Monetary Policy through Wholesale Funding Markets: the Bank Lending Channel Revisited

Jinyoung Seo [*] [†]
Wake Forest University

January 2025

Abstract

This paper shows that the bank lending channel operates primarily through banks' access to wholesale funding markets. I exploit bank organizational structure to identify how funding constraints shape lending responses to monetary policy. I find that banks affiliated with multibank holding companies maintain lending following monetary tightening through better wholesale funding access, while standalone banks significantly contract lending due to funding outflows. The wholesale funding channel has important aggregate implications: states with higher standalone bank share experience larger responses of GDP and unemployment to monetary policy. Moreover, standalone banks exhibit heightened failure probabilities after monetary tightening, contributing to elevated levels of systemic bank risk as measured by the bank-at-risk (BaR). These findings reveal a novel link between monetary policy and financial stability through banks' funding composition.

[*]Department of Economics, Wake Forest University. (Email: seoj@wfu.edu).

[†]I am deeply indebted to my advisors, Alan Taylor, Sanjay Singh, and Nicolas Caramp for valuable advice and support. I also thank Aeimit Lakdawala, as well as seminar participants at Wake Forest University and various seminars and conferences for helpful comments and discussions. All remaining errors are my own.

1 Introduction

The transmission of monetary policy through banking sector has been a central focus in macroeconomics and banking research. The bank lending channel posits that monetary policy affects the real economy through its impact on bank loan supply (Kashyap and Stein, 1995) Recent findings emphasize the role of deposits in this transmission mechanism (Drechsler et al., 2017), which stems from the dominance of deposits in bank funding structure. However, the growing importance of wholesale funding, which has long been considered as an important amplifiers of monetary transmission (Kashyap and Stein, 2000), in recent decades promotes the interaction between monetary policy change, different funding sources of banks and lending decisions by banks. Despite the attention that this idea has gained, there has been limited number of research that directly investigate the role of wholesale funding markets in the bank lending channel.

This paper provides novel evidence on the role of wholesale funding markets in the bank lending channel by exploiting variation in banks' organizational structure. I first show that the bank lending channel is mainly driven by wholesale funding flows, not deposit flows. Next, I find that banks' access tow wholesale funding markets plays a critical role in shaping their responses to monetary policy When banks have internal capital markets through multibank holding companies (MBHC), those banks enjoy lower wholesale funding costs and larger inflows of wholesale funding in the event of monetary tightening Deposit outflows explain cut in lending in the first few quarters but loose its explanatory power quickly.

The finding that the bank lending channel works through wholesale funding markets has significant implications, which has not been found in the previous literature. First, in states where banks without MBHC affiliations (stand-alone banks, henceforth) dominate, those states experience stronger responses to monetary policy, which include further decrease in GDP and increase in unemployment following monetary contraction. Second, I find evidence that stand-alone banks contribute to the overall increase in the probability of bank failure. 25 bp increase in 2 year Treasury yield increases the probability of bank failure by 30 bp, which leads to significant increase in the possibility of aggregate bank failure, proxied by the bank-at-risk proposed by Correia et al. (2023).

This finding provides novel policy implications. First, the results imply that the bank lending channel has been stronger due to the relative increase in the size of stand-alone banks. As the share of stand-alone banks in banking industry increases, the bank lending channel could gain more strength, making monetary policy more effective but the banking industry more vulnerable. Second, monetary policy generates financial stability

consequences through its effect on bank funding structure. Monetary authority should notice the impact of the leaning against the wind policy on financial stability because it could result in unintended adverse consequence on an economy.

I first estimate the bank lending channel at aggregate level, using the Call reports and high frequency identified monetary policy shocks. Consistent with previous study, the bank lending channel does exist. Following a 25bp increase in two year Treasury yield, bank lending gradually falls by 4 percent in 20 quarters out. But the lending responses are not explained by deposit flows. Deposits flow out of banking sector in the first several quarters but after that, it starts to flow in and shows the opposite paths to lending. In contrast, wholesale funding shows highly correlated responses with bank lending, which explains most of the bank lending channel.[1]

Next, to investigate the mechanism, I use bank level data and find that bank affiliation status serves as an important predictor of access to wholesale funding markets. I categorize banks based on their organizational structure: those affiliated with multibank holding companies (MBHC) and stand-alone banks that do not have such affiliation. These two types differ in their structure because affiliated banks have internal capital markets and implicit guarantee from other banks and MBHC in their network. After controlling for various bank characteristics, I find that affiliated banks pay lower spreads in wholesale funding markets and have lower pass-through to these spreads when policy rate changes This evidence indicates that affiliated banks have better access to wholesale funding than stand-alone banks

Exploiting panel local projection on bank level data (Jordà et al., 2019), I estimate the dynamic effects of monetary policy shocks on bank balance sheets, including loans, securities, liquid assets, core deposits, liabilities and equity. This gives a comprehensive picture of the balance sheet dynamics of banks and reveals the underlying mechanism through which the bank lending channel works. I find strong heterogeneity among banks and the role of wholesale funding in the monetary transmission through banking sector. Following a monetary contraction, stand-alone banks significantly cut their lending while lending responses of affiliated banks are largely muted and the difference is statistically significant. For a 25 bp increase in 2 year Treasury yield, stand-alone banks reduce the lending size by 7 percentage points but affiliated banks do not change their lending size.

The heterogeneous bank lending responses are mainly explained by wholesale funding. After an increase in policy rates, stand-alone banks experience significant deposit outflows, which is around 3 percentage points at trough. Those banks raise wholesale

[1]This finding is robust to shocks and specifications.

funding to offset deposit outflows so it is initially increasing before it change the course. Importantly, the paths of wholesale funding growth matches very closely with those of lending growth. Loan size keeps decreasing until 20 quarters out, but the size of other balance sheet items, including securities, liquid assets and core deposits is largely unchanged by then. In contrast, wholesale funding growth is initially significantly positive but after around 10 quarters, turns negative, matching with loan growth.

Affiliated banks show different dynamics in their balance sheet. For the entire estimations horizon, loan growth of affiliated banks does not turn significantly negative and is indistinguishable from zero. The heterogeneity in lending is 6 percent between affiliated and stand-alone banks, which is also highly significant. Affiliated banks also have significant deposit outflows, although it is smaller than those of stand-alone banks. Other balance sheet items of affiliated banks have similar dynamics to stand-alone banks.

But wholesale funding shows significant heterogeneity, which can explain the different lending responses. Affiliated banks increase wholesale funding by around 10 percentage point and it remains positive until the end of the estimation horizon. The difference between two banks is more than 10 percent, which is highly significant. The paths of and the difference in wholesale funding well matches with lending responses, unlike others. I find further evidence that most of these wholesale funding responses are driven by large time deposits and federal funds, which constitute more than 80 percent of wholesale funding held by banks. This evidence shows the importance of wholesale funding market access in the monetary transmission through banking sector.

The bank lending channel through wholesale funding markets has novel aggregate implications. I first explore this at US state level, exploiting cross-sectional variation in the share of stand-alone banks across US states. I estimate the impulse responses of state GDP and unemployment and find that states with high concentrations of stand-alone banks experience more pronounced declines in GDP and larger increase in unemployment following a contractionary monetary policy shocks. This confirms that the bank lending channel is stronger when banks have limited ability to counteract deposit flows.

Next, I explore the implications of the shifts in bank funding structure. Because bank funding structure has a critical impact on bank failure (Correia et al., 2023), disproportionate effects on bank funding structure can result in heterogeneous exposure to monetary policy in terms of funding vulnerability of banks, which leads to financial stability consequences at aggregate level. I estimate the bank failure probability in response to 25 bp increase in 2 year Treasury yield increase and find that the probability of failure of stand-alone banks increases by 30 bp. Affiliated banks, on the other hand, show a fall in failure probability. This result can be interpreted as the results of funding vulnerability

due to the heterogeneous wholesale funding access. Stand-alone banks have poor access to external funding markets and severe downsizing in lending, which result in elevated failure risks.

Finally, I estimate the responses of the Bank-at-Risk (BaR) measure, proposed by Correia et al. (2023) to gauge the overall exposure of the banking sector to a 'wave' of banking failure. It shows that the BaR increases significantly and persistently after a contractionary shock, which is driven by the increase in the failure rate of stand-alone banks.

This paper makes several contributions to the literature. First, this paper contributes to the large body of literature on the bank lending channel of monetary policy by showing that wholesale funding markets play an important role in the transmission of monetary policy. I find evidence that the bank lending responses are mostly driven by those banks that have poor access to wholesale funding markets, which results in the shrink in bank balance sheet. Earlier contributions focus on bank size and leverage (Gambacorta and Mistrulli, 2004; Gambacorta and Shin, 2018; Kashyap and Stein, 2000; Kishan and Opiela, 2000) and recent studies find loan and deposit market power affect bank lending (Drechsler et al., 2017; Schaffer and Segev, 2022; Scharfstein and Sunderam, 2016; Wang et al., 2022). There has been an attention on more market-based funding (Begenau and Stafford, 2023; Choi and Choi, 2020; Disyatat, 2011; Grimm, 2024; Supera, 2024), but my result directly speaks to the source of the different wholesale funding access. In this regard, my approach is close to that of Ashcraft (2006), while my approach directly investigates the source of the heterogeneous lending responses.

Second, this paper sheds light on the implications of banks' organizational structure and internal capital markets. I contribute to the literature by showing that internal capital markets and the role of implicit guarantor by bank holding companies determine banks' access to wholesale funding markets and in turn, the responses of banks to interest rate change. Previous research has extensively explored the functioning of wholesale funding markets, including interbank markets, revealing susceptibility to counterparty risk and its role in triggering the 2008 financial crisis (Afonso et al., 2011; Aguirregabiria et al., 2016; Campello, 2002; Gilje et al., 2016; Gorton and Metrick, 2012; Pérignon et al., 2018), but these studies are abstract from the transmission of monetary policy. Cetorelli and Goldberg (2012) studies monetary policy transmission through global banks.

Third, this paper also makes contributions to the growing body of literature on monetary and financial stability. A contractionary monetary policy deteriorates financial conditions and especially shifts bank funding structure toward more unstable, run-prone liabilities. This has disproportionate effects to stand-alone banks, which have limited access to external funding markets. As a result, monetary policy affects financial stability

through its impact on bank funding structure. This result is in line with the recent findings in the literature (Boissay et al., 2021; Grimm et al., 2023; Schularick et al., 2021; Uppal, 2024).

2 Bank lending channel revisited

Recent discussion on the bank lending channel centers on the flows of deposits in and out of the banking sector, which is referred as the deposit channel (Drechsler et al., 2017). The main argument of the deposit channel is that when interest rates increase, deposits flow out of banking sector because of an increase in deposit spread, the difference between the federal funds rate and deposit rate. Banks optimally choose to increase deposit spread due to its local deposit market power. Importantly, if a bank operates in a less competitive market, it increases the spread even higher to exploit its market power. As a result, banks operating in more competitive local deposit markets experience smaller deposit outflows, which allows them to shield their loans. Drechsler et al. (2017) empirically show the existence of the deposit channel and the quantitative relevance of it.

Here, I evaluate the quantitative importance of the deposit channel by comparing the significance of different funding sources: deposits, wholesale funding and bank equity. Roughly 60% of assets are funded by deposits, 30% by wholesale funding and Bank liability consists of those three items, where deposits roughly account for 70%, wholesale funding accounts for 20% and equity accounts for the remaining 10%. Because deposits are the largest funding source for banks, it would be the one that drives the bank lending channel if its responses dominate the others. But because deposits are stable, the fluctuations in deposits may not be large enough to drive bank lending channel and rather, other part of bank liabilities can be more important.

Specifically, I estimate the following local projections:

$$y_{t+h} - y_{t-1} = \alpha_h + \beta_h \Delta R_t + \Gamma_h X_{t-1} + e_{t+h},\ h = 0, \cdots, H \tag{1}$$

where $h \geq 0$ is the forecast horizon, ΔR is the change in the two year Treasury yields instrumented by identified monetary policy shocks from Bauer and Swanson (2023). y_t is a dependent variable which will be specified for each LP result. X_{t-1} is a set of control variables, including lags of dependent variables, log of GDP and CPI. The estimated coefficient β_{gh} has an interpretation of the cumulative impulse response of a dependent variable y in the period $t + h$ to an unanticipated monetary policy shock in the period t.

The main dataset in this study is the Call Report, encompassing all commercial banks

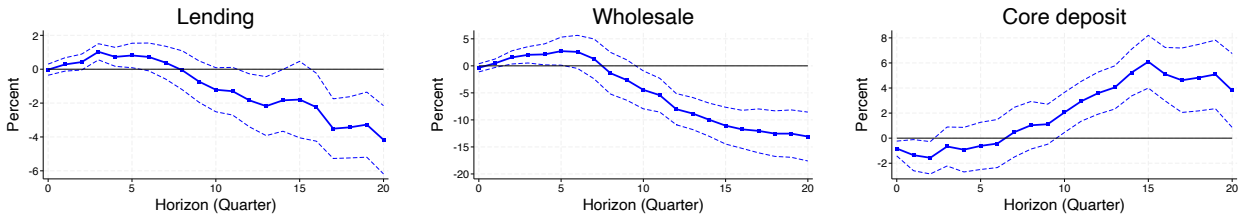


Figure 1: Impulse response of aggregate lending, wholesale funding and core deposits to contractionary monetary policy shock

Notes: The figure shows the estimated impulse response functions for the growth rate of aggregate lending, wholesale funding and core deposits following a 25 bps increase in two year Treasury yield. Relative effects is the impulse response of affiliated banks relative to that of standalone banks. Dashed lines show the 68 percent confidence intervals. Standard errors are clustered by banks and time.

operating within the United States. This quarterly report comprehensively outlines the financial conditions of US banks and is submitted to the Federal Deposit Insurance Corporation (FDIC). Moreover, the Call Report contains details regarding the bank holding company affiliated with a given bank, facilitating the discernment of whether a bank functions as a regional bank or a subsidiary bank. Financial statements for all US commercial banks are acquired at a quarterly frequency. The sample period spans from 1988 to 2019.

Here, I aggregate the bank level data and estimate equation (7) using the aggregated time series data, together with the high frequency identified monetary policy shocks by Bauer and Swanson (2023).

