Do Wholesale Financiers Discipline Risky Banks? Evidence from the Financial Crisis of 2008

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Abstract

Using US commercial bank data from 2002 to 2012, this paper investigates whether wholesale financiers discipline banks by withdrawing funds from risky ones or charging them higher interest rates. We focus on the impact of individual bank risks and market-common risks on the supply of wholesale funding. We find that market disciplinary behavior varies across the types of investors and types of risks. Both short- and long-term wholesale financiers disciplined risky banks during the pre-crisis period. However, neither of them was sensitive to bank risk during the crisis, when the US government implemented extensive rescue programs. The lack of market discipline continued in the post-crisis period, although the Dodd–Frank Wall Street Reform and Consumer Protection Act was enacted in 2010. These results are robust even after controlling for the effect of the Troubled Asset Relief Program, for the quantitative easing policy, and for credit demands of bank borrowers.

JEL classification: G21, G28

Keywords: Wholesale Funding, Market Discipline, Financial Crisis, Bank Risk, Market-common risk

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1. Introduction

Literature published before the financial crisis of 2008 argues for the benefit of wholesale funding[1] as a bank's alternative funding source. Wholesale financiers provide market discipline because they are more sensitive to bank risk and more informed on bank projects than retail depositors (Calomiris and Kahn 1991; Calomiris 1999; Flannery 2001)[2]. Unlike insured depositors, uninsured liability holders bear the losses from bank failures. Empirical studies that find interest rates on wholesale funding increase with bank risk support this view (e.g., Hannan and Hanweck 1988). Other studies focusing on both price and quantity analysis also supports this view. That is, riskier banks pay higher interest rates and have wholesale funds withdrawn early (Park and Peristiani 1998; King 2008).

In contrast to the evidence supporting the presence of market discipline before the crisis, experiences in the wholesale funds market during the crisis raise questions about the presence of market discipline (Acharya, Gale, and Yorulmazer 2011; Huang and Ratnovski 2011; Hahm, Shin, and Shin 2013). The sudden dry-up of short-term money market funding during the crisis posed a serious problem to banks relying heavily on these markets. Several healthy banks with a higher non-core funding ratio failed as they had difficulty raising funds from their wholesale financiers, suggesting that wholesale fund markets do not differentiate safe banks from risky ones (Shin 2009). This contradicts the conventional view that wholesale financiers penalize banks for taking higher risks. In fact, using data on subordinated notes and debentures (SNDs) from 2009 through 2011, Balasubramnian and Cyree (2014) report that market discipline, defined as whether the funding advantage of too-big-to-fail

[1] Wholesale funding in this study refers to the sum of federal funds purchased, securities sold under agreements to repurchase, subordinated notes and debentures, brokered deposits, other borrowed money, deposits in foreign offices, and uninsured long-term deposits.

[2] Market discipline in the banking sector refers to the market-based monitoring mechanism in which bank liability holders punish banks for taking greater risks by imposing higher interest rates or reducing their investments (Flannery 1998; Martinez Peria and Schmukler 2001; Nier and Baumann 2006).

(TBTF) banks was reduced, improved only after the Dodd–Frank Wall Street Reform and Consumer Protection Act (Dodd-Frank Act) was enacted in 2010.

This study aims to reconcile these two conflicting views concerning the disciplining role of wholesale financiers using more recent data covering the periods before and after the financial crisis of 2008. We investigate the presence of market discipline considering both a bank's risks and market-wide risks, such as the 2008 crisis. First, we empirically examine whether wholesale financiers discipline banks for taking greater risk by imposing higher interest rates on their investments (the price dimension) or withdrawing their funds (the quantity dimension). Second, we investigate whether market discipline still exists when banks face market (common) risks by examining whether wholesale financiers punish risky banks more during periods of market stress and how government intervention during the crisis by rescuing risky banks affects market discipline. Third, we investigate whether different types of wholesale financiers have different incentives to monitor banks. For example, we consider whether long-term individual wholesale financiers, such as large time depositors, discipline banks differently from short-term institutional wholesale financiers, such as lenders in the Federal (Fed) funds market in the US. Finally, we examine whether wholesale financiers behave differently depending on bank size, and whether financiers have different incentives to discipline large banks or small banks depending on the change in market-wide risk.

Considering market risk in this study is important because banks are exposed to changes in market environments during periods of market stress. Borrowers' economic activities suffer from negative macro-economic shocks, leading to higher borrower default rates and lower recovery rates. Therefore, wholesale financiers are more likely to bear losses from bank failures during crises. In fact, 465 banks failed between 2008 and 2012, while only 21 banks failed between 2002 and 2007.[3]

Facing a market (common) risk, wholesale financiers' ex-ante incentives to discipline risky banks

[3] FDIC failed bank list. https://www.fdic.gov/bank/individual/failed/banklist.html

are ambiguous, depending on whether the government intervenes. Without government intervention to rescue failing banks, weaker banks face more credit risks and become even more vulnerable during tight economic periods. For example, even insured depositors might leave risky banks during or after a crisis (Martinez Peria and Schmukler 2001), making it difficult for risky banks to secure financing. On the other hand, when the government intervenes to stabilize the economy during a crisis, risky banks might gain stronger (implicit) guarantees, as the government is more likely to bailout distressed banks because it might not be able to determine which banks are riskier. There exists an information asymmetry between banks and the government as to whether a bank fails due to bank-specific problems or common market shocks (Freixas and Jorge 2008; Afonso, Kovner, and Schoar 2011). Therefore, the chance of bailing out bad banks increases when the government tries to bear the systemic risks in the banking sector. In this case, wholesale financiers may take advantage of strengthened government guarantees instead of making efforts to influence banks to avoid excessive risks during a crisis.

Interestingly, researchers analyzing wholesale financiers' behavior have not fully considered that the incentives to discipline banks may vary by type of investor, as most previous studies examine only one type of wholesale funds in a study. For instance, researchers primarily focus on uninsured deposits (Keeley 1990; Goldberg and Hudgins 1996; Park and Peristiani 1998), SNDs (Avery, Belton, and Goldberg 1988; Flannery and Sorescu 1996), or overnight interbank loans (Furfine 2001; King 2008; Afonso, Kovner, and Schoar 2011). Each component of these wholesale funds has different maturities, and there are different types of wholesale financiers, such as banks in the overnight Fed funds market, institutional investors in the repo market, or individual time depositors.

From the perspective of the types of wholesale funds, market monitoring by wholesale financiers may stem from different incentives based on maturity, the strength of government protection, or the ability to collect and process information. First, the incentives to discipline based on maturity are

ambiguous ex ante. On the one hand, because of an extremely short-term maturity, interbank lenders and repo lenders may provide better discipline because their losses from withdrawing funds before maturity are relatively small. For example, sellers in the overnight Fed funds market can stop funding risky banks without losing accrued interests when they perceive risks. In contrast to short-term money market investors, long-term wholesale financiers such as large time depositors might not engage in disciplinary activities because they have to forfeit some of accrued interests if they withdraw before maturity. Therefore, large time depositors must weigh the cost and benefit from early withdrawals. On the other hand, the extremely short-term maturity may create little incentive for short-term wholesale financiers to monitor banks. This may simply be because investors in the overnight Fed funds markets can get their money back the next day (King 2008; Craig and Dinger 2013). However, large time depositors may have more incentive to monitor banks because the longer maturities force more prudence in when and where they make deposits.

Second, the ability to monitor banks may affect market discipline. Short-term wholesale financiers are large institutional investors, that is, banks are the participants in the Fed funds market (Furfine 2001). Repo lenders are largely money market mutual funds and security lending firms, while repo borrowers are broker-dealers and banks (Gorton and Metrick 2012; Krishnamurthy, Nagel, and Orlov 2014). However, large time depositors are small individual investors, and institutional investors have an advantage in collecting and processing information. Therefore, short-term wholesale financiers may provide better discipline than long-term wholesale financiers.

Finally, the strength of government protection may affect incentives to provide discipline. Historically, the government is concerned about bank runs by depositors (Diamond and Dybvig 1983), and will therefore provide better protection for depositors. In fact, the US government provided strong depositor protection during this recent crisis, such as increasing the deposit insurance coverage from $100,000 to $250,000 and unlimited guarantees for non-interest bearing transaction accounts.

Additionally, uninsured large time depositors enjoyed both explicit and implicit government protection during the crisis. Conversely, interbank and repo lenders rely only on implicit government safety nets. Therefore, large time depositors may have less incentive to discipline banks or even exploit strong government guarantees.

Using 183,618 US commercial bank data points from 2002 to 2012, we present evidence that both short- and long-term wholesale financiers discipline banks for their individual risks during stable economic periods. However, we find little evidence for the presence of market discipline during the financial crisis of 2008, suggesting that wholesale financiers take advantage of the higher possibility for bailouts during the crisis. Interestingly, there is no evidence for market discipline during the post-crisis period, which includes the period after the Dodd-Frank Act was passed, implying that the Dodd-Frank Act is not effective. Both large and small banks show the same results before, during, and after the crisis, except for large time depositors during the pre-crisis period, which neither charge higher interest rates for large, risky banks nor withdraw their funds during stable economic periods. In our analysis, we control for bank characteristics (such as size, profitability, and capital ratio), market structure (such as market concentration), and macro-economic conditions, and the results are robust even after controlling for government interventions to rescue specific banks through the Troubled Asset Relief Program(TARP)[4], for Quantitative Easing (QE), and for liquidity demands from bank loan borrowers. In addition, we use several methods to check for robustness. For bank specific risks, we use non-performing loans (NPL) as a proxy of bank risk, with Z-scores and risk-weighted assets (RWA) as alternative proxies. Local market recessions at the MSA level and the TED spread are used as proxies of market-wide risks, other than the financial crisis of 2008. The results remain unchanged even after

[4] The TARP was established in October 2008 by the US government to strengthen market stability in response to the financial crisis of 2008. Under the program, the Treasury Department was allowed to purchase up to $700 billion of distressed assets or to purchase senior preferred stock and warrants in qualified financial institutions. The TARP was one of the largest government rescue programs in the United States (Black and Hazelwood 2013; Li 2013).

considering these additional proxies for a bank's internal risk and market-wide shocks.

The results explain why wholesale financiers failed to discipline risky banks during the 2008 crisis. While the aggregate value of wholesale funds plummeted during the crisis, investors withdrew funds from safe banks rather than risky ones. Surprisingly, wholesale funding for risky banks rather increased during the crisis, a result discussed further in Section 3. Previous studies demonstrate that market discipline tends to be weak during a crisis because uninsured investors expect implicit or explicit protection provided by government safety nets (e.g., Calomiris 1999). Using yields on subordinated debentures from 1983 to 1991, Flannery and Sorescu (1996) find that SND investors are insensitive to banks' risk-taking when government guarantees cover bank debentures. However, the results from this study provide stronger evidence that market discipline broke down during the crisis period; riskier banks attracted more wholesale funds, without experiencing lower interest rates. In particular, riskier banks gained more large time deposits, paying higher interest rates on the deposits during the crisis, suggesting that riskier banks exploited government interventions to stabilize the economy during the severe crisis.

If the lack of market discipline is attributed to monitoring ability, then ineffective market discipline by individual depositors should be observed for both large and small banks compared to institutional investors. Alternatively, the lack of market discipline from depositors should be more prominent in small banks than in large banks because they are generally more opaque than large banks. However, this study's results show that large time depositors do not discipline large banks while they punish small banks during stable economic periods. Therefore, the lack of discipline is not related to ability.

The results from this study instead suggest that the lack of discipline is an outcome of the interaction between maturity and the strength of government protection. In stable economic periods, maturity seems to be prioritized over the strength of government protection, as this study's results

demonstrate that short-term wholesale financiers provide monitoring by adjusting both the price and quantity. However, long-term wholesale financiers only discipline banks through quantity rationing. Furthermore, long-term wholesale financiers do not discipline large banks during stable economic periods, suggesting that the strength of government protection has a small amount of influence during stable economic periods because uninsured time depositors do not monitor large banks, which are more likely to be bailed out. The strength of government protection becomes more important than maturity during the severe crisis period. The extensive government rescue programs during the crisis removed the incentives for bank creditors to monitor their borrowers, since these protections eliminated the probability of bank failure.

Interestingly, the absence of market discipline continued during the post-crisis period, inconsistent with Martinez Peria and Schmukler (2001) and Balasubramnian and Cyree (2014). Using insured and uninsured deposit data in Argentina, Chile, and Mexico between the 1980s and the 1990s, Martinez Peria and Schmukler (2001) conclude that market discipline improved in the after math of crises because depositors become more responsive to bank risk through their experiences of massive bank defaults during the crisis. Balasubramnian and Cyree (2014) show that SND investors better reflect bank default risk after the Dodd-Frank Act. However, the results from this study show that investors still maintain an expectation of government protections after the Dodd-Frank Act, though this act aimed to limit this expectation. This study's findings imply that in the post-crisis period, the financial crisis of 2008 failed to change wholesale financiers' opinions, and that the Dodd-Frank Act is ineffective.

The rest of the paper proceeds as follows. Section 2 reviews related literature. Section 3 graphs the time-series trends of the quantity and cost of wholesale funding, both at the aggregate and the bank level. Section 4 describes the data and empirical methodology, and Section 5 presents the empirical results. Section 6 describes the robustness tests for the empirical findings. Finally, Section 7 concludes

the paper.

2. Related Literature

There are two conflicting views on the disciplining role of wholesale financiers. Market discipline refers to the market-based monitoring mechanism in which bank creditors punish banks for excessive risk-taking by imposing higher interest rates or withdrawing their investments. A great deal of literature prior to the 2008 crisis provides evidence that market discipline is in effect, although some earlier empirical studies report insignificant coefficients of bank risk measures on interest rates paid by banks (e.g., Avery, Belton,and Goldberg 1988; Gorton and Santomero 1990). Studies after the crisis, however, raise questions about the presence of market discipline.

Earlier studies focus on the advantages of wholesale funding as an alternative funding source, arguing that wholesale funds complement retail deposits, and uninsured wholesale financiers play an essential role in disciplining banks. Proponents for the presence of market discipline argue that wholesale financiers, as informed but uninsured investors, influence banks to avoid excessive risks. Calomiris and Kahn (1991) show that uninsured bank creditors have an incentive to invest in information-gathering in order to monitor banks because they face sequential service constraints (first-come, first-served rule for demanded payments). Therefore, better informed wholesale financiers penalize banks by withdrawing their funding when bankers act against the interests of the short-term creditors. Similarly, Diamond and Rajan (2001) argue that wholesale financiers discipline banks by using their early withdrawal abilities, focusing more on the ex-post disciplining role.

