MANAGING BANK LIQUIDITY RISK: HOW DEPOSIT-LOAN SYNERGIES VARY WITH MARKET CONDITIONS[†]

Preliminary Findings:
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I. Overview

Banks have traditionally provided liquidity on demand, both to borrowers with open lines of credit and loan commitments (we use these terms interchangeably), and to depositors in the form of checking and other transactions accounts. Both contracts allow customers to receive liquidity (cash) on short notice. In fact, the combination of these two products in a single firm constitutes a reasonable working definition of a 'bank'. This liquidity insurance role, however, exposes banks to the risk that they will have insufficient cash to meet random demands from their depositors and borrowers.[1]

While there is a large theoretical literature that attempts to understand banks' role in liquidity production, much less is known about how banks manage liquidity risk in practice. Our research addresses this issue by extending the results in Gatev, Schuermann and Strahan (2004), who study bank risk exposures during the liquidity crisis of the Fall of 1998 when credit spreads across many markets widened dramatically and, for a few weeks, the U.S. commercial paper market ceased to function. Our research extends the earlier work by testing how bank liquidity risk varies systematically with business and market conditions. We are particularly interested in the extent to which a bank's transactions deposit base may help mitigate the liquidity exposure stemming from loan commitments and unused credit lines.

II. Background and previous research

To the extent that liquidity demands are independent across customers, a bank can use scale-related diversification to mitigate its need to hold cash to meet unexpected

[1] Liquidity risk has been used to justify government deposit insurance (e.g. Diamond and Dybvig, 1983).

liquidity demands from its depositors and borrowers.[2] Kashyap, Rajan and Stein (2002) present a model based on this notion, in which a risk-management motive explains the combination of transactions deposits and loan commitments. They argue that as long as the demand for liquidity from depositors through the checking account is not highly correlated with liquidity demands from borrowers, an intermediary will be able to reduce its need to hold cash by serving both customers. Thus, their model yields a diversification synergy between transactions deposits and unused loan commitments. This synergy helps explain the basic structure of banks. As evidence, they show that banks offering more transaction deposits tend also to make more loan commitments. Another way of framing their idea is that transactions deposits act as a hedge against the liquidity risk stemming from issuing loan commitments and lines of credit.

Our previous work extends Kashyap et al. (KRS) by considering the possibility that liquidity production could exposes banks to a systematic risk. A bank with many open credit lines, for example, may face a problem if, rather than facing just idiosyncratic demands for cash, it sometimes faces increased demand for liquidity by many borrowers simultaneously. For example, during the first week of October 1998, following the coordinated restructuring of the hedge fund Long Term Capital Management (LTCM), spreads between safe Treasury securities and risky commercial paper rose dramatically. Many large firms were consequently unable to roll over their commercial paper as it came due, leading to a sharp reduction in the amount of commercial paper outstanding and a corresponding increase in take-downs on pre-existing lines of credit (Saidenberg and Strahan, 1999). As a result of this market pullback, banks faced a systematic spike in

[2] In a world with taxes, financial distress, or agency costs, holding cash or other liquid assets is costly for banks and other firms (e.g. Myers and Rajan, 1998).

demand for cash as many of their largest customers drew funds from pre-existing backup lines of credit. Gatev and Strahan (2003) show, however, that funding supply to banks increases as the availability of market liquidity declines. Thus, banks were able to weather the 1998 storm because deposit funding flowed in just as it was needed by borrowers.

In Gatev, Schuermann and Strahan (2004), we focus on the behavior of bank stocks during the 1998 crisis, which began with the Russian Default in the middle of August. During the subsequent three-months, bank stock prices where buffeted by news of the Russian crisis, followed by the demise of the hedge fund LTCM in late September, and finally by the drying up of the commercial paper market in the first week of October. Figure 1 shows that bank stock volatility (measured as the conditional volatility from a EGARCH (1,1) model) reflected those events, and highlights the difference between bank risk exposures in different business conditions. During the crisis, bank stock volatility was higher than overall general market volatility, while it was lower in the "normal" pre-crisis period.[3] In our earlier paper we then focus on explaining the *cross-section* of banks' stock return volatility. We show that during the 1998 crisis, banks with more unused loan commitments had higher equity risk, but that this risk was offset by high levels of transactions deposits.