Figure 1 does confirm the existence of the bank lending channel: an unexpected contractionary monetary policy shock causes a persistent decline in bank lending. Lending growth is initially positive, but then turns negative from 9 quarters. But lending and deposit growth are at odds with the deposit channel. According to the estimated IRF, the path of deposits is opposite to that of lending, where deposits actually increase after 6 quarters out, while lending keeps decreasing. Instead, the response of wholesale funding exhibits much closer trajectory. It initially increases then it falls below the initial level persistently.

The magnitude of the wholesale funding response is noticeable. Wholesale funding decreases by 15 percentage point in 20 quarters, which is much stronger response than deposits and lending. Also, the wholesale funding response is quantitatively large. A decrease in wholesale funding alone can explain more 5 percent drop in lending, while an increase in core deposits accounts for around 2 percent increase in lending.

The aggregate responses of bank lending and liabilities show that it is wholesale fund-

ing, rather than deposits, that is more closely correlated with bank lending channel.[2] In the following sections, I will explore the importance of wholesale funding in bank lending channel, using bank level data.

3 Structure of US commercial banks

3.1 Theoretical background

The bank lending channel literature posits that banks are subject to financial frictions that prevent them from freely substituting deposits and other sources of funding. First, the deposit channel implies that if banks have different flow of deposits, then their lending behavior exhibits heterogenous pattern. Deposits are the most stable source of bank liability and it has been considered the center of the monetary policy transmission through banking sector. Drechsler et al. (2017) show that deposit market competition influences the deposit spread, the spread between deposit rate and the federal funds rate, which affects banks' overall funding costs. This deposit channel is the mechanism behind the bank lending channel.

Second, even if banks have similar deposit flows, when they have different access to wholesale funding, their lending behavior can differ from each other (Kashyap and Stein, 2000). As of 2019, the share of wholesale funding[3] for US commercial banks around 25 percent of total assets, down from the peak of 45 percent in 2007. Despite its size, wholesale funding could be important for bank lending (Choi and Choi, 2020; Grimm, 2024) because it is more sensitive to risks and poliy change. Unlike deposit markets which are protected by deposit insurance, the wholesale funding market is subject to asymmetric information and hence financial frictions (Afonso et al., 2011).

Previous studies have found that the wholesale funding markets are characterized by significant imperfections that prevent substitution between deposits and wholesale funding. These market imperfections arise from various sources, including asymmetric information between lenders and borrowers, search frictions, and monitoring costs that make wholesale funding providers more selective in their lending (Pérignon et al., 2018). These frictions create varying degrees of access to wholesale funding across banks, making some banks more vulnerable to monetary policy shocks than others.

[2]This finding is quite robust across various specifications and shock series.

[3]In this paper, I define wholesale funding as the sum of non-retail deposits (brokered, foreign), large time deposits, federal funds, and other borrowed money.

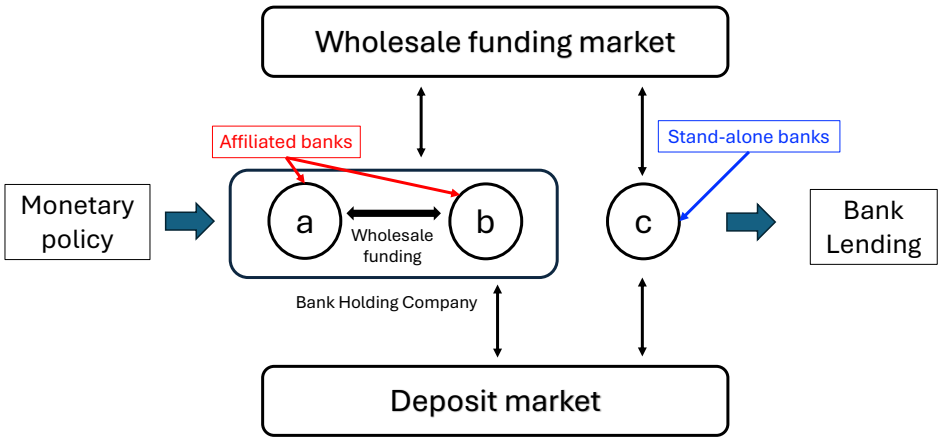


Figure 2: Bank affiliation with bank holding company

The theoretical framework suggests that the effectiveness of monetary policy transmission through the banking sector depends crucially on banks' access to wholesale funding markets. Banks facing lower frictions in these markets should exhibit more moderate lending responses to monetary policy shocks, as they can more readily substitute lost deposits with wholesale funding.

In this paper, I show that bank affiliation status, whether a bank is under a multibank holding company (MBHC), offers a better measure of financial frictions, which is based on bank organizational structure and internal financial markets. Figure 2 depicts how monetary policy transmits through banking sector where there are two types of banks: affiliated and standalone banks. Affiliated banks (labeled as a and b) that are under control of a MBHC have other affiliated banks under the same MBHC. In contrast, if a bank is not associated with a MBHC, I classify the bank as a standalone bank (labeled as c). MBHC affiliation can significantly mitigate a bank's exposure to financial frictions in several ways.[4]

When a monetary policy shock hits, banks experience deposit outflow, which puts downsizing pressure on their asset. Affiliated banks can mitigate this by owing to its organizational benefit, which standalone banks cannot exploit.

First, affiliated banks have access to internal capital markets that allow them to transfer funds across subsidiaries, providing liquidity and capital support when needed. This access helps mitigate financial frictions.[5] The internal capital market plays an important

[4]Ashcraft (2006) suggests to use bank affiliation status to isolate the variations in financial constraints.

[5]Gilje et al. (2016) finds that bank branch and internal capital markets play an important role in bank lending behavior. Ashcraft (2008) demonstrated that banks affiliated with MBHCs were more resilient during the 2007–2008 financial crisis due to their ability to tap into internal liquidity sources, which underscore

role in providing buffer against external funding shocks. Second, affiliation with a MBHC provides a signaling effect to external creditors, which leads to better access to wholesale funding markets, compared to standalone banks. The presence of a strong parent company signals financial stability and reduces the perceived risk of lending to an affiliated bank.[6] Given the risk sensitive nature of wholesale funding, low perceived risk offer better ability to borrow in wholesale funding markets. Third, affiliated banks are better positioned to buffer against market volatility. Internal liquidity resources allow them to maintain funding even when external markets freeze.[7]

The theoretical framework thus predicts heterogeneous responses to monetary policy shocks based on bank organizational structure. Affiliated banks can shield their loan portfolios by tapping into internal capital markets and maintaining better access to wholesale funding markets.[8] The presence of a holding company structure serves as an implicit guarantee mechanism, reducing the risk premium demanded by wholesale funding providers and maintaining funding access when market conditions tighten. In contrast, following a monetary contraction, standalone banks face more severe constraints in accessing wholesale funding markets. Those banks, lacking external funding alternatives, must adjust their lending more significantly in response to monetary policy changes.

3.2 Historical trend

Commercial bank assets are primarily funded through three distinct sources: bank capital, core deposits and wholesale funding. Figure 3 illustrates the evolution of these funding sources held by US commercial banks and the wholesale funding ratio from 1985 to 2020, alongside the wholesale funding ratio (defined as wholesale funding to total as-

---

the importance of institutional structures in reducing financial frictions. Houston et al. (1997) found that banks affiliated with MBHCs enjoyed lower borrowing costs in wholesale funding markets compared to their independent counterparts.

[6] Raykov and Silva-Buston (2020) argue that affiliation with MBHCs acts as a form of implicit guarantee, reducing borrowing costs by enhancing market confidence in the bank's solvency and liquidity. Standalone banks, even if large or well-capitalized, do not benefit from this implicit backing, making them relatively more vulnerable to financial frictions, particularly during market turbulence.

[7] Ivashina and Scharfstein (2010) shows that affiliated banks could continue lending during a period when many standalone banks were forced to cut back. The ability to draw on internal capital mitigates the impact of external shocks, reducing reliance on liquidity constraints because they rely on external markets for funding. This makes them more vulnerable to financial frictions during periods of market stress, when wholesale funding markets can become illiquid or prohibitively expensive.

[8] As documented by Afonso et al. (2011), wholesale funding providers actively discriminate between borrowers based on perceived risks, making the internal capital market advantages of affiliated banks especially valuable during periods of monetary tightening.

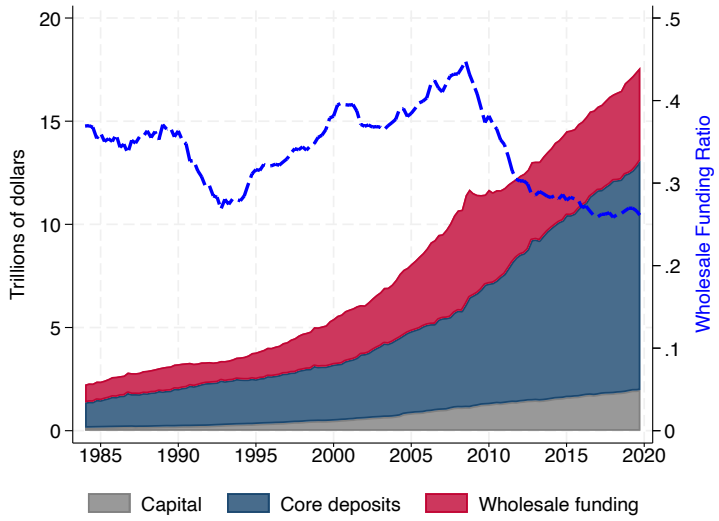


Figure 3: US commercial bank liabilities and wholesale funding ratio

Notes: Data from the Call report and author's calculation. Capital is the book value of outstanding shares of bank equity. Core deposits are checking and savings deposits as well as small denomination time deposits (less than $100,000). Wholesale funding is defined as the sum of large time deposits (greater than or equal to $100,000), federal funds and repo, foreign deposits, brokered deposits, and other borrowed money. Wholesale funding ratio (blue dashed line) is defined as wholesale funding to total assets.

sets). In the context, bank capital represents the book value of outstanding shares of bank equity, while core deposits comprise checking and savings deposits, as well as small-denomination time deposits (less than $100,000). Wholesale funding is the sum of large time deposits (greater than or equal to $100,000), federal funds and repurchase agreements, foreign deposits, brokered deposits, and other borrowed money.

Wholesale funding, while often loosely defined in the literature, it is distinctively 'wholesale' in nature as it is borrowed from other financial institutions at costs typically exceeding those of core deposits. A crucial characteristic that distinguishes wholesale funding is its lack of insurance coverage from the Federal Deposit Insurance Corporation (FDIC). This uninsured status renders crisis when wholesale funding markets emerged as the epicenter of market stress (Gorton and Metrick, 2012). This vulnerability to credit risk assessment makes wholesale funding access heterogeneous across banks, potentially leading to divergent lending responses to monetary policy changes.

The historical trajectory depicted in figure 3 reveals several notable patterns in banks' liability composition. Bank capital has demonstrated remarkable stability throughout the period, maintaining approximately 10 percent of total assets. While this level exceeds regulatory capital requirements, the relatively high cost of equity capital has constrained

its role as a primary funding source, despite its reliability.

Core deposits have historically constituted the majority of bank liabilities, consistently accounting for more than half of total assets throughout the sample period. However, this dominance was temporarily interrupted during the pre-financial crisis era, when wholesale funding markets had grown rapidly. The post-crisis period has witnessed a resurgence in core deposits' prominence within bank balance sheets, likely reflecting a broader shift toward more stable funding sources.

The path of wholesale funding and its share (blue dashed line) exhibits particularly dynamic behavior. Beginning at approximately 35 percent in the mid-1980s, it experienced a substantial surge to 45 percent immediately preceding the financial crisis. The post-crisis era has been characterized by a marked decline in wholesale funding reliance, with the ratio falling below 30 percent. This pattern implies a significant transformation in banks' funding strategies, potentially influenced by both regulatory changes and market discipline following the crisis.

The pre-crisis elevation in wholesale funding ratio implies banks' increased vulnerability to funding disruptions during this period, as they became increasingly reliant on less stable, uninsured liabilities to enhance leverage. However, the financial crisis of 2008 precipitated a notable shift toward core deposits, which are more stable and less costly.

The post-crisis era has ushered in a period characterized by the shift toward core deposits. This structural trend in liability composition suggests a broader transformation in bank funding strategies, potentially reflecting both regulatory imperatives and a reassessment of funding stability following the crisis experience. The historical swings of wholesale funding ratio indicates an important dimension of bank financing strategies, with implications for monetary policy transmission.

These patterns in bank liability structure challenge traditional views of commercial banking that emphasize the primary role of deposit funding. Over the sample period, wholesale funding has emerged as an important funding source, which accounts for around 30 percent of bank assets. Given the risk-sensitiveness of wholesale funding, even if the share of wholesale funding in total assets is smaller than that of deposits, the behavior of wholesale funding potentially shapes the overall bank lending response.

3.3 Descriptive statistics: Affiliated vs. Standalone banks

The empirical approach in this paper is based on the identifying assumption that banks have different degree of access to wholesale funding markets and bank's affiliation status is a predictor of the degree of access. To be specific, banks can be classified into

two groups: those with internal banking networks under a MBHC and other banks that lack such networks. The Call Report data provides information about the bank holding company identifiers associated with each commercial bank. Based on the bank holding company status of each commercial bank, I categorize them into one of two groups: affiliated banks (A bank) and standalone banks (S bank). A bank is considered as an affiliated bank if it has a bank holding company, and there are other commercial banks within the same holding company. A bank is deemed a standalone bank if it is either not under a bank holding company or if it has a bank holding company but is the sole commercial bank within that holding company.