Many earlier empirical studies supporting the presence of market monitoring have argued that wholesale financiers charge different prices depending on the borrower's risks. As wholesale financiers are reluctant to lend money, riskier banks face higher funding costs. Examining the relationship

between insolvency risk and the cost of uninsured wholesale funding, existing empirical studies have focused on one type of wholesale funds in their studies. Baer and Brewer (1986), Hannan and Hanweck (1988), and Keeley (1990) empirically test the relationship between insolvency risk and interest rates on large certificates of deposit (CDs). Flannery and Sorescu (1996) find a positive relationship between bank risk and SND yield spreads. Furfine (2001) finds that the interest rate paid on federal funds transactions are sensitive to bank risk.

From the perspective of the quantity analysis, correctly pricing bank risk is often difficult in reality. Furthermore, investors cannot observe prices when quantity rationing occurs (King 2008). In this case, quantity rationing itself provides information on market discipline although prices do not reflect the change in bank risk. Therefore, later studies focused on both the price and quantity dimensions. Park and Peristiani (1998) find that riskier banks pay higher interst rates and attract less uninsured deposits. King (2008) also find that market discipline exists both in the price and quantity dimension in the Fed funds market. Additionally, some studies find evidence for market discipline in the quantity dimension, even when controlling for funding costs (Maechler and McDill 2006).

The financial crisis in 2008 has changed the view on market discipline. Not only the sudden freeze in the wholesale funds market, but also the fact that healthy banks with sound assets could not take out short-term debt during the crisis raised questions about the presence and effectiveness of market discipline (Shin 2009; Acharya, Gale, and Yorulmazer 2011). In addition, Hahm, Shin, and Shin (2013) report that aggressive lending based on the growth of wholesale funding leads to vulnerability to a financial crisis for both emerging and developing economies.

The impact of a financial crisis on market discipline is ambiguous ex ante depending on government intervention. With limited and selective government interventions to bailout failing banks, uninsured financiers bear losses from the banks' bankruptcies. Weaker banks become even more vulnerable and face more credit risks during a market-wide crisis. Using bank-level data on deposits in

Argentina, Chile, and Mexico, Martinez Peria and Schmukler (2001) find that uninsured depositors discipline banks by withdrawing deposits and demanding higher risk premiums in the aftermath of banking crises. In particular, depositors become more sensitive to risks after experiencing bank failures and depleted deposit insurance funds during crises. On the other hand, government bails outs of banks during a crisis can lead to moral hazard behavior among banks. With a strong belief in government intervention to rescue failing banks, uninsured financiers take advantage of implicit government guarantees instead of conducting costly monitoring (Calomiris 1999; Nier and Baumann 2006). Balasubramnian and Cyree (2014) find that market discipline has improved after the enactment of the Dodd-Frank Act through a decrease in TBTF banks' funding advantage on SND yield spreads by using SND transactions between June 2009 and December 2011.

3. Background Information on Wholesale Funding and its Relationship with Bank Risk

In this study, wholesale funding consists of 1) purchased federal funds (Fed funds), 2) securities sold under agreements to repurchase (repos), 3) SNDs, 4) brokered deposits, 5) other borrowed money, 6) deposits in foreign offices, and 7) uninsured time deposits of more than $100,000 ($250,000 starting from the first quarter in 2010)[5]. The volume of aggregate wholesale funding has greatly fluctuated in the 2000s (Brunnermeier 2009). Figure 1 shows that the aggregate wholesale funding for all

[5] The temporary increase in deposit insurance limits was effective in October 2008, and then permanently rose to $250,000 in July 2010. However, reporting thresholds on time deposits in the Call Reports reflect this change in deposit insurance limits from 2010:Q1. Therefore, the decrease in the total amount of wholesale funds from the decrease in uninsured time deposits occurs in 2010:Q1. The results remain robust even when reflecting the changes in deposit insurance coverage.

commercial banks in the US increased until the break of the 2008 financial crisis, although the US entered a recession in 2007. Thereafter, aggregate wholesale funding plummeted from the fourth quarter of 2008, after the Lehman Brothers' bankruptcy. Such trends are robust even after considering the change in the deposit insurance limit from $100,000 to $250,000. These results suggest that wholesale financiers merely responded to the outbreak of the crisis, which was a macro shock affecting all banks, rather than take the preemptive measure of reducing their exposure before the crisis.

Since bank size affects accessibility to the Fed funds and SND markets, figures 1.2 and 1.3 show the wholesale funding trends by bank size and multi-market operation, respectively. Large or multi-market banks contribute the most to the wholesale funds market trend fluctuations. These trends suggest that large or multi-market banks are more likely to attract uninsured wholesale funding than small or single-market banks.

Wholesale funding also depends on bank risk. Figure 2.1 shows wholesale funding trends in banks with high-risk (high NPL ratio), medium-risk (medium NPL ratio), and low-risk (low NPL ratio), divided into these groups based on the annual tercile values of non-performing loans over total loans. High risk banks have higher wholesale funding than low-risk banks during the sample period. Furthermore, aggregate wholesale funding increased for high-risk banks, while funding decreased for medium- and low-risk banks during the crisis. That is, the decline in aggregate wholesale funds during the crisis mainly results from the decrease in funding for safe (medium- and low-risk) rather than risky banks. This figure suggests that wholesale financiers are not sensitive to individual bank risk.

Figures 2.2 and 2.3 show the trends of wholesale funding in high-risk, medium-risk, and low-risk banks in groups of large and small banks, respectively. The banks are sorted first by size, then by risks. For each year, they are divided into two groups, large and small, then into three risk groups to reflect the fact that wholesale funding depends on bank size and risk. In both size groups, the amount of wholesale funding varies similar to risk level. In the group of large banks, high-risk banks have more

wholesale funding than low-risk banks. Furthermore, the aggregate wholesale funds of large high-risk banks increased over the period of the 2008 financial crisis (See Figure 2.2). Small high-risk banks obtained more wholesale funds than low-risk banks during the crisis (See Figure 2.3). Note that in both size groups, the significant decline in the wholesale funds market during the crisis mainly came from medium and low-risk banks.

In addition to aggregate wholesale funding itself, we also analyze how the ratio of wholesale funding to total assets (*WF/TA*) varies across bank size and bank risk. Differences in the average *WF/TA* between high-risk and low-risk banks are positive for both large (Figure 2.4) and small banks (Figure 2.5), suggesting that risky banks rely more on wholesale funding more than safe ones. In the group of large banks, the difference in average *WF/TA* dramatically increases during the recession periods in 2001-2002 following the burst of the dot-com bubble, and in 2008-2009 after the Lehman Brothers bankruptcy. In small banks, the difference dramatically increased over the 2008-2009 crisis and post-crisis periods. Even after the Dodd-Frank Act was enacted, risky banks relied more on wholesale funding than safe banks. In short, wholesale financiers do not seem to withdraw from risk banks, especially during recessions. In fact, they seem to take more risk by increasing their investment in risky banks when markets are distressed due to liquidity risk.

We investigate whether risky banks pay higher interest rates on wholesale funds than safe banks by comparing the average cost of wholesale funds (*WF_RATE*) for high-risk banks with that of low-risk banks for a given bank size group. *WF_RATE* is measured by the quarterly expenses of wholesale funding as a fraction of the quarterly average amount of wholesale funding. This variable measures average costs of wholesale funding, though it does not measure exact price. Large risky banks pay higher interest rates on wholesale funds than safe banks except for a few quarters (Figure 3.1). For small banks, however, risky banks often pay lower interest rates than safe banks (Figure 3.2). For large banks, the difference in average funding costs between risky and safe banks is lower than 0.2%. For

small banks, it is less than 0.15%. Combining the results in Figures 2 and 3 suggests that risky banks obtain more financing more from wholesale funds than safe ones. While risky banks often pay higher interest rates than safe banks, the difference is quite small.

4. Data and Methodology

4.1 Data

We build a quarterly panel data set from the beginning of 2002 through the fourth quarter of 2012 that includes all insured US commercial banks, and collect financial information for commercial banks providing Consolidated Reports of Condition and Income (Call Reports) from the Federal Financial Institutions Examination Council (FFIEC). The Call Reports include quarterly bank financial information and the components of wholesale funds such as the amount of Fed funds, repos, and uninsured deposits. The data excludes banks with zero total assets, zero total loans, and zero total deposits. We also winsorize financial statement variables at the top and bottom 1% of the distribution of each variable. The final sample consists of 183,618 bank-quarter observations for 5,966 US commercial banks.

We identify bank holding companies using information from Federal Deposit Insurance Corporation (FDIC). Information on aggregate deposits in the Metropolitan Statistical Area (MSA) markets is collected from the Summary of Deposits (SOD) database of the FDIC. Income growth and the real GDP of MSA information are collected from the Bureau of Economic Analysis (BEA). Information about the business cycle and the TED spread are obtained from National Bureau of

Economic Research (NBER) and Federal Reserve Economic Data (FRED), respectively. Data on the effective Fed funds rate and monetary aggregates (M2) are retrieved from the Federal Reserve Board (FRB). Information about the Troubled Asset Relief Program (TARP) is obtained from the US Treasury Department.

4.2 Econometric Methods

The following two fixed effects models are used to test for the presence of market discipline:

$$Spreads\ on\ funds_{it} = \alpha_0 + \alpha_1 Bank\ Risk_{it-1} + \alpha_2 Crisis_t + \alpha_3 Bank\ Risk_{it-1} * Crisis_t + \alpha_4 Other\ controls_{it-1} + \mu_{1i} + \tau_{1t} + \varepsilon_{it} \quad (1)$$

$$\Delta Wholesale\ funds_{it} = \beta_0 + \beta_1 Bank\ Risk_{it-1} + \beta_2 Crisis_t + \beta_3 Bank\ Risk_{it-1} * Crisis_t + \beta_4 Other\ controls_{it-1} + \mu_{2i} + \tau_{2t} + \eta_{it} \quad (2)$$

Where μ_1 and μ_2 are bank-fixed effects to control for time-invariant unobserved heterogeneity at the bank level (i), and τ_1 and τ_2 are time-fixed effects to account for changes in the economic environment across quarters (t). ε_{it} and η_{it} are error terms. Explanatory variables related to bank financial data take values lagged by one quarter to avoid the potential endogeneity problem. All panel regressions are estimated with robust standard errors clustered at the bank level to account for within-bank serial correlation. We estimate each of these equations separately for large (with total assets greater than $1 billion) and small (with total assets less than $1 billion) banks since accessibility to wholesale funding varies by bank size, which is elaborated in detail below. Table 1 provides detailed definitions of the variables used in the estimation. All variables, except for macroeconomic variables,

are winsorized at the 1st and 99th percentiles.

$Spreads\ on\ funds_{it}$ and $\Delta Wholesale\ funds_{it}$ represents the quantity and the cost of wholesale funding, respectively. Therefore, Equation (1) tests whether wholesale financiers discipline banks' risk-taking by demanding higher interest rates, and Equation (2) tests whether wholesale financiers adjust their investment holdings when the bank takes on more risk. We focus on three components of wholesale funds depending on different maturities: *Fed funds* (extremely short-term), *large time deposits*, and *wholesale funds* (total wholesale funding).[6] *Fed funds* is defined as the sum of federal funds and repos[7]. Since both types of funding have very short-term marities (Furfine 2001; Gorton and Metrik 2012), the interest rate on *Fed funds* can be taken as the cost of very short-term wholesale liabilities (Craig and Dinger 2013). *Large time deposits* are uninsured time deposits over $100,000 until 2009:Q4 and over $250,000 from 2010:Q1.

Maturity based wholesale funding addresses differences in practical accessibility to wholesale funds markets. Whereas a large portion of wholesale funding for small banks comes from uninsured time deposits, large banks have more access to the wholesale funds market by various means, such as issuing debentures and taking foreign deposits. Most banks have a type of wholesale funding (for example, uninsured time deposits), but not all. About 60 percent of the wholesale funding for small banks is uninsured time deposits. Furthermore, banks purchasing federal funds or issuing SNDs are often large banks. In contrast, small and risky banks often fail to obtain Fed funds or repos. The methodology section below describes how we address the sample selection problem depending on different wholesale funding products.

[6] We do not analyze how wholesale financiers discipline banks that issue SNDs. About 8,893 bank-quarter observations are available among 183,618 total observations. The dataset includes fewer than 500 unique banks that have issued SNDs. Furthermore, among banks with any SNDs, the portion of their funding based on SNDs is less than 3 percent of total assets.

[7] Expenses for Fed funds and repos are reported as the sum of the two accounts in income statements although the amounts of Fed funds and repos are reported separately in balance sheets. Therefore, we employ a variable *Fed funds* by combining Fed funds and repos together.

As explained in Table 1, the price of wholesale funding ($Spreads\ on\ funds_{it}$) is measured as the spread, expressed in annual terms, between the implicit interest rates on *Fed funds* (*large time deposits* and *wholesale funds*) and the effective Fed funds rate (one-year treasury constant maturity rate), since large time depositors and wholesale funding sources other than *Fed funds* tend to have long maturities of around one year. The implicit interest rates are calculated as the quarterly average expenses of *Fed funds* divided by the quarterly average amounts of *Fed funds*. The expenses for *wholesale funds* include interests on uninsured time deposits, SNDs, deposits in foreign offices, and Fed funds and repo expenses[8].

We measure the quantity of wholesale funding ($\Delta Wholesale\ funds_{it}$) as the change in wholesale funds during the quarter normalized by the total assets at the beginning of the period ($Total\ assets_{it-1}$). Specifically, *Changes in Fed funds* (*large time deposits* and *wholesale funds*) is the quarterly change in the amounts of *Fed funds* (*large time deposits* and *wholesale funds*) during the quarter as a fraction of the start of quarter total assets.

The variable of interest is bank risk. $Bank\ Risk_{it-1}$ refers to bank-specific risk. We employ NPL, the ratio of non-performing loans to total loans, as a proxy for bank risk. A bank classifies loans as non-performing when they are 90-days or more past due or nonaccrual in the Call Reports. We also employ additional proxies for bank risk taking. The first is the ratio of risk-weighted assets to total assets. NPL ratios based on a bank's lending outcomes are an ex-post indicator for bank risk taking. Based on Basel rules, banks are required to calculate their own risk weighted assets to determine a bank's real world exposure to potential losses. All assets and off-balance sheet activities are assigned different relative risk weights according to their perceived credit risks (Avery and Berger 1991; Berger and Udell 1994). For example, commercial loans are perceived to be riskier than Treasury securities

[8] Income statements do not provide information about the expenses for brokered deposits and other borrowed money. These are therefore excluded from interest rate calculations for wholesale funds.

according to the risk-based capital standard. RWA is an ex-ante measure reflecting bank asset risk based on the allocation of assets. The second risk measure is the Z-score, which indicates a bank's overall risk by measuring the distance to default, and is calculated as the sum of the return on assets (ROA) and the equity ratio divided by the standard deviation of ROA. The means and standard deviations of the Z-score components are estimated over rolling windows of 12 quarters. A higher value indicates a lower risk of default.