The current project extends this idea to a much broader set of market conditions. We examine how bank liquidity risk exposure varies with market conditions such as the level of credit spreads in the commercial paper market, and we test more rigorously

[3] Both Gatev and Strahan (2003) and Gatev, Schuermann, and Strahan (2004) are currently unpublished. The first paper is forthcoming at the *Journal of Finance*, while the second is forthcoming in an NBER book.

whether or not bank transactions deposits help them hedge liquidity risk. For example, do bank stocks become systematically more volatile when market liquidity dries up (e.g., when the commercial paper spread changes, or when asset prices fall sharply)? And, most important, are those banks funded more with transactions deposit less affected by variation in market liquidity than other banks?

III. Empirical design

To build our sample, we start with the largest 100 domestic banks (based on market capital) at the beginning of 1990.[4] We then drop all banks that engaged in a merger or acquisition during 1990, leaving us with 85 banks. We then construct the weekly conditional volatility for stock returns for these banks during 1990. Using daily returns, we fit a GARCH(1,1) model for each bank, and then aggregate up daily volatilities to weekly frequency. For our purposes, a week begins on Wednesday as this is the weekday with the fewest public holidays which might close the markets. We then repeat this process for every year between 1991 and 2002. Note that it is important to drop both acquirers and targets around M&A announcements because speculation about such deals generates a large amount of stock price volatility having nothing to do with the basic risks banks face (market, credit, liquidity, etc.). So, for example, we drop both JP Morgan and Chase during the year of their merger, but these two banks are included in the years prior to that merger. As a result the maximum number of banks in any year is 98 (2002), and the minimum is 68 (1996). The sample-generating procedure leaves us with a 171 banks, and over 50,000 bank-week observations overall.

[4] We begin in 1990 because that is the first year when unused retail loan commitments are available which we shall control for as a robustness check. Prior to 1990 only total commitments are reported.

Table 1 reports the mean level of the conditional volatilities (annualized standard deviation of stock returns). We split the data into four cells, based on the level of the ratio of transactions deposits to total deposits and the level of unused loan commitments to total commitments plus total loans (our measure of liquidity-risk exposure). This admittedly simple table illustrates the main hedging idea of our research: banks with high levels of transactions deposits have low risk, *regardless of their liquidity exposure.* Note that in both cells, banks with high levels of deposits have an average conditional volatility of 28%. For banks with low levels of transactions deposits, however, increased liquidity exposure comes with higher stock-return volatility: 34% average conditional volatility for high liquidity exposure versus 30% for low exposure banks. The deposit base therefore seems to act as a natural hedge against liquidity exposure.

To demonstrate this first result more formally, we model the conditional volatility as a function of bank liquidity exposure, deposits, and other market and bank-level characteristics in the following structure:

$$\sigma_{it} = \alpha + \beta_1 LoanCommitments_{t\text{-}1,i} + \beta_2 DepositBase_{t\text{-}1,i} + \beta_3 (LoanCommitments_{t\text{-}1,i} * DepositBase_{t\text{-}1,i}) + OtherControls + \varepsilon_{i,t}, \quad (1)$$

where σ_{it} is the conditional stock-return volatility for bank i at time t; $LoanCommitments_{t\text{-}1,i}$ is the ratio of unused loan commitments to commitments plus loans (measured in the previous quarter); and, $DepositBase_{t\text{-}1,i}$ is the ratio of transactions deposits to total deposits (again, from the prior quarter). If deposits hedge liquidity risk, as suggested by Table 1, then $\beta_3 < 0$.

As time-varying controls in the regression, we include the contemporaneous stock return volatility for the S&P 500 as a whole, estimated with a GARCH(1,1) model in the same fashion as the bank specific volatilities; the three-month T-bill rate; and the spread between the high-grade three-month commercial paper rate and the three-month T-bill rate. To be consistent with the conditional volatilities, the interest rate data are taken for the Wednesday of a given week. For bank-level controls, we include the following: the log of assets, the ratio of cash plus securities to total assets, the ratio of capital to assets, and the ratio of Fed Funds purchased to assets. We also use a second loan commitment variable as a robustness test that removes retail commitments (e.g. credit card lines) from both the numerator and the denominator. Unused retail commitments may be less likely to expose banks to risk relative to business-loan commitments, where take-down demand is both less predictable and more likely to have a systematic component such as the one observed in the fall of 1998.