Table 1: Descriptive statistics of US commercial banks

	Standalone Banks			Affiliated Banks		
	mean	median	sd	mean	median	sd
Assets (mill. $)	652	96	8,987	3,635	107	61,324
Loans (mill. $)	415	57	4,877	1,878	64	27,090
Core deposits (mill. $)	442	68	5,702	1,984	77	36,142
WSF (mill. $)	157	14	2,946	1163	15	20,040
Liquidity/Assets	0.105	0.084	0.080	0.097	0.077	0.076
Loans/Assets	0.602	0.612	0.143	0.609	0.622	0.139
WSF/Assets	0.178	0.149	0.160	0.173	0.141	0.133
Capital/Assets	0.105	0.097	0.038	0.095	0.087	0.041
Time deposit/WSF	0.792	0.892	0.242	0.725	0.790	0.275
Federal funds/WSF	0.053	0.000	0.126	0.139	0.017	0.207
Brokered deposit/WSF	0.047	0.000	0.117	0.036	0.000	0.101
Foreign deposit/WSF	0.001	0.000	0.026	0.006	0.000	0.051
Other borrowed money/WSF	0.107	0.000	0.173	0.094	0.000	0.167
Obs. (Bank $\times$ quarter)		845,293			246,837	

Notes: Data from the Call report and author's calculation. Assets are total amounts of assets held by US commercial banks. Liquidity is cash reserves. Loans are total amounts of loans of all category. Core deposits are amounts of checking and savings deposits as well as small denomination time deposits (less than $100,000). Wholesale funding is the liabilities net of core deposits. Capital is the book value of outstanding shares of bank equity. A regional bank is a commercial bank that is not under a bank holding company, or a bank that is under a bank holding company but is the only bank under the same bank holding company. A subsidiary bank is a commercial bank that is under a bank holding company and there are other banks within the same bank holding company.

Table 1 presents descriptive statistics comparing affiliated and standalone banks across key balance sheet items. A first noticeable observation is that affiliated banks exhibit sub-

stantially larger mean assets ($3.6 trillion) compared to standalone banks ($652 million), reflecting the fact that larger institutions tend to operate within bank holding company structure.

However, when comparing median values, the difference in size becomes much smaller. Affiliated banks report median assets of $107 million and standalone banks have median assets of $96 million. This relatively modest difference implies the extreme right-skewness in the size distribution, particularly for affiliated banks. The standard deviations further shows this pattern. Assets held by affiliated banks are significantly more dispersed than that held by standalone banks. This indicates that affiliated banks have a much wider range of institution sizes.

Despite the substantial size differences, both types of banks exhibit similar portfolio allocation. Affiliated banks maintain marginally higher loans to total assets ratios (0.609 vs. 0.602). These banks also hold slightly less liquid assets to total assets ratios (0.095 vs. 0.105). On average, affiliated banks hold relatively less liquid asset portfolio, but this difference is modest, compared to the drastic gap in sizes.

The funding side of bank balance sheets shows even smaller distinction between bank types. Affiliated and standalone banks hold virtually same wholesale funding to total assets ratios, although standalone banks are relatively more capitalized. Hence, both types of banks have similar degree of dependence on wholesale funding.

These patterns in balance sheet composition and size suggest that while affiliated and standalone banks operate at different scales, they do so under similar portfolio composition, despite their organizational difference. This implies that affiliated and standalone banks are ex-ante similar except their average size and organizational structure, providing better situation to investigate the consequence of MBHC affiliation on wholesale funding access and bank lending behavior.

Despite similar wholesale funding ratio, the composition of wholesale funding is different across bank affiliation types. Wholesale funding held by stand-alone banks are composed of 80% of time deposits, 5% of federal funds and brokered deposits, and 10% of other borrowed money. In contrast, affiliated banks hold significantly more federal funds than stand-alone banks, which accounts for 14% of its wholesale funding. This difference is informative, as federal funds are overnight funding between banks. Because affiliated banks have internal capital markets, they exploit this by relying more on federal funds.

Panel (a) in figure 4 provides the share of assets and loans held by standalone banks. Standalone banks' share of total assets and loans remained relatively modest until 2010, hovering between 20-30%. However, both measures have shown substantial increases

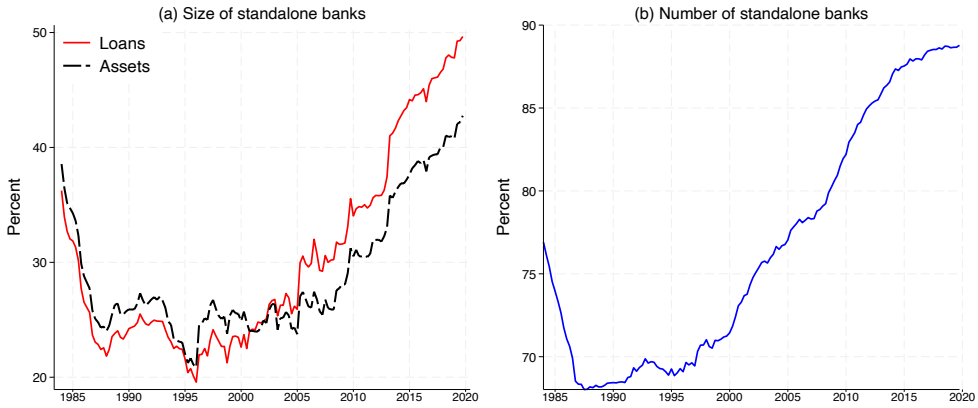


Figure 4: Relative size and the number of standalone banks

Notes: Data from the Call report and author's calculation. The graph on top shows the asset and loan share of standalone banks. The graph at the bottom shows the share of the number of standalone banks in total number of banks in the US.

since the financial crisis, with loan share rising more dramatically than asset share. By 2019, standalone banks accounted for approximately 50% of total loans and 42% of total assets in the banking system.

Panel (b) in figure 4 represents the share of standalone banks, defined as the number of standalone banks out out total number of commercial banks. The figure shows that this measure has experienced similar trajectory as the loan and asset shares in the top. Initially, there was a sharp decline in the mid-1980s, coinciding with the initial wave of interstate banking deregulation. This was followed by a relatively stable period through the 1990s, where the share remained around 70%.

However, since 2000, the share of standalone banks showing a persistent upward trend, accelerating particularly after the financial crisis in 2008. After the financial crisis, standalone banks constituted nearly 90% of all banks, representing a substantial increase from their pre-crisis levels.

These trends can be explained by several factors related to post-crisis regulatory changes. As discussed earlier, the implementation of enhanced prudential standards under the Dodd-Frank Act created significant regulatory burdens for larger affiliated banks. The differential regulatory treatment appears to have created incentives for some banks to maintain or adopt standalone structures, particularly those just below the regulatory thresholds. The Dodd-Frank Act imposed significant restrictions on transactions between banks and their affiliates, particularly through amendments to Sections 23A and 23B of the Federal Reserve Act. These provisions limited the ability of banks to engage in certain types of transactions with their affiliates, such as securities lending, borrowing, and

repurchase agreements, by increasing collateral requirements and imposing quantitative limits on such transactions. This made internal transactions more costly and less attractive for banks affiliated with multibank holding companies The more rapid increase in loan share relative to asset share suggests that standalone banks have focused particularly on traditional lending activities, while affiliated banks may have diversified into other financial services following the Gramm-Leach-Bliley Act of 1999.

4 Empirical analysis

4.1 Bank affiliation status and the access to wholesale funding

4.1.1 Evidence on wholesale funding spread level

Identifying the degree of access to wholesale funding, or financial frictions in general, is challenging, as it is determined by unobservable characteristics of banks. To overcome this issue, I exploit the bank affiliation status that I discussed in earlier section. Specifically, I categorize commercial banks into two groups, banks that are affiliated with multibank holding company and banks that do not have the affiliation. The first type of banks will be called affiliated banks and the second type will be called standalone banks.

Because a bank holding company serves as an umbrella entity overseeing one or more commercial banks, if a commercial bank is associated with a bank holding company that governs multiple commercial banks, those affiliated banks can take benefit from the internal capital markets among affiliated banks, as well as suffer from less severe financial frictions to outside creditors.

To give evidence on whether the MBHC affiliation leads to better access to wholesale funding markets, I test implications from the identification scheme. If the MBHC affiliation gives better access to wholesale funding markets, then affiliated banks should benefit from lower funding costs to wholesale funding. To test this, I run the following cross-sectional OLS:

$$y_{ict} = \alpha_i + \eta_{ct} + \gamma_s \mathbb{I}_{ict} + \Gamma' Z_{ict} + e_{ict} \tag{2}$$

where α_i is a bank i fixed effect, η_{ct} is the county-level deposit market Herfindahl index (HHI) in county c and period t. The HHI index for local deposit markets represents how concentrated a local deposit market is and captures the potential compounding factors from deposit market competition. $\mathbb{I}_{ict}$ is a dummy variable for standalone bank groups, which takes zero if a bank i an affiliated bank, and takes one if i is a stand-alone bank. Z_{it}

comprises a set of controls at both bank and macro level, including the log of assets, the growth rate of assets, capital ratio, log of the number of employees, the growth rate of the number of employees, log of bank age, return on assets, net income to assets ratio, quarter dummy, up to four quarters lags of the growth rate of GDP, and quarterly inflation rate.

Dependent variables, y_{ict}, are spreads on either large time deposits, federal funds or other debt items (debt spread, henceforth). Spreads are computed as the difference between the Fed funds rate and the interest expenses on each wholesale funds. The OLS regression in (3) estimates the level effects of the difference in affiliation status. If affiliated banks have better access to wholesale funding markets, then the coefficient on stand-alone bank would be positive, i.e. $\gamma_{\text{stand-alone}} > 0$.

Table 2 reports the regression results. Panel A shows the OLS regression on large time deposit spread. The first two columns show the results for the full sample periods (1976-2023). It confirms that stand-alone banks incur more costly wholesale funding, which is reflected by a smaller spread. That means on average, stand-alone banks pay higher costs to wholesale funds that they borrow. The spread gap is around 18 bps under the baseline specification and it is slightly higher when macro controls are excluded (23 bps).

In the third and fourth columns, I address the potential confounding effects due to bank size. The statistical difference between the two banks can be driven by the their size difference, although I already control for level and growth rates of total assets and the number of employment. Here, I split the sample so that the first sample (column (3)) contains only banks that are below 95th quantile of asset size distribution, while the second sample (column (4)) contains larger banks that are above 95th quantile of size distribution. The result is striking that the difference in time deposit spread is even larger among big banks, which tend to have better external financing options. The spread for small, standalone banks is 18 bps lower than that for small, affiliated banks, while this gap widens to 38 bps among big banks.

Fifth and sixth columns separately estimate large time deposit spread for banks in more competitive (column (5)) and less competitive (column (6)) deposit markets. This specification tries to address confounding effects due to deposit market power. That is, if a bank has market power in a local deposit market, this provides more stable funding, which can lead to higher wholesale funding spread. But the results show that there are economically small difference according to deposit market competition. In both cases, stand-alone banks face lower time deposit spread, meaning costly wholesale funds.

Panel B and C show similar OLS results on fed funds and debt spread. It confirms the previous prediction that stand-alone banks suffer higher wholesale funding costs, or smaller spreads on wholesale funds. The previous results for small/big banks and

Table 2: Bank affiliation and wholesale funding access

	Full sample		Bank size		Deposit market	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Large time deposit spread						
Stand-alone bank	-0.184***	-0.227***	-0.182***	-0.376***	-0.183***	-0.170***
	(0.012)	(0.014)	(0.013)	(0.033)	(0.014)	(0.025)
County HHI	Yes	Yes	Yes	Yes	Yes	Yes
Macro control	Yes	No	Yes	Yes	Yes	Yes
Observations	296,492	296,494	274,040	22,417	222,267	73,894
R^2	0.513	0.374	0.516	0.553	0.522	0.563
Panel B: Fed funds spread						
Stand-alone bank	-0.042***	-0.033***	-0.031***	-0.139***	-0.040***	-0.076***
	(0.008)	(0.010)	(0.010)	(0.019)	(0.010)	(0.019)
County HHI	Yes	Yes	Yes	Yes	Yes	Yes
Macro control	Yes	No	Yes	Yes	Yes	Yes
Observations	375,440	375,449	323,574	51,802	286,033	88,626
R^2	0.666	0.556	0.661	0.728	0.668	0.697
Panel C: Debt spread						
Stand-alone bank	-0.238***	-0.271***	-0.231***	-0.308***	-0.265***	-0.190***
	(0.015)	(0.016)	(0.017)	(0.028)	(0.017)	(0.30)
County HHI	Yes	Yes	Yes	Yes	Yes	Yes
Macro control	Yes	No	Yes	Yes	Yes	Yes
Observations	217,228	217,230	177,531	39,597	16,4051	52,878
R^2	0.560	0.452	0.562	0.554	0.567	0.602

Notes: Standard errors are clustered by bank. Column (3) is the results for small banks (¡ 95th percentile in size), and column (4) is the results for big banks ($\geq$ 95th percentile in size). Column (5) shows the results for banks operating in more competitive deposit markets (below median HHI), and less competitive deposit markets (above median HHI). *** p<0.01, ** p<0.05, * p<0.1

high/low deposit market competition still hold. Regardless of bank size or deposit market competition, stand-alone banks incur smaller debt spread.

4.1.2 Evidence on wholesale funding spread beta

The regression in equation (3) estimates the average level difference according to bank affiliation. It confirms that on average, stand-alone banks have smaller wholesale funding spread. In this subsection, I investigate whether bank affiliation also results in different beta on wholesale funding spread when short-term interest rate (federal funds rate) changes.

Specifically, I run the following regression:

$$\Delta y_{ict} = \alpha_i + \eta_{ct} + \gamma \Delta R_t + (\gamma_s + \beta_s \Delta R_t)\mathbb{I}_{ict} + \Gamma' Z_{ict} + e_{ict} \tag{3}$$

where α_i is a bank i fixed effect, η_{ct} is the county-level HHI as before, $\mathbb{I}_{ict}$, $g \in \mathcal{G} =$ affiliated, stand-alone is a dummy variable for affiliated and standalone bank groups. Z_{ict} includes a set of controls at both bank and macro level, including the growth rate of assets, capital ratio, the growth rate of the number of employees, log of bank age, return on assets, net income to assets ratio, quarter dummy, up to four quarters lags of the growth rate of GDP, and quarterly inflation rate. ΔR_t is a change in federal funds rate, instrumented by high frequency identified monetary policy shocks by Bauer and Swanson (2023). Dependent variables, y_{ict}, are the change in time deposit spreads or debt spreads.

Table 3 reports the regression results. As before, in column (1) and (2), the regressions are run on the full sample. In both panel A and B, wholesale funding beta is around 0.6, 0.581 for time deposit and 0.604 for debt. That means that every an unexpected 1 bp increase in federal funds rate would increase the spread by 0.6 bp, implying 0.4 bp increase in wholesale funds.

The interaction term, which turns on for stand-alone banks, shows a negative coefficient, which is statistically significant. This indicates that as federal funds rate increases, wholesale funding spreads increase less for stand-alone banks. A negative coefficient is consistent with the prediction that stand-alone banks have poor access then affiliated banks, because smaller increase in spreads means higher increase in wholesale funding rate. So, stand-alone banks not only pay higher interest on wholesale funds on average, but also its cost is more sensitive to monetary policy.