Market-wide liquidity shocks are measured through an indicator variable for the 2008 financial crisis. We divide the 2008 crisis period into two sub-periods using the failure of Lehman Brothers as the watershed. The Lehman failure has different implications in terms of government intervention. The pre-Lehman crisis periods (*CrisisI*) covers the third quarter of 2007 to the second quarter of 2008 (2007:Q3-2008:Q2), and the post-Lehman crisis period (*CrisisII*) starts from the third quarter of 2008 to the second quarter of 2009 (2008:Q3-2009:Q2). In addition to the crisis period, we employ two additional variables as proxies for market-wide liquidity shocks. The first is a dummy variable for recessions at the MSA level (*Recession_MSA).* We set the indicator equal to one when a bank operates in an MSA that experiences a decline in real GDP for two consecutive quarters. In the case of a multi-market bank, the value is one when the bank experiences a decline in at least 25% or more of the MSAs in which it operates. The second market risk variable is the TED spread (*TED spread*), which is the spread between the three-month London Interbank Offered Rate (LIBOR) based on US dollars and the three-month T-bill rate. The TED spread is a measure of credit risk in the economy because LIBOR is risky while T-bills are risk-free. An increase in the TED spread means lenders believe that the risk of default on interbank loans is increasing. In general, the TED spread widens during a crisis (Brunnermeier2009; Cornett, McNutt, Strahan, and Tehranian 2011).

The effect of bank risk on the quantity or the cost of *Fed funds* depends on a bank's ability to attract *Fed funds*. A bank's financial soundness affects its probability of participating in the overnight

Fed funds and repo markets. A specific distribution of the unobservable characteristics jointly affects participation and the supply of wholesale funding. Large or multi-market banks are more likely to obtain non-core funds (Park and Pennacchi 2009). In general, large banks are purchasers while small banks are suppliers in the overnight Fed funds market (Ho and Saunders 1985). To address this sample selection problem, we apply Heckman's (1979) two-stage model when analyzing the Fed funds and repo markets. Specifically, we first estimate the probability that a bank attracts funds in each quarter using a probit model for all banks in the sample. In the second stage, we conduct ordinary least squares (OLS) for banks with a positive volume of *Fed funds* using Heckman's (1979) lambda (*Lambda*) estimated from the first-stage probit model.

Since sophisticated investors make lending decisions based on bank-specific factors as well as market and macroeconomic factors, we also include bank-specific, market, and macroeconomic variables as other control variables ($Other\ controls_{it-1}$). Bank-specific control variables include bank size (*Log total assets*), capital ratio (*Capital ratios*), and profitability (*Return on assets*) to control for the effect of bank characteristics on the quantity or cost of wholesale funding. *Log total assets* are measured as the natural log of total assets in million dollars. As mentioned above, large or multi-market banks have an advantage in wholesale funding compared to small or single-market banks (Park and Pennacchi 2009).[9]*Return on assets* represents return on assets (ROA). *Capital ratios* are measured as the ratio of bank equity to total assets. Well-capitalized banks are more likely to obtain wholesale funding because they are more stable, especially in periods of market stress, thanks to their capital buffers (Jokipii and Milne 2008; Acharya and Mora 2014). *Bank holding company* indicates a quarterly dummy variable that takes a value of one for a member of a bank holding company. During the 2008 crisis, the US government intervened and bailed out banks by providing TARP funds. *TARP*

[9] Due to a high correlation (=0.4943) between bank size (*Log total assets*) and multi-market operation, we exclude multi-market operation in the regressions to avoid the multicollinearity problem.

amounts indicate a bank's amount of received TARP funds, which is scaled by total assets.

Market level variables include deposit-market concentration (*Weighted HHI*) and income growth rate (*Weighted income growth*). *Weighted HHI* (Herfindahl–Hirschman Index) is calculated using branch-level deposit data from the FDIC's SOD database. When a bank operates in multiple-MSA markets, we weight MSA level variables (HHI and income growth rate) by the proportion of the bank's deposits in each MSA. Additionally, macroeconomic conditions include the level of money supply (*M2/GDP*), calculated as M2 divided by GDP to account for the effect of a quantitative easing policy.

Table 2 shows summary statistics for the variables employed in the estimations. Variables except for *M2/GDP* and *TED spread* are winsorized at the 1st and 99th percentiles to reduce the impact of outliers. Not surprisingly, interest rates on time deposits are higher than those on Fed funds due to longer maturities; the mean of the implicit interest rates on *Fed funds* is 0.0232 while that on *large time deposits* is 0.03. The average changes in *Fed funds* are lower relative to *large time deposits* and *wholesale funds*; the mean percentage change for *Fed funds* is 0.16; for *large time deposits* is 0.18; and for *wholesale funds* is 0.46.

5. Empirical Results

5.1 The Effect of Bank Risk on the Price and Quantity of Wholesale Funds: Basic Results

Table 3 shows how wholesale financiers, including (short-term) sellers of Fed funds and (long-term) large time depositors, change their behavior of disciplining banks depending on macroeconomic conditions. To investigate, we employ interaction terms between bank risk (*NPL*) and market risk (*Crisis*): *NPL*CrisisI*, *NPL*CrisisII*, and *NPL*Postcrisis*. *CrisisI*, *CrisisII*, and *Postcrisis* are defined

as periods 2007:Q3 through 2008:Q2, 2008:Q3 through 2009:Q2, and 2009:Q3 through 2012:Q4, respectively. As this study examines the presence of market discipline both in the price and quantity dimensions, the dependent variables are the implicit cost (*Spreads on Fed funds*) and the change in *Fed funds* during the quarter (*Changes in Fed funds*) in Panel A, the imputed cost (*Spreads on large time deposits*) and the change in large time deposits (*Changes in large time deposits*) in Panel B, and the imputed cost (*Spreads on wholesale funds*) and the change in total wholesale funding (*Changes in wholesale funds*) in Panel C. Models (1) and (2) for Fed funds and repos are estimated using Heckman's (1979) two-stage procedure to control for the sample selection problem arising from access to short-term money markets. *Lambda* indicates the inverse Mills ratio from the first-stage probit model. R^2 of the probit regression represents Pseudo-R^2. Models (3)-(6) show the coefficients in the fixed effects regressions.

The first column of Panel A in Table 3 shows the regression estimates of the probit model for whether banks attract Fed funds or repos. A bank is more likely to obtain Fed funds or repos if it is larger and has fewer troubled assets. Bank holding company status also played a significant role in participation in Fed funds or repo markets. A member of a bank holding company has a higher chance of securing Fed funds or repos. Models (1) and (2) report the second stage estimates of the Heckman procedure for the cost and quantity of funding, respectively. The coefficient of *NPL* in Model (1) is positive and significant at the 5% level, implying that lenders in the overnight Fed funds market require a risk premium when the bank takes greater risks. Furthermore, the coefficient of *NPL* in Model (2) is negative and significant at the 1% level, suggesting that interbank lenders withdraw their money when the bank increases its risk-taking. Putting these results for *NPL* into Models (1) and (2) together indicates that interbank lenders disciplined banks during the pre-crisis period by adjusting both price and quantity, a result consistent with Furfine (2001) and King (2008). However, the results of the interaction term between *NPL* and the macroeconomic crisis do not provide evidence for market

discipline. The coefficients of *NPL*CrisisI* in Models (1) and (2) are 0.0141 and -0.0118, respectively, and insignificant. *NPL*CrisisII* also has insignificant coefficients in both the price and quantity equations. These results suggest that risky banks do not pay higher interest rates when they borrowed from short-term wholesale financiers, and did not experience withdrawal of funds during the 2008 crisis. Furthermore, *NPL*Postcrisis* in Models (1) and (2) also has insignificant coefficients, implying that there is no evidence of market discipline, even during the post-crisis period. These results are inconsistent with the disciplinary argument in which banks are less likely to be rescued in case of failure because governments have committed to rescuing too-big-to-fail banks since the Dodd-Frank Act was enacted. The absence of market discipline during the post-crisis period raises questions about the effectiveness of the Dodd-Frank Act, a result inconsistent with Balasubramnian and Cyree (2014) who argue that market discipline improved after the Dodd-Frank Act.

In Panel B for large time deposits, *NPL* has an insignificant coefficient in the price equation but a significantly negative coefficient in the quantity equation, indicating that large time depositors discipline banks by rationing investments, although they do not adjust the price based on bank risk during stable economic periods. That is, risky banks experienced the withdrawal of funds but not higher funding costs for uninsured time deposits. *NPL*CrisisI* has significantly negative coefficients in both the price and quantity equations. That is, risky banks paid lower interest rates and attracted fewer large time deposits during the pre-Lehman crisis period. One possible explanation for this result is regulatory discipline. Risky banks may decrease deposits by reducing their risky assets in response to regulatory pressure wherein risky banks were required to increase their risk-based capital ratio during a crisis. In this case, banks may lower deposit rates to reduce deposits due to the decrease in assets. Regulatory discipline is different from market discipline because risky banks pay lower interest rates on financing instead of a higher one (Martinez Peria and Schmukler 2001). On the other hand, *NPL*CrisisII* has significantly positive coefficients in both the price and quantity equations. Risky

banks paid higher interest rates on large time deposits and increased the amount of deposits during the post-Lehman crisis period (*CrisisII*), suggesting that risky banks may attempt to increase time deposits by increasing interest rates. That is, risky banks obtained more uninsured time deposits than safe banks after the Lehman Brothers failure. Therefore, large time depositors did not punish banks for increased risks during the post-Lehman crisis period. Rather, they deposited more money into risky banks that provided higher interest rates during one of the most severe crises in US history. This result implies that large time depositors may exploit the increased possibility of government aid during a crisis. Interestingly, we find no evidence for the presence of market discipline, even in the post-crisis period when the Dodd-Frank Act was enacted, as with the results of Panel A.

Panel C shows regression estimates for total wholesale funding. As described in Table 1, total wholesale funding includes Fed funds, repos, and other long-term wholesale funds. The results in Panel C are very similar to those in Panel B. That is, we find evidence for market discipline in the form of quantity rationing during stable periods. However, we find evidence for regulatory discipline during the *CrisisI* period. In addition, we find little evidence for market discipline during *CrisisII* and *Postcrisis*.

In short, market discipline occurs during stable economic periods. However, market discipline methods differ between short-term and long-term investors. Investors in the very short-term money markets actively reflect bank risk in their pricing decisions. Large time depositors penalize banks for increasing risks by withdrawing funds, though they do not adjust prices in response to bank risk. As discussed previously, this may be attributed to the difference in maturities. Long-term investors may incur larger losses from forfeiting accrued interest while short-term investors may not have this kind of risk. Therefore, investors in the Fed funds or repo market have more incentive to discipline banks. The most interesting finding in this study is the absence of market discipline during the 2008 crisis. Our results are similar to those of Flannery and Sorescu (1996), though this study's results provide stronger

evidence for the absence of market discipline during tight economic periods when government intervention is expected. We consider both the price and quantity dimensions for market discipline, while Flannery and Sorescu (1996) do not examine responses along the quantity dimensions on banks' increased risk. Furthermore, we find an increase in the probability of wholesale funding for risky banks during the crisis. When wholesale financiers anticipate an increase in government aid and the possibility of bailouts, they have little incentive to discipline banks (Calomiris 1999; Nier and Baumann 2006). In addition, we find evidence for the ineffectiveness of the Dodd-Frank Act because there is no evidence of market discipline from all wholesale financiers during the post-crisis period. Furthermore, we control for the effect of QE using the level of money supply (*M2/GDP*) in all regressions, and the results remain robust after controlling for the effect of QE.

5.2 Controlling for Bank Borrowers' Credit Demands and Government Intervention

Some may argue that high NPL banks may attract more funding by providing higher interest rates because these banks rely on wholesale funds to satisfy borrowers' increased loan demands during a crisis. In this case, this study's main results may be driven by bank borrower demands, not by the lack of market discipline. In Table 4, we address the situation wherein risky banks in need of funding during the crisis attract wholesale funds by increasing their interest rates. Since borrowers used their lines of credit to meet liquidity demands during the crisis (Ivashina and Scharfstein 2010), we employ the changes in the sum of loans and undrawn credit lines scaled by the sum of deposits and equity (*ΔCredits*) as a proxy of borrowers' credit demands.

In addition, we examine whether the banks that received TARP funds attracted more wholesale funding, to ensure that the main findings for the increase in wholesale funding are driven by the banks

instead of the lack of market discipline. The US government assisted some banks through the TARP during the crisis. The TARP was introduced in October 2008 when the US government tried to increase government support for the banking system immediately after the Lehman failure, and aimed to strengthen the financial system's stability by helping sound banks in financial distresses (Black and Hazelwood 2013; Li 2013; Acharya and Mora2014).

Our results are robust after controlling for the both the effects of borrowers' credit demands and TARP banks. The overall results in Table 4 are similar to those in Table 3. In stable economic periods, short-term wholesale financiers discipline banks by demanding higher interest rates and by withdrawing funds, while long-term wholesale financiers discipline banks only by decreasing their investment amounts. During the 2008 crisis, however, short-term wholesale financiers did not reflect bank risk in their pricing and quantity decisions. Long-term wholesale financiers (large time depositors) were also insensitive to bank risks during the crisis. There was regulatory discipline during the pre-Lehman crisis period (*CrisisI*). During the post-Lehman crisis period (*CrisisII*), long-term wholesale financiers required higher interests rates for riskier banks, but they also increased their investments in weaker banks. This result implies that large time depositors exploit government safety nets by investing in riskier banks that provided higher interest rates. Furthermore, all types of wholesale financiers failed to discipline banks for increased risk during the crisis. This result may indicate moral hazard from wholesale financiers with little incentive to provide discipline because of extensive government guarantees during the crisis. In particular, large time depositors received both explicit and implicit government support during the crisis. Aside from bank bailouts (implicit government safety nets), deposits were protected during the crisis by the increase in deposit insurance coverage and unlimited guarantees for non-interest bearing transaction accounts (explicit government safety nets). Therefore, depositors may have more incentive to exploit these safety nets by increasing risky investments because depositors are more likely to be protected than other types of uninsured creditors.

This result is consistent with Nier and Baumann (2006)'s argument that the extent of government guarantees affects the effectiveness of market discipline. Furthermore, we also find no evidence of market discipline during the post-crisis period, confirming our earlier findings.