Data on unused commitments, transactions deposits, as well as the other bank characteristics, come from the most recent quarter of the *Reports of Income and Condition* ('call reports') prior to the time at which we measure the stock return variability. So for example, all weeks in 1990Q2 are matched to call report data for 1990Q1. Stock return data come from the *Center for Research in Securities Prices* (CRSP). Data on interest rates are available daily from the Federal Reserve Board of Governors. Note that since the regulatory data is available only quarterly, it remains unchanged for all weeks within a given quarter.

Table 2 reports the summary statistics for all of the variables reported in the regressions. Bank-stock volatility averages about 30% percent per year, well above the

16% for the S&P 500 index. We would expect, of course, index volatility to be lower due to portfolio effects. In our sample the mean loan commitments ratio is about 0.33 and the mean level of transactions deposits to total deposits equals 0.26. We have constructed our variables to lie between zero and one, or in the case of assets we have logged the variable. Hence, there is no concern about outliers driving the results.

IV. Preliminary Results

Tables 3-5 report our preliminary findings. In Table 3, we report the regressions from equation (1) above using all of our data. Note that we have a very large sample (almost 50,000 bank-week observations), but we cluster the data by bank to avoid assuming independence over time for each bank. This clustering raises the standard errors by a factor of about 10 relative to the OLS standard errors.[5]

The main result in Table 3 supports the idea that loan commitment risk (liquidity risk) can be hedged with transactions deposits. The coefficient on the interaction term (β_3) is negative and highly significant. For a bank with transactions deposits at the 25th percentile of the distribution (0.19), the coefficients suggest that loan commitments expose banks to risk. For such a bank, a one standard deviation increase in the loan commitment ratio would come with an increase in stock-return volatility of 5.2 percentage points (relative to a sample standard deviation of about 13 percentage points). For a bank with transaction deposits at the 75th percentile, however, the same increase in loan commitments comes with an increase in stock-return volatility of just 2.2 percentage

[5] The regressions work similarly to using the 'between' estimator – that is, where the regressions use bank-level means, and coefficients are driven by pure cross-sectional variation.

points, and for banks with deposits at the 90th percentile there is almost no increase in volatility.

Table 4 sharpens this result and ties it more closely to liquidity risk. Here, we compare the model coefficients from 'normal' market conditions with the coefficients estimated when market liquidity becomes scarce. Following our earlier work, we use the spread between commercial paper rates and T-bill rates to measure market liquidity. We then separate periods when this paper-bill spread is above 75 basis points (the 95th percentile of its distribution) from other periods. By comparison, recall from Table 2 that the average CP spread over the sample period is about 40 basis points. Our earlier results suggested that transactions deposits acted as an especially powerful hedge during the 1998 LTCM crisis. These regressions test this idea out more formally and more systematically.

The results in Table 4 indicate that transactions deposits do in fact act as a more powerful hedge when CP rates are unusually high. When the commercial paper spread is above 75 basis points, there is a stronger positive link from loan commitments to risk (the linear coefficient on loan commitments rises from 0.28 to 0.34), and also a greater hedge associated with deposit (the interaction effect nearly doubles, from -0.63 to -1.16). Note also that the direct effect of the CP spread on bank risk is much greater during period of scarce market liquidity such as what occurred in the Fall of 1998. Indeed it is insignificant during tranquil, liquid times. We also find similar results using the alternative measure of loan commitments.

Table 5 repeats these regressions, but replaces the time-varying variables (S&P 500 volatility, the level of interest rates, and the spread) with a full set of time indicator

variables (i.e. a separate intercept for each week). The market-level variables are not identified in this model because the time effects sweep out all common shocks to bank-stock volatility. The advantage of this approach is that time effects remove any missing common factors that may move bank-stock volatility around, such as changes in regulations.[6] The effects of interest, however, remain robust in these specifications. In fact, the coefficients on the deposit and loan commitment variables are very close to those reported in Table 4.

