The Bank Lending Channel under Great Moderation and Great Recession

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Abstract

This paper revisits the bank lending channel in monetary policy transmission under the background of great moderation and great recession. Evidence shows that a cross sectional bank lending channel exists as I investigate bank level data. Banks that enlarge their loan spread more also have more losses on loan portfolios when facing an adverse policy shock. Monetary policies are more likely to impact the spending on long term assets and investments, compared to the traditional perspective that change in policy rate mostly effect short live consumption. Some bank specific characteristics can have large impacts on commercial banks provision of loans. Well capitalized banks, or banks with higher deposits, are less sensitive to the change in the policy rate. I also find that changes in banks funding pattern and business models have modified the transmission mechanism, and securitization activity became particularly important during the great recession when unconventional policies are adopted.

1 Background and Motivation

1.1 A review of monetary policy transmission channels

The transmission channels of monetary policies have long been under study and investigation, and how asset prices and general economic variables are affected as a result of monetary policy decision forms the major strands of current literature. This paper investigates the roles that commercial banks play in the transmission of monetary policies in United States since mid 1980. The time period under examination covers both great moderation and the following great recession, when the macroeconomic environments are totally different. Great moderation features relatively stable macroeconomic fluctuations, ended by the 2008 global financial crisis, when unconventional monetary policies are first widely adopted and zero lower bound of nominal policy rate has been binding. This paper can fill the current existing literature in the following aspects: I extend the investigation of spending item responses till the unconventional policy era and try to build a connection between these non standard reactions with some features of the unconventional policies. The findings in the aggregate level responses lead my further examination of the bank level data, and I try to construct a more detailed and broader bank credit channel that fits the recent decades' macroeconomic environment as well as taking bank specific characteristics and financial crisis into consideration. This paper aims at checking whether the traditional bank credit channel still plays a vital role in the new era of monetary policies; whether the 2008 financial crisis helps amplify the impact of monetary policies on banks lending behaviors and credit provision; and whether the modern features and business model of commercial banks has made any difference in the bank credit channel of monetary policy transmission.

The traditional channels of how monetary policies are transmitted have been documented in plenty of existing studies and researches. Sim (1999)[20] used monthly data in a VAR system to prove that innovations to monetary policy variable has the potentiall in affecting

the other macroeconomic variables. The response of real output to an interest rate shock follows a hump-shaped pattern. A contractionary monetary policy shock generates negative deviation in output from its steady state, and the bottom is observed after several horizons and the effects then gradually die out.A puzzling effect is found by Christinao (1992)[7] as M1, a measure of the money supply, is considered as the monetary policy instead of the federal funds rate. The paper claims that an increase in M1 shock, interpreted as an expansionary monetary policy, is followed by a decline in output. The increase in money supply lowers the short term nominal interest rate and the short term real rate as well. With the expectations hypothesis of the term structure, stating that the longer term interest rate is an average of expected future short term interest rates, the lower short term real rates push down the longer term real interest rates. Firms increase business fixed investment as they predict the long term interest rates would decline. Additionally, this interest rate channel should also have effects on household decisions about purchasing new real properties and consumer durables: monetary expansion leads to more residential housing and consumer durable expenditures. Even in the situation when the nominal interest rate hits the floor of zero, this interest rate channel could still be effective. When the nominal rate is at zero, an expansion in the aggregate money supply can raise the expected price level and hence expected inflation. Thereby, the real interest rate is lowered even when the nominal rate is at zero, and spending could be stimulated.

Because the unique role commercial banks play in the financial system, some borrowers will not have access to the credit markets unless they receive loans from banks, but most savers have alternative options in dealing with their money if they feel the deposit rates offered by commercial banks are not attractive. When there is a tightening monetary policy, the interest rate on deposits usually rises less than the policy rate, and under the assumption that there is no perfect substitution of retail bank deposits, banks attract less deposits. When banks receive fewer deposits, banks also should have fewer funds available to make

loans, which cause the investment spending. Given that some percentage of consumers are borrowing constrained, aggregate consumer spending is expected to drop as well. As the current U.S authority no loner imposes restrictions on banks interest rates ceilings paid to saver, this bank lending channel is suspected to be not as powerful as it was. From 1966 to 1979, with regulation Q in effect, certificate of deposits (CDs) were subjected to reserve requirements and all types of deposits are restricted by ceiling rates. Banks are hard to find replacement of the deposits that flowed out of the banks during a tightening policy, and this met the assumption for the bank lending channel to be in effect. 1980 to March 1986 marked the gradual phase out of regulation Q and banks can easily erase the loss of retail deposits by issuing CDs at market interest rates that are not required to be backed up by required reserves, or other forms of deposit liabilities by paying higher interests. The bank lending is suggested to be less potent and receive lots of challenges.

The balance sheet channel also arises from the asymmetries in credit markets. Under a contraction policy, discount rate rises as the federal funds rate rises, dampens the net worth of firms. Lower net worth indicates that lenders have less collateral against their potential loans, and banks would choose to make less amount of loans facing shrinking collateral values. The lowered net worth of firms also generates more severe moral hazard problem since the owners have less equity stake in their firms and they have incentives to take on riskier investments. An important assumption in this balance sheet channel is that it is the nominal interest rate, not the real interest rate that affects the firms' balance sheet and cash flow. This channel shall apply equally well to consumer spending. Declines in bank lending generated by a contraction monetary policy should lead to a decline in consumer durables and housing purchases by the population who do not have access to other sources of credit. Similarly, the increase in interest rate generates a deterioration in households asset values and cash flow as well. From the view of liquidity effect, the balance sheet channel should also be in effect in households. Consumer durables and housings are relatively non-liquid

assets. If household expect themselves would be in the financial distress situation in the near future, they would rather hold liquid assets that can easily be cashed at the market value (such as stocks and bonds), rather than purchase durable goods or real properties. Thus, a contraction policy should lead to a decline in household consumption as well.

1.2 Bank Credit Channels In the Context of Unconventional Monetary Policies

To combat the great recession, the Federal Reserve purchased particular assets in multiple rounds of quantitative easing (QE) since 2008. On the theory side, the large scale asset purchases (LSAPs) lower yields and increase values of banks' current asset holdings, thereby should improve the condition of banks' balance sheets and encourage banks to make more loans. Fed officials have already documented this theoretical price impact of QE. (Yellen, 2012 [23]; Bernanke, 2012 [2]). The effects of QE on macroeconomic variables and asset prices have been under investigation since the adoption of the policies. Krishnamurthy and Vissing-Jorgensen (2011) [18] provides empirical evidence by evaluating the effect of the purchase on long term treasuries and other long term bonds on interest rates. The paper concludes that which asset classes are purchased are crucial and they found a signaling channel that there exists a unique demand for long term safe assets .

Concerns and doubts on the effectiveness of LSAPs also arise. Stroebel and Taylor (2009) [21] examined the quantitative impact of the MBS purchase program on mortgage interest rate spreads and their empirical results suggest that a very smallportion of the program contributes to the decline in mortgage rates, the impact has not increased with the additional purchases of MBS since the start of the program. Brunnermeier and Sannikov (2015)[6] even debate that unconventional policies came with undesirable side effects, such as the accumu-

lation of asset bubbles: securitization and huge stock on derivatives improve risk sharing and may lead to higher leverage and more frequent crises. Di Maggio and Kacperczyk (2017)[9] find that in response to policies that keep interest rates at zero lower bounds, money funds invest in riskier asset classes, hold less diversified portfolios.

The pass-through of zero nominal policy rates to most market rates appears to be relatively strong, although with some extend of delay in timing. Jobst and Lin (2016)[16] report in the Euro area, negative interest rate policy contributed to a modest expansion in credit and achieve its price stability objective. Retail and household deposit rates appear to have a floor at zero, and the unconventional policies are having very minimal effect on lowering the bound. (Eisenschmidt and Smets (2018)[13]). The effect of QE on banks' lending rates and volumes depend on their business model and funding model. Some studies merely find the transmission from policy rates to lending rates, while others discover evidence to support the pass through of the policy rates to lending rates: not only lending rates dropped but loan volumes have also increased. As the effectiveness of the pass through of policy rates to commercial market rates is ambiguous, it is possible that the zero policy rate and the unconventional policies reduce the spread between lending rates and deposit rate, shrink net interest margins and bank profits. But banks may temper this effect by shifting their portfolios towards riskier assets. Low nominal interest rate lowers the opportunity cost of holding reserves and collateral. Bank can generate larger balance sheets and higher leverage. On the side of household consumption, forward guidance and LSAPs convey the expectation of a low policy rate even after the zero lower bound no longer binds. As suggested by the Euler equation, current consumption and future spending should both increase as the expected nominal interest rate declines. (Drager and Nghiem (2018)[11]) The fall in nominal interest rate plus the increase in spending generate increased expected inflation. Lower long term nominal interest rates and higher inflation together indicate a decline in long term real interest rates.

2 Facts from the Aggregate Data

In this section, I follow closely with Bernanke and Gertler (1995)[3] to investigate the responses to policy shocks using vector autoregressive framework. A vector autoregression (VAR) is a system of ordinary lease square regressions, in which each of variable is regressed on lagged values of both itself and the other variables in the set. The VARs I adopt in this research include combinations of macroeconomic variables and the policy rate. The federal funds rate is used as an indicator of monetary policy in period before 2008 financial crisis and great recession. From 2009, as the federal fund rate reached zero and is kept at zero lower bound till 2015, I use shadow rate introduced in Wu and Xia (2016)[22], which reflects the unconventional monetary policies, as the indicator of the real policy rate. Unlike the observed short-term interest rate, the shadow rate, first introduced by Fischer Black (1995)[5], is not bounded zero. The input data for the Wu and Xia model are one-month forward rates beginning n years hence. The model uses forward rates corresponding to $n = 1/4, 1/2, 1, 2, 5, 7, and 10$ years. These forward rates are constructed with end-of-month Nelson-Siegel-Svensson yield curve parameters from the Gurkaynak, Sack, and Wright (2007)[15] dataset. In short, the shadow rate is assumed to be a linear function of three latent variables called factors, which follow a VAR(1) process. The latent factors and the shadow rate are estimated with the extended Kalman filter.