5.3 Results for Subsamples based on Bank Size

Table 5 reports regression estimates testing whether the effect of bank risk on the price and quantity of wholesale funding varies by bank size. Investors may have different incentives to monitor a bank depending on its size because large banks are more likely to be bailed out when the economy tightens. Therefore, uninsured investors have less incentive to monitor a large bank compared to a small bank. Furthermore, these incentives may be different depending on macroeconomic conditions. During times of tight liquidity, uninsured investors may have less incentive to monitor large banks than small banks either because of governments' too-big-to-fail policy and/or weaker banks become riskier during a crisis. Small banks are generally weaker than large banks. Investors should monitor riskier banks to protect their investments. Even during stable economic periods, large banks are also more viable and profitable than small banks. Therefore, uninsured investors may have little incentive to monitor large banks, regardless of macroeconomic market conditions. Panels A and B present estimates for large and small banks, respectively. Large banks are defined as banks with greater than $1 billion in total assets, and small banks with less than $1 billion in total assets.

Panel A1 of Table 5 shows that Fed funds or repo market investors discipline banks by demanding higher interest rates. The coefficient *NPL* on *Spreads on Fed funds* is positive (0.0325) and significant at the 5 % level, while that of *NPL* on *Changes in Fed funds* is statistically insignificant. The coefficients for both price and quantity of *NPL*CrisisI* and *NPL*CrisisII* are insignificant, implying that market discipline was lacking during the 2008 crisis. Also, consistent with our earlier findings, this

evidence for the absence of market discipline continues during the post-crisis period, suggesting the ineffectiveness of the Dodd-Frank Act.

Panel A2 shows that large time depositors do not punish large riskier banks since both price and quantity do not reflect the change in bank risk because the coefficients of both *Spreads on large time deposits* and *Changes in large time deposits* are insignificant. Large time depositors may have a stronger expectation of government protection through implicit or explicit government safety nets when their borrowers fail. Historically, governments have tried to protect deposits to prevent bank runs (Bernanke 1983; Diamond and Dybvig 1983). Therefore, uninsured time depositors may have less incentive to monitor banks than other types of uninsured liability holders. Alternatively, they may not have enough information because monitoring is costly. In general, time depositors are small, individual investors, while short-term money market participants are institutional investors. Repo lenders are largely money market mutual funds and security lending firms, while repo borrowers are broker-dealers and banks (Krishnamurthy, Nagel, and Orlov 2014). However, our results show that this lack of discipline from large time depositors is due to the greater possibility for government support, and not the lack of information since large time depositors discipline small banks during stable economic periods (see Panel B of Table 1.5). If information matters, uninsured time depositors would do better to monitor large banks that have more public information. This implies that uninsured time depositors have less incentive to discipline large banks than small banks because of the low risk of failure.

Panel B of Table 5 for small banks shows very similar results to the main findings in Tables 3 and 4. That is, all wholesale financiers, including short- and long-term wholesale financiers, played a disciplinary role for small banks by discouraging greater risks in the pre-crisis period. However, they did not penalize small banks during the crisis and post-crisis periods. Uninsured time depositors increased their deposits in small risky banks that provided higher interest rates during the *CrisisII* period. Combining the results of Panels A and B, high expectations of bank bailouts during the crisis

affects both large and small banks. Furthermore, this expectation continued during the post-crisis period, inconsistent with Martinez Peria and Schmukler (2001), who report that the incentive to monitor banks increases after a banking crisis because a crisis increases depositors' awareness of the risk from a possible depletion of deposit insurance funds. Our contrasting findings seem to be related to the the credibility of explicit and implicit government guarantees. Martinez Peria and Schmukler (2001) investigate the cases of Argentinian, Chilean, and Mexican banking crises, while the current study examines the US. Wholesale financiers who invest in US commercial banks seem not to worry about the depletion of deposit insurance funds and rely on strong guarantees for the US banking system.

6. Robustness Tests

This section presents the results of a number of robustness tests to check the validity of the results. First, we re-estimate the models, controlling for the impact of government intervention and bank borrower demands by using two additional proxies for market risks: MSA-level macro liquidity risk (*Recssion_MSA*) and credit risk in the general economy (*TED spread*). Second, we consider two additional proxies for bank risks: *RWA* and *Z-score*. Finally, we exclude funding from the Federal Home Loan Bank (FHLB) and funding from the TARP funds received in the form of SNDs.

6.1 Macroeconomic Risk: MSA Level Market Risk and the TED Spread

As many banks operate in certain MSAs, local market conditions can affect banks' profits and credit risks, since local market conditions affect borrowers more than national economic conditions. As a

proxy for a market recession, we use a quarterly dummy variable for two consecutive quarters of decline in real GDP at the MSA level (*Recession_MSA*). For a multi-market bank, the value of *Recession_MSA* is one if a bank experiences a recession in at least 25 percent or more of the MSAs in which it operates. We control for both local market recessions and the national crisis of 2008 because local market recessions do not necessarily coincide with national recessions. Each MSA has its own economic situations and development. The local economy is broadly related to the national economy, though it is possible that the relationship between the two is low. In fact, the correlation between MSA-level recessions and the crisis is low: the correlation between *Recession_MSA* and *CrisisI* is 0.1419, and the correlation between *Recession_MSA* and *CrisisII* is 0.2969.

Table 6 presents the robustness tests for the effect of bank risk on the price and quantity of wholesale funding, using recession periods at the MSA level as an alternative proxy for market-wide liquidity risk. Our results are robust even in the case of local recessions. In Panel A, the coefficients of *NPL* on *Spreads on Fed funds* (price) and *Changes in Fed funds* (quantity) are 0.0255 and -0.0226, respectively, which are statistically significant at the 1% level. This result shows that interbank and repo lenders discipline banks during stable economic conditions after controlling for local market recessions and the national crisis. The coefficients of both the price and quantity of *NPL*Recession_MSA* are insignificant, implying that the price and quantity of short-term wholesale funding did not reflect the change in bank risk during local market recession periods. This result confirms that the findings for the national economy also hold local market cases. Therefore, during both local market recessions and national recessions, short-term wholesale financiers do not discipline risky banks, while they provide discipline during stable economic periods.

Panel B also provides results consistent with our earlier findings. Large time depositors are sensitive to bank risk during stable economic periods. They discipline banks by withdrawing funds, though they do not require higher interest rates. However, the coefficients of *NPL*Recession_MSA* on

Spreads on large time deposits and *Changes in large time deposits* are positive and significant at the 1% level. As with the results in Tables 3 and 4, this result suggests that large time depositors seem to invest in risky banks providing higher interest rates during local market recessions.

Panel C also confirms our earlier results in terms of local market recessions. Wholesale financiers discipline banks by reducing investments in riskier banks during stable economic periods after controlling for local market recessions and the 2008 financial crisis. The coefficient of *Changes in wholesale funds* is negative and significant, while that of *Spread on wholesale funds* is positive but insignificant. However, during local market recessions, wholesale financiers do not discipline banks. The coefficients of *NPL*Recession_MSA* for both the price and quantity equations are insignificant, suggesting that wholesale financiers neither demand higher interest rates nor adjust their investments in response to the increased bank risk during local market recessions at the MSA level.

In addition, in Table 7, we re-estimate our models using the TED spread as a proxy for market-wide liquidity shocks. Cornett, McNutt, Strahan, and Tehranian (2011) report that the TED spread, which indicates the counterparty risk between banks, closely mirrored the severity of the 2008 crisis. Our data also show that the correlation between *TED spread* and *CrisisI* is 0.5369, and the correlation between *TED spread* and *CrisisII* is 0.6115. Therefore, we do not include crisis dummies to avoid the multicollinearity problem in the estimations in Table 7. These results are also consistent with our earlier findings. During periods of high credit risks between banks (high *TED spread*), neither short-term wholesale financiers nor long-term wholesale financiers punished banks for increased risks. All coefficients of *NPL*TED spread* in Panels A and B are insignificant. Both coefficients of *NPL*TED spread* for the price and quantity equations in Panel C are negative and significant.

6.2 Bank-Specific Risk: Risk Weighted Assets (RWA) and the Z-score

Table 8 shows the results of the robustness tests for the effect of bank risk on the price and quantity of wholesale funding using risk weighted assets as an alternative proxy for bank risk. RWA is an ex-ante risk measure, while NPL is an ex-post risk measure. Wholesale financiers' decisions based on a forward-looking risk measure may differ from those based on the (ex-post) outcome of bank risk. However, our results for the crisis and post-crisis periods are robust after employing the ex-ante risk measure. During the crisis and post-crisis periods, all wholesale financiers, including interbank lenders, repo lenders, and large time depositors, did not discipline banks. Only *RWA*CrisisI* in Panel B shows the presence of market discipline during the pre-Lehman crisis period. This may be attributed to a low expectation of government intervention during the pre-Lehman crisis period (*CrisisI*), though the US government provided extensive government support immediately after the Lehman Brothers failure (*CrisisII*). From the ex-ante bank risk perspective, long-term wholesale financiers may have worried about bank failures during the pre-Lehman crisis period. Their concerns about bank safety definitely changed after substantial government rescue programs were implemented during the post-Lehman crisis period. Furthermore, both short-term and long-term wholesale financiers had little incentive for monitoring and discipline after the crisis, implying that strong government protection during the crisis may make wholesale financiers insensitive to banks' risk despite the enactment of the Dodd-Frank Act.

Table 9 presents robustness tests for the effect of bank risk on the price and quantity of wholesale funding using the Z-score as an alternative proxy for bank risk. A higher Z-score value indicates a lower risk of failure. Note that the Z-score is negatively associated with bank risk. Therefore, we expect the opposite signs on the estimated coefficients. The results are similar to our earlier results, in that there was a lack of market discipline during the crisis and post-crisis periods for all types of wholesale financiers.

6.3 Excluding Funding from Government Agencies

Our finding of the lack of market discipline contradicts the previous literature supporting the disciplinary role of wholesale financiers. Market discipline is effective when investors are concerned about losses in the event of a bank failure. Government interventions to prevent bank runs, however, eliminate the possibility of a decrease in investors' wealth. In this case, wholesale financiers have little incentive to discipline banks. In this section, we examine whether the absence of market discipline can be attributed partly to government support provided through funding from government agencies during the 2008 crisis.

Some banks received TARP funds in the form of subordinated debentures, which represents part of the wholesale funding measure in this study. Therefore we exclude the support in the form of SNDs in the amount of total wholesale funds (*wholesale funds*) to account for the effect of government intervention. Additionally, borrowings from the Federal Home Loan Bank (FHLB), which lends funds to their member banks on favorable terms, must be considered.

Table 10 shows robustness tests for the effect of bank risk on wholesale funding considering government intervention in the form of TARP funds and FHLB loans. The dependent variable, *Changes in wholesale funds*, is the quarterly growth of wholesale funds. *Wholesale funds* are measured by excluding the amount of SNDs among the types of TARP funds and the amount of FHLB loans. The regression results for *Spreads on wholesale funds* is shown in column (5) in Table 4 because interest rates on wholesale funds excluding the TARP funds or FHLB loans are not reported in income statements. Since the proportions of funding from FHLB and TARP funds (SNDs) are very small, the results for price would not change, though their impact on the price variable is considered. Our findings remain robust after accounting for these government funding sources. Consistent with our

earlier findings, there is evidence for the presence of market discipline by wholesale financiers during stable economic periods. However, market discipline disappeared during the crisis and post-crisis period.

7. Conclusion

Many previous studies argue for the benefit of using wholesale funds as an alternative source of funding. While deposits are very stable, wholesale funding seeks profitable investments and encourages banks to prudently invest in projects. Numerous studies show that market discipline exists by examining different countries during various time periods. The financial crisis of 2008, however, raises questions about whether these sophisticated investors really discipline banks by conducting costly monitoring.

In our analyses, we find no evidence that wholesale financiers demanded higher prices from risky banks and withdrew funds during the crisis; wholesale financiers invested even more money into risky banks while they withdrew funds from safe banks. In addition, in the post-crisis period, we find no evidence of market discipline. This finding for the post-crisis period suggests that neither the Dodd-Frank Act improved market discipline (Balasubramnian and Cyree 2014), nor that the crisis contributed to increased awareness for the risk of bearing losses related to concerns about the depletion of deposit insurance funds (Martinez Peria and Schmukler 2001). Considering the fact that wholesale financiers did not withdraw their funds from risky banks during the financial crisis, it seems that wholesale financiers do not worry about the depletion of the US deposit insurance funds. Right after the Lehman Brothers bankruptcy, the US government worked to reassure nervous investors through extensive government interventions such as the increase in deposit insurance coverage, bank bailouts, quantitative easing (QE), and providing TARP funds. These emergency actions to stabilize the

economy during the severe financial crisis may encourage an expectation among sophisticated investors of implicit/explicit government safety nets, thereby removing their incentives to discipline banks.

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Figure 1 Trends in the Total Amount of Wholesale Funds

These figures present trends in the total amount of wholesale funds by bank size and multi-market operation over the period between 2002:Q1 and 2012:Q4. Aggregate wholesale funds ($100,000) indicate the amount of wholesale funds without applying the increase in FDIC deposit insurance coverage from $100,000 to $250,000. Aggregate wholesale funds ($250,000) are the amount of wholesale funding reflecting the increase in the deposit insurance coverage. Aggregate wholesale funds based on deposit insurance coverage of $100,000 are applied to Figures 1.2 and 1.3 to avoid a drop in wholesale funds resulting from the impact of the regulatory change. Large banks are defined as banks with greater than $1 billion in total assets, and small banks with less. Multi-market banks are defined as banks that operate in multiple Metropolitan Statistical Areas (MSAs), and single-market banks otherwise. The data are obtained from Call Reports.