Columns (3) and (4) shows sub-sample results, where I split the sample into small and big banks. The result shows that the difference in wholesale funding beta is even larger among big banks. For example, time deposit beta for big stand-alone banks is 0.2 bps lower than affiliated banks, while that difference is 0.08 bps among small banks. This also

Table 3: Bank affiliation and wholesale funding access

	Full sample		Bank size		Deposit market	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: ΔLarge time deposit spread						
ΔR	0.581***	0.512***	0.570***	0.641***	0.580***	0.564***
	(0.010)	(0.011)	(0.011)	(0.026)	(0.011)	(0.020)
Stand-alone bank x ΔR	-0.094***	-0.119***	-0.081***	-0.200***	-0.089***	-0.104***
	(0.011)	(0.012)	(0.012)	(0.034)	(0.013)	(0.022)
County HHI	Yes	Yes	Yes	Yes	Yes	Yes
Macro control	Yes	No	Yes	Yes	Yes	Yes
Observations	291,222	291,223	269,249	21,938	218,190	72,704
R^2	0.188	0.056	0.189	0.208	0.194	0.208
Panel B: ΔFed funds spread						
ΔR	0.624***	0.793***	0.591***	0.711***	0.624***	0.596***
	(0.009)	(0.010)	(0.011)	(0.015)	(0.010)	(0.020)
Stand-alone bank x ΔR	-0.200***	-0.329***	-0.169***	-0.291***	-0.196***	-0.202***
	(0.012)	(0.013)	(0.014)	(0.027)	(0.014)	(0.026)
County HHI	Yes	Yes	Yes	Yes	Yes	Yes
Macro control	Yes	No	Yes	Yes	Yes	Yes
Observations	291,917	291,921	247,742	44,099	222,921	68,335
R^2	0.158	0.061	0.144	0.283	0.161	0.163
Panel C: ΔDebt spread						
ΔR	0.604***	0.619***	0.588***	0.640***	0.598***	0.604***
	(0.013)	(0.014)	(0.016)	(0.024)	(0.015)	(0.027)
Stand-alone bank x ΔR	-0.108***	-0.232***	-0.083***	-0.196***	-0.096***	-0.148***
	(0.016)	(0.017)	(0.018)	(0.035)	(0.018)	(0.032)
County HHI	Yes	Yes	Yes	Yes	Yes	Yes
Macro control	Yes	No	Yes	Yes	Yes	Yes
Observations	196,416	196,418	162,033	34,301	148,545	47,595
R^2	0.195	0.048	0.201	0.182	0.201	0.197

Notes: Standard errors are clustered by bank. *** p<0.01, ** p<0.05, * p<0.1

shows that the difference in wholesale funding beta does not come from bank size.

Similarly, the low wholesale funding beta for stand-alone banks is not driven by the deposit market competition. For both high and low deposit markets, stand-alone banks experience low beta, meaning higher sensitivity of wholesale funding costs to monetary policy. In summary, the estimated wholesale funding beta confirms that stand-alone banks have relatively poor access to wholesale funding markets or those banks are more constrained in wholesale funding markets, which is reflected by their higher sensitivity of wholesale funding costs to monetary policy.

4.2 Impulse responses to monetary policy shock

4.2.1 Specification

This section provides the main empirical results and examines how bank funding liquidity risk affects its lending response. Commercial bank's balance sheet can be roughly described as follows. Bank assets can be accounted for by loans, securities and liquid assets (cash and reserves). On the liability side, banks fund their asset holdings by core deposits, wholesale funding and equity, which account for roughly 60 percent, 30 percent and 10 percent of liabilities, respectively.

Assets	**Liabilities**
Loans	Deposits
Securities	Wholesale funding
Liquid assets	Equity

In the existing literature, the bank lending channel works mainly through the deposit channel (Drechsler et al., 2017), where deposit flow plays a critical role. When a central bank hikes short-term interest rate, it causes deposit outflows and banks that are facing unexpectedly low deposits cut their lending. But as one can see from the balance sheet of a commercial bank, deposit flows may not capture the complete picture of how banks adjust in response to monetary shocks. That is, banks can either reduce their securities or liquid asset holdings, or increase wholesale funding to shield their loans when facing deposit outflows.

The empirical approach in this paper is to try to draw a comprehensive picture of how bank balance sheet adjusts, following an unexpected monetary policy shock. To this end, I estimate dynamic responses of each balance sheet item: loans, securities, liquid assets,

deposits, wholesale funding and equity. By estimating all balance sheet items, one can have a complete view of the bank's response to monetary policy.

The empirical framework to estimate the dynamic causal effects of monetary policy on bank lending and other balance sheet items is the panel Local Projection Instrumental Variable (LP-IV) technique (Jordà et al., 2019). As Ramey (2016) pointed out, the local projection can address possible specification errors that could be compounded in the traditional VAR method. One substantial advantage of the LP-IV over the traditional VAR is to allow one to conveniently estimate impulse response functions using panel data and exploit micro-level heterogeneity. The empirical specification for the current LP-IV setting is the following:

$$(4)\quad y_{ict+h} - y_{ict-1} = \alpha_{ih} + \sum_{g\in\mathcal{G}} \Big(\beta_{gh}\Delta R_t + \gamma_{gh}\Big)\mathbb{I}[x_{ict} \in g] + \Gamma_h X_{ict-1} + e_{ict+h},\ h = 0, \cdots, H$$

where $h \geq 0$ is the forecast horizon, α_{ih} is a bank i fixed effect at the horizon h. $\mathbb{I}(x_{ict} \in g),\ g \in \mathcal{G} =$ standalone, affiliated is a dummy variable for standalone or affiliated bank groups, respectively. ΔR is the change in the two year Treasury yields instrumented by identified monetary policy shocks. y_{ict} is a dependent variable which will be specified for each LP result. X_{ict-1} is a set of control variables, including lags of dependent variables, bank size, quarter dummy, and county level deposit market Herfindahl index (HHI), which captures potential local deposit market competition effects. The estimated coefficient β_{gh} has an interpretation of the cumulative impulse response of a dependent variable y in the period $t + h$ to an unanticipated monetary policy shock in the period t, for a bank in a group g.

Each impulse response estimates a response to a 25 bps unexpected increase in the two year Treasury yield as in Bauer and Swanson (2023) and is estimated using equation 1. I report the 68 percent confidence intervals, which are depicted as the area between two dashed lines. In each panel, the graphs on the right side show the relative effects of subsidiary banks over regional banks with the 68 percent confidence intervals. For each local projection, I report the impulse responses up to 20 quarters.

4.2.2 Bank lending

Figure 5 reports the impulse responses of lending growth of affiliated (red square) and stand-alone (blue circle) banks. Following a 25 bps surprise increase in two year Treasury yield, standalone banks gradually cut their lending, which touches 7 percentage point

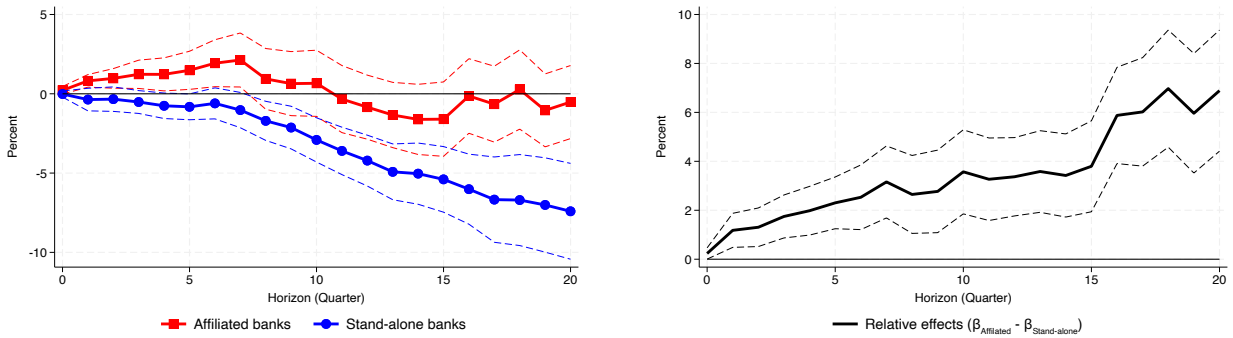


Figure 5: Impulse response of bank lending to contractionary monetary policy shock

Notes: The figure shows the estimated impulse response functions for the growth rate of loans for affiliated and standalone banks following a 25 bps increase in two year Treasury yield. Relative effects is the impulse response of affiliated banks relative to that of standalone banks. Dashed lines show the 68 percent confidence intervals. Standard errors are clustered by banks and time.

drop by 20 quarters out. In contrast, the path of lending growth of affiliated banks goes a different route. In the first 10 quarters after a shock, lending by affiliated banks in fact increases, with peak effect of around 2 percent increase. After that, lending response of affiliated banks become insignificant. This heterogeneous bank lending behavior is significant. The right panel shows the relative effect of affiliated banks to standalone banks. It shows that the differential bank lending responses is not only statistically significant but also economically large. By 20 quarters after a shock, the difference widens by 7 percentage point.

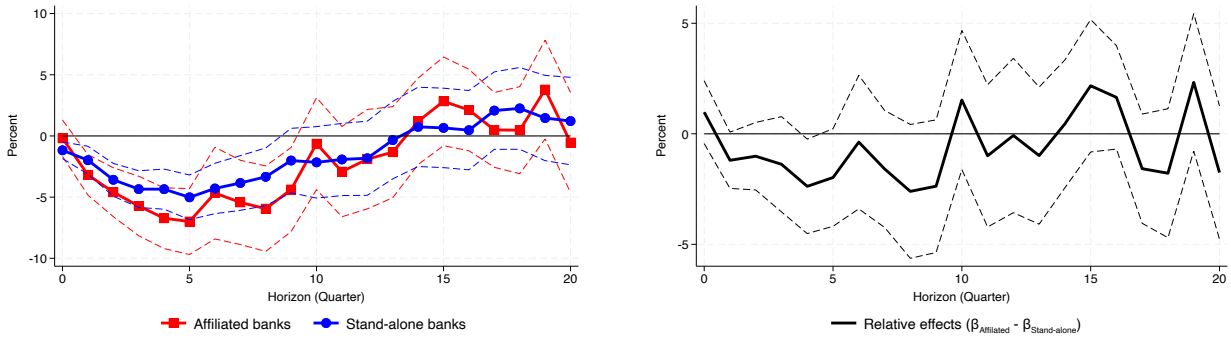
The result in figure 5 confirms the existence of the bank lending channel. More importantly, it indicates that the bank lending channel is led by the response of standalone banks, which experience significant cut in lending. As discussed earlier, banks having different affiliation status have different access to wholesale funding markets. As such, this heterogeneity implies that the different wholesale funding access can drive the bank lending channel. To explore this hypothesis, I estimate impulse responses of all balance sheet items, which include securities, liquid assets, core deposits, wholesale funding and equity.[9]

4.2.3 Security and liquid assets

Figure 6 reports the impulse responses of other assets, including securities and liquid assets. If banks have different asset management strategy, the heterogeneous bank lending responses can be driven by the difference in the change in asset holdings. If banks

[9]Liquid assets include cash and federal funds and repurchase agreements.

Panel A: Securities growth



Panel B: Liquid assets growth

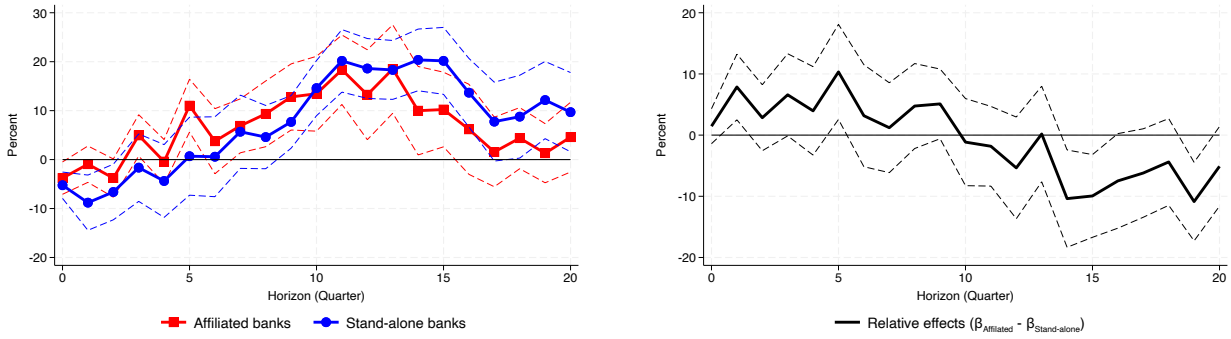


Figure 6: Impulse response of other assets to contractionary monetary policy shock
Notes: The figure shows the estimated impulse response functions for the growth rate of security holdings and liquid assets for affiliated and standalone banks following a 25 bps increase in two year Treasury yield. Relative effects is the impulse response of affiliated banks relative to that of standalone banks. Dashed lines show the 68 percent confidence intervals. Standard errors are clustered by banks and time.

show differing impulse responses of securities and liquid assets which reconcile the above banks lending growth, the bank lending channel can be explained by the change in the composition of bank assets.

However, the estimated impulse responses exhibit no significant difference between affiliated and stand-alone banks. Following an interest rate hike, banks cut their security holdings. While affiliated banks cut their holding slightly more (7 percent vs 5 percent drop at trough), this difference is not statistically significant. Insignificance among banks also holds for liquid asset growth. Banks slowly increase their liquid asset holdings, which peak around 13 quarters following a shock.

Figure 5 and 6 imply that banks first cut their security holdings, which is more liquid than loans. Then, banks slowly reduce their loan size, while at the same time hoard more liquid assets. Importantly, affiliated banks unload their security holdings and increase liq-

uid assets in their balance sheet, but they do not significantly change their lending. They slightly increase it, instead. Therefore, the bank lending channel and the heterogeneous lending behavior are not explained by their asset management.

4.2.4 Liabilities

Figure 7 depicts the impulse responses of core deposit and wholesale funding growth. Stand-alone banks face larger deposit outflows in the first 2 years, which is significant at 68 percent, but this effect disappears after that.[10] It is noteworthy that starting 6th quarter, core deposit growth of banks start to become insignificant. Recall from figure 5 that the disproportionate effects on lending responses are larger in the later quarters, especially since 6th quarter. Thus, core deposit flows cannot fully explain this divergence, in terms of the magnitude and the timing.