2.1 Responses from Spending Components in GDP

All data employed in this research expands from 1985 to 2019, and currently available from St. Louis Federal Reserve database. I separate the full sample into two periods: great moderation (1985-2008) and great recession (2009-2019). In the pre crisis period, normal federal funds rate is used as the monetary policy rate, while in the great recession period, since the nominal funds rate is kept at zero and could not convey any new information, and shadow rate that is constructed to be able to go below zero is used as the policy rate. Figure 1 is based on a VAR system that includes the log of different spending items, the log of GDP deflator and the policy rate (in percentage). The spending items being tested are private residential investment, domestic business investment, consumer durables, and consumer nondurables. Figure 1 shows the estimated dynamic responses of the items to a positive, one standard deviation shock to the federal funds rate (a sudden unanticipated tightening of monetary policy). The impulse responses with confidence intervals are attached as figure 8 and 9 in the appendix.

According to the response patterns shown in the upper panel of Figure 1, private residential investment drops sharply following a monetary policy tightening and gradually goes back to steady state after 12 months of the shock. The domestic business investment drops sharply as well at the time of the shock but bounce back to normal level very quickly. The consumption on durable goods and non-durable goods both respond weirdly as they fluctuate around the steady state during almost all horizons and show no significance at all. Investigating the lower panel in Figure 1, domestic business investment has the immediate response in a policy shock. The private residential investment doesn't decline much at the beginning, and reaches the bottom in 6 months. Again, the consumption of durable and non durable goods show very limit responses. However, the responses of residential and business investments are larger quantitatively.

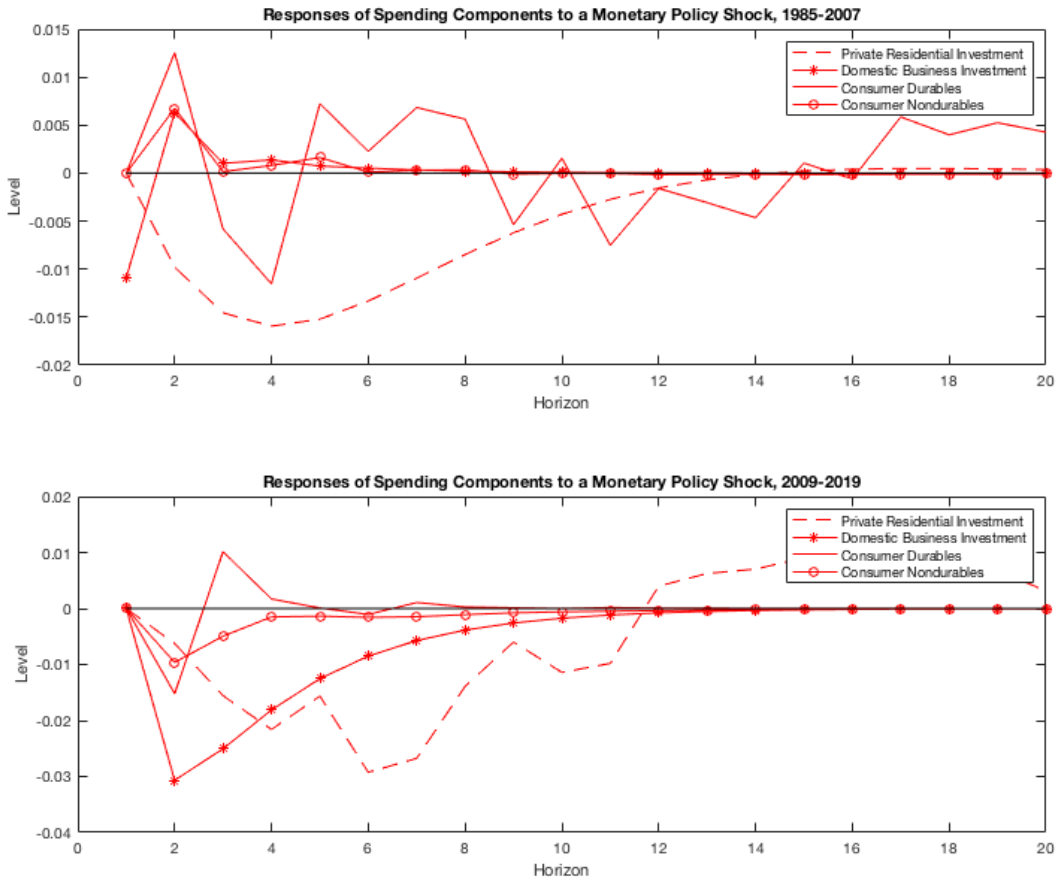

Figure 1: Spending Components of GDP, 1985-2019

Theoretically, monetary policy is expected to have its most direct effects on short-term rates, and it should have its most significant impact on spending on shorter lives assets - consumer durables, for example. Yet the most rapid and strongest effect of monetary policy is on residential investment and business investment. This finding is counter-intuitive and puzzling because investments are typically very long-lived and thus, according to the conventional view, should be most sensitive to long-term real interest rates, not the short-term rates most directly influenced by the Fed. It might be suggesting that the unconventional policies have more impacts on the longer term rates, which is along with the purpose of LSAPs and forward guidance.

2.2 Responses from Banks' Balance Sheet

In this section I substitute the spending components in the previous VAR system with all commercial banks' total deposits, total loans and total security holdings. The data is revealed by the Federal Reserve every month. The log levels of each of three bank balance-sheet variables are all deflated by the CPI. I calculated the implied impulse response functions to a monetary policy shock. In the conventional perspective, banks deposits are expected to fall following in contraction monetary policy shock, because of the banks' lending channel in transmission. The asset components: loans and security holdings, behave differently. The fall in assets shall mostly concentrated on the decline in security holdings, and total loans hardly move because loans are quasi-contractual commitments whose stock is difficult to change immediately. When facing an unanticipated increase in the policy rate, and fall deposits, banks react to the shock by selling securities quickly. However, security holdings begin gradually to be rebuilt, as banks re-balance their portfolios, and this is the time when loans start to fall significantly.

Figure 2 is the impulse responses of the banks balance sheet items during 1973 to 1984. This is the time when the deposit rate ceiling is still existing. When there is a monetary policy tightening, the deposit rate usually does not rise as much as the effective federal funds rate, banks attract less regular deposits when facing an increase in the policy rate. When there is deposit rate ceiling in place, banks cannot easily substitute the loss deposits with other types of financing tools (such as cerfiticate of deposits, (CD)), thus the decline in retail deposits is highly likely to happen and the banks' lending channel should be in effect. Also, as expected, Figure 2 shows that the banks security holdings drop almost simultaneously and sharply at the beginning months, and gradually go back later, and the decline in total loans is relatively smoother and limited.

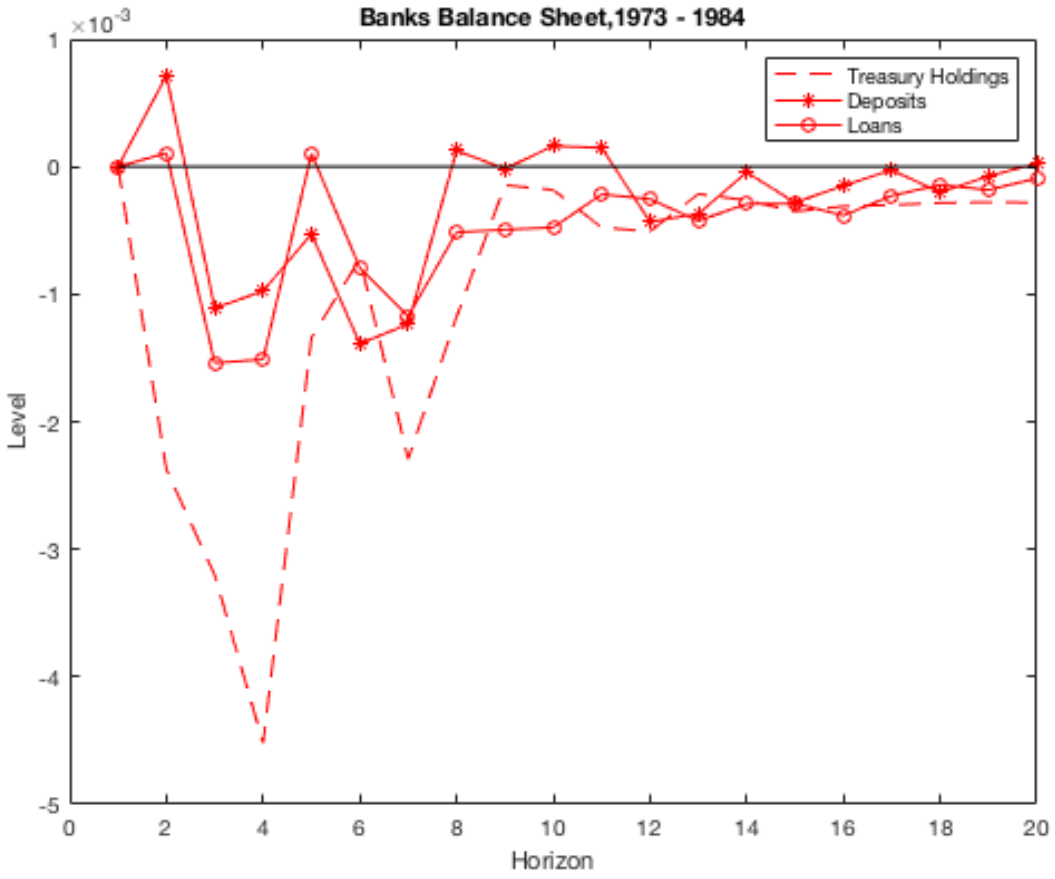

Figure 2: Banks balance sheet items, 1973-1984

The upper figure of Figure 3 is the responses using data from 1985 to 2008, and the lower part is using the data from 2009 to 2019, referring to the unconventional policy period. The responses of the three items are very different from pre-1985 period. One explanation could be the financial reform and deregulation. As the interest rate ceiling on deposits no loner exists since 1985, banks are more capable of replacing lost deposits, so the deposits don't respond much to a monetary policy shock. But the security holdings remain to be the most reactive item since they are still the most flexible assets on banks balance sheet. Entering the unconventional monetary policy regime, the banks balance sheet channel seems to come back, as the deposits drop sharply following an increase in the policy rate. However, on the assets side, the decline are almost equally distributed to loans and securities, which is contrary to the common understanding. Another point worth mentioning is that the three major balance