Figure 1.1 Total amount of wholesale funds ($ billion)

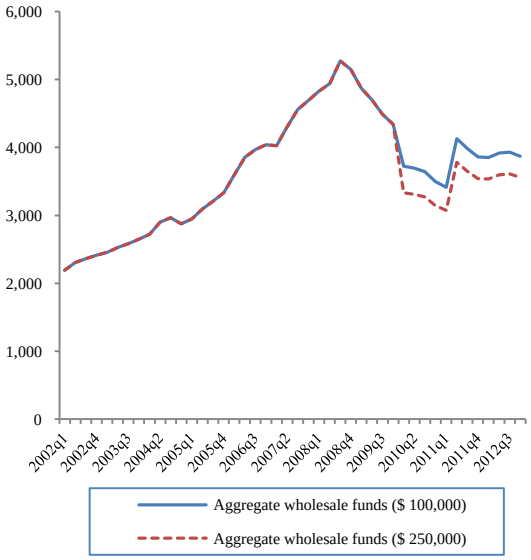


Figure 1.2 Total amount of wholesale funds by bank size ($ billion)

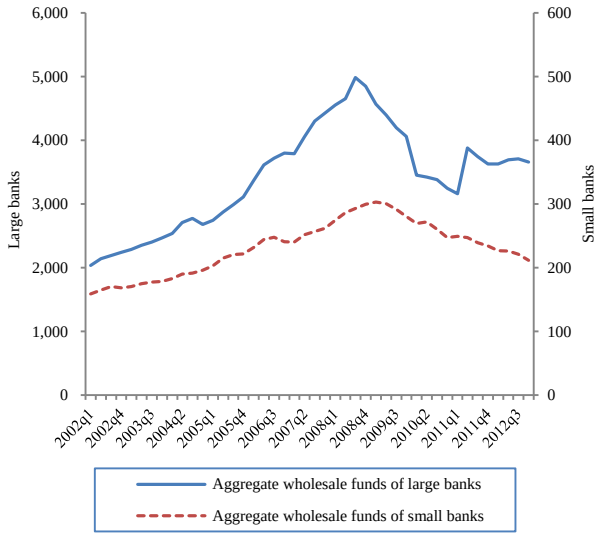


Figure 1.3 Total amount of wholesale funds by multimarket operation ($ billion)

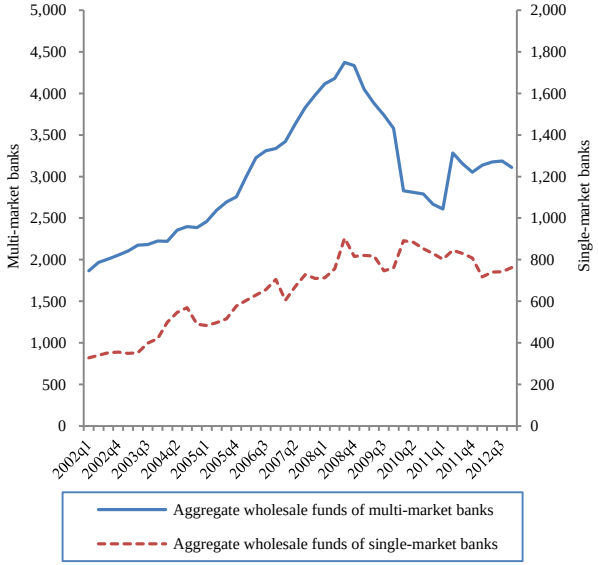


Figure 2 Bank Risk and the Quantity of Wholesale Funding

Figure 2.1 shows time-trends in the aggregate quantity of wholesale funding by bank risk depending on the level of NPL: high, medium, and low risk. Figure 2.2 shows aggregate wholesale funding by bank risk in large banks with total assets of $1 billion and Figure 2.3 shows the trend by bank risk in small banks. Figures 2.4 and 2.5 show the difference in the portion of wholesale funding over total assets between high-risk banks and low-risk banks in the group of large banks and in the group of small banks, respectively. In all figures, wholesale funds include time deposits above $100,000. The data are obtained from Call Reports.

1) Quantity of wholesale funds: Aggregate level

Figure 2.1 Total amount of wholesale funds by bank risk ($ billion)

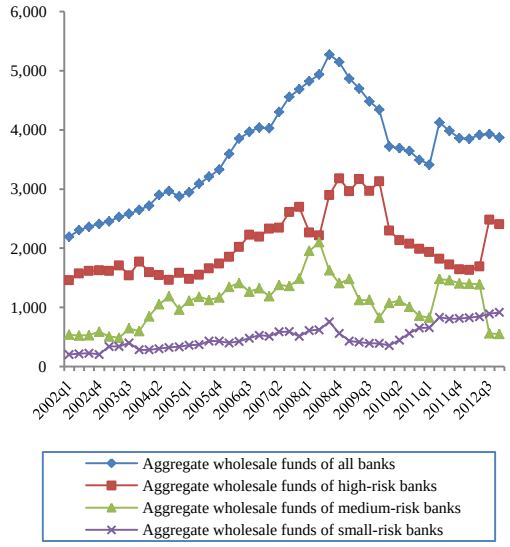


Figure 2.2 Aggregate wholesale funding by the risk level among large banks ($ billion)

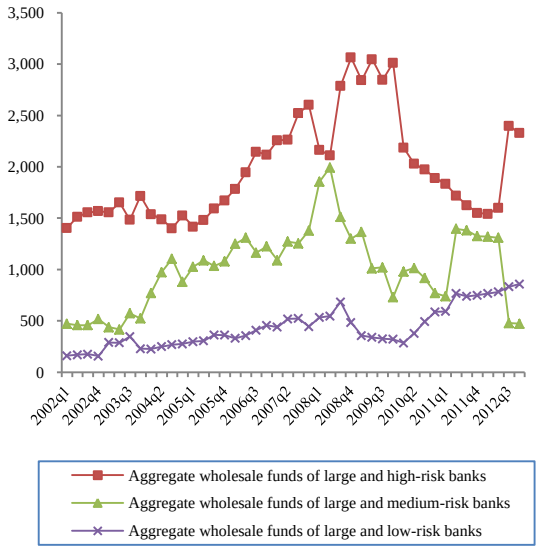
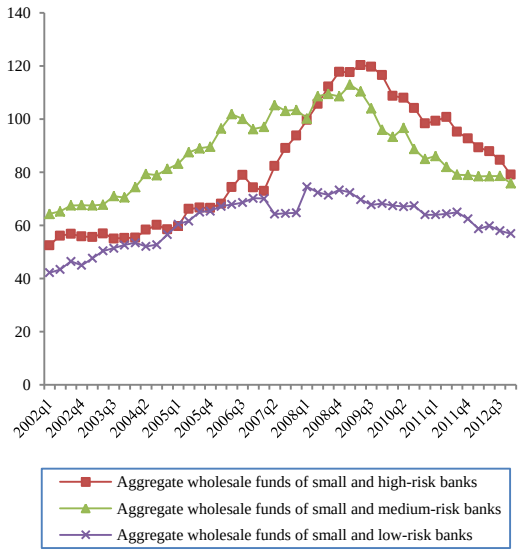


Figure 2.3 Aggregate wholesale funding by the risk level among small banks ($ billion)



2) Quantity of wholesale funds: Bank level (Ratio of wholesale funds to total assets: *WF/TA*)

Figure 2.4 Difference in the average *WF/TA* between high-risk banks and low-risk banks among large banks

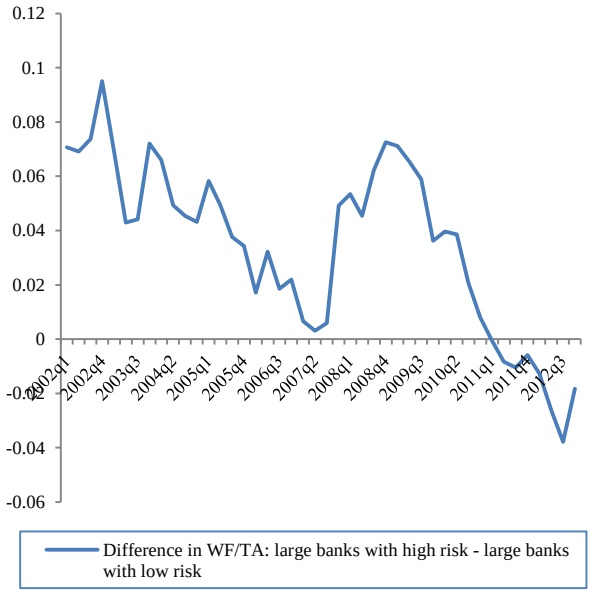


Figure 2.5 Difference in the average *WF/TA* between high-risk banks and low-risk banks among small banks

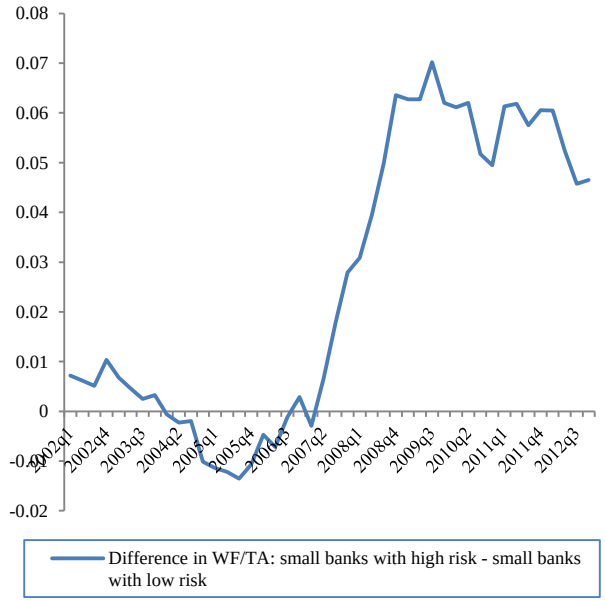


Figure 3 Bank Risk and the Cost of Wholesale Funding

These figures show the net level of the average cost of wholesale funds (*WF_RATE*), calculated as the wholesale funding expense divided by the amount of wholesale funding, between high-risk and low-risk banks among large (Figure 3.1) and small banks (Figure 3.2). The data are obtained from Call Reports.

Figure 3.1 Difference in the average *WF_RATE* between high-risk banks and low-risk banks among large banks

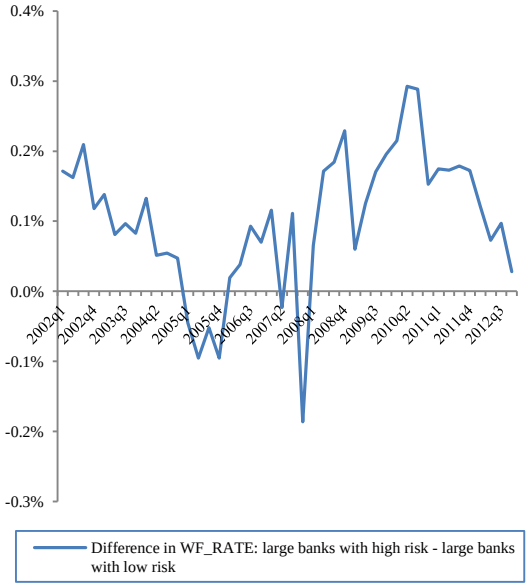


Figure 3.2 Difference in the average *WF_RATE* between high-risk banks and low-risk banks among small banks

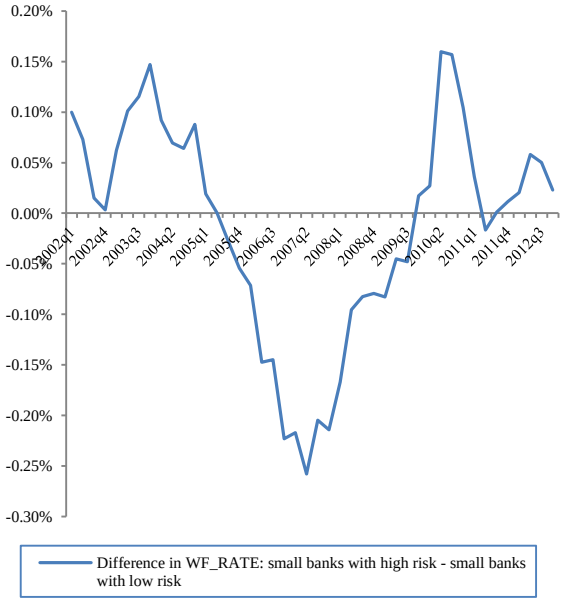


Table 1 Variable Definitions and Data Sources

This table presents the definitions of variables and data sources.

Variable	Definition	Source
Dependent variables		
Price variables		
Spreads on fed funds	Spreads between the implicit interest rates on *fed funds* and the effective federal funds rate, expressed in annual terms. *fed funds* is defined as the sum of federal funds purchased andsecurities sold under agreements to repurchase. The imputed rates are calculated as the quarterly average expenses of *fed funds* divided by the quarterly average amounts of *fed funds.*	Call Reports. Authors' calculations
Spreads on large time deposits	Spreads between the implicit interest rates on large time deposits and the one-year treasury constant maturity rate, expressed in annual terms. Large time deposits are uninsured deposits over $100,000 until 2009:Q4 and $250,000 from 2010:Q1). The implicit rates are calculated as the quarterly average expenses of large time deposits divided by the quarterly average amounts of large time deposits.	Call Reports. Authors' calculations
Spreads on wholesale funds	Spreads between the implicit interest rates on total wholesale funds and the one-year treasury constant maturity rate, expressed in annual terms. The imputed rates are calculated as the quarterly average expenses of total wholesale funds divided by the quarterly average amounts of total wholesale funds. Total wholesale funds are defined as the sum of 1) federal funds purchased, 2) securities sold under agreements to repurchase 3) subordinated notes and debentures, 4) brokered deposits, 5) other borrowed money, 6) the estimated amount of deposits obtained through the use of deposit listing services that are not brokered deposits 7) deposits in foreign offices, and 8) uninsured large time deposits.	Call Reports. Authors' calculations
Quantity variables		
Changes in fed funds	Quarterly change in the amounts of *fed funds* during the quarter as a fraction of beginning of quarter total assets: $(fed\ funds_t – fed\ funds_{t-1})/total\ assets_{t-1}$.The amount of *fed funds* is quarterly averages.	Call Reports. Authors' calculations

Changes in large time deposits	Quarterly change in the amounts of large time deposits during the quarter divided by beginning of quarter total assets: *(large time deposits$_t$– large time deposits$_{t-1}$)/total assets$_{t-1}$*	Call Reports. Authors' calculations
Changes in wholesale funds	Quarterly change in the amounts of total wholesale funds during the quarter as a fraction of beginning of quarter total assets: *(wholesale funds$_t$–wholesale funds$_{t-1}$)/total assets$_{t-1}$*	Call Reports. Authors' calculations
Explanatory variables		
NPL	Non-performing loans divided by total loans; non-performing loans are defined as the sum of loans past due 90days or more and nonaccrual loans. A higher ratio indicates a riskier loan portfolio.	Call Reports. Authors' calculations
RWA	Risk-weighted assets as a fraction of total assets. A higher value indicates a riskier loan portfolio.	Call Reports. Authors' calculations
Z-score	A bank's distance to default, calculated as the sum of the return on assets and the equity ratio divided by the standard deviation of the return on assets. A higher value indicates lower risk of default.	Call Reports. Authors' calculations
Log total assets	Natural log of total assets (in million dollars)	Call Reports
Return on assets	Return on assets	Call Reports
Capital ratios	Bank equity capital divided by total assets	Call Reports
Bank holding company	Dummy that equals 1 if the bank belongs to a bank holding company	FDIC
TARP amounts	The amounts of received TARP funds as a fraction of total assets	Treasury Department
ΔCredits	Quarterly change in the amount of credits. Credits are defined as the sum of loans and loan commitments divided by equity and core deposits	Call Reports Authors' calculations

Weighted HHI	Bank-level Herfindahl–Hirschman Index, weighted by the proportion of the bank's deposits in each MSA where the bank operates.	FDIC SOD Authors' calculations
Weighted income growth	Bank-level income growth rate, weighted by the proportion of the bank's deposits in each MSA where the bank operates.	BEA Authors' calculations
Recession_MSA	Quarterly dummy variable for the recession periods at the MSA level; the value is 1 when a bank operates in the MSA which experiences the decline in real GDP for two consecutive quarters. In the case of a multimarket bank, the value is 1 when the bank experiences the decline in at least 25% or more of the MSAs where the bank operates.	BEA Authors' calculations
CrisisI	Dummy for the pre-Lehman crisis periods: 2007Q3- 2008Q2	NBER Authors
CrisisII	Dummy for the post-Lehman crisis periods: 2008Q3- 2009Q2	NBER Authors
Postcrisis	Dummy for the post-crisis periods: 2009Q3-2012Q4	NBER Authors
TED spread	TED spread, calculated as the spread between the three-month LIBOR and the three-month Treasury bill rate	FRED
M2/GDP	Money supply, measured as M2 divided by GDP	FRB

Table 2 Summary Statistics

This table provides discriptive statistics forthe variables used in the estimations. *Spreads on fed funds* indicates the difference between the implicit interest rate on *fed funds* and the effective federal funds rate. *fed funds* is defined as the sum of federal funds purchased (fed funds) andsecurities sold under agreements to repurchase (repos). *Spreads on large time deposits* (*wholesale funds*) are defined as the difference between the implicit interest rates on *large time deposits* (*wholesale funds*) and the one-year treasury constant maturity rate. The implicit interest rate is calculated as the quarterly average interest expenses on wholesale funds divided by the quarterly average amounts of the components of wholesale funds, based on Call Report data. Quantity variables are changes in fed funds and repos, large time deposits, and total wholesale funds, scaled by the start of quarter total assets, respectively. *Changes in fed funds* are calculated based on quarterly average amounts. Table 1 provides detailed information about the variables. Variables except for *M2/GDP* and *TED spread* are winsorized at the 1st and 99th percentiles.