In Panel B, wholesale funding growth exhibits more pronounced heterogeneity. From the impact quarter, affiliated and stand-alone banks have different wholesale funding growth. For the entire horizon, stand-alone banks have lower wholesale funding growth and it becomes negative since 12th quarter. In contrast, affiliated banks raise wholesale funding debt and it does not fall into negative territory until 20th quarter.

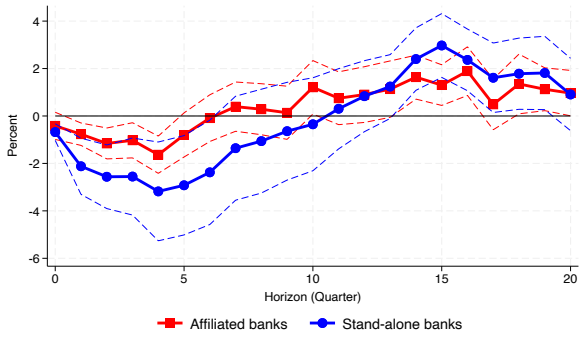
The difference in wholesale funding growth peaks at 15 percent in 18 quarters, which is also statistically significant. In addition, the path of the relative wholesale funding growth matches up with the path of lending growth, which peaks around the same time. The significant divergence in wholesale funding growth can account for the majority of the difference in lending responses.

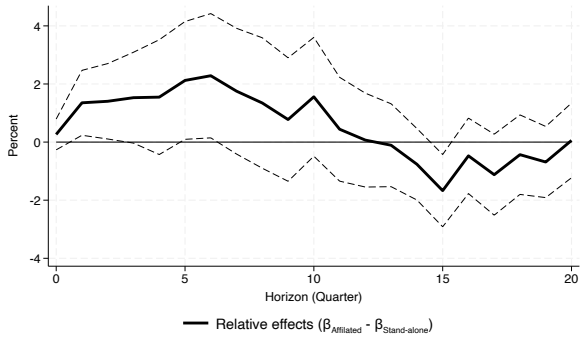
The estimated impulse responses are consistent with the previous discussion. Affiliated and stand-alone banks have different access to wholesale funding markets due to their organizational structure, which leads to the heterogeneous wholesale funding growth. The timing and magnitude of this divergence matches up with the bank lending responses, which shows significant fall in lending by stand-alone banks since 6th quarter.

Panel C displays the estimated impulse responses of bank equity in book value. Equity does not move much in the first 2 to 3 years, then since 15th quarter, book value of stand-alone banks start to decline. This is potentially driven by a fall in profit when stand-alone banks cut their lending. But again, this different only partially explains the heterogeneous bank lending responses.

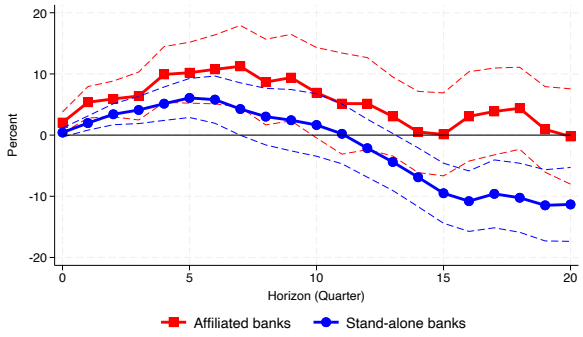
[10] In data, stand-alone banks tend to operate in a region with high HHI, which means that this type of banks face low deposit market competition. According to the deposit channel, this gives them incentive to raise deposit spread more, which leads to larger deposit outflows.

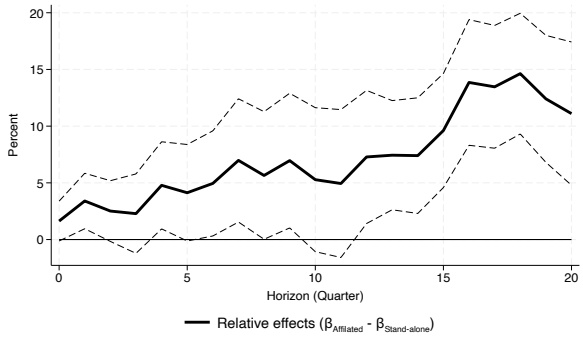
Panel A: Core deposit growth



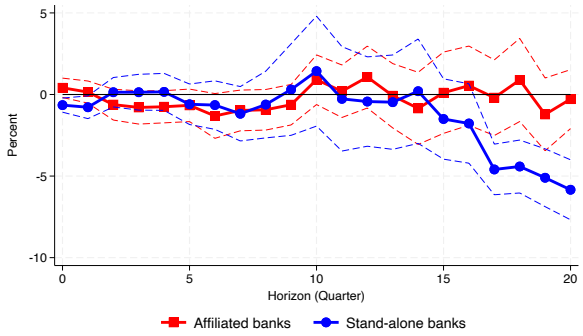


Panel B: Wholesale funding growth





Panel C: Equity growth



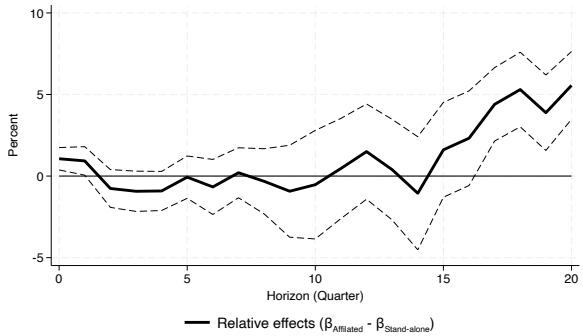


Figure 7: Impulse response of core deposits and wholesale funding to contractionary monetary policy shock

Notes: The figure shows the estimated impulse response functions for the growth rate of core deposits and wholesale funding for affiliated and standalone banks following a 25 bps increase in two year Treasury yield. Relative effects is the impulse response of affiliated banks relative to that of standalone banks. Dashed lines show the 68 percent confidence intervals. Standard errors are clustered by banks and time.

4.2.5 Discussion

The above results indicate the importance of bank funding for their credit supply. When an unexpected interest hike hits, banks experience deposit outflows, and reduce their security holdings, while slowly hoarding liquid assets. In 2 years after the shock, stand-alone banks do not decrease their lending significantly, and affiliated banks increase their lending. In this earlier time window, affiliated banks can raise substantial amount of wholesale funding, and do stand-alone banks, although the amount is significantly smaller. After 2 years, bank lending start to diverge remarkably. While affiliated banks remain unchanged, stand-alone banks show considerable amount of lending cut.

Note that all balance sheet items, including loans, securities, liquid assets, core deposits, approach the initial level. In addition, affiliated banks hold similar amount of wholesale funding and hence can shield their loan. But stand-alone banks cut their lending due to negative wholesale funding growth. This is also partially explained the fall in equity, which reflect negative profits that stand-alone banks incur.

The estimated balance sheet dynamics of banks provide novel implications. First, the effects of monetary policy on bank lending is limited in the first two years. This is because even though banks experience deposit outflows, they first cut their security holdings and tap into wholesale funding markets to offset the deposit outflows. But due to the heterogeneous wholesale funding access, stand-alone banks raise only half amount of wholesale funding than affiliated banks do.

Second, the heterogeneity in lending responses is more pronounced as time goes, while those on core deposits dissipate. By 20th quarter, stand-alone banks reduce their lending by 7 percentage point. This translates into 4 percent decrease in asset. This is accounted for by 11 percent fall in wholesale funding, which translates into around 1.8 percent adjustment in liability side. Therefore, wholesale funding accounts for approximately 45% of the bank lending responses, while deposit growth do not explain a decrease in lending.

This result both confirms and challenges the finding of Drechsler et al. (2017), where authors find strong evidence on the role of deposit flows in the bank lending channel. There are at least two explanations on the difference. First, Drechsler et al. (2017) mainly focuses on the contemporaneous impact of monetary policy, while the local projection in my specification estimates the dynamic responses. In my result, core deposit growth play a role in the first quarters, which die out fast. Second, Drechsler et al. (2017) provides the evidence on new lend, while I show the total loan holdings, which combines the new and the existing loans. Due to data limitation, my approach cannot address the unobserved effects on new lending, which can be economically significant. But the above analysis

indicates the monetary policy significantly affects bank lending and there is an important role of wholesale funding.

4.3 Wholesale funding responses by type

In this section, I explore the responses of each type of wholesale funding: time deposits, federal funds, brokered deposits, foreign deposits, and other borrowed money. I estimate the same local projection (4), but now dependent variables are each wholesale funding type. The estimation results (appendix) show that most types of wholesale funding contribute to the heterogeneous responses. In the earlier periods, large time deposits and federal funds are main driver of the heterogeneous responses. In the later periods, other borrowed money, brokered deposits and foreign deposits also have distinct responses, which contribute the results.

4.4 Robustness

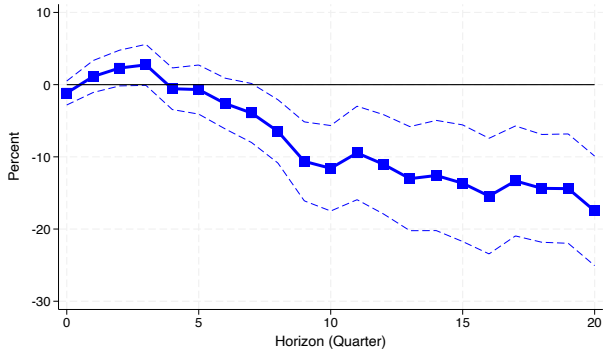
In this section, I assess the robustness of the previous results. Specifically, I examine whether the findings in the preceding section are influenced by bank size. Large banks are considered safer than smaller banks and maintain close connections with other financial institutions, which can give them relatively better access to wholesale funding (Kashyap and Stein, 2000). I estimate the same local projections for large and small banks separately, where the former consists of banks above 95th percentile of size distribution and the latter contains banks below 95th percentile. It turns out that even among big banks, stand-alone banks show significant contraction in lending size, which is largely driven by by wholesale funding responses (See appendix for estimation results). That is, the size of banks do not explain the bank lending channel and the wholesale funding responses.

5 Aggregate implication

5.1 State level evidence

To further investigate the implications of the wholesale funding channel, I exploit a cross-sectional variation in stand-alone bank shares. The idea is that if a states is more populated by stand-alone banks, then the state would experience stronger decline in bank lending in response to contractionary monetary policy, which leads to severe downturn in real economic activity.

Panel A: State bank lending



Panel B: State GDP (left) and unemployment rate (right)

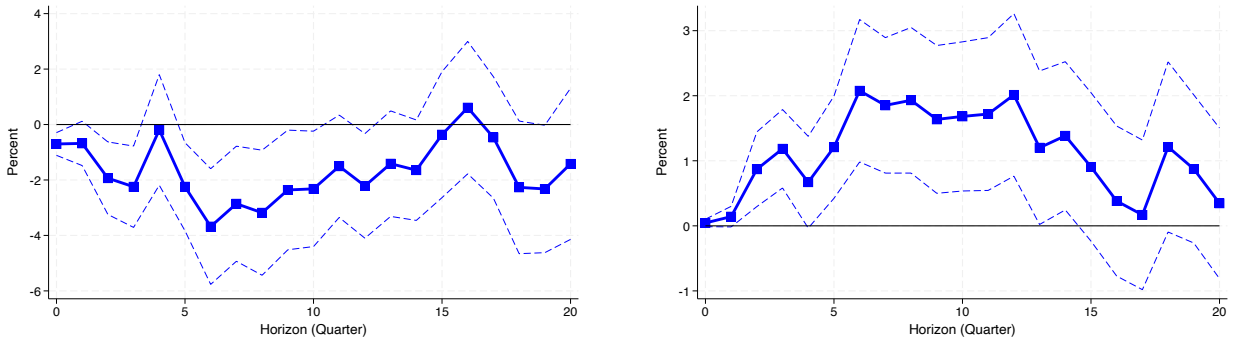


Figure 8: Impulse responses of state bank lending, GDP and unemployment rate to contractionary monetary policy shock

Notes: The figure shows the estimated impulse response functions for the growth rate of state bank lending, GDP and the change in unemployment rate following a 25 bps increase in two year Treasury yield. Relative effects is the impulse response of affiliated banks relative to that of standalone banks. Dashed lines show the 68 percent confidence intervals. Standard errors are clustered by banks and time.

I aggregate each variable up to state level, and estimate the following local projections.

$$(5) \quad y_{st+h} - y_{st-1} = \alpha_{sh} + \beta_h \Delta R_t S_{st-1} + \delta_h^1 \Delta R_t + \delta_h^2 S_{st-1} + \Gamma_h X_{st-1} + e_{st+h}, \ h = 0, \cdots, H$$

Here, a dependent variable y_{st} is either the sum of total loans held by banks in state s, GDP or unemployment rate for a state s in period S_{st} is the share of stand-alone banks in the total loan size in each state s, and X_{st} include controls. The coefficient β_h is interpreted as the impulse response to monetary policy shock, conditional on stand-alone bank share S_{st-1}.

Figure 8 reports the results. In panel A, the response of bank lending at the state level shows significant amplification effects due to stand-alone banks. When stand-alone bank

share is 10% point higher, then the state would experience 1.5 percentage point further decrease in bank lending. This confirms that the share of stand-alone banks determines the extent of the bank lending channel through heterogeneous access to wholesale funding.

In panel B, on the left graph, state GDP growth decreases further when a state exhibits a high share of stand-alone banks. If an asset share of stand-alone banks is 10 percentage point higher than average in a state, then the state would experience 0.8 percentage point further decline in state GDP after a contractionary monetary shock. On the right, similar amplifying effects occur in unemployment. Stand-alone share amplifies contractionary effects of an interest hike. If a state has 10 percentage point higher stand-alone bank share in assets than average, it translates to 0.4 percentage point further increase in state unemployment rate.

State level local projections confirms the importance of the size of stand-alone banks in a cross-section. If the banking sector is more populated by stand-alone banks, which is the trend in the US, then the bank lending channel of monetary policy would be stronger due to the wholesale funding channel. This results in more volatile macroeconomic dynamics, which can be confirmed from the above state level evidence. Heterogeneous regional effects due to financial intermediation has been documented, for example Mian et al. (2020). My paper complements this study and show the organizational structure of local banks is important for the monetary policy transmission.