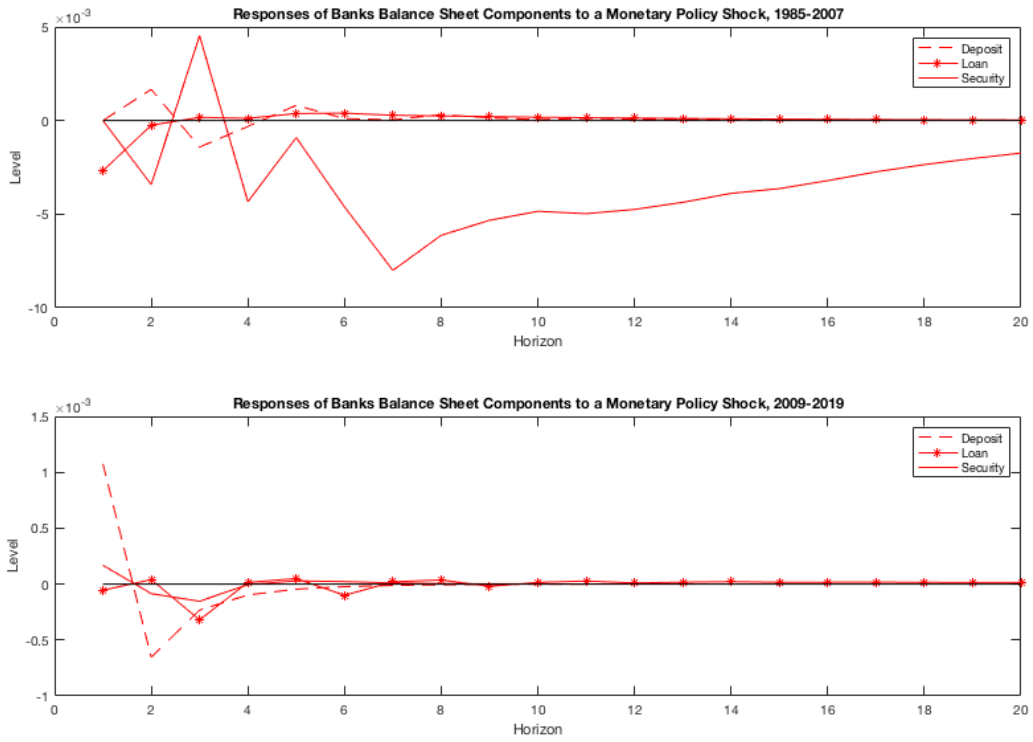

Figure 3: Banks balance sheet items, 1985 - 2019

sheet items all respond very limited to a monetary policy shock, which may indicate that the unconventional policies do not work through the traditional bank transmission mechanism that much as before.

Figure 5 shows the responses from some deposit items: time deposit and brokered deposit on commercial banks' balance sheet. A time deposit is interest bearing and has a pre-set date of maturity. A certificate of deposit (CD) is one of the typical examples. Time deposits usually pay higher interest rate than a regular savings account, and longer the maturity is, higher the interest rate would be. A brokered deposit is a type of deposit made to a bank with the assistance of a third-party broker. Deposit brokers facilitate the placement of other people's deposits with banks and banks sell large denomination deposits to deposit brokers, who divide these large deposits into smaller investments sold to individual investors. Individ-

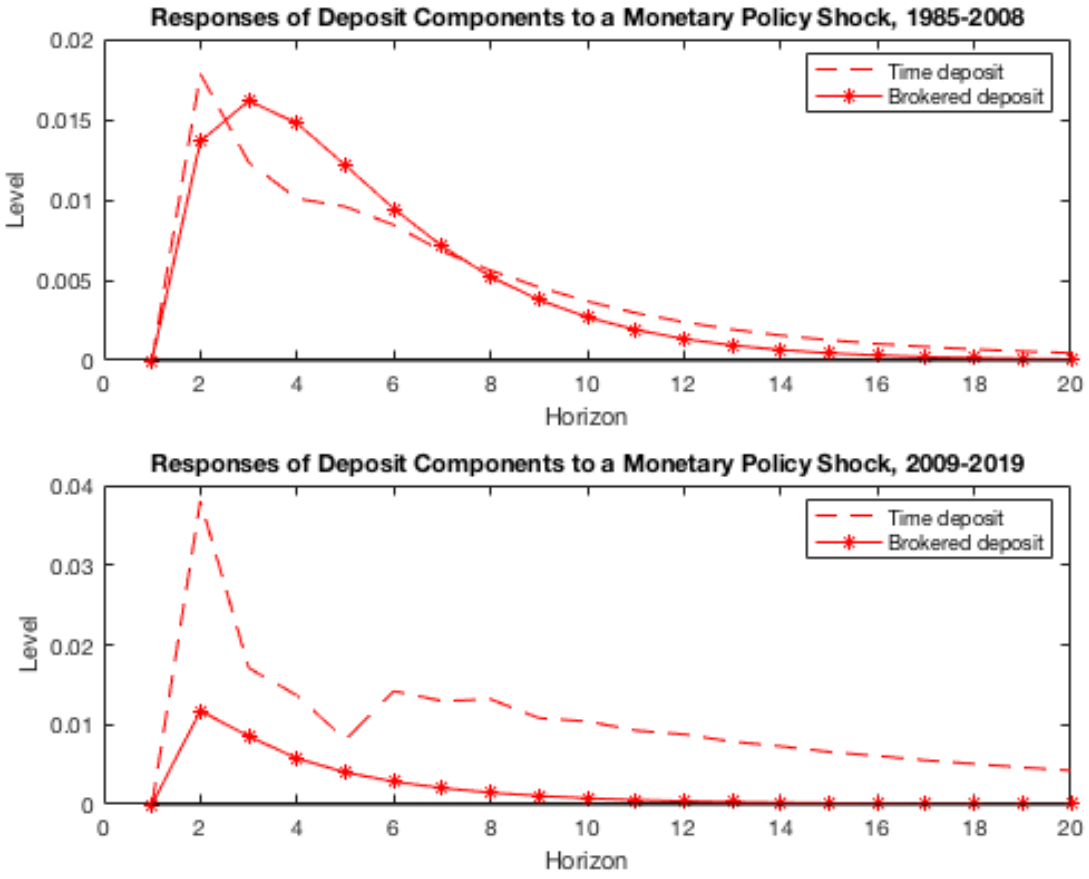

Figure 4: Deposit accounts, 1985 - 2019

ual investors who purchase brokered deposits receive higher interest rates than traditional deposits. The time deposits and brokered deposits could be viewed as the substitutes of traditional demand deposits, as their interest rates are able to go higher if necessary. The impulse responses with confidence intervals are included as figure 10 in the appendix.

It is not surprising that when there is a contraction monetary policy shock, the amount of time deposits and brokered deposits surge immediately. When the price ceiling on interest rates was abandoned after mid 1980, the cost of holding demand deposit during the contraction policy rate period is increasing, as other tools of bank deposit could offer higher returns and adjust closely to the movement in the policy rate. During the unconventional policy regime, there is even larger responses from the time deposits, and the impact sustained

for a very long period. This might be an indication that people believe that the unconventional policies also influence the longer term rates substantially and are will to invest in fixed return investment pays higher than traditional deposits.

2.3 Responses from Banks' Loans

In this section I run a detailed investigation into the commercial banks' major loan portfolios. Figure 5 is an overview of the major loans in all commercial banks in the United States. The loans backed up by real properties are the major type of loans, and shows the fastest growth among all loan categories. Commercial and industrial loans are the second largest by volume, and presents close connection with the business cycle. Consumer and personal loans are the most stable category. The sudden jump in the beginning of 2010 was due to an adjustment in accounting and report regulations, and besides that it shows relatively smooth growth trend.

I substitute the banks' balance sheet item in the previous VAR system with these detailed loan categories and try to capture the responses of these loan items to an unanticipated contractionary monetary policy shock. Also, the full sample expands from 1985 to 2019, and I separate it into great moderation period and unconventional policy period, to see whether the unconventional policies make difference on the responses of loans to contractionary shocks. Figure 5 reports the impulse responses.