V. Conclusions and Extensions

Our research demonstrates the potential for deposits to reduce liquidity exposure at banks. The results are particularly striking to us because they reverse the standard notion of liquidity risk at banks, where runs from depositors had been seen as the cause of trouble (e.g Diamond and Dybvig, 1983). Today, with safety nets protecting banks, they are viewed as safe havens for funds, and investors seem to move money into deposits during periods of market turmoil. These funding flows thereby allowing banks to supply credit when markets can't or won't.

In continuing this research program, we plan to investigate in more detail whether certain types of transactions deposits (e.g. demand deposits) matter most in hedging liquidity risk and whether this deposit-lending synergy varies by bank type (e.g. larger v. smaller banks; banks with high v. low levels of liquid assets). In addition, we will test for the robustness of our results to different volatility models, such as the EGARCH (1,1) to incorporate leverage effects.

[6] For example, passage of the Financial Modernization Act in 1999 may have increase bank stock return volatility temporarily by increasing speculation about merger activity among financial companies.

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Figure 1 Panel A
Banks Price Index May 14 - Nov 17,1998

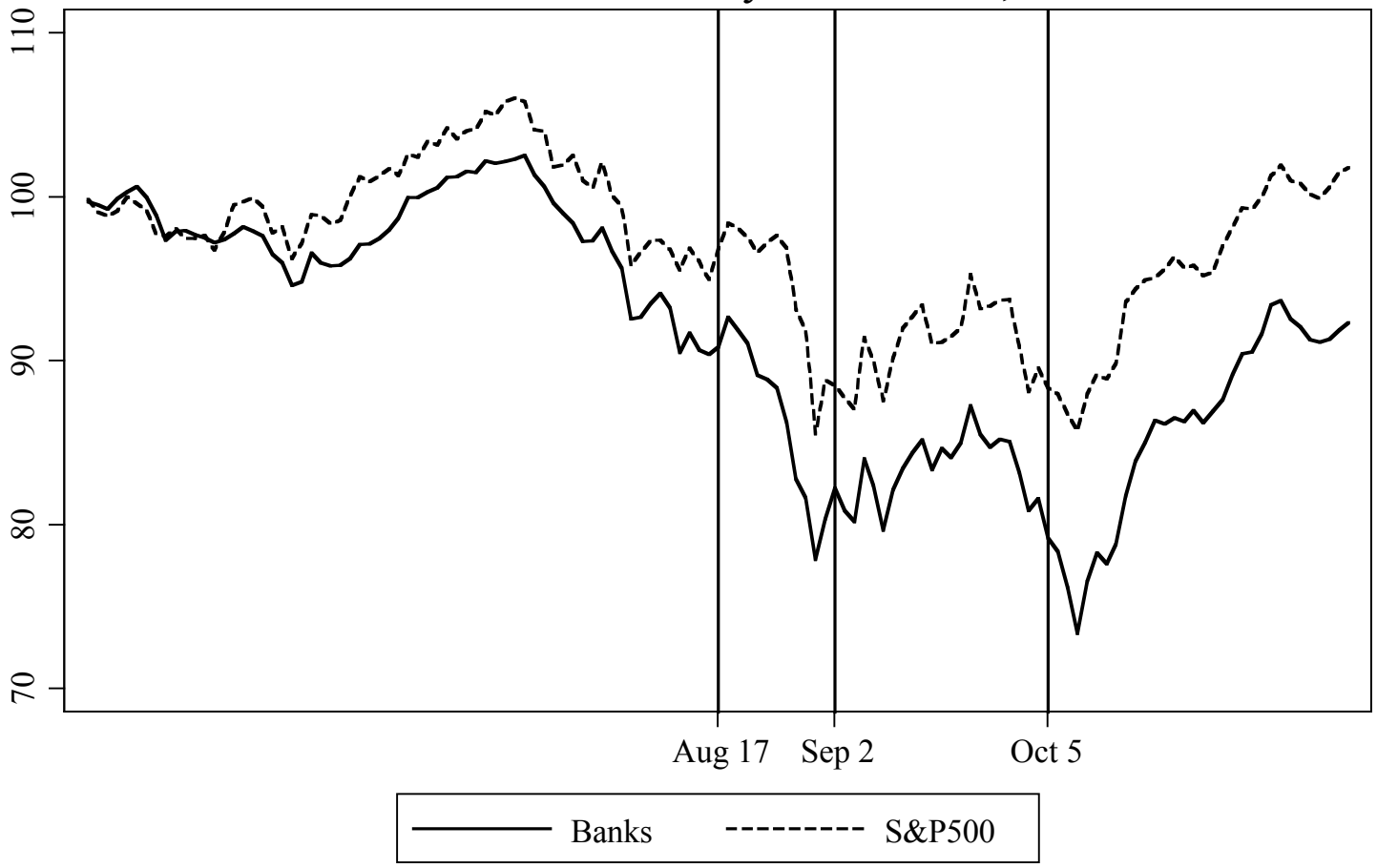

