural logarithm of total assets, return on assets (ROA), total loans to total assets, commercial and industrial loans to total loans and liquid asset ratio, where liquid asset is defined as the ratio of cash and balances due from depository institutions to total assets. We winsorize all observations above the 95th percentile and below the 5th percentile to exclude the effects of outliers on the estimation. Standard errors are clustered at the bank level.

Table 5: Baseline Regression: Standard Deviation of ROA

	(1)	(2)	(3)	(4)
SFFR	-0.000365***	-0.000366***		
	(0.000)	(0.000)		
L.NIBDepRat*SFFR	0.00115***	0.00112***	0.00105***	0.000975***
	(0.000)	(0.000)	(0.000)	(0.000)
L.Tier1Rat*SFFR	0.00398***	0.00391***	0.00429***	0.00411***
	(0.000)	(0.000)	(0.000)	(0.000)
L.NIBDepRat	-0.00264***	-0.00268***	-0.000758	-0.000203
	(0.000)	(0.000)	(0.130)	(0.680)
L.Tier1Rat	-0.000933	-0.00217	0.00139	-0.000457
	(0.514)	(0.118)	(0.347)	(0.747)
Bank FE	Yes	Yes	Yes	Yes
Time FE	No	No	Yes	Yes
Control	No	Yes	No	Yes
N	111594	109609	111594	109609
R^2	0.472	0.485	0.490	0.518

p-values in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: the dependent variable in this table is the one-year rolling standard deviation of return of assets. The key independent variable is the interaction term of the non-interest-bearing deposits to the total assets and shadow Fed funds rate. The samples cover 1996Q1 to 2021Q3 because the risk weighted asset is available from 1996Q1 and the capital ratio is only available until 2021Q3. The control variables include the interaction of Tier 1 ratio and shadow Fed funds rate, Tier 1 ratio, non-interest-bearing deposits ratio, natural logarithm of total assets, return on assets (ROA), total loans to total assets, commercial and industrial loans to total loans and liquid asset ratio, where liquid asset is defined as the ratio of cash and balances due from depository institutions to total assets. We winsorize all observations above the 95th percentile and below the 5th percentile to exclude the effects of outliers on the estimation. Standard errors are clustered at the bank level.

Table 6: Baseline Regression: Quarter SD of Stock Return

	(1)	(2)	(3)	(4)
SFFR	-0.00300***	-0.00276***		
	(0.001)	(0.001)		
L.NIBDepRat*SFFR	0.0115***	0.0138***	0.00829***	0.00952***
	(0.000)	(0.000)	(0.003)	(0.001)
L.Tier1Rat*SFFR	0.000837	0.00838	0.0332***	0.0351***
	(0.925)	(0.330)	(0.000)	(0.000)
L.NIBDepRat	-0.0943***	-0.114***	-0.0193*	-0.0125
	(0.000)	(0.000)	(0.052)	(0.262)
L.Tier1Rat	-0.267***	-0.236***	-0.316***	-0.275***
	(0.000)	(0.000)	(0.000)	(0.000)
Bank FE	Yes	Yes	Yes	Yes
Time FE	No	No	Yes	Yes
Control	No	Yes	No	Yes
N	36175	35546	36175	35546
R^2	0.108	0.133	0.298	0.303

p-values in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: the dependent variable in this table is the standard deviation of the stock return. The key independent variable is the interaction term of the non-interest-bearing deposits to the total assets and shadow Fed funds rate. The samples cover 1996Q1 to 2021Q3 because the risk weighted asset is available from 1996Q1 and the capital ratio is only available until 2021Q3. The control variable include the interaction of Tier 1 ratio and shadow Fed funds rate, Tier 1 ratio, non-interest-bearing deposits ratio, natural logarithm of total assets, return on assets (ROA), total loans to total assets, commercial and industrial loans to total loans and liquid asset ratio, where liquid asset is defined as the ratio of cash and balances due from depository institutions to total assets. We winsorize all observations above the 95th percentile and below the 5th percentile to exclude the effects of outliers on the estimation. Standard errors are clustered at the bank level.