Some micro level evidence are provided on how the macro economy and commercial banks react to monetary policy rate shocks during great moderation and great recession, where there is no deposit interest rate ceiling and unconventional policies are introduced. The first thing worth discussing is that the responses to unconventional policies are very mini-

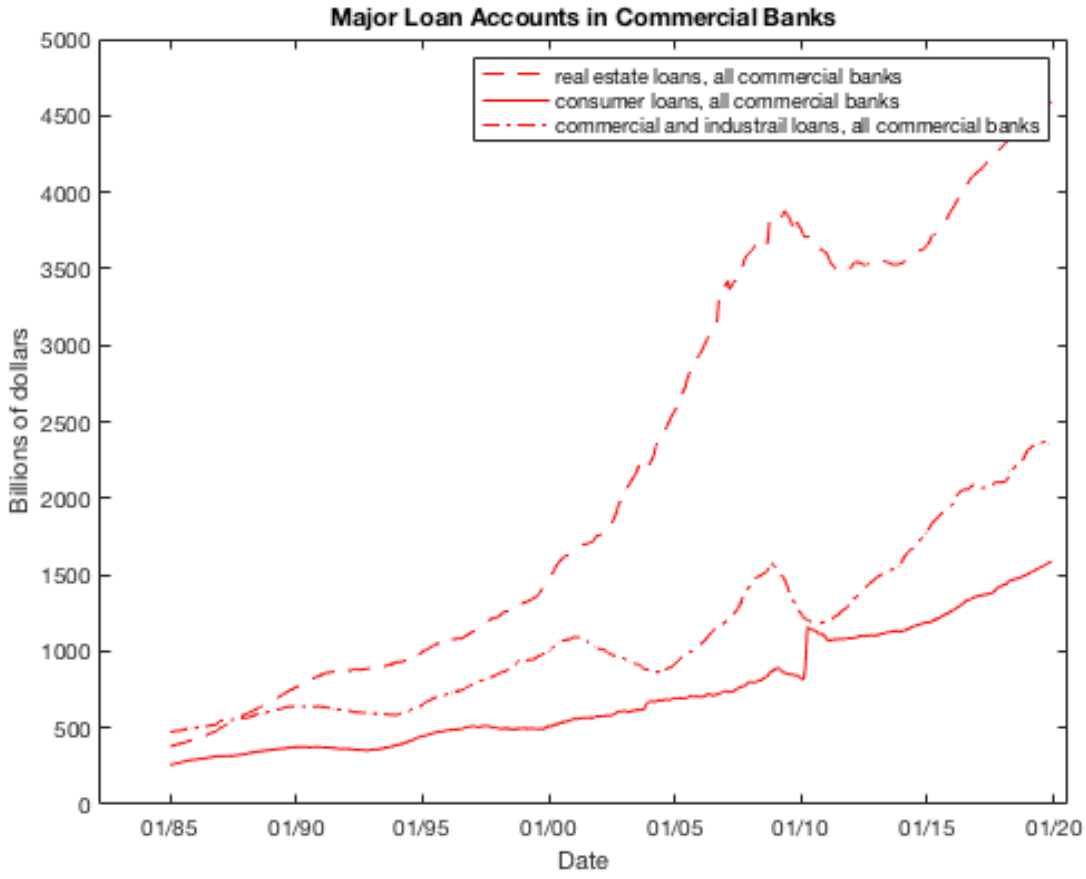

Figure 5: All Commercial Banks' Loan Holdings, 1985 - 2019

mal, which is consistent with the results in the previous subsection that the unconventional policies may not work through the traditional banks' credit channel as before. Before the outbreak of global financial crisis and the employment of unconventional tools, the responses of consumer loans are the smallest among the three major types of loan. This is along with the trend that personal loans grow most smoothly over time, and might not be closely tied with the business cycle. Real estate loans and commercial loans experience almost the same magnitudes of decline immediately following a sudden policy tightening, with real estate loans going back to the steady state more gradually and commercial loans showing more fluctuation. If figure 6 is paired with figure 1 together, it verifies the situation that the private residential investment, as supported by real estate loans, and business investment, as supported by commercial and industrial loans, are the spending components that are most

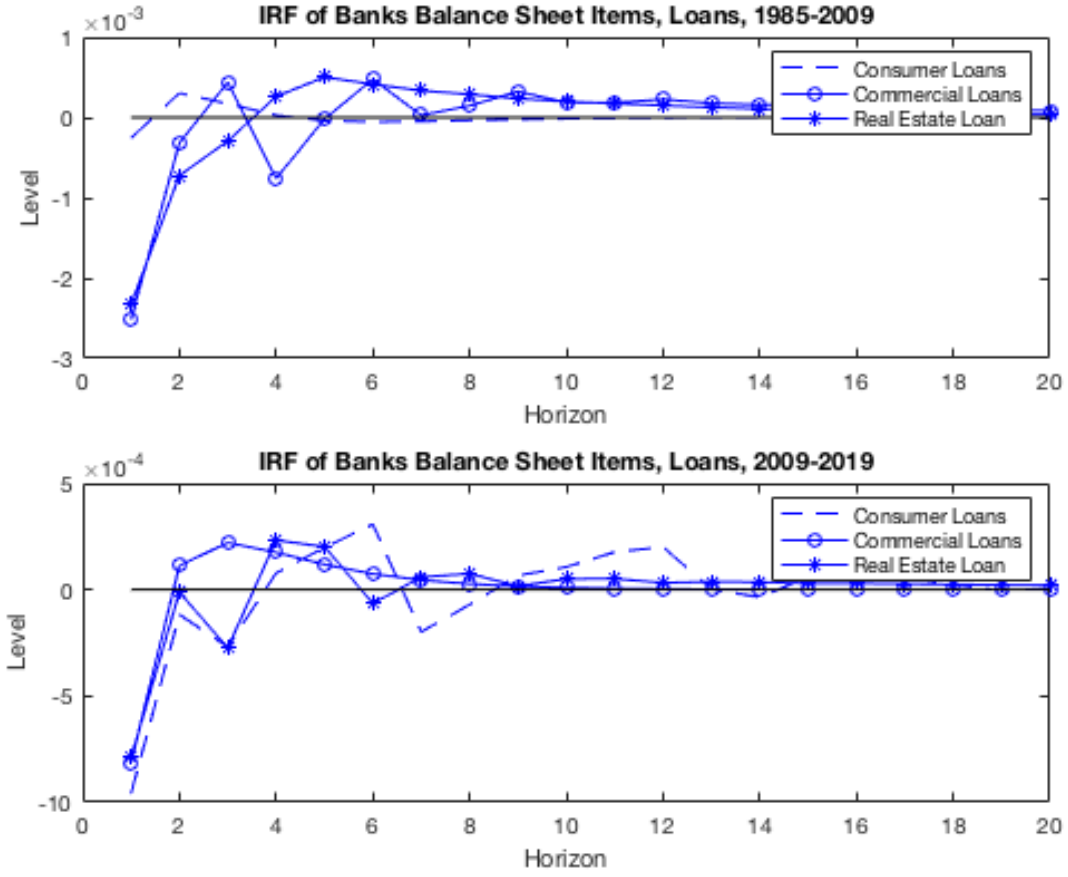

Figure 6: Banks Loans by Category, 1985 - 2019

responsive to a monetary policy shock.

Another part worth investigating is the different responses of commercial borrowers and individual borrowers. The conventional perspective would indicate consumers respond fastest and strongest to a policy shock, and due to the presence of sticky prices and all levels of rigidity, businesses shall not react immediately. However, the impulse responses show a reverse story. There might be some reasons to explain this situation: For commercial borrowers, their balance sheet deteriorated at the moment when the central bank raises the target rate, so they are not able to get an new loans immediately when the shock happens, so the commercial loans and real estate loans drop dramatically at the beginning. But for consumers, if they receive regular pays, their credit scores and credit lines don't drop simultaneously as

the policy rate goes up. There would be using more credits and paying back debts slower. So the responses of consumer loans are relatively moderate.

3 Empirical Methods using Bank Level Data

3.1 Data Description

In this section, I employ the data collected in Reports of Condition and Income (Call Reports). The CALL report provides very sophisticated individual bank level sources for detailed interest expenses and loan amounts for all insured commercial banks operating in the United States. I use the data on banks balance sheet and income statement spanning from the first quarter of 1985 till the last quarter of 2018. The time frame covers both great moderation and great recession. The total number of bank-quarter observations is 217613. All implausible negative and zero entries have been removed to ensure the data consistency. Also, to correct the survival bias, I include only banks that have operation history of five years or longer. The major item under consideration as the bank level year to year growth of loans, which is also the main dependent variable. Other variables include the bank specific data: bank size as measured by total assets, capitalization as measured by capital to asset ratio, and securitization as measured by security holdings to asset ratio.

Some macroeconomics data are also added into the empirical methodology. The most important macroeconomic control is the monetary policy, and in the main regression, it is represented by change in the previous quarter's federal funds rate. As illustrated in the previous sections, the federal funds rate is substituted with the shadow rate in order to capture the negative real rate during the great recession. Another macroeconomic control is the real gross domestic product growth. So in line with the literature, I add log real industrial

production index into this regression. I also consider the effect of the financial crisis and I am interested in testing whether the its occurrence has reshaped the banks transmission of monetary policy. So I add a dummy variable which takes the value one if the observation date is after the third quarter of 2008, and takes the zero if the observation is before crisis.

3.2 Results from Fixed Effect Regression

On the asset side, if banks following the credit channel, banks lending shall decrease following an interest rate hike. Table 1 reports the results testing the responses of loan accounts to the changes in the nominal policy rate. Panel A reports the result when using changes in loan amount as the dependent variables. I fail to establish significant negative relationship between innovations in loan amounts and the changes of policy rate. The traditional bank transmission is expecting the amount of loans to decline while the policy rate rises, however, the regression result cannot verify it. Panel B is testing whether the interest rate on loans set by commercial banks are related to the changes in federal funds rate. The loan rate spread (computed as average interest rate on loans minus federal funds rate) show significant negative relationship to the changes in the policy rate. When there is an increase in the Fed's nominal rate, the loan rate spread narrows, indicating the interest rate on loans do not go up as much as the policy rate. When there is a policy rate cut, the interest rates charged by commercial banks decline, but also they are not lowered as much as the policy rate. This finding shows that commercial banks may serve as a "wedge" between the Federal Reserve and borrowers by conveying the latest monetary policy through a shrinkage tunnel. This motivates the next section where I test the banks lending channel depends on the ability of banks to convey the innovations in policy rates, and the transmission of policy relies on the banks market power.