Figure 1 Panel B
Banks Conditional Volatility May 14 - Nov 17, 1998

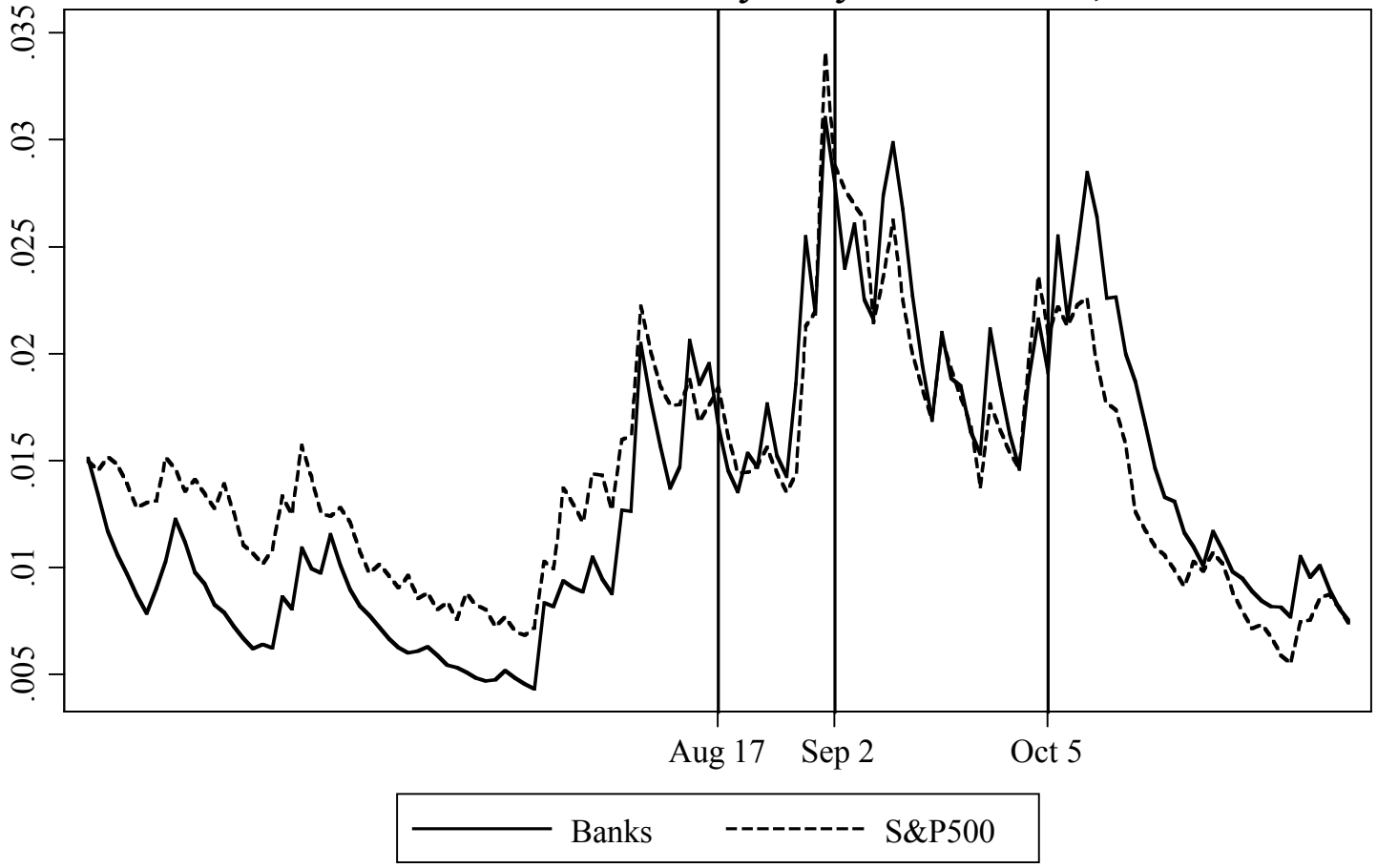

Table 1: Mean (Standard Deviation) for Bank-Stock Conditional Return Volatility

	Transactions Deposits / Total Deposits:	
	Above Median	Below Median
Unused Commitments / (Commitments + Loans)	(1)	(2)
Above Median	0.282	0.346
	(0.12)	(0.14)
Below Median	0.285	0.301
	(0.12)	(0.12)
Difference in Means	-0.003	0.045
T-Stat[1]	(1.58)	(26.51)

[1]This is a simple T-test in which, under the null hypothesis, data in each column are i.i.d.

Table 2: Summary Statistics for Variables Included in Regression Models

	Mean	Standard Deviation
Dependent Variable	(1)	(2)
Bank-Stock Return Volatility (Annualized Return Standard Deviation)	0.30	0.13
Commitments and Deposits		
Commitments / (Commitments + Loans)	0.33	0.15
(Commitments-Retail Commitments) / (Commitments-Retail Commitments) + Loans))	0.24	0.13
Transactions Deposits / Total Deposits	0.26	0.11
Controls for Market Conditions		
Volatility of S&P 500 (Annualized Return Standard Deviation)	0.16	0.06
Commercial Paper - T-Bill Yield Spread (% pts)	0.40	0.21
Yield on Three-Month Treasury Bill (% pts)	4.52	1.55
Controls for Bank Characteristics		
Log of Bank Assets[1]	16.44	1.33
(Cash + Securities) / Assets	0.25	0.14
Fed Funds Purchased / Assets	0.08	0.06
Equity / Assets	0.05	0.05

[1]This translates into $13.8 billion in assets.