5.2 The effects on bank failure

Recent studies have found evidence that reliance on wholesale funding could lead to higher fragility in banking sector (Grimm, 2024; Begenau and Stafford, 2023). Having evidence on the bank lending channel, which speaks to the important role of wholesale funding, there could be aggregate impact from monetary policy on financial fragility.

To investigate the implications of monetary policy on financial sector fragility, I estimate the causal effects of contractionary monetary policy shocks on bank failure. Specifically, I use historical bank failure data from FDIC, and estimate the following local projection

$$p_{ict+h} = \alpha_{ih} + \sum_{g \in \mathcal{G}} \Big(\beta_{gh} \Delta R_t + \gamma_{gh}\Big) \mathbb{I}[x_{ict} \in g] + \Gamma_h X_{ict-1} + e_{ict+h},\ h = 0, \cdots, H \tag{6}$$

Here, a dependent variable p_{ict} is an indicator variable that takes one if a bank i in county c fails within one year from period t.

Figure 9 shows the results. Following a contractionary monetary policy shock, the

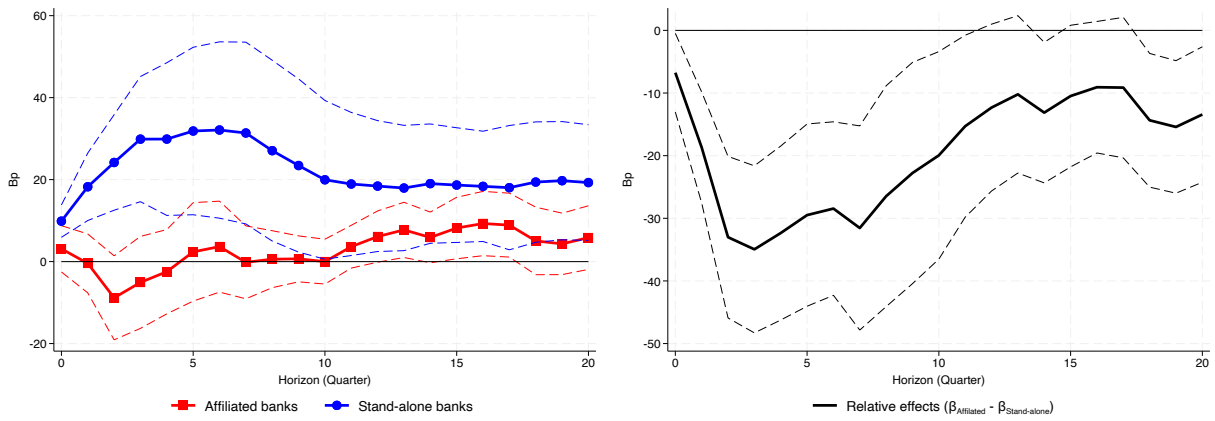


Figure 9: Impulse response of bank failure in one year to contractionary monetary policy shock

Notes: The figure shows the estimated impulse response functions for the change in the probability of bank failure in one year for affiliated and standalone banks following a 25 bps increase in two year Treasury yield. Relative effects is the impulse response of affiliated banks relative to that of standalone banks. Dashed lines show the 68 percent confidence intervals. Standard errors are clustered by banks and time.

probability of bank failure increases for stand-alone bank. The probability gradually increases from the impact period, and the peak occurs in 5 quarters, which shows an increase in the failure probability by 30 basis point. Then it slightly decreases but stay positive for an extended period of time. This implies that a contractionary monetary policy shock elevates failure rates of stand-alone banks. This can be understood by the fact that stand-alone banks become more dependent on wholesale funding, which is more costly and vulnerable to run.

In contrast, the failure probability of affiliated bank shows largely muted responses and is not significantly different from zero. Even though affiliated banks also exhibit higher reliance on wholesale funding, they face lower failure rate. A possible explanation is that because of the MBHC affiliation, affiliated banks have ability to shield their illiquid assets and raise external funds more easily than stand-alone banks. This is particularly important when a bank incurs large losses or run on its liability. For those banks that have tight relationship with other banks, offsetting outflows of liabilities is easier than other banks that do not have such relationship.

This complements to the recent study by Correia et al. (2023). They show that bank failure is predictable by balance sheet of banks, and in particular, bank funding vulnerability and insolvency are good predictor of financial crisis. In my empirical framework, it is standalone banks that change its lending in response to monetary policy because of their poor wholesale funding access. This leads to higher bank failure probability due to

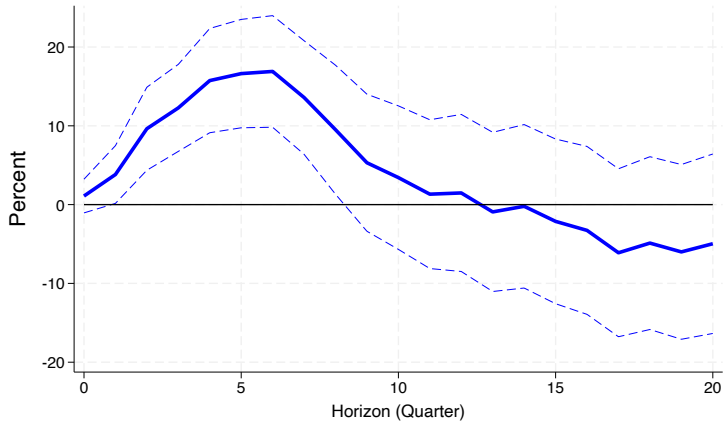


Figure 10: Impulse response of bank-at-risk to contractionary monetary policy shock

Notes: The figure shows the estimated impulse response functions for the change in bank-at-risk (BaR) for affiliated and standalone banks following a 25 bps increase in two year Treasury yield. Relative effects is the impulse response of affiliated banks relative to that of standalone banks. For the detail in BaR calculation, see Correia et al. (2023). Dashed lines show the 68 percent confidence intervals. Standard errors are clustered by banks and time.

elevated funding vulnerability and insolvency.

To evaluate the consequence of monetary policy, I estimate the following local projection on the bank-at-risk (BAR) measure developed by Correia et al. (2023).

$$BaR_{t+h} - BaR_{t-1} = \alpha_h + \beta_h \Delta R_t + \Gamma_h X_{t-1} + e_{t+h},\ h = 0, \cdots, H \tag{7}$$

Here, BaR_t measures the thickness of the right tail of the predicted distribution of bank failure. Intuitively speaking, BaR_t captures the share of banks that have elevated probability of failure, predicted by its funding vulnerability and insolvency by the period t. Higher BaR_t implies that a higher share of banks are $at\ risk$, meaning close to failure.

Figure 10 shows the result. Following a contractionary monetary policy shock, the BaR gradually increases, which peaks around 6 quarters. At peak, BaR is 16 percentage point higher than initial level, which is more than two standard deviation increase. Therefore, the local projection implies that an unexpected contractionary monetary policy significantly increases

The consequence on bank fragility shows an important policy implication. That is, when monetary policy tightens, it transmits through real economy by contracting economic activity, but also through banking sector, which works by reducing the overall size of bank loans and changing bank liability towards wholesale funding. This leads to ele-

vated bank failure risks, which can materialize in some cases.[11] Therefore, it is crucial to notice that monetary authority should consider its financial stability consequence through banking sector.

6 Concluding remarks

In this paper, I revisit the bank lending channel and show that the bank lending channel is driven by banks' ability to raise wholesale funding in response to contractionary monetary policy shocks. Using bank level data, I exploit the organizational structure of banks and find that banks with MBHC affiliation have better access to wholesale funding, which allows them to shield their loans when interest rate increases. In contrast, stand-alone banks that have no such relationship, suffer from outflows of both deposits and wholesale funding, which force them to cut their lending.

I further show that this channel is quantitatively important even at aggregate level. Using variation in stand-alone bank shares at state level, I show that state level bank lending responses to monetary policy shocks are amplified as stand-alone bank share increases. This amplification causes real effects, which is more pronounced effects on state level GDP and unemployment.

Finally, I find that the interaction of bank affiliation, wholesale funding access and monetary policy have important macroeconomic implications. Due to poor access to external funding markets, stand-alone banks exhibit higher increase in failure probability. This contributes to economy wide increase in BaR in response to a contractionary monetary policy. This also implies that monetary policy has financial stability consequences, mainly through the potential failure of banks, the probability of which is tilted more toward stand-alone banks.

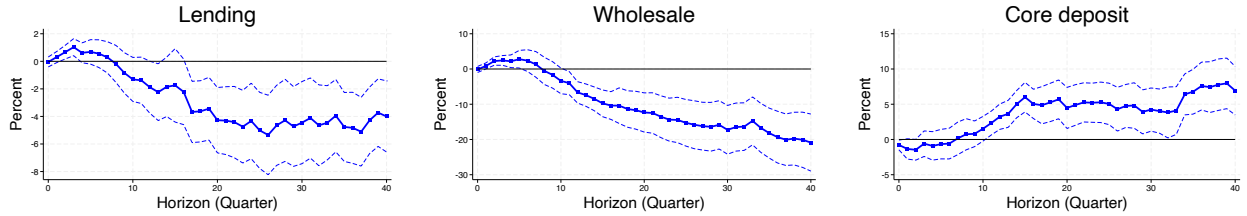
The empirical evidence in this paper indicate that wholesale funding markets play an important role in the monetary transmission. It also implies that monetary policy can affect financial stability through funding composition of banks, which has disproportionate effects on stand-alone banks.

[11] Schularick et al. (2021) find evidence from historical sample that shows contractionary monetary policy after a period of loose monetary policy stance can increase the probability of financial crisis.

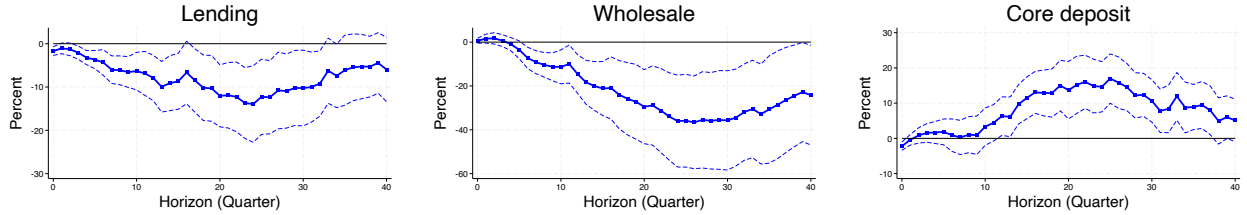
Appendix

6.1 Additional graphs

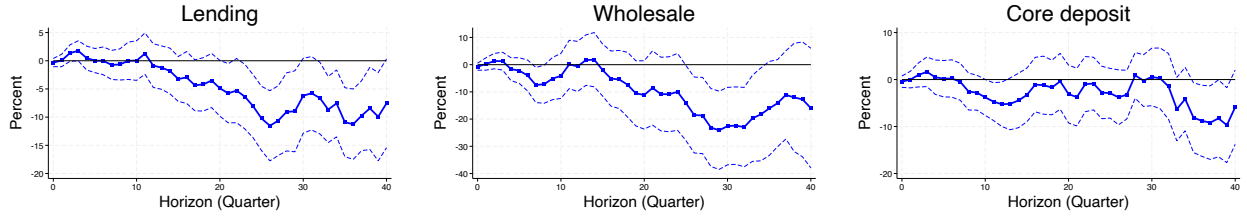
(a) Bauer-Swanson



(b) Miranda-Agrippino-Rico



(c) Bu-Rogers-Wu



(d) Jarocinski-Karadi

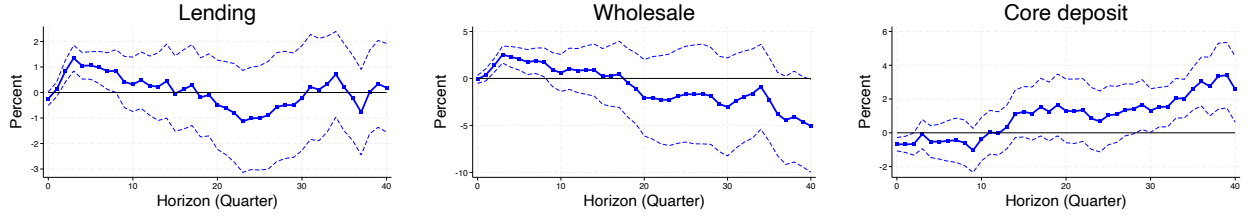
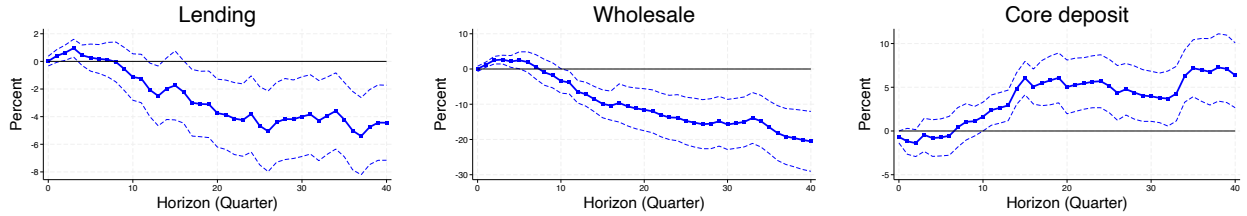


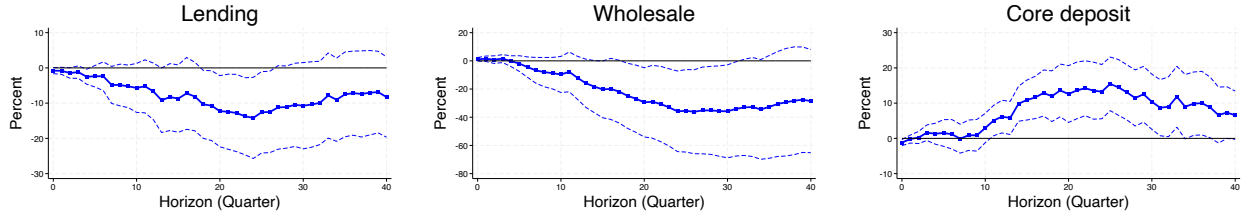
Figure 11: Impulse response of aggregate lending, wholesale funding and core deposits to various monetary policy shock

Notes: The figure shows the estimated impulse response functions for the growth rate of aggregate lending, wholesale funding and core deposits following a 25 bps increase in two year Treasury yield. Relative effects is the impulse response of affiliated banks relative to that of standalone banks. Dashed lines show the 68 percent confidence intervals. Standard errors are clustered by banks and time.