Table 1: Responses of Loan Amounts and Loan Rate Spread on Policy Rate Change

	$log(loan)_{t,i}$
$log(loan)_{t-1,i}$	0.953^***
	(0.004)
ΔFFR_{t-1}	0.180^***
	(0.029)

(a) Panel A

	$LoanSpread_{t,i}$
$LoanSpread_{t-1,i}$	0.880^***
	(0.008)
ΔFFR_{t-1}	-0.587^***
	(0.030)

(b) Panel A

The table reports the regression results on the equation: $y_{i,t} = \alpha_i + \beta_1 y_{i,t-1}\beta_2 \Delta FF_{t-i} + \epsilon_{it}$. In panel A, the dependent variable is the log level of total amount in each commercial bank. In panel B, the dependent variable is the loan spread, computed as the average interest rate charge on loans minus the target rate. All coefficients are reported with their standard deviations in parenthesis and significance level.

As inspired by Drechsler, Savov and Schnabl(2017)[12], I define a bank's *Spread Beta* (β^{Spread}) by running Equation (1) for each bank in my defined data set.

$$\Delta y_{it} = \alpha_i + \sum_{\tau=0}^{4} \beta_i^{\tau} \Delta FF_{t-\tau} + \epsilon_{it} \tag{1}$$

ΔFF_t is the change in the Fed Funds rate from date date t to $t+1$. Four periods of lags is allowed because it takes time for banks to reset non-zero maturity deposit (loan) rates.[1] $\beta_i^{Spread} = \sum_{\tau=0}^{4} \beta_i^{\tau}$. The dependent variable Δy_{it} is the loan spread (computed as average interest rate on loans minus federal funds rate) of each bank at time t. The *Spread Beta* can be interpreted as a measurement of banks responsiveness to the change in policy rate. Larger *Spread Beta* indicated more active response to policy innovation. Next I compute each bank's *Flow Beta* by rerunning the same regression but substitute the changes spread with the changes in loan amounts as the dependent variable. So the *Flow Beta* can be viewed as the change in the amount of loans when there is a change in the policy rate. In the third step, I cluster all commercial banks into at most 100 bins by their *Spread Beta*. The highest *Spread Beta* indicates the bank is very responsive to the policy rate: it actively raise or cut the interest rate on loans in response to the fluctuations of monetary policies. I

[1]The lag order follows the setting in Drechsler, Savoy and Schnabl (2017)

calculate the average *Spread Beta* and *Flow Beta* for each bin and regress *Flow Beta* on *Spread Beta*. By checking the coefficients, I am able to get a picture whether the flows of loans depends on the bank's pricing on loans, and I plot the regression results into Figure 7. All coefficients are negative and statistically significant. The results indicate the negative relationship between the banks spread beta and flow beta. When there is a tightening monetary policy, banks with higher loan rate spread beta increase their lending interest rates even higher, shall have a larger negative flow beta, or they have more decline and outflow of loans. This finding can be served as an evidence that the bank's credit channel still has its place in great moderation and the following great recession period that deposit interest rate ceiling is no longer effective. Heterogeneous banks play diverse roles in this transmission channel by diversifying their loan interest rates.

3.3 Bank specific regressions

My empirical specification in this section is based on Kashyap and Stein (1995) where the bank specific characteristics are first introduced into bank lending channel investigation. My baseline regression takes the form as shown in equation (2):

$$\Delta L_{t,i} = \alpha_i + \rho_i * \Delta L_{t-1,i} + \beta_i * \Delta i_{t-1} + \sigma_i * \Delta y_{t-1} + \gamma_i * B_{i,t} + \epsilon_{i,t} \tag{2}$$

The bank level credit growth $\Delta L_{t,i}$ is regressed on its own lagged value $\Delta L_{t-1,i}$, change in the policy rate Δi_{t-1}, macroeconomic control Δy_{t-1}, representing log real industrial production index, and bank characteristics $B_{i,t}$. $B_{i,t} = [log(assets)_{i,t}, leverage_{i,t}, Securities_{i,t}]'$ are bank size, represented by total assets, capitalization level, represented by capital to asset ratio, and securitization level, represented by security holdings to asset ratio. The summary statistics of the variables are listed in table 1 for reference.

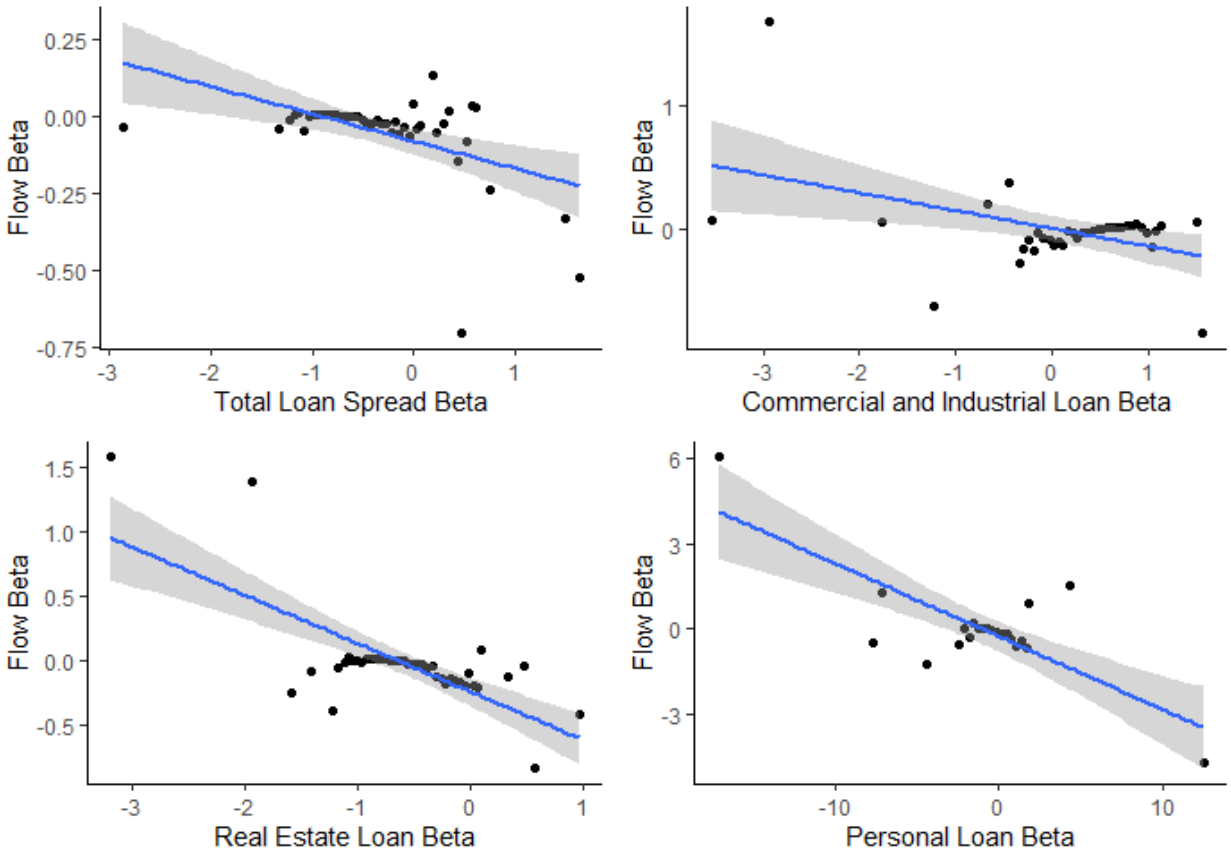

Figure 7: Bank loan rate spread and bank level outcome

I estimate the *Total Loan Spread Beta* for each bank in the sample. The *Spread Beta* on the vertical axis is estimated using the equation: $\Delta y_{it} = \alpha_i + \sum_{\tau=0}^{4} \beta_i^{\tau} \Delta FF_{t-\tau} + \epsilon_{it}$, where δy_{it} is the change in the loan spread (calculated as the average interest rate on loans minus federal funds rate) of bank i from date t to $t+1$ and ΔFF_t is the change in the Fed Funds rate from date date t to $t+1$. The Spread Beta of bank i equals $\sum_{\tau=0}^{4} \beta_i^{\tau}$. The *Flow Beta* of each major loan product (commercial and industrial loan, real estate loan, personal loan) is estimated using the same methodology as Spread Beta, but rerunning the same regression with the log growth of C& I loans, loans supported by real properties, and personal loans, and I refer the sensitivities of these flows to the change in federal funds rate as *Flow Beta*. The third step is estimating the relationship between *Loan Spread Beta* and its corresponding *Flow Beta*. I sort banks into at most a hundred bins by their total loan spread betas. A higher spread beta indicates that banks are more responsive to a change in the monetary policy. I compute the average spread beta and flow beta in each bin and regress average flow beta on average spread beta.