Variables	Observations	Mean	Std. Dev.	Min	Max
Dependent variables					
Price variables					
Spreads on fed funds	75,848	0.0030	0.0175	-0.0284	0.1657
Spreads on large time deposits	180,843	0.0105	0.0120	-0.0177	0.0399
Spreads on wholesale funds	183,618	0.0029	0.0138	-0.0333	0.0304
Quantity variables					
Changes in fed funds	75,848	0.0016	0.0137	-0.0456	0.0528
Changes in large time deposits	180,843	0.0018	0.0271	-0.1302	0.0945
Changes in wholesale funds	183,618	0.0046	0.0435	-0.1556	0.1732
Explanatory variables					
Bank risk variables					
NPL	183,618	0.0171	0.0236	0	0.1237
RWA	183,618	0.7113	0.1291	0.3449	0.9894
Z-score	117,001	32.0728	16.7470	5.5678	97.9014
Other control variables					
Log total assets	183,618	5.3210	1.3106	2.6983	10.0472
Return on assets	183,618	0.0044	0.0077	-0.0309	0.0234
Capital ratios	183,618	0.1048	0.0367	0.0540	0.3127
Bank holding company	183,618	0.8308	0.3749	0	1
TARP amounts	183,618	0.0016	0.0078	0	0.0625
ΔCredits	176,950	-0.0086	0.1080	-0.5493	0.3813
Weighted HHI	183,618	0.6973	0.0647	0.2848	0.8399
Weighted income growth	183,618	0.0408	0.0323	-0.0583	0.1184
M2/GDP	183,618	0.5366	0.0409	0.4934	0.6212
TED spread	183,618	0.4898	0.4631	0.1470	2.4472

Table 3 Effect of Bank Risk on the Price and Quantity of Wholesale Funds

This table shows the effect of bank risk on the price and quantity of wholesale funding, using the Heckman's (1979) two-stage estimation [Models (1) and (2)] and the fixed effects model [Models (3)-(6)] for a panel dataset for US commercial banks from 2002:Q1 to 2012:Q4. Panels A, B, and C present regression estimates for fed funds and repos (*fed funds*), large time deposits (*large time deposits*), and total wholesale funds (*wholesale funds*), respectively. *Crisis I*, *Crisis II*, and *Postcrisis* are respectively defined as periods 2007:Q3 through 2008:Q2, 2008:Q3 through 2009:Q2, and 2009:Q3 through 2012:Q4. Detailed information on the variables is provided in Table 1. The probit regression estimates the probability that a bank attracts fed funds or repos. *Lambda* indicates the inverse Mills ratio in the Heckman procedure. R^2 of the probit regression represents Pseudo-R^2. Robust standard errors of Models (3)-(6) are clustered by bank to control for heteroskedasticity and within-bank serial correlations. T-statistics are in parentheses. ***, **, and *represent significance at the 1%, 5%, and 10% levels, respectively.

	Panel A: Federal funds and repos			Panel B: Large time deposits		Panel C: Total wholesale funds	
	Probit (Participation)	*Spreads on fed funds*	*Changes in fed funds*	*Spreads on large time deposits*	*Changes in large time deposits*	*Spreads on wholesale funds*	*Changes in Wholesale funds*
	First stage	(1) Second stage	(2) Second stage	(3) FE	(4) FE	(5) FE	(6) FE
NPL	-4.9398***	0.0212**	-0.0234***	-0.0024	-0.1325***	-0.0013	-0.2225***
	(-28.98)	(2.48)	(-3.32)	(-0.57)	(-11.99)	(-0.25)	(-12.52)
CrisisI		0.0082***	0.0013	0.0154***	-0.0029***	0.0146***	0.0062***
		(5.82)	(1.12)	(101.41)	(-4.83)	(88.43)	(5.70)
*NPL*CrisisI*		0.0141	-0.0118	-0.0131**	-0.0279*	-0.0175**	-0.1081***
		(0.95)	(-0.96)	(-2.42)	(-1.69)	(-2.32)	(-3.99)
CrisisII		0.0140***	0.0008	0.0303***	0.0062***	0.0299***	0.0140***
		(2.61)	(0.17)	(130.55)	(6.40)	(124.79)	(6.56)
*NPL*CrisisII*		-0.0143	-0.0026	0.0156***	0.0504***	0.0075	0.0206
		(-1.17)	(-0.26)	(3.17)	(3.40)	(1.22)	(0.91)
Postcrisis		0.0079	0.0018	0.0253***	0.0010	0.0349***	-0.0037
		(1.03)	(0.28)	(38.86)	(0.34)	(56.71)	(-0.51)
*NPL*Postcrisis*		-0.0123	-0.0016	-0.0059	0.0740***	0.0086	0.0572***
		(-1.30)	(-0.20)	(-1.30)	(6.62)	(1.45)	(3.10)
Log total assets	0.5183***	0.0011***	0.0005***	0.0008***	-0.0097***	-0.0010***	-0.0163***
	(168.74)	(7.33)	(4.53)	(5.54)	(-19.45)	(-5.12)	(-17.73)
Return on assets	-5.2216***	-0.0506***	-0.0180*	-0.0264***	0.0514***	-0.0198***	0.0528**
	(-10.05)	(-4.45)	(-1.96)	(-6.52)	(3.60)	(-3.52)	(1.97)
Capital ratios	-2.0143***	-0.0080***	0.0054***	0.0012	0.0971***	0.0095***	0.2025***
	(-20.42)	(-3.52)	(2.94)	(0.76)	(21.05)	(4.48)	(23.82)
Weighted HHI		-0.0060***	-0.0000	0.0019	-0.0025	-0.0062***	-0.0014
		(-6.24)	(-0.02)	(1.10)	(-0.65)	(-2.69)	(-0.22)
Weighted income growth		0.0002	0.0119***	0.0037***	0.0023	0.0145***	-0.0103*
		(0.06)	(4.58)	(3.18)	(0.69)	(9.56)	(-1.84)
M2/GDP		0.0063	-0.0300	-0.1069***	-0.0435*	-0.0941***	0.0224
		(0.10)	(-0.54)	(-20.54)	(-1.79)	(-20.51)	(0.36)
Bank holding company	0.3061***						
	(32.57)						
Lambda		0.0080***	0.0034***				
		(15.08)	(7.96)				
Constant		-0.0146	0.0102	0.0450***	0.0726***	0.0406***	0.0648**
		(-0.44)	(0.37)	(15.39)	(5.72)	(14.10)	(2.06)
Bank fixed effects	No	No	No	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	No	No	No	Yes	Yes	Yes	Yes
R-squared	0.1853			0.7600	0.3562	0.7607	0.2220
Wald exogeneity test (p-value)		0.0000	0.0000				
Observations	183,618	183,618	183,618	180,843	180,843	183,618	183,618
Censored observations		107,789	107,789				
Uncensored observations		75,829	75,829				

Table 4 Effect of Bank Risk on Wholesale Funding: Bank Borrowers' Credit Demands and the Impact of TARP

This table shows robustness tests for the effect of bank risk on the price and quantity of wholesale funds, controlling for bank borrowers' demands for loans (*ΔCredits*) and the impact of the TARP (*TARP amounts*). Models (1) and (2) report the second stage estimates of the Heckman's (1979) two-stage model and Models (3)-(6) report results of the fixed effect model. *Crisis I*, *Crisis II*, and *Postcrisis* are respectively defined as periods 2007:Q3 through 2008:Q2, 2008:Q3 through 2009:Q2, and 2009:Q3 through 2012:Q4. Detailed information on the variables is provided in Table 1. *Lambda* indicates the inverse Mills ratio in the Heckman procedure. R^2 of the probit regression represents Pseudo-R^2. Robust standard errors of Models (3)-(6) are clustered by bank to control for heteroskedasticity and within-bank serial correlations. T-statistics are in parentheses. ∗∗∗, ∗∗, and ∗represent significance at the 1%, 5%, and 10% levels, respectively.

	Panel A: Federal funds and repos		Panel B: Large time deposits		Panel C: Total wholesale funds	
	Spreads on fed funds	*Changes in fed funds*	*Spreads on large time deposits*	*Changes in large time deposits*	*Spreads on wholesale funds*	*Changes in wholesale funds*
	(1) Heckman	(2) Heckman	(3) FE	(4) FE	(5) FE	(6) FE
NPL	0.0260***	-0.0237***	-0.0029	-0.1207***	-0.0032	-0.2136***
	(3.00)	(-3.28)	(-0.69)	(-11.31)	(-0.60)	(-12.31)
CrisisI	0.0095***	0.0016	0.0151***	0.0036***	0.0141***	0.0137***
	(6.79)	(1.36)	(121.02)	(5.35)	(91.76)	(12.52)
*NPL *CrisisI*	-0.0010	-0.0094	-0.0144***	-0.0313*	-0.0166**	-0.0967***
	(-0.07)	(-0.76)	(-2.73)	(-1.92)	(-2.19)	(-3.64)
CrisisII	0.0163***	0.0015	0.0300***	0.0134***	0.0294***	0.0226***
	(3.08)	(0.34)	(149.45)	(13.69)	(128.03)	(11.32)
*NPL *CrisisII*	-0.0234*	0.0020	0.0144***	0.0467***	0.0093	0.0213
	(-1.91)	(0.20)	(2.96)	(3.22)	(1.49)	(0.97)
Postcrisis	0.0107	0.0027	0.0243***	0.0119***	0.0341***	0.0086
	(1.41)	(0.43)	(41.86)	(4.10)	(55.76)	(1.20)
*NPL *Postcrisis*	-0.0150	0.0009	-0.0057	0.0700***	0.0101*	0.0577***
	(-1.56)	(0.11)	(-1.29)	(6.46)	(1.67)	(3.20)
Log total assets	0.0010***	0.0006***	0.0009***	-0.0091***	-0.0011***	-0.0156***
	(6.97)	(4.79)	(5.80)	(-18.37)	(-5.41)	(-16.76)
Return on assets	-0.0344***	-0.0027	-0.0306***	0.0941***	-0.0164***	0.0814***
	(-2.91)	(-0.28)	(-7.15)	(6.42)	(-2.75)	(2.97)
Capital ratios	-0.0107***	0.0029	-0.0021	0.0869***	0.0090***	0.1949***
	(-4.57)	(1.53)	(-1.34)	(18.32)	(3.91)	(21.51)
Weighted HHI	-0.0056***	0.0002	0.0014	-0.0019	-0.0061***	-0.0026
	(-5.81)	(0.21)	(0.81)	(-0.53)	(-2.59)	(-0.40)
Weighted income growth	0.0003	0.0123***	0.0030***	0.0027	0.0147***	-0.0083
	(0.09)	(4.70)	(2.58)	(0.83)	(9.35)	(-1.49)
M2/GDP	-0.0107	-0.0373	-0.0996***	-0.0820***	-0.0918***	-0.0156
	(-0.16)	(-0.68)	(-20.93)	(-3.35)	(-19.78)	(-0.25)
TARP amounts	0.0249***	-0.0001	-0.0268***	-0.0256**	0.0013	-0.0968***
	(3.51)	(-0.02)	(-5.61)	(-2.39)	(0.17)	(-4.52)
ΔCredits	0.0018***	0.0021***	-0.0003*	0.0123***	-0.0025***	0.0175***
	(3.24)	(4.58)	(-1.85)	(12.60)	(-13.54)	(9.77)
Lambda	0.0077***	0.0035***				
	(14.65)	(8.03)				
Constant	-0.0067	0.0134	0.0419***	0.0824***	0.0405***	0.0738**
	(-0.20)	(0.49)	(15.36)	(6.45)	(13.83)	(2.33)
Bank fixed effects	No	No	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	No	No	Yes	Yes	Yes	Yes
R-squared			0.7861	0.3608	0.7661	0.2232
Wald exogeneity test (p-value)	0.0000	0.0000				
Observations	176,950	176,950	174,232	174,232	176,950	176,950

Table 5 Effect of Bank Risk on Wholesale Funding: Large vs. Small banks

This table presents whether the effect of bank risk on the price and quantity of wholesale funding varies across bank size. Large banks are defined as banks with greater than $1 billion in total assets, and small banks otherwise. *Crisis I*, *Crisis II*, and *Postcrisis* are respectively defined as periods 2007:Q3 through 2008:Q2, 2008:Q3 through 2009:Q2, and 2009:Q3 through 2012:Q4. Detailed information on the variables is provided in Table 1. Robust standard errors are clustered by bank to control for heteroskedasticity and within-bank serial correlations. T-statistics are in parentheses. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Large banks