Table 7: Robustness Check: Negative Interest Rates

	(1) llprat	(2) minuszscore	(3) roa_sd4	(4) RETSD
L.NIBDepRat*SFFR	0.000705***	2.733***	0.000828***	0.0108***
	(0.000)	(0.001)	(0.000)	(0.002)
L.NIBDepRat*SFFR*Negative	-0.00000588	2.188**	0.000371**	-0.00122
	(0.971)	(0.021)	(0.024)	(0.801)
L.Tier1Rat*SFFR	0.000895***	0.285	0.000875***	0.00803**
	(0.000)	(0.834)	(0.001)	(0.010)
L.Tier1Rat*SFFR*Negative	0.000542	22.95***	0.00438***	0.0268**
	(0.121)	(0.000)	(0.000)	(0.012)
Bank FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Control	Yes	Yes	Yes	Yes
N	113703	108837	108837	35229
R^2	0.648	0.486	0.519	0.303

p-values in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: the dependent variables in this table are the respective measure for risk taking. The key independent variable is the interaction term of the non-interest-bearing deposits to the total assets, shadow Fed funds rate and a dummy whether the rate is negative. The samples cover 1996Q1 to 2021Q3 because the risk weighted asset is available from 1996Q1 and the capital ratio is only available until 2021Q3. The regressions correspond to the last columns in tables 3, 4, 5 and 6. Standard errors are clustered at the bank level.

Table 8: Robustness Check: Fed Balance Sheet

	(1)	(2)	(3)	(4)
	llprat	minuszscore	roa_sd4	RETSD
L.NIBDepRat*Shock	-0.00473	165.4***	0.0285***	0.506***
	(0.483)	(0.000)	(0.000)	(0.000)
L.Tier1Rat*Shock	0.00771	527.1***	0.132***	0.967**
	(0.694)	(0.000)	(0.000)	(0.031)
L.NIBDep	-0.00149**	13.28***	0.00194***	0.0128
	(0.033)	(0.000)	(0.000)	(0.173)
L.Tier1Rat	0.00153	-89.59***	0.00242	-0.159***
	(0.341)	(0.000)	(0.121)	(0.000)
Bank FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Control	Yes	Yes	Yes	Yes
N	71494	69263	69263	23531
R^2	0.670	0.464	0.467	0.379

p-values in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: the dependent variables in this table are the respective measure for risk taking. The key independent variable is the interaction term of the non-interest-bearing deposits to the total assets and the percentage change in the Fed balance sheet (shock). The samples cover 1996Q1 to 2021Q3 because the risk weighted asset is available from 1996Q1 and the capital ratio is only available until 2021Q3. The regressions correspond to the last columns in tables 3, 4, 5 and 6. Standard errors are clustered at the bank level.

Table 9: Robustness Check: Interest Rate Shocks (BRW)

	(1)	(2)	(3)	(4)
	llprat	minuszscore	roa_sd4	RETSD
L.NIBDepRat*Shock	0.0816**	236.4***	0.0526***	0.530
	(0.026)	(0.006)	(0.001)	(0.178)
L.Tier1Rat*Shock	0.513***	1204.7***	0.295***	-0.914
	(0.001)	(0.000)	(0.000)	(0.601)
L.NIBDep	-0.00125	9.101*	-0.000931	0.000137
	(0.397)	(0.066)	(0.326)	(0.992)
L.Tier1Rat	-0.0110**	-140.9***	0.00656	-0.367***
	(0.013)	(0.000)	(0.435)	(0.000)
Bank FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Control	Yes	Yes	Yes	Yes
N	113891	108997	108997	35078
R^2	0.529	0.274	0.411	0.293

p-values in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: the dependent variables in this table are the respective measure for risk taking. The key independent variable is the interaction term of the non-interest-bearing deposits to the total assets and the shock. The samples cover 1996Q1 to 2021Q3 because the risk weighted asset is available from 1996Q1 and the capital ratio is only available until 2021Q3. The regressions correspond to the last columns in tables 3, 4, 5 and 6. Standard errors are clustered at the bank level.