Notations of variables are interpreted as followed: α_i is the bank fixed effect. B_i stands for a vector of each bank's specific controls, including Dep: Deposit Ratio; $ln(Assets)$: log(total asset); Lev: Leverage Ratio; Sec: Securitization Ratio. There are a few reasons to support my choice of bank specific variables. Dep, deposit ratio, is calculates as bank's total deposit divided by its total liability. This is a common variable to measure a bank's funding reliability on deposits. Total asset is included to evaluate the size of the bank. Lev, leverage ratio, computed as bank's total capital divided by its total asset, as the standard Tier I ratio that has been adopted as part of the Basel III Accord on bank regulation. It's included to measure a bank's financial strength. The inclusion of securitization ratio is to align with the new business model of banks: from "originate and hold" to "originate, repack and sell". The variable Δi_{t-1} is the indicator of monetary policy innovation, and takes the Federal funds rate in the previous quarter. I use shadow rate instead of FFR after 2008 Q4. C is a dummy variable from my construction referring to the time period of financial crisis or not. C equals 0 before fourth quarter of 2008 and 1 for the rest of the times.

In the following section, to learn better about the interaction relations of the monetary policies and bank characteristics, I modify the baseline regression in equation 2 by adding some dummy variables and interactive variables. I separate the time horizon into before and after the great recession by including a time dummy. I include some interactive variables to verify whether some bank specific features could help amplify the bank's lending channel.

$$\begin{aligned}\Delta L_{t,i} = \alpha_i + \rho_i * \Delta L_{t-1,i} + \beta_i * \Delta i_{t-1} + \sigma_i * \Delta y_{t-1} + \gamma_i * B_{i,t} \\ + \psi_i * \Delta i_{t-1} * C_{i,t} \\ + \phi_i * \Delta i_{t-1} * B_{i,t} \\ + \kappa * \Delta i_{t-1} * B_{i,t} * C_{i,t} + \epsilon_{i,t}\end{aligned} \tag{3}$$

Before running the regression, I listed some of the key hypothesis that I target to test and verify. (1)The impact of the change in the target rate on the banks lending behaviors, which is the coefficient (β_i) being estimated in front of the Δi_{t-1} in equation (3). It is believed to be significantly negatively if the decrease in the federal funds rate helps to increase the amount of loans that commercial banks make, and could be viewed as a verification towards the existence of the bank lending channel. (2) How bank specific features can impact the transmission of monetary policies. For bank specific controls, I have leverage ratio, securitization ratio and deposit ratio in the regression. Leverage ratio is proposed to have positive impact on the growth of loans as well capitalized banks should be more likely to expand supply of loans. $\gamma_{i,Lev}$ should be positive. Deposit ratio is working in a similar way that banks with more deposits as funding shall have more supply of funds as loans. $\gamma_{i,Dep}$ should also show positive sign. Also, for banks with higher holdings of securities, securitization should be able to work as a source of capital relief, so it is supposed to be also positively linked with the amount of loans. $\gamma_{i,Sec}$ is regarded as positive.

Some interaction terms are harder to predict in an economic manner. The sign in front of $\Delta i_{t-1} * C_{i,t}$, (ψ_i) is ambiguous as the financial crisis and unconventional monetary policies can either amplify or dampen the traditional bank lending channel. Higher level of securitization is another trend in modern banks balance sheet as banks have accumulated more treasury holdings and mortgage backed securities, however, the interaction between security holdings and great recession is also open to debate as higher securitization level may make

banks balance sheet more vulnerable facing the financial crisis. Table 4 in the appendix is a list of all regressors in the equation, with their variable description, expected sign, and my arguments to explain the expectations.

3.4 Empirical Results

Table 2 summarizes the regression results on equation (3). The growth in the total loans is the dependent variable and the first column lists the regressors. The second column records the estimated coefficients for the independent variables. I also switch the dependent variables with major loan categories, respectively commercial and industrial loans, loans backed up by real properties, and personal loans, and column 4,5, and 6 report their estimated coefficients correspondingly. The standard errors are all recorded in the parenthesis below the coefficient, and significant level is marked by asterisks.

The negative coefficient attached to the policy rate suggests that a tightening monetary policy leads to the decline in the loan amounts, which could be served as an evidence for the bank lending channel. This effect is amplified by the great recession. In normal times, a one percent hike in the policy rate would generate 0.4% drop in the total loan amount. During the financial crisis, this effect is enlarged by 0.072%, but the difference in total loan amount is not statistically significant. Among the three major loan categories, personal loans is the only type of loans that shows this amplified effect at significant level. Personal loans have a negative relation with the policy rate, and this relation is enlarged after 2008. This could be interpreted that the drop in the policy rate helps to boost the banks lending during the financial crisis, and the personal loans surge the most during this period. Contrarily, the other two categories, commercial loans and real estate loans, both show negative and significant relations with the policy rate, but the relations are countered during the great recession.

Banks' heterogeneity in capital ratio and liquidity level account for a vital part in their transmission of monetary policies. The liquidity ratio is supposed to be positively related to the amount of loan outstanding. Banks with more liquid balance sheets shall be able to keep their original credit portfolios when a sudden rise in policy rate. In other words, higher liquidity ratio make banks have more buffers towards unanticipated policy shocks. The regression results show significant and positive sign in regard to the liquidity level (calculated as capital to asset ratio), which matches my expectation and is consistent with major thoughts in the literature. The interaction between liquidity level and monetary policy is also positive and statistically significant. This result indicates that lending in banks with higher liquidity show less responses to unanticipated policy rate shocks. However, this pattern is reversed after the adoption of unconventional policies during the great recession. After 2008, lending from more liquid banks react more towards monetary policy innovations. Another result worth future exploring is the bank size. I obtain significant negative coefficients attached with log total assets. The size of bank, if measured by its total assets, does not help to explain the decline in banks' loan during a tightening monetary policy. Compared to smaller banks, large banks do not necessarily outperform small banks in keeping less lost in loans portfolios during the adverse monetary policy shocks.

The effect of securitization level is also interesting. Referring to the interaction of policy rate and securitization level, it is suggested that securitization is positively correlated with the bank lending channel, but there does not show any significant in the coefficients. If all other variables are kept constant, banks that have more of their assets securitized should experience higher growth in lending and loans. These findings are contrary to the traditional viewpoints. My result shows that banks with better access to the security market are not necessarily more capable to buffer their lending performance against contractionary policy shocks. However, securitization plays a more crucial role during the financial crisis

and its recovery under unconventional policies. As recorded in the last row of table 2, the positive interaction between securitization and monetary policy rate is enlarged in the great recession, suggesting that banks with more securitized assets are better in maintaining their lending growth against adverse policy shocks in the crisis.

3.5 Robustness Check

In this section, I modified the variables in equation (3) in order to get a more robust investigation on banks specific features and their impacts on monetary policy transmission. I introduce three new dummy variables: $Cap.d$, $Dep.d$, $Sec.d$ as controls of bank characteristics. $Cap.d$ is a dummy variable indicating the capital ratio of the bank. It equals to 1 if the bank is among the top ten percent capitalized banks among all banks in that quarter, and equals to 0 if the bank's capitalized ratio is not listed as the top ten percent. Similarly, $Dep.d$ takes the value 1 if the deposit over total liability ratio of the bank is among the top ten percent of all banks, and takes the value 0 otherwise; $Sec.d$ equals 1 if the bank's assets are more heavily concentrated on security holdings and the security holding ratio is larger than ninety percent of other banks. I substitute the specific variables $B_{i,t}$ in equation (3) with these dummy variables, and perform the same regression is shown in equation (3) and table 2. The results of the regression is reported in table (4) with their estimated coefficients, standard errors, and significance levels.

The results in the robustness check can verify some of the implications I obtained from the empirical methodology. The capital ratio still is crucial in the monetary policy transmission. In second row of table 3, it is indicated that banks among the top ten percent of equity to asset ratio are more capable in buffering with total lending against adverse monetary policy shock. However, the situation is reversed during the great recession. During great

Table 2: Regression Results

Variables	$\Delta ln(totalloans)_{t,i}$	$\Delta ln(CIloans)_{t,i}$	$\Delta ln(realestateloans)_{t,i}$	$\Delta ln(personalloans)_{t,i}$
$\Delta ln(loans)_{t-1,i}$	0.187^{***}	-0.033^{***}	0.043^{***}	-0.085^{***}
	(0.002)	(0.002)	(0.002)	(0.002)
Asset	-0.017^***	-0.022^***	-0.025^***	-0.013^***
	(0.001)	(0.001)	(0.001)	(0.001)
Lev	0.003^***	0.180^***	0.113^***	0.165^***
	(0.0003)	(0.023)	(0.013)	(0.025)
Dep	0.103^***	0.092^***	0.092^***	0.038^***
	(0.004)	(0.011)	(0.006)	(0.011)
Sec	0.0004	0.016^*	0.003	0.009
	(0.0003)	(0.009)	(0.005)	(0.010)
IndusProd	0.065^***	0.204^***	0.045^***	0.167^***
	(0.003)	(0.008)	(0.005)	(0.009)
FFR	-0.400^***	-0.418^***	-0.152^***	-0.416^***
	(0.034)	(0.090)	(0.052)	(0.096)
$FFR * Cap$	0.732^***	0.880^**	0.536^***	1.965^***
	(0.102)	(0.268)	(0.153)	(0.285)
$FFR * Dep$	0.207^**	-0.112	0.359^**	0.388
	(0.104)	(0.274)	(0.157)	(0.291)
$FFR * Sec$	-0.035	-0.107	-0.185	-0.117
	(0.104)	(0.274)	(0.157)	(0.291)
$FFR * Crisis$	0.072	-0.400^**	-0.249^**	0.980^***
	(0.071)	(0.187)	(0.107)	(0.199)
$FFR * Crisis * Cap$	-1.957^***	-1.692^**	-1.309^***	-3.494^***
	(1.996)	(0.526)	(0.301)	(0.559)
$FFR * Crisis * Dep$	0.310	1.449^***	0.004	0.594
	(0.202)	(0.532)	(0.304)	(0.565)
$FFR * Crisis * Sec$	0.668^***	0.666	0.410	0.290
	(0.203)	(0.535)	(0.306)	(0.569)
$Adj.R^2$	0.12	0.07	0.08	0.08
No. of banks	6273	6273	6273	6273

Note: *p<0.1; **p<0.05; ***p<0.01

The table reports the regression results on equation (3). FFR stands for the change in the Federal Reserve policy rate; *Dep* stands for the deposits ratio; *Lev* stands for the capital to asset (leverage) ratio; *Sec* stands for the securitization ratio; *Crisis* is a dummy variable differentiates great moderation and great recession; *Asset* stands for log of total asset; *IndusProd* stands for log of Industrial Production. All coefficients are reported with their standard deviations in parenthesis and significance level.