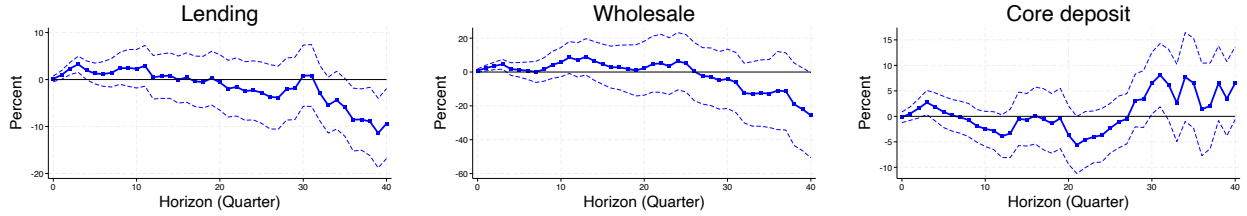
(a) Bauer-Swanson



(b) Miranda-Agrippino-Rico



(c) Bu-Rogers-Wu



(d) Jarocinski-Karadi

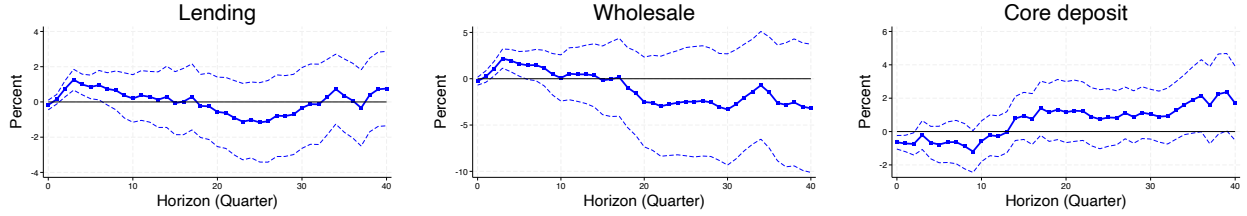
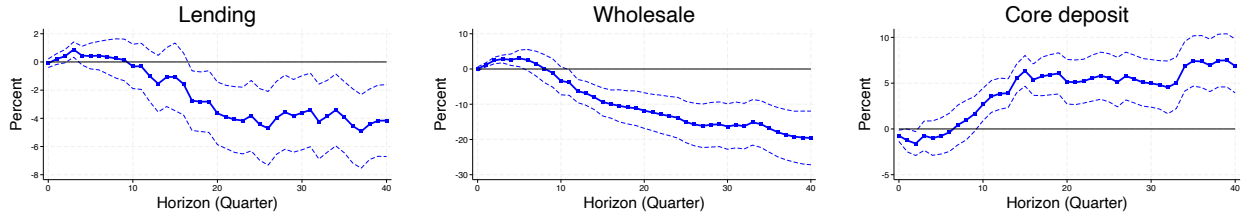


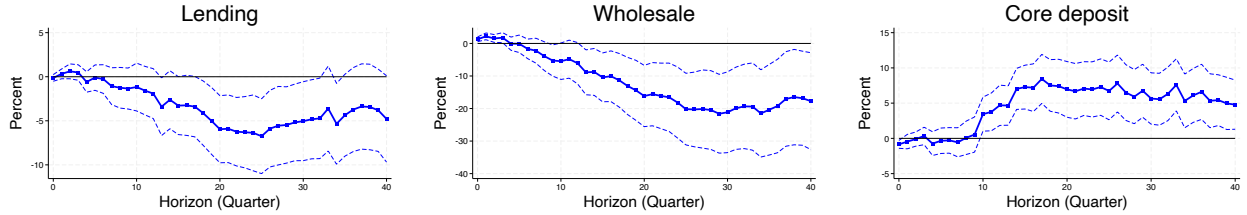
Figure 12: Impulse response of aggregate lending, wholesale funding and core deposits to various monetary policy shock (no macro control)

Notes: The figure shows the estimated impulse response functions for the growth rate of aggregate lending, wholesale funding and core deposits following a 25 bps increase in two year Treasury yield. Relative effects is the impulse response of affiliated banks relative to that of standalone banks. Dashed lines show the 68 percent confidence intervals. Standard errors are clustered by banks and time.

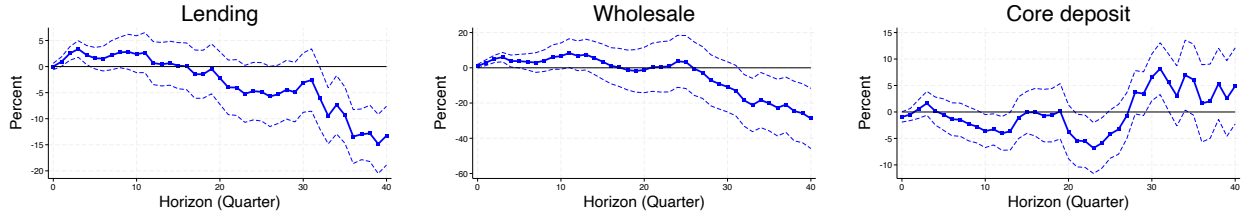
(a) Bauer-Swanson



(b) Miranda-Agrippino-Rico



(c) Bu-Rogers-Wu



(d) Jarocinski-Karadi

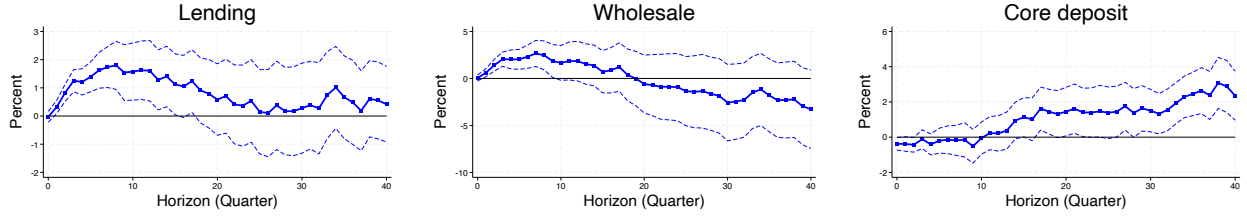
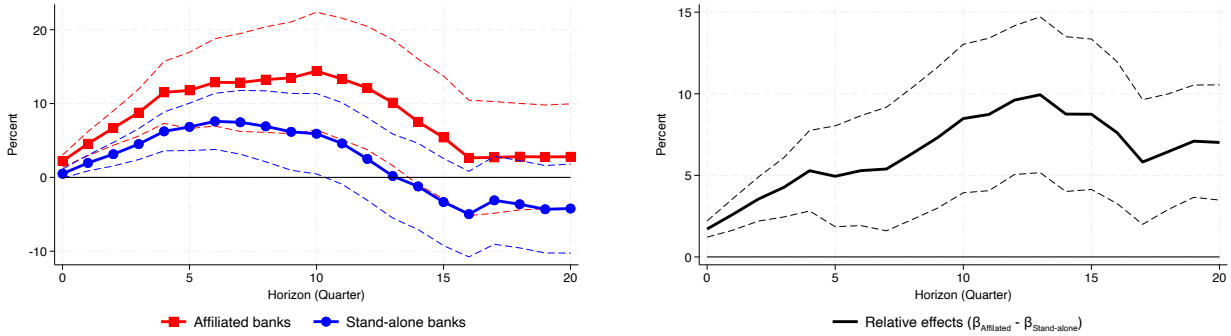


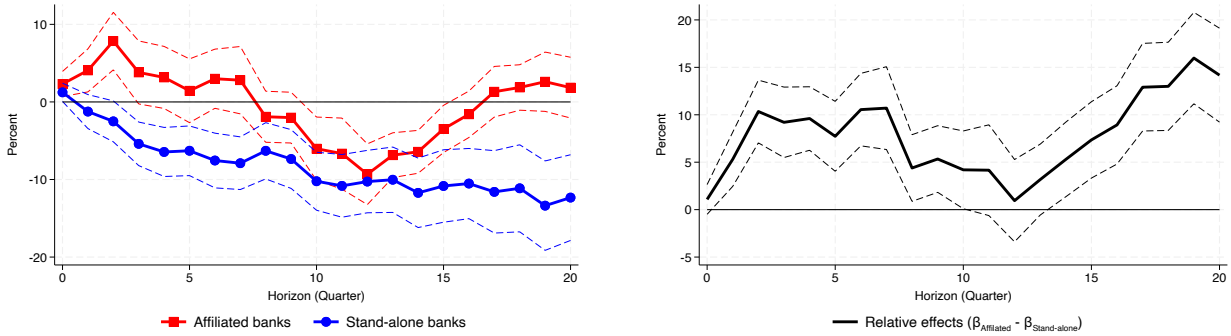
Figure 13: Impulse response of aggregate lending, wholesale funding and core deposits to various monetary policy shock (one year lag and no macro control)

Notes: The figure shows the estimated impulse response functions for the growth rate of aggregate lending, wholesale funding and core deposits following a 25 bps increase in two year Treasury yield. Relative effects is the impulse response of affiliated banks relative to that of standalone banks. Dashed lines show the 68 percent confidence intervals. Standard errors are clustered by banks and time.

(a) Large time deposits



(b) Federal funds



(c) Brokered deposits

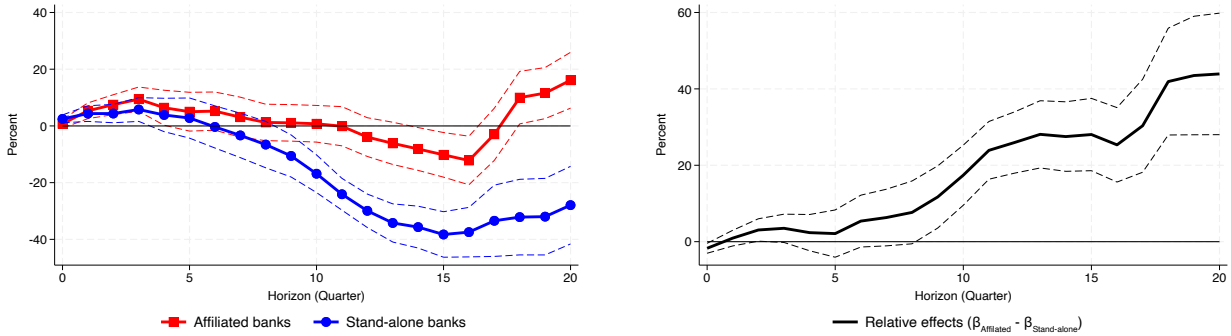
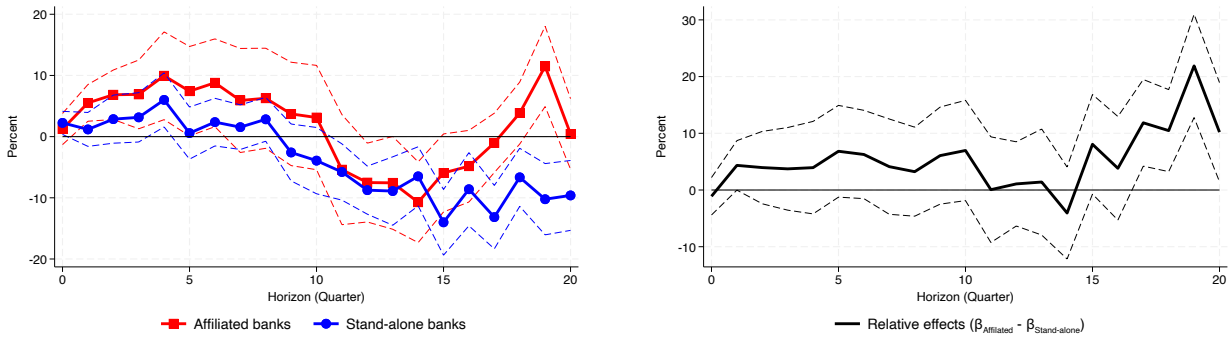


Figure 14: Impulse response of each wholesale funding type to contractionary monetary policy shock

Notes: The figure shows the estimated impulse response functions for affiliated and standalone banks following a 25 bps increase in two year Treasury yield. Relative effects is the impulse response of affiliated banks relative to that of standalone banks. Dashed lines show the 68 percent confidence intervals. Standard errors are clustered by banks and time.