Table 3: Regressions of Bank Stock Return Volatility on Liquidity Exposure and Transaction Deposits Ratio

	Dependent Variable: Weekly Bank Stock Return Volatility	
Unused Commitments and Deposits	(1)	(2)
Commitments / (Commitments + Loans)	0.284	-
	(0.051)***	-
(Commitments-Retail Commitments) /	-	0.401
(Commitments-Retail Commitments) + Loans))	-	(0.094)***
Transactions Deposits / Total Deposits	0.237	0.179
	(0.078)***	(0.103)*
Commitments / (Commitments + Loans) *	-0.653	-
Transactions Deposits / Total Deposits	(0.174)***	-
(Commitments-RC) / (Commitments-RC+Loans) *	-	-0.772
Transactions Deposits / Total Deposits	-	(0.286)***
Controls for Market Conditions		
Volatility of S&P 500[1]	1.021	0.969
	(0.043)***	(0.041)***
Paper-Bill Spread	0.043	0.050
	(0.008)***	(0.008)***
Yield on Three-Month Treasury Bill	0.011	0.011
	(0.001)***	(0.001)***
Controls for Bank Characteristics		
Log of Bank Assets	-0.002	-0.006
	(0.003)	(0.004)
(Cash + Securities) / Assets	-0.065	-0.091
	(0.030)**	(0.029)***
Fed Funds Purchased / Assets	0.095	0.022
	(0.075)	(0.075)
Equity / Assets	-0.165	-0.178
	(0.087)*	(0.088)**
Observations	49,994	49,994
Number of Independent Clusters (banks)	171	171
R-squared	0.2763	0.2760

Robust standard errors in parentheses, clustered by bank. All regressions include an intercept.
* significant at 10%; ** significant at 5%; *** significant at 1%

[1]Note that the coefficient is not statistically different from one.