	A1: Federal funds and repos		A2: Large time deposits		A3: Total wholesale funds	
	Spreads on fed funds	*Changes in fed funds*	*Spreads on large time deposits*	*Changes in large time deposits*	*Spreads on wholesale funds*	*Changes in wholesale funds*
	(1) Heckman	(2) Heckman	(3) FE	(4) FE	(5) FE	(6) FE
NPL	0.0325**	-0.0300	0.0436	-0.0440	-0.0115	-0.2381***
	(2.02)	(-1.37)	(1.48)	(-1.05)	(-0.51)	(-2.88)
CrisisI	0.0080***	0.0016	0.0122***	0.0004	0.0031***	0.0105***
	(4.64)	(0.67)	(21.85)	(0.22)	(5.76)	(3.18)
*NPL*CrisisI*	0.0136	-0.0051	-0.0182	0.0056	0.0040	-0.1180
	(0.49)	(-0.13)	(-0.56)	(0.09)	(0.12)	(-0.70)
CrisisII	0.0145**	0.0093	0.0156***	0.0124***	0.0228***	0.0201***
	(2.30)	(1.07)	(22.62)	(5.31)	(35.37)	(3.84)
*NPL*CrisisII*	0.0117	0.0035	-0.0051	-0.0598	0.0434*	0.0360
	(0.55)	(0.12)	(-0.16)	(-1.06)	(1.77)	(0.37)
Postcrisis	0.0123	0.0132	0.0111***	0.0126	0.0293***	0.0152
	(1.36)	(1.07)	(6.26)	(1.62)	(16.23)	(0.72)
*NPL*Postcrisis*	-0.0102	0.0216	-0.0390	-0.0289	0.0223	0.0058
	(-0.60)	(0.93)	(-1.29)	(-0.65)	(0.90)	(0.07)
Log total assets	0.0005***	-0.0002	-0.0001	-0.0114***	-0.0006	-0.0275***
	(3.76)	(-1.15)	(-0.21)	(-7.60)	(-0.90)	(-10.40)
Return on assets	-0.0890***	0.1050***	-0.0081	0.1817***	-0.0164	0.2674***
	(-5.63)	(4.89)	(-0.55)	(4.61)	(-0.86)	(3.40)
Capital ratios	-0.0210***	-0.0003	-0.0166***	0.0047	-0.0080	0.1136***
	(-6.72)	(-0.07)	(-2.98)	(0.40)	(-1.08)	(3.35)
Weighted HHI	-0.0047***	0.0003	0.0012	0.0036	-0.0155**	0.0028
	(-4.59)	(0.22)	(0.20)	(0.39)	(-2.31)	(0.12)
Weighted income growth	-0.0077	0.0066	0.0031	-0.0000	0.0163***	0.0113
	(-1.58)	(0.98)	(0.64)	(-0.00)	(2.69)	(0.55)
M2/GDP	0.0025	-0.1300	-0.1081***	-0.0976	-0.0765***	-0.1290
	(0.03)	(-1.21)	(-7.00)	(-1.34)	(-5.41)	(-0.66)
TARP amounts	-0.0012	-0.0053	-0.0304**	-0.0103	-0.0316	-0.0841*
	(-0.15)	(-0.49)	(-2.52)	(-0.53)	(-1.41)	(-1.73)
ΔCredits	-0.0002	0.0018**	0.0003	0.0021	-0.0011**	0.0058
	(-0.35)	(1.97)	(0.60)	(1.03)	(-2.29)	(1.34)
Lambda	0.0029**	0.0018				
	(2.42)	(1.13)				
Constant	-0.0069	0.0669	0.0670***	0.1397***	0.0419***	0.2815***
	(-0.18)	(1.24)	(7.06)	(3.63)	(4.54)	(2.74)
Bank fixed effects	No	No	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	No	No	Yes	Yes	Yes	Yes
R-squared			0.7312	0.3401	0.7208	0.1797
Wald exogeneity test (p-value)	0.0000	0.0000				
Observations	18,588	18,588	18,243	18,243	18,588	18,588

Panel B: Small banks

	B1: Federal funds and repos		B2: Large time deposits		B3: Total wholesale funds	
	Spreads on fed funds	*Changes in fed funds*	*Spreads on large time deposits*	*Changes in large time deposits*	*Spreads on wholesale funds*	*Changes in wholesale funds*
	(1) Heckman	(2) Heckman	(3) FE	(4) FE	(5) FE	(6) FE
NPL	0.0464***	-0.0209***	-0.0034	-0.1217***	-0.0010	-0.2085***
	(4.53)	(-2.70)	(-0.82)	(-10.97)	(-0.19)	(-11.44)
CrisisI	0.0093***	0.0012	-0.0010***	0.0023***	-0.0041***	0.0076***
	(5.25)	(0.89)	(-5.05)	(3.83)	(-16.60)	(7.35)
*NPL*CrisisI*	-0.0000	-0.0068	-0.0165***	-0.0382**	-0.0174**	-0.0925***
	(-0.00)	(-0.53)	(-3.09)	(-2.26)	(-2.26)	(-3.40)
CrisisII	0.0183***	-0.0012	0.0139***	0.0122***	0.0116***	0.0172***
	(2.69)	(-0.23)	(61.73)	(13.90)	(45.88)	(9.45)
*NPL*CrisisII*	-0.0265*	0.0039	0.0128***	0.0522***	0.0061	0.0246
	(-1.85)	(0.36)	(2.62)	(3.46)	(0.96)	(1.07)
Postcrisis	0.0131	-0.0009	0.0081***	0.0119***	0.0162***	0.0050
	(1.34)	(-0.12)	(13.68)	(4.09)	(26.19)	(0.69)
*NPL*Postcrisis*	-0.0130	-0.0018	-0.0058	0.0707***	0.0075	0.0574***
	(-1.16)	(-0.22)	(-1.31)	(6.26)	(1.22)	(3.01)
Log total assets	-0.0024***	0.0001	0.0011***	-0.0100***	-0.0014***	-0.0170***
	(-5.74)	(0.17)	(6.22)	(-18.94)	(-5.91)	(-17.16)
Return on assets	-0.0020	-0.0362***	-0.0329***	0.0956***	-0.0141**	0.0681**
	(-0.14)	(-3.35)	(-7.42)	(6.04)	(-2.26)	(2.32)
Capital ratios	0.0025	0.0054**	0.0003	0.0925***	0.0091***	0.2058***
	(0.83)	(2.35)	(0.19)	(17.99)	(3.75)	(21.57)
Weighted HHI	-0.0051***	0.0002	0.0014	-0.0025	-0.0054**	-0.0044
	(-3.88)	(0.19)	(0.81)	(-0.63)	(-2.12)	(-0.66)
Weighted income growth	0.0023	0.0136***	0.0029**	0.0025	0.0135***	-0.0100*
	(0.62)	(4.79)	(2.42)	(0.72)	(8.41)	(-1.74)
M2/GDP	-0.0160	-0.0023	-0.0982***	-0.0930***	-0.0949***	-0.0292
	(-0.19)	(-0.04)	(-19.54)	(-3.61)	(-19.16)	(-0.45)
TARP amounts	0.0187*	0.0049	-0.0219***	-0.0421***	0.0112	-0.0961***
	(1.95)	(0.68)	(-4.04)	(-3.27)	(1.29)	(-4.08)
ΔCredits	0.0025***	0.0023***	-0.0004***	0.0138***	-0.0029***	0.0190***
	(3.52)	(4.25)	(-2.75)	(12.79)	(-14.41)	(9.83)
Lambda	0.0001	0.0024***				
	(0.11)	(3.01)				
Constant	0.0192	-0.0006	0.0562***	0.0911***	0.0610***	0.0880***
	(0.45)	(-0.02)	(19.52)	(6.71)	(19.45)	(2.65)
Bank fixed effects	No	No	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	No	No	Yes	Yes	Yes	Yes
R-squared			0.7920	0.3658	0.7729	0.2333
Wald exogeneity test (p-value)	0.0000	0.0000				
Observations	158,362	158,362	155,989	155,989	158,362	158,362

Table 6 Robustness Tests: Market Risk - Recessions at the MSA Level

This table presents robustness tests for the effect of bank risk on the price and quantity of wholesale funding using recession periods at the MSA level as an alternative proxy for market-wide liquidity risk. *Recession_MSA* is a quarterly dummy variable for the recession period at the MSA level; the value is 1 when a bank operates in the MSA which experiences the decline in real GDP for two consecutive quarters. *Crisis I*, *Crisis II*, and *Postcrisis* are respectively defined as periods 2007:Q3 through 2008:Q2, 2008:Q3 through 2009:Q2, and 2009:Q3 through 2012:Q4. Models (1) and (2) report the second stage estimates of the Heckman procedure. Detailed information on variables is provided in Table 1. Robust standard errors are clustered by bank to control for heteroskedasticity and within-bank serial correlations. T-statistics are in parentheses. ∗∗∗, ∗∗, and ∗ represent significance at the 1%, 5%, and 10% levels, respectively.

	Panel A: Federal funds and repos		Panel B: Large time deposits		Panel C: Total wholesale funds	
	Spreads on fed funds	*Changes in fed funds*	*Spreads on large time deposits*	*Changes in large time deposits*	*Spreads on wholesale funds*	*Changes in Wholesale funds*
	(1) Heckman	(2) Heckman	(3) FE	(4) FE	(5) FE	(6) FE
NPL	0.0255***	-0.0226***	-0.0036	-0.1223***	-0.0036	-0.2124***
	(2.92)	(-3.12)	(-0.87)	(-11.40)	(-0.68)	(-12.17)
Recession_MSA	-0.0000	-0.0000	-0.0003***	-0.0003	-0.0007***	-0.0001
	(-0.11)	(-0.05)	(-3.11)	(-1.33)	(-5.01)	(-0.20)
*NPL*Recession_MSA*	0.0051	-0.0093	0.0078***	0.0154*	0.0058	-0.0100
	(0.66)	(-1.47)	(2.98)	(1.89)	(1.61)	(-0.73)
CrisisI	0.0095***	0.0016	0.0151***	0.0037***	0.0141***	0.0136***
	(6.79)	(1.35)	(121.22)	(5.43)	(91.23)	(12.44)
*NPL*CrisisI*	-0.0029	-0.0059	-0.0168***	-0.0363**	-0.0179**	-0.0930***
	(-0.19)	(-0.47)	(-3.16)	(-2.22)	(-2.34)	(-3.47)
CrisisII	0.0163***	0.0014	0.0301***	0.0136***	0.0295***	0.0225***
	(3.09)	(0.31)	(149.04)	(13.79)	(126.44)	(11.29)
*NPL*CrisisII*	-0.0262**	0.0073	0.0107**	0.0391***	0.0071	0.0265
	(-2.03)	(0.68)	(2.17)	(2.64)	(1.10)	(1.16)
Postcrisis	0.0108	0.0025	0.0244***	0.0120***	0.0340***	0.0084
	(1.42)	(0.40)	(42.01)	(4.16)	(55.26)	(1.17)
*NPL*Postcrisis*	-0.0154	0.0017	-0.0065	0.0687***	0.0094	0.0585***
	(-1.60)	(0.21)	(-1.46)	(6.35)	(1.56)	(3.25)
Log total assets	0.0010***	0.0006***	0.0009***	-0.0091***	-0.0011***	-0.0156***
	(6.97)	(4.81)	(5.74)	(-18.41)	(-5.30)	(-16.70)
Return on assets	-0.0339***	-0.0039	-0.0304***	0.0950***	-0.0170***	0.0803***
	(-2.86)	(-0.40)	(-7.09)	(6.48)	(-2.85)	(2.92)
Capital ratios	-0.0107***	0.0029	-0.0020	0.0868***	0.0091***	0.1950***
	(-4.58)	(1.54)	(-1.33)	(18.31)	(3.97)	(21.53)
Weighted HHI	-0.0056***	0.0002	0.0014	-0.0019	-0.0060**	-0.0025
	(-5.80)	(0.26)	(0.83)	(-0.52)	(-2.56)	(-0.40)
Weighted income growth	0.0005	0.0117***	0.0025**	0.0026	0.0128***	-0.0092
	(0.15)	(4.32)	(2.13)	(0.78)	(8.14)	(-1.63)
M2/GDP	-0.0112	-0.0363	-0.1001***	-0.0830***	-0.0919***	-0.0148
	(-0.17)	(-0.66)	(-21.05)	(-3.40)	(-19.75)	(-0.24)
TARP amounts	0.0248***	0.0002	-0.0266***	-0.0257**	0.0020	-0.0964***
	(3.50)	(0.03)	(-5.58)	(-2.39)	(0.25)	(-4.50)
ΔCredits	0.0018***	0.0021***	-0.0003*	0.0123***	-0.0025***	0.0175***
	(3.24)	(4.58)	(-1.84)	(12.60)	(-13.56)	(9.76)
Lambda	0.0077***	0.0034***				
	(14.66)	(8.00)				
Constant	-0.0065	0.0130	0.0422***	0.0831***	0.0406***	0.0733**
	(-0.20)	(0.47)	(15.50)	(6.50)	(13.84)	(2.32)
Bank fixed effects	No	No	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	No	No	Yes	Yes	Yes	Yes
R-squared			0.7861	0.3608	0.7663	0.2232
Wald exogeneity test (p-value)	0.0000	0.0000				
Observations	176,950	176,950	174,232	174,232	176,950	176,950

Table 7 Robustness Tests: Market Risk -TED Spread

This table presents robustness tests for the effect of bank risk on the price and quantity of wholesale funding using the TED spread as an alternative proxy for market-wide liquidity risk. TED spread is the spread between 3-Month LIBOR based on US dollars and 3-Month Treasury bill. Models (1) and (2) report the second stage estimates of the Heckman procedure. Detailed information on variables is provided in Table 1. Robust standard errors are clustered by bank to control for heteroskedasticity and within-bank serial correlations. T-statistics are in parentheses. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