Table 3: Regression Results

Variables	$\Delta ln(totalloans)_{t,i}$	$\Delta ln(CIloans)_{t,i}$	$\Delta ln(realestateloans)_{t,i}$	$\Delta ln(personalloans)_{t,i}$
FFR	-0.343^***	-1.405	-0.254^*	-0.112^*
	(0.036)	(0.988)	(0.101)	(0.055)
$FFR * Cap.d$	0.509^***	0.830^**	0.360^**	1.464^***
	(0.104)	(0.275)	(0.158)	(0.293)
$FFR * Dep.d$	0.149	0.206	0.318^*	0.223
	(0.105)	(0.275)	(0.157)	(0.293)
$FFR * Sec.d$	-0.034	-0.106	-0.186	-0.118
	(0.104)	(0.274)	(0.157)	(0.291)
$FFR * Crisis$	0.058	-0.527^**	-0.349^**	0.765^***
	(0.075)	(0.187)	(0.113)	(0.209)
$FFR * Crisis * Cap.d$	-1.160^***	-1.118^*	-0.892^**	-1.893^***
	(0.204)	(0.536)	(0.307)	(0.570)
$FFR * Crisis * Dep.d$	0.183	1.324^*	0.093	0.381
	(0.203)	(0.535)	(0.306)	(0.569)
$FFR * Crisis * Sec.d$	0.660^**	0.662	0.404	0.284
	(0.203)	(0.535)	(0.306)	(0.569)
$Adj.R^2$	0.13	0.08	0.08	0.08
No. of banks	6273	6273	6273	6273
Note:				*p<0.1; **p<0.05; ***p<0.01

The table reports the regression results on equation (3) with dummy variables to indicate the bank level specific characteristics. FFR stands for the change in the Federal Reserve policy rate; $Dep.d$ stands for the dummy variable of deposits ratio level; $Lev.d$ stands for dummy variable representing the capital to asset ratio; $Sec.d$ stands for the dummy variable representing the securitization ratio; $Crisis$ is a dummy variable differentiates great moderation and great recession; See detailed definitions of variables in the text. All coefficients are reported with their standard deviations in parenthesis and significance level.

moderation, a one percent increase in the federal funds rate leads to a drop in total lending of 0.343% for the average bank, but leads to an increase in total lending of 0.166% for a bank that is in the last quantile of the distribution of capital ratio. In great recession when unconventional policies are in place and the shadow rate is used an the indicator of monetary policy, a 1% drop in the shadow rate generates 0.058% increase in total lending growth for an average bank (although the coefficient is not statistically significant), and top capitalized banks' total lending drop by 1.1%.

Regarding the securitization level, the insignificant coefficient in row 3 of table 3 suggest that securitization activities do not significantly impact the transmission of monetary policies during the great moderation. In great recession, 1% increase in the shadow rate lead to an increase of 0.718% of growth rate in total lendings among the most active banks in the securitization market. The significant and positive interaction between securitization and shadow rate during the great recession is in line with the findings in the previous section, that under unconventional monetary policies, banks with more access and participation in securitization activities can mitigate the negative effect of adverse policy shocks on their credit portfolios.

4 Conclusion

This study focuses on the monetary policy transmission through the commercial banks from mid 1980. The recent decades witness a new era of macro economy: great moderation with low macroeconomic volatility and great recession with zero nominal policy rate and unconventional policies. Questions have been raised on whether the monetary policy innovations under the new environment still share the traditional bank credit channels to impact the

economy. I first investigate the responses from the aggregate demand and its more detailed spending categories. It is surprising that since 1985, monetary policies have more impact on purchases of longer lived assets instead of short term items, which contradicts the standard perspective that shocks on short term rates are mostly affecting the purchases of short live assets.

I then document one key difference by plotting the impulse responses of banks balance sheet items: deposits, security holdings and loans: from mid 1980s, or starting at great moderation, the amount of loans does not necessarily decline following a tightening monetary policy. There are two possible explanations towards this situation: one is that since great moderation, as the deposit rate ceiling being gradually abandoned, commercial banks are easier to find substitutes of loss deposits. As states in Koch (2015)[17], deposit rate ceilings embodied in Regulation Q significantly affected bank lending, and the traditional bank lending channel weakened with deposit rate deregulation since early 1980s. Another explanation towards my aggregate level finding is that banks build a more security heavy asset portfolio. In this case, deposits are not the only and most important source of funding to make loan. Securities become the most reactive item that banks can adjust to encounter sudden shocks in monetary policies. In this sense, we see securities being the most responsive balance sheet account that follows very closely to a monetary policy shock.

However, if check the bank level data instead of the aggregate data, I find that the bank credit channel is present in a more "broader" format. At the individual bank's level, the bank credit channel in monetary policy transmission still exist and hold during great moderation and great recession, even though the deposit rate ceiling is abandoned and unconventional policies are in place. I estimate each commercial bank's loan spread beta (the measurement of the bank's responsiveness on loan pricing when facing a policy rate shock) and loan flow beta (the measurement of the bank's adjustments on loan amounts when facing a policy rate

shock), and I sort banks into at most a hundred bins from the smallest loan rate spread beta to the highest spread beta. By regressing the loan flow beta on loan spread beta, the significant negative coefficient indicated that at individual bank level, when there is a contractionary monetary policy, banks with higher loan rate spread (banks that charge higher interest rates on loans) lose more loans, compared to banks with lower loan spread beta. In other words, when there is a hike in the policy rate and all banks would raise the interest rates they charge on loans, and the banks who raise their interest rate more, would have more loss and decline in lending.

Another interesting finding in this paper is that the bank specific features: size, leverage ratio and deposit ratio, play vital roles in banks lending decision, and shape the bank's level credit channel. This is consistent with the findings in the traditional bank lending channel literature. Well capitalized banks, or banks with higher deposits, are less sensitive to the change in the federal funds rate. They adjust their loan amounts and credit portfolio less dramatically when facing monetary policy shocks. What is surprising is that the securitization activity, which becomes the new trend in the recent decade in banks' balance sheets, does not serve as an important characteristic when banks choose how many loans they own. But securitization is important in transmitting the monetary policy during the great recession when unconventional policies are adopted. It does not show any significance in its interaction with monetary policy alone, or in other words, in normal times securitization does not help to shrink or amplify the bank credit channel. However, securitization is significant in amplifying the transmission of unconventional monetary policies. A possible explanation is that the unconventional policies majorly consists of large-scale purchase of treasuries and securities, which is exactly the type of securities that commercial banks hold. This might help to convey the monetary shocks in an accelerated way through the operation of commercial banks, and the mechanism of how security holdings reshape the monetary policy transmission worth further investigating in my future research.

Appendix

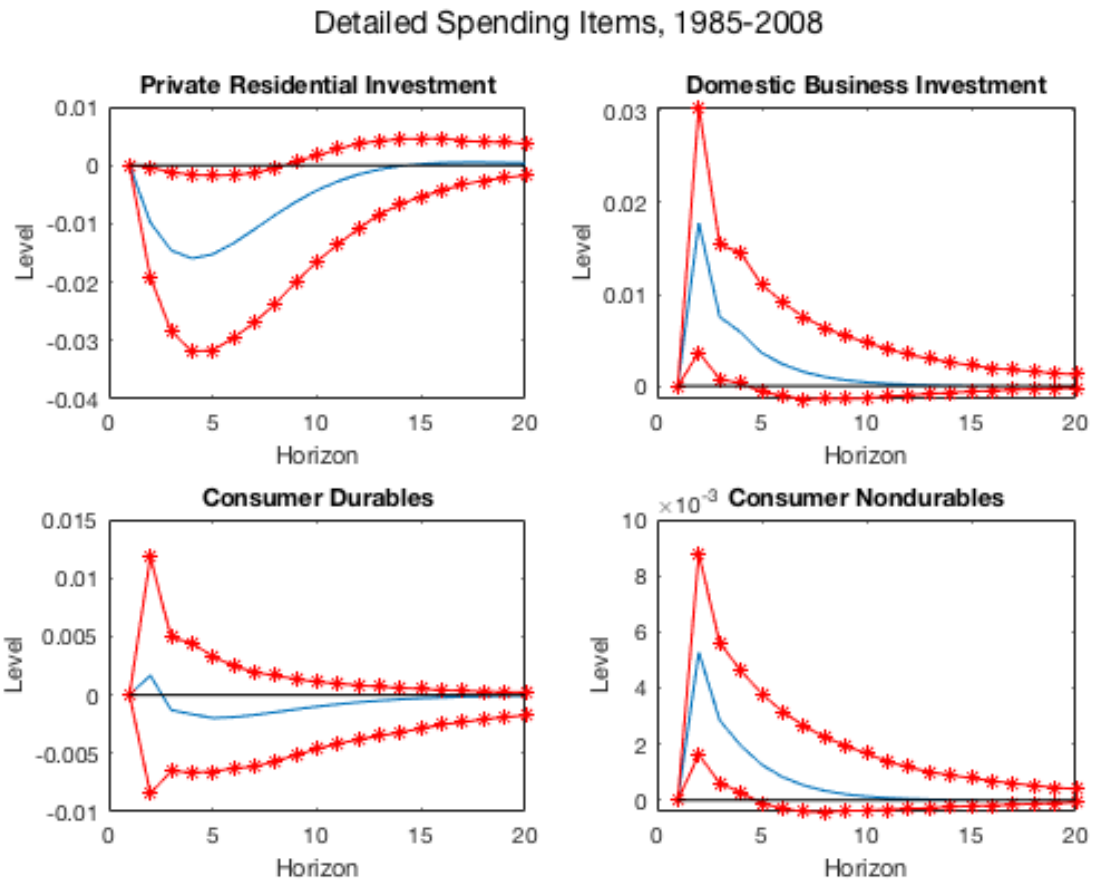

Figure 8: Impulse responses of spending components in GDP with confidence intervals, great moderation