(d) Foreign deposits



(e) Other borrowed money

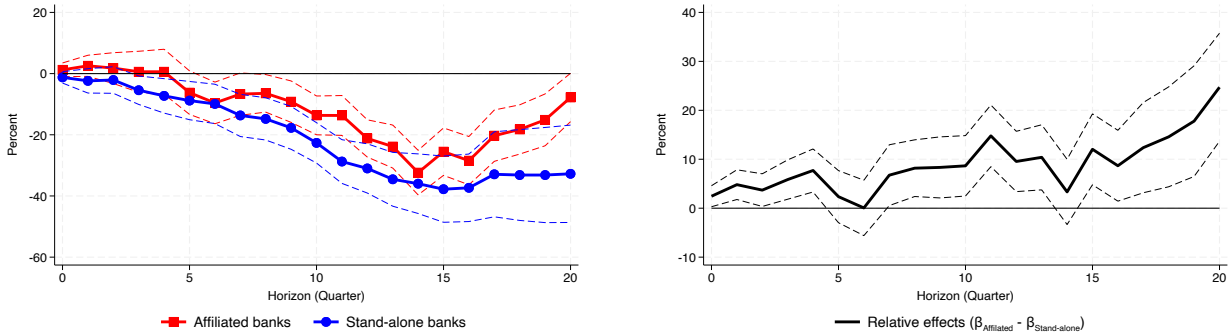
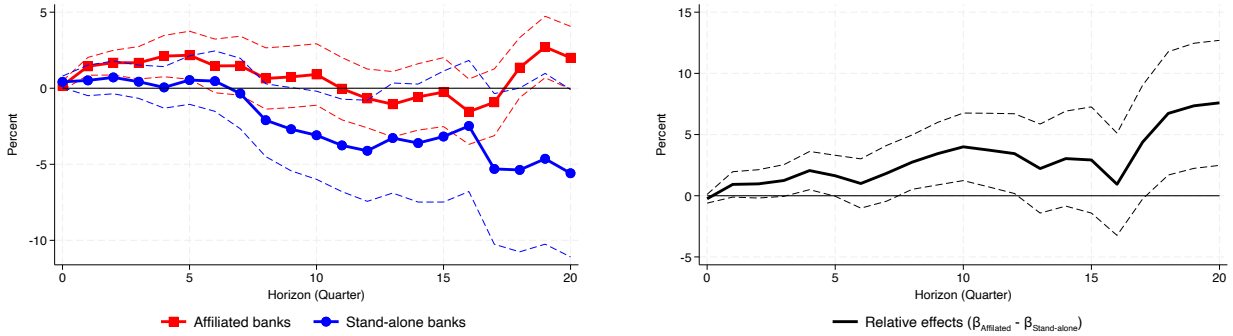


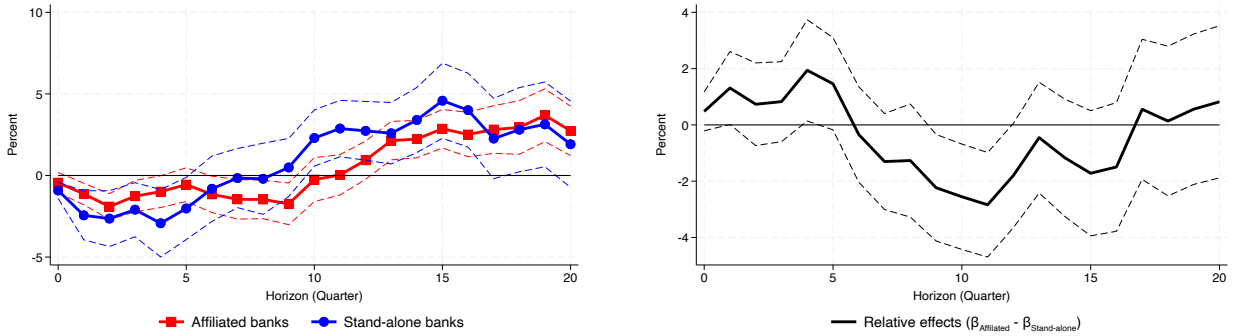
Figure 14: Impulse response of each wholesale funding type to contractionary monetary policy shock (continued)

Notes: The figure shows the estimated impulse response functions for affiliated and standalone banks following a 25 bps increase in two year Treasury yield. Relative effects is the impulse response of affiliated banks relative to that of standalone banks. Dashed lines show the 68 percent confidence intervals. Standard errors are clustered by banks and time.

(a) Lending



(b) Deposits



(c) Wholesale funding

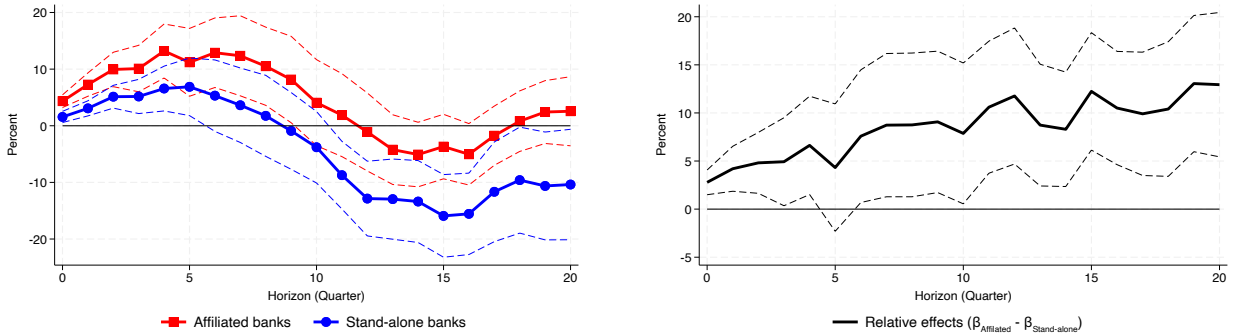
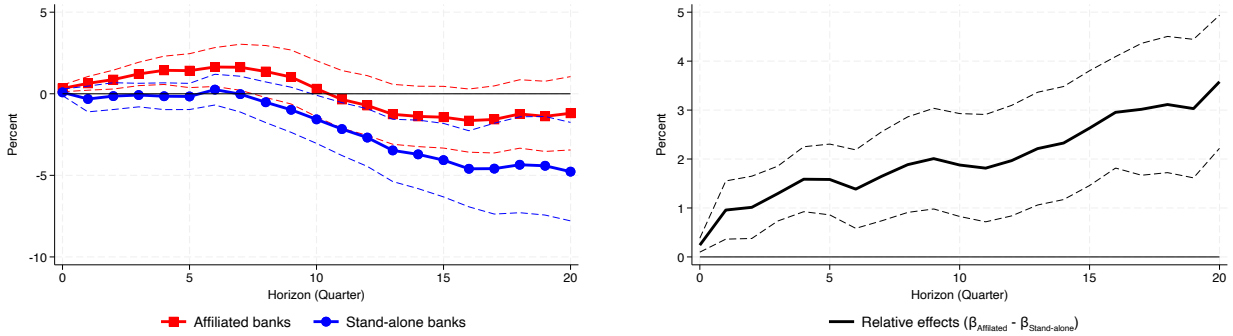


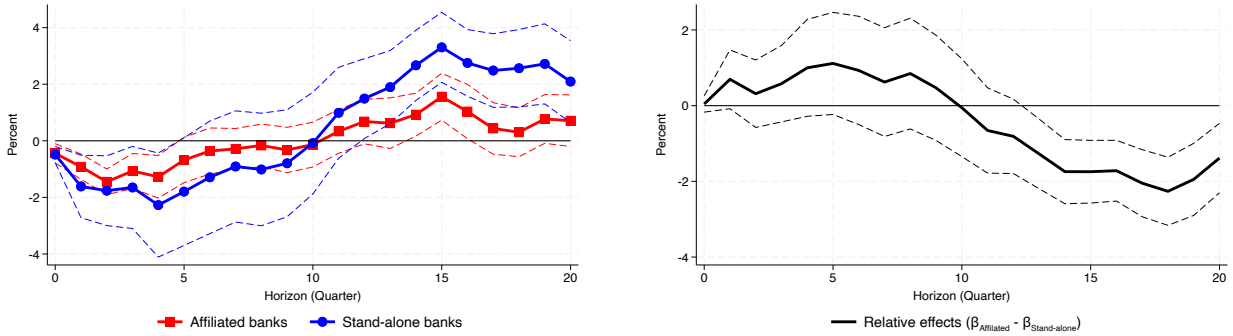
Figure 15: Impulse response of bank lending to contractionary monetary policy shock (Big banks)

Notes: The figure shows the estimated impulse response functions for affiliated and standalone banks above 95th percentile in bank size distribution following a 25 bps increase in two year Treasury yield. Relative effects is the impulse response of affiliated banks relative to that of standalone banks. Dashed lines show the 68 percent confidence intervals. Standard errors are clustered by banks and time.

(a) Lending



(b) Deposits



(c) Wholesale funding

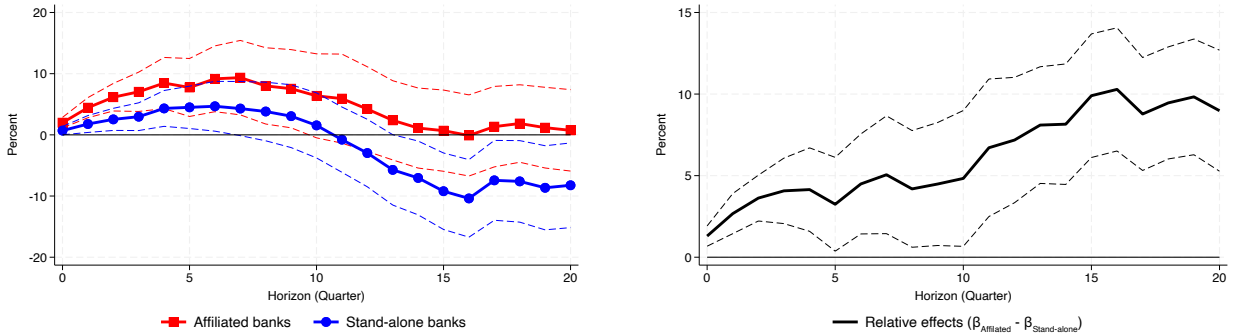


Figure 16: Impulse response of bank lending to contractionary monetary policy shock (Big banks)

Notes: The figure shows the estimated impulse response functions for affiliated and standalone banks below 95th percentile in bank size distribution following a 25 bps increase in two year Treasury yield. Relative effects is the impulse response of affiliated banks relative to that of standalone banks. Dashed lines show the 68 percent confidence intervals. Standard errors are clustered by banks and time.

References

Afonso, G., Kovner, A., & Schoar, A. (2011). Stressed, not frozen: The federal funds market in the financial crisis. *The Journal of Finance*, *66*(4), 1109–1139.

Aguirregabiria, V., Clark, R., & Wang, H. (2016). Diversification of geographic risk in retail bank networks: Evidence from bank expansion after the Riegle-Neal Act. *The RAND Journal of Economics*, *47*(3), 529–572.

Ashcraft, A. B. (2006). New evidence on the lending channel. *Journal of Money, Credit and Banking*, 751–775.

Ashcraft, A. B. (2008). Are Bank Holding Companies a Source of Strength to Their Banking Subsidiaries? *Journal of Money, Credit and Banking*, *40*(2-3), 273–294.

Bauer, M. D., & Swanson, E. T. (2023). A reassessment of monetary policy surprises and high-frequency identification. *NBER Macroeconomics Annual*, *37*(1), 87–155.

Begenau, J., & Stafford, E. (2023). Uniform rate setting and the deposit channel. *Available at SSRN 4136858*.

Boissay, F., Collard, F., Galí, J., & Manea, C. (2021). *Monetary policy and endogenous financial crises* (tech. rep.). National Bureau of Economic Research.

Campello, M. (2002). Internal capital markets in financial conglomerates: Evidence from small bank responses to monetary policy. *The Journal of Finance*, *57*(6), 2773–2805.

Cetorelli, N., & Goldberg, L. S. (2012). Banking globalization and monetary transmission. *The Journal of Finance*, *67*(5), 1811–1843.

Choi, D. B., & Choi, H.-S. (2020). The effect of monetary policy on bank wholesale funding. *Management Science*.

Correia, S., Luck, S., & Verner, E. (2023). Failing banks. *Available at SSRN 4650834*.

Disyatat, P. (2011). The bank lending channel revisited. *Journal of money, Credit and Banking*, *43*(4), 711–734.

Drechsler, I., Savov, A., & Schnabl, P. (2017). The deposits channel of monetary policy. *Quarterly Journal of Economics*, *132*(4), 1819–1876.

Gambacorta, L., & Mistrulli, P. E. (2004). Does bank capital affect lending behavior? *Journal of Financial intermediation*, *13*(4), 436–457.

Gambacorta, L., & Shin, H. S. (2018). Why bank capital matters for monetary policy. *Journal of Financial Intermediation*, *35*, 17–29.

Gilje, E. P., Loutskina, E., & Strahan, P. E. (2016). Exporting liquidity: Branch banking and financial integration. *The Journal of Finance*, *71*(3), 1159–1184.

Gorton, G., & Metrick, A. (2012). Securitized banking and the run on repo. *Journal of Financial economics*, *104*(3), 425–451.

Grimm, M. (2024). The effect of monetary policy on systemic bank funding stability.

Grimm, M., Jordà, Ò., Schularick, M., & Taylor, A. M. (2023). Loose monetary policy and financial instability.

Houston, J., James, C., & Marcus, D. (1997). Capital market frictions and the role of internal capital markets in banking. *Journal of financial Economics*, *46*(2), 135–164.

Ivashina, V., & Scharfstein, D. (2010). Bank lending during the financial crisis of 2008. *Journal of Financial economics*, *97*(3), 319–338.

Jordà, Ò., Schularick, M., & Taylor, A. M. (2019). The effects of quasi-random monetary experiments. *Journal of Monetary Economics*, *112*, 22–40.

Kashyap, A., & Stein, J. C. (2000). What Do a Million Observations on Banks Say About the Transmission of Monetary Policy? *American Economic Review*, *90*(3), 407–428.

Kashyap, A. K., & Stein, J. C. (1995). The impact of monetary policy on bank balance sheets. *Carnegie-Rochester Conference Series on Public Policy*, *42*, 151–195.

Kishan, R. P., & Opiela, T. P. (2000). Bank size, bank capital, and the bank lending channel. *Journal of Money, credit and banking*, *32*(1), 121–141.

Mian, A., Sufi, A., & Verner, E. (2020). How does credit supply expansion affect the real economy? the productive capacity and household demand channels. *The Journal of Finance*, *75*(2), 949–994.

Pérignon, C., Thesmar, D., & Vuillemey, G. (2018). Wholesale funding dry-ups. *The Journal of Finance*, *73*(2), 575–617.

Ramey, V. A. (2016). Macroeconomic Shocks and Their Propagation. In *Handbook of Macroeconomics* (pp. 71–162, Vol. 2). Elsevier.

Raykov, R., & Silva-Buston, C. (2020). Holding company affiliation and bank stability: Evidence from the US banking sector. *Journal of Corporate Finance*, *65*, 101739.

Schaffer, M., & Segev, N. (2022). The deposits channel revisited. *Journal of Applied Econometrics*, *37*(2), 450–458.

Scharfstein, D., & Sunderam, A. (2016). Market power in mortgage lending and the transmission of monetary policy. *Unpublished working paper. Harvard University*, *2*.

Schularick, M., Ter Steege, L., & Ward, F. (2021). Leaning against the wind and crisis risk. *American Economic Review: Insights*, *3*(2), 199–214.

Supera, D. (2024). Running out of time (deposits): Falling interest rates and the decline of business lending.

Uppal, A. (2024). Do higher interest rates make the banking system safer? evidence from bank leverage. *Unpublished working paper*.

Wang, Y., Whited, T. M., Wu, Y., & Xiao, K. (2022). Bank market power and monetary policy transmission: Evidence from a structural estimation. *The Journal of Finance*, *77*(4), 2093–2141.