	Panel A: Federal funds and repos		Panel B: Large time deposits		Panel C: Total wholesale funds	
	Spreads on fed funds	*Changes in fed funds*	*Spreads on large time deposits*	*Changes in large time deposits*	*Spreads on wholesale funds*	*Changes in Wholesale funds*
	(1) Heckman	(2) Heckman	(3) FE	(4) FE	(5) FE	(6) FE
NPL	0.0171***	-0.0225***	-0.0043**	-0.0652***	0.0079***	-0.1620***
	(3.30)	(-5.28)	(-2.17)	(-11.83)	(2.75)	(-16.20)
TED spread	0.0098	0.0145	-0.0452***	0.0030	0.0034	-0.0991***
	(0.23)	(0.41)	(-80.37)	(0.19)	(1.58)	(-2.68)
*NPL*TED spread*	-0.0069	-0.0022	0.0028	-0.0123	-0.0092***	-0.0357***
	(-1.06)	(-0.39)	(1.34)	(-1.61)	(-3.03)	(-2.71)
Log total assets	0.0010***	0.0006***	-0.0001	-0.0093***	-0.0012***	-0.0158***
	(7.00)	(4.79)	(-0.46)	(-18.91)	(-5.59)	(-17.17)
Return on assets	-0.0313***	-0.0033	-0.0018	0.0822***	-0.0185***	0.0696**
	(-2.67)	(-0.35)	(-0.44)	(5.55)	(-3.13)	(2.52)
Capital ratios	-0.0105***	0.0029	-0.0061***	0.0852***	0.0088***	0.1936***
	(-4.50)	(1.53)	(-3.87)	(17.98)	(3.84)	(21.42)
Weighted HHI	-0.0056***	0.0002	-0.0010	-0.0017	-0.0060**	-0.0023
	(-5.78)	(0.21)	(-0.57)	(-0.47)	(-2.58)	(-0.36)
Weighted income growth	0.0001	0.0123***	-0.0233***	0.0035	0.0145***	-0.0079
	(0.03)	(4.69)	(-19.89)	(1.05)	(9.23)	(-1.42)
M2/GDP	0.1365	0.1847	0.0265***	-0.0421	-0.0433	-1.5563***
	(0.21)	(0.34)	(18.91)	(-0.17)	(-1.32)	(-2.74)
TARP amounts	0.0244***	0.0000	-0.0245***	-0.0243**	0.0012	-0.0958***
	(3.44)	(0.00)	(-5.12)	(-2.26)	(0.15)	(-4.46)
ΔCredits	0.0018***	0.0021***	-0.0011***	0.0124***	-0.0025***	0.0176***
	(3.22)	(4.58)	(-6.60)	(12.63)	(-13.45)	(9.81)
Lambda	0.0078***	0.0034***				
	(14.73)	(8.03)				
Constant	-0.0900	-0.1251	0.0112***	0.0709	0.0439**	1.0642***
	(-0.22)	(-0.36)	(8.36)	(0.45)	(2.10)	(2.94)
Bank fixed effects	No	No	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	No	No	Yes	Yes	Yes	Yes
R-squared			0.7539	0.3603	0.7660	0.2229
Wald exogeneity test (p-value)	0.0000	0.0000				
Observations	176,950	176,950	174,232	174,232	176,950	176,950

Table 8 Robustness Tests: Bank Risk - RWA

This table shows robustness tests for the effect of bank risk on the price and quantity of wholesale funding using risk weighted assets (RWA) as an alternative proxy for bank risk. A higher value indicates higher risk of failure. Models (1) and (2) report the second stage estimates of the Heckman procedure. *Crisis I*, *Crisis II*, and *Postcrisis* are respectively defined as periods 2007:Q3 through 2008:Q2, 2008:Q3 through 2009:Q2, and 2009:Q3 through 2012:Q4. Detailed information on variables is provided in Table 1. Robust standard errors are clustered by bank to control for heteroskedasticity and within-bank serial correlations. T-statistics are in parentheses. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

	Panel A: Federal funds and repos		Panel B: Large time deposits		Panel C: Total wholesale funds	
	Spreads on fed funds	*Changes in fed funds*	*Spreads on large time deposits*	*Changes in large time deposits*	*Spreads on wholesale funds*	*Changes in Wholesale funds*
	(1) Heckman	(2) Heckman	(3) FE	(4) FE	(5) FE	(6) FE
RWA	0.0025***	-0.0003	0.0039***	0.0286***	-0.0014*	0.0598***
	(3.60)	(-0.61)	(6.45)	(18.72)	(-1.69)	(20.57)
CrisisI	0.0109***	-0.0015	0.0138***	0.0119***	0.0201***	0.0026
	(5.73)	(-0.95)	(31.40)	(8.16)	(32.92)	(1.07)
*RWA*CrisisI*	-0.0019	0.0037***	0.0015**	-0.0122***	-0.0083***	0.0120***
	(-1.11)	(2.63)	(2.57)	(-6.76)	(-10.28)	(3.84)
CrisisII	0.0217***	0.0086*	0.0291***	0.0085***	0.0330***	0.0117***
	(3.98)	(1.90)	(53.58)	(4.82)	(50.27)	(3.68)
*RWA*CrisisII*	-0.0081***	-0.0097***	0.0013*	0.0057***	-0.0043***	0.0116***
	(-4.36)	(-6.30)	(1.92)	(2.73)	(-5.11)	(3.30)
Postcrisis	0.0133*	0.0026	0.0268***	0.0271***	0.0291***	0.0365***
	(1.74)	(0.41)	(37.25)	(9.03)	(34.65)	(5.00)
*RWA*Postcrisis*	-0.0044***	-0.0002	-0.0042***	-0.0203***	0.0088***	-0.0394***
	(-3.38)	(-0.19)	(-6.26)	(-14.32)	(9.05)	(-15.86)
NPL	0.0138***	-0.0232***	-0.0036**	-0.0606***	0.0005	-0.1559***
	(3.47)	(-7.13)	(-2.20)	(-13.66)	(0.21)	(-19.13)
Log total assets	0.0010***	0.0006***	0.0010***	-0.0089***	-0.0012***	-0.0153***
	(6.93)	(4.65)	(6.30)	(-18.60)	(-5.77)	(-16.88)
Return on assets	-0.0357***	-0.0072	-0.0345***	0.0607***	-0.0155***	0.0160
	(-3.03)	(-0.75)	(-8.11)	(4.10)	(-2.62)	(0.58)
Capital ratios	-0.0104***	0.0032*	-0.0019	0.0864***	0.0092***	0.1945***
	(-4.44)	(1.66)	(-1.22)	(18.56)	(4.03)	(22.11)
Weighted HHI	-0.0057***	0.0002	0.0014	-0.0015	-0.0058**	-0.0021
	(-5.84)	(0.24)	(0.81)	(-0.42)	(-2.52)	(-0.33)
Weighted income growth	-0.0003	0.0116***	0.0033***	0.0070**	0.0133***	0.0019
	(-0.10)	(4.43)	(2.80)	(2.14)	(8.50)	(0.34)
M2/GDP	-0.0075	-0.0351	-0.0964***	-0.0759***	-0.0984***	0.0037
	(-0.11)	(-0.64)	(-20.21)	(-3.10)	(-21.09)	(0.06)
TARP amounts	0.0277***	0.0025	-0.0229***	-0.0061	-0.0084	-0.0480**
	(3.87)	(0.41)	(-4.84)	(-0.56)	(-1.04)	(-2.24)
ΔCredits	0.0018***	0.0022***	-0.0006***	0.0104***	-0.0022***	0.0130***
	(3.25)	(4.80)	(-3.74)	(10.64)	(-11.43)	(7.26)
Lambda	0.0078***	0.0034***				
	(14.66)	(7.81)				
Constant	-0.0101	0.0128	0.0370***	0.0569***	0.0451***	0.0179
	(-0.30)	(0.46)	(13.28)	(4.42)	(14.88)	(0.56)
Bank fixed effects	No	No	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	No	No	Yes	Yes	Yes	Yes
R-squared			0.7866	0.3639	0.7686	0.2298
Wald exogeneity test (p-value)	0.0000	0.0000				
Observations	176,950	176,950	174,232	174,232	176,950	176,950

Table 9 Robustness Tests: Bank Risk -Z-score

This table presents robustness tests for the effect of bank risk on the price and quantity of wholesale funding using the Z-score as an alternative proxy for bank risk. The Z-score is measured as the sum of the return on assets and the equity capital ratio divided by the standard deviation of the return on assets. A higher value indicates lower risk of default. Models (1) and (2) report the second stage estimates of the Heckman procedure. *Crisis I*, *Crisis II*, and *Postcrisis* are respectively defined as periods 2007:Q3 through 2008:Q2, 2008:Q3 through 2009:Q2, and 2009:Q3 through 2012:Q4. Detailed information on variables is provided in Table 1. Robust standard errors are clustered by bank to control for heteroskedasticity and within-bank serial correlations. T-statistics are in parentheses. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

	Panel A: Federal funds and repos		Panel B: Large time deposits		Panel C: Total wholesale funds	
	Spreads on fed funds	*Changes in fed funds*	*Spreads on large time deposits*	*Changes in large time deposits*	*Spreads on wholesale funds*	*Changes in Wholesale funds*
	(1) Heckman	(2) Heckman	(3) FE	(4) FE	(5) FE	(6) FE
Z-score	0.0001	0.0001	-0.0012**	-0.0014	-0.0005	-0.0049**
	(0.11)	(0.09)	(-2.26)	(-1.14)	(-0.67)	(-2.49)
CrisisI	0.0020***	-0.0002	-0.0009***	-0.0003	-0.0059***	0.0063***
	(2.63)	(-0.33)	(-3.81)	(-0.39)	(-18.35)	(4.62)
*Z-score*CrisisI*	0.0033**	-0.0016	0.0002	-0.0007	0.0005	0.0005
	(2.06)	(-1.14)	(0.29)	(-0.38)	(0.60)	(0.18)
CrisisII	0.0114***	-0.0024***	0.0199***	0.0039***	0.0184***	0.0002
	(11.44)	(-2.81)	(64.17)	(4.30)	(48.43)	(0.10)
*Z-score*CrisisII*	0.0038**	0.0027**	0.0005	-0.0009	0.0000	0.0045
	(2.40)	(2.01)	(0.83)	(-0.50)	(0.05)	(1.50)
Postcrisis	0.0093***	-0.0016**	0.0110***	0.0009	0.0179***	0.0020
	(10.75)	(-2.19)	(39.83)	(1.35)	(48.66)	(1.50)
*Z-score*Postcrisis*	0.0015	-0.0002	0.0020***	0.0015	-0.0019**	0.0079***
	(1.43)	(-0.17)	(3.21)	(1.26)	(-2.14)	(3.91)
Log total assets	0.0012***	0.0002	0.0007***	-0.0102***	-0.0013***	-0.0183***
	(7.85)	(1.41)	(3.50)	(-16.01)	(-4.57)	(-15.32)
Return on assets	-0.0058	0.0347***	-0.0231***	0.1193***	-0.0012	0.0886***
	(-0.42)	(2.97)	(-4.66)	(7.04)	(-0.17)	(2.80)
Capital ratios	-0.0177***	0.0036	-0.0059***	0.0649***	0.0063*	0.1760***
	(-6.04)	(1.47)	(-2.63)	(10.52)	(1.83)	(14.44)
Weighted HHI	-0.0041***	0.0005	-0.0012	0.0082*	-0.0071***	0.0102
	(-3.75)	(0.55)	(-0.61)	(1.89)	(-2.61)	(1.41)
Weighted income growth	0.0008	0.0132***	0.0005	0.0019	0.0121***	-0.0123**
	(0.25)	(4.64)	(0.45)	(0.56)	(7.73)	(-2.17)
M2/GDP	-0.0525***	-0.0014	-0.1215***	-0.0059	-0.1164***	-0.0187**
	(-6.51)	(-0.20)	(-71.25)	(-1.37)	(-60.96)	(-1.96)
NPL	0.0321***	-0.0083**	-0.0081***	-0.0612***	0.0013	-0.1624***
	(7.93)	(-2.36)	(-4.27)	(-12.01)	(0.47)	(-18.61)
TARP amounts	0.0271***	-0.0060	-0.0288***	-0.0129	0.0021	-0.1002***
	(3.83)	(-0.98)	(-5.32)	(-1.11)	(0.22)	(-4.23)
ΔCredits	0.0018***	0.0009	-0.0005***	0.0105***	-0.0030***	0.0127***
	(2.79)	(1.53)	(-3.04)	(9.13)	(-13.54)	(6.21)
Lambda	0.0070***	0.0018***				
	(13.22)	(3.99)				
Constant	0.0197***	-0.0011	0.0724***	0.0488***	0.0752***	0.0897***
	(4.44)	(-0.28)	(40.69)	(10.72)	(31.55)	(10.52)
Bank fixed effects	No	No	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	No	No	Yes	Yes	Yes	Yes
R-squared			0.8144	0.3993	0.7921	0.2447
Wald exogeneity test (p-value)	0.0000	0.0000				
Observations	117,001	117,001	115,025	115,025	117,001	117,001

Table 10 Robustness Tests: Government Intervention

This table shows robustness tests for the effect of bank risk on wholesale funding considering government intervention in the form of TARP funds and FHLB loans. The dependent variable, *Changes in wholesale funds*, is the quarterly growth of wholesale funds. Wholesale funds are measured by excluding the amount of subordinated debentures among types of TARP supports or the amount of loans from FHLB. The regression result of *Spreads on wholesale funds* is from column (5) in Table 4 because interest rates on wholesale funds excluding the amount of TARP funds in the form of subordinated debentures or FHLB loans are not reported in income statements. *Crisis I*, *Crisis II*, and *Postcrisis* are respectively defined as periods 2007:Q3 through 2008:Q2, 2008:Q3 through 2009:Q2, and 2009:Q3 through 2012:Q4. Detailed information on variables is provided in Table 1. Robust standard errors are clustered by bank to control for heteroskedasticity and within-bank serial correlations. T-statistics are in parentheses. ∗∗∗, ∗∗, and ∗ represent significance at the 1%, 5%, and 10% levels, respectively.

	Spreads on wholesale funds	*Changes in Wholesale funds*
	(1) FE	(2) FE
NPL	-0.0032	-0.9319***
	(-0.60)	(-11.06)
CrisisI	0.0141***	0.0139***
	(91.76)	(2.58)
*NPL*CrisisI*	-0.0166**	-0.1570
	(-2.19)	(-1.34)
CrisisII	0.0294***	0.0562***
	(128.03)	(3.69)
*NPL*CrisisII*	0.0093	0.2122**
	(1.49)	(2.14)
Postcrisis	0.0341***	-0.0627
	(55.76)	(-1.01)
*NPL*Postcrisis*	0.0101*	0.2775***
	(1.67)	(3.07)
Log total assets	-0.0011***	-0.0639***
	(-5.41)	(-15.59)
Return on assets	-0.0164***	-0.3395**
	(-2.75)	(-2.40)
Capital ratios	0.0090***	0.9712***
	(3.91)	(20.72)
Weighted HHI	-0.0061***	-0.0320
	(-2.59)	(-0.98)
Weighted income growth	0.0147***	-0.0226
	(9.35)	(-0.80)
M2/GDP	-0.0918***	0.5638
	(-19.78)	(1.05)
TARP amounts	0.0013	-0.3909***
	(0.17)	(-4.20)
ΔCredits	-0.0025***	0.0454***
	(-13.54)	(7.22)
Constant	0.0405***	0.0202
	(13.83)	(0.07)
Bank fixed effects	Yes	Yes
Time fixed effects	Yes	Yes
Clustering	Yes	Yes
R-squared	0.7661	0.1612
Observations	176,950	176,950