Table 4: Regressions of Bank Stock Return Volatility on Liquidity Exposure and Transaction Deposits Ratio during High and Low Paper-Bill Spread Market Conditions

	Dependent Variable: Weekly Bank Stock Return Volatility			
	Spread < 75 Basis Points		Spread >= 75 Basis Points	
Unused Commitments and Deposits	(1)	(2)	(3)	(4)
Commitments / (Commitments + Loans)	0.282	-	0.338	-
	(0.049)***	-	(0.060)***	-
(Commitments-Retail Commitments) /	-	0.391	-	0.468
(Commitments-Retail Commitments) + Loans))	-	(0.094)***	-	(0.134)***
Transactions Deposits / Total Deposits	0.236	0.178	0.451	0.302
	(0.078)***	(0.103)*	(0.117)***	(0.131)**
Commitments / (Commitments + Loans) *	-0.633	-	-1.164	-
Transactions Deposits / Total Deposits	(0.171)***	-	(0.257)***	-
(Commitments-RC) / (Commitments-RC+Loans) *	-	-0.745	-	-1.174
Transactions Deposits / Total Deposits	-	(0.286)***	-	(0.408)***
Controls for Market Conditions				
Volatility of S&P 500[1]	0.961	0.912	1.487	1.475
	(0.042)***	(0.040)***	(0.089)***	(0.088)***
Paper-Bill Spread	-0.002	0.012	0.087	0.081
	(0.010)	(0.011)	(0.014)***	(0.014)***
Yield on Three-Month Treasury Bill	0.013	0.013	0.040	0.034
	(0.002)***	(0.002)***	(0.009)***	(0.010)***
Controls for Bank Characteristics				
Log of Bank Assets	-0.003	-0.007	0.023	0.015
	(0.003)	(0.004)*	(0.008)***	(0.008)*
(Cash + Securities) / Assets	-0.058	-0.083	-0.006	-0.042
	(0.030)*	(0.028)***	(0.063)	(0.067)
Fed Funds Purchased / Assets	0.094	0.020	0.006	-0.055
	(0.073)	(0.074)	(0.156)	(0.153)
Equity / Assets	-0.091	-0.111	-0.340	-0.454
	(0.082)	(0.085)	(0.237)	(0.243)*
Observations	47,288	47,288	2,706	2,706
Number of Independent Clusters (banks)	171	171	155	155
R-squared	0.2556	0.2538	0.2383	0.2340

Robust standard errors in parentheses, clustered by bank. All regressions include an intercept.
* significant at 10%; ** significant at 5%; *** significant at 1%

[1]Note that in columns (1) and (2) the coefficient is not statistically different from one.

Table 5: Regressions of Bank Stock Return Volatility on Liquidity Exposure and Transaction Deposits Ration during High and Low Paper-Bill Spread Market Conditions
With Week Effects Included[1]

	Dependent Variable: Weekly Bank Stock Return Volatility			
	Spread < 75 Basis Points		Spread >= 75 Basis Points	
Unused Commitments and Deposits	(1)	(2)	(3)	(4)
Commitments / (Commitments + Loans)	0.253	-	0.286	-
	(0.032)***	-	(0.049)***	-
(Commitments-Retail Commitments) /	-	0.298	-	0.350
(Commitments-Retail Commitments) + Loans))	-	(0.090)***	-	(0.120)***
Transactions Deposits / Total Deposits	0.268	0.185	0.394	0.248
	(0.055)***	(0.091)**	(0.102)***	(0.117)**
Commitments / (Commitments + Loans) *	-0.615	-	-1.052	-
Transactions Deposits / Total Deposits	(0.116)***	-	(0.237)***	-
(Commitments-RC) / (Commitments-RC+Loans) *	-	-0.614	-	-0.924
Transactions Deposits / Total Deposits	-	(0.255)**	-	(0.376)**
Controls for Bank Characteristics				
Log of Bank Assets	-0.000	-0.003	0.022	0.017
	(0.003)	(0.004)	(0.008)***	(0.008)**
(Cash + Securities) / Assets	0.066	0.036	0.106	0.058
	(0.036)*	(0.038)	(0.087)	(0.090)
Fed Funds Purchased / Assets	-0.016	-0.070	-0.071	-0.111
	(0.074)	(0.076)	(0.164)	(0.160)
Equity / Assets	0.055	-0.124	0.354	0.039
	(0.235)	(0.254)	(0.492)	(0.486)
Observations	47,288	47,288	2,874	2,874
Number of Independent Clusters (banks)	171	171	155	155
R-squared (within)	0.0777	0.0582	0.0626	0.0547

Robust standard errors in parentheses, clustered by bank
* significant at 10%; ** significant at 5%; *** significant at 1%

[1]The week effects fully control for market conditions, as well as any other cycles or trends in the data.