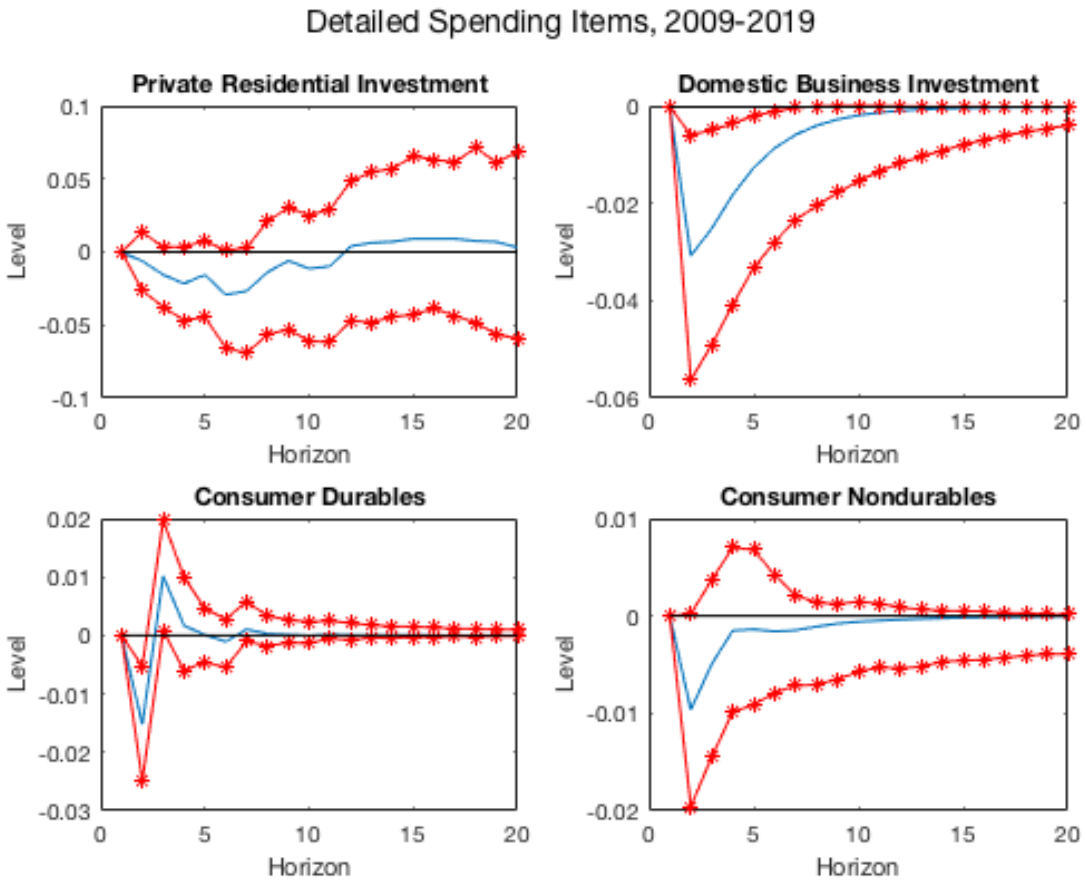

Figure 9: Impulse responses of spending components in GDP with confidence intervals, great recession

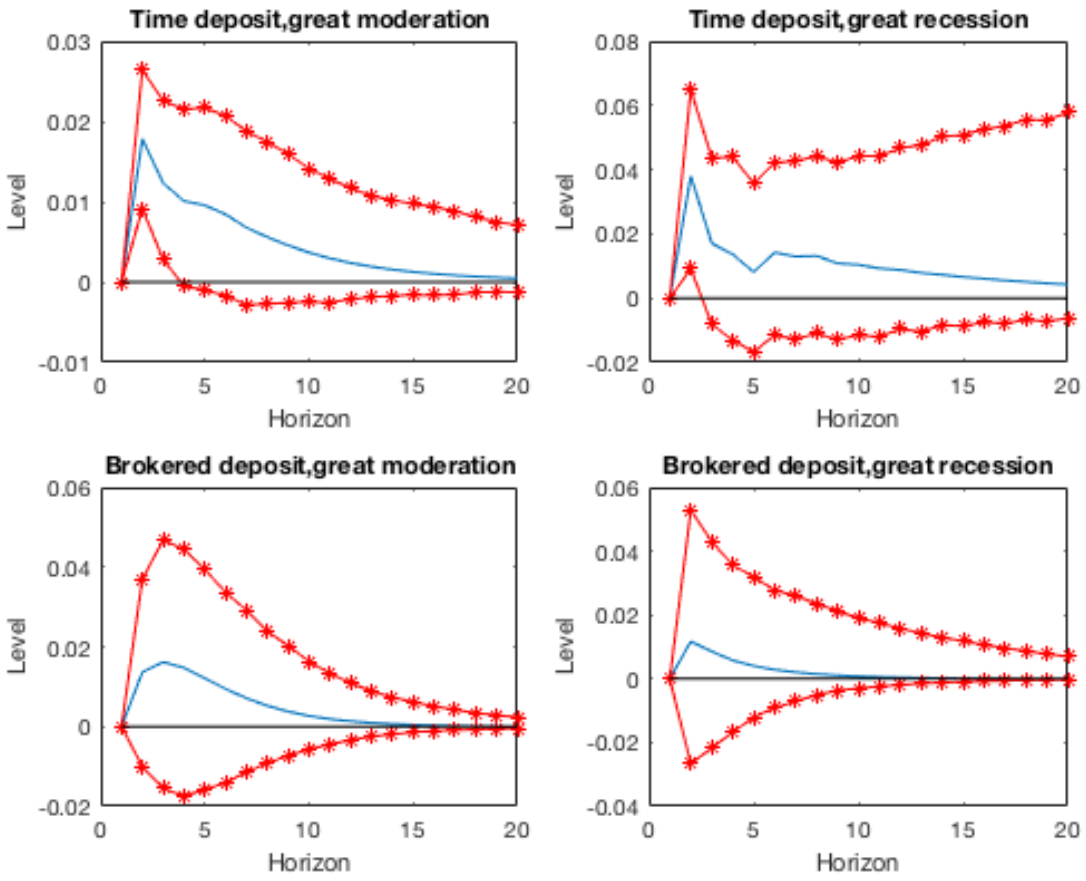

Figure 10: Impulse responses of time deposit and brokered deposits to a monetary policy shock

Table 4: Descriptive Statistics

Variable	Description	Mean	Std	Max
$\Delta ln(loans)_{t-1,i}$	Growth rate of loan amount	0.022	0.071	2.880
Δi_{t-1}	Quarterly change in the policy rate	-0.001	0.005	0.009
$Asset$	Log of total assets	12.058	1.316	21.520
$log(Dep)$	Log of total deposit	11.862	1.273 8	21.041
Lev	Equity to total asset ratio	0.103	0.032	0.758
Sec	Security holding to total asset ratio	0.066	0.087	0.941

The table reports the descriptive statistics of the major variables in the regression in the main text of the paper.

Table 5: Summary of Regression Variables

	Dependent variable: $\Delta ln(loans)_{t,i}$		
Variables	Description	Expected Sign	Argument
$\Delta ln(loans)_{t-1,i}$	Log of loans last quarter		
Δi_{t-1}	Quarterly change in the nominal policy rate	-	Tightening monetary policies lead to decline in lending.
$Asset$	Log of total assets	+/-	Larger banks may better isolate adverse shocks.
Lev	Leverage ratio	+	Banks with higher leverage ratio has more stable supply of loans.
Dep	Deposit ratio	+	Banks with higher deposit ratio has more stable supply of loans.
Sec	Securitization ratio, equals to security holdings divided by total asset.	+	Securitization has some relief on funding of the bank.
$Crisis$	Crisis dummy, equals to 0 before 2008 Q4 and 1 after 2008 Q4		
$\Delta i_{t-1} * Crisis$		+/-	In zero nominal rate period the effect of monetaru policy is amplified (-) or impaired (+)
$\Delta i_{t-1} * Dep$		+	Banks with fewer deposit funding amplify monetary policy shocks.
$\Delta i_{t-1} * Sec$		+/-	Securitization amplifies (+) or impairs (-) monetary policy shocks.
$\Delta i_{t-1} * Dep * Crisis$		+	Banks with fewer deposit funding amplify monetary policy shocks particularly during the financial crisis.
$\Delta i_{t-1} * Crisis * Sec$		+/-	Securitization amplifies (+) or impairs (-) monetary policy shocks during the financial crisis.

The table the main variables, their notations and economic wise descriptions used in regression of equation 2. The table also summarizes main hypothesis on the signs of the regression coefficients of these variables, and economic meaning and explanations of these hypothesis.

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