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International Banking and Liquidity Risk Transmission: Evidence from the United States

RICARDO CORREA, LINDA S. GOLDBERG, and TARA RICE*

The balance sheet structure of U.S. banks influences how they respond to liquidity risks. We find the responses differ in fundamental ways across banks without foreign affiliates vs. those with foreign affiliates. Among banks without foreign affiliates, cross-sectional differences in response to liquidity risk depend on the banks' shares of core deposit funding, Tier 1 capital, and outstanding credit commitments. Among banks with foreign affiliates, the global banks, liquidity management strategies as reflected in internal borrowing and lending across the global organization matter. This intrabank borrowing serves as a shock absorber and affects lending growth to domestic and foreign customers. Across all banks, the use of official sector emergency liquidity facilities tends to reduce the importance of ex ante differences in balance sheets as drivers of cross-sectional differences in lending in response to market liquidity risks. [JEL G21, G01, F42]
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*Ricardo Correa is the Chief of the International Financial Stability Section at the Federal Reserve Board. Linda Goldberg is Vice President of Financial Intermediation at the Federal Reserve Bank of New York. Tara Rice is in the Division of International Finance at the Federal Reserve Board. The authors thank Jason Goldrosen for excellent research assistance and thank anonymous referees, Claudia Buch, Ben Craig, Pierre-Olivier Gourinchas, Katheryn Russ, Charles Thomas, participants at the International Banking Research Network workshops in Potsdam and Paris, seminar participants at the U.S. Treasury and at the Financial Stability Group Seminar in Lima, Peru for thoughtful suggestions. The views expressed in this paper are solely those of the authors and should not be interpreted as reflecting the view of the Board of Governors, Federal Reserve Bank of New York, or the staff of the Federal Reserve System.

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The recent financial crisis underscored the importance of understanding how market liquidity conditions influence bank lending to domestic and foreign customers. As part of a larger initiative of the International Banking Research Network described in Buch and Goldberg (2015), this paper examines the domestic and international lending responses to liquidity risks across different types of large U.S. banks before, during, and after the global financial crisis. These banks are economically important both in the United States and in other countries.

The sensitivity of U.S. banks' activities to liquidity conditions has been the focus of several strands of the literature that have studied both the bank lending channel of monetary policy and the liquidity risks faced by banks during periods of financial stress. These studies have found that small U.S. banks have relatively strong lending responses to liquidity risks compared with large banks (Kashyap and Stein, 2000; Cornett and others, 2011: hereafter CMST). Research also has documented differences both across small and large U.S. banks in the ex ante balance sheet compositions that influence the cross-sectional lending response (CMST). For example, if a bank has stable deposit funding or maintains more liquid assets on its balance sheet, its lending might be less affected by aggregate liquidity shocks, all else equal.

Even exclusively within the group of large U.S. banks, we expect the links between liquidity risk and banks' lending activities to warrant additional consideration for (at least) three reasons. First, banks have distinct channels through which they may adjust their balance sheets in response to liquidity strains. The distinctions could be particularly acute between U.S. banks that are domestically oriented and those that are more internationally oriented. Banks with more lending to foreign markets could potentially shift the burden of their balance sheet adjustment to external clients. Second, banks with foreign affiliates, often referred to as global banks, also can actively move funds across their organizations in line with their business priorities. In this centralized liquidity management arrangement, liquidity conditions changes can lead to funding reallocations whereby there is an offset of the effects on core business areas, with the potential effect of insulating lending in their home markets (Cetorelli and Goldberg, 2012a) and in those foreign markets which are prioritized (Cetorelli and Goldberg, 2012c). Third, banks' balance sheet adjustments due to liquidity risk can differ between times of normal market functioning and those of high stress. The mechanisms for adjustment and the role of balance sheet constraints may differ in part because of the availability of official sector liquidity facilities and bank willingness to use these facilities in periods of aggregate liquidity stress. Access to central bank liquidity facilities priced at terms below private market rates might relax some constraints normally imposed by the composition of banks' balance sheets on their access to external funding. The result is a temporary shift or weakening of the relationship between ex ante balance sheet characteristics and the banks' lending (Buch and Goldberg, 2015).

All these points are addressed in the analysis of the present paper on the experiences of U.S. banks. We confirm that elevated levels of liquidity risk matter for lending growth across large U.S. banks (as in CMST) and highlight the balance sheet characteristics that appeared important in prior studies. We find that when the domestic and foreign recipients of loans are distinguished, the empirical

specifications only have substantial predictive power for domestic lending and credit extension. Patterns of foreign lending growth are not well explained. When we make the distinction between large banks according to whether or not the banks are global (have foreign affiliates), we find distinct mechanisms for liquidity risk adjustment through the ex ante balance sheet characteristics and types of lending specifically available to global banks.

For large and nonglobal banks, the key balance sheet characteristics that explain cross-sectional differences in loan growth during periods of low liquidity stress are the share of core deposits in bank funding, the scale of ex ante credit commitments, and the share of risk-weighted assets financed with Tier 1 capital, confirming the pattern of results documented by CMST for large banks. By contrast, in the sample of large and global banks, a more limited and starkly different set of balance sheet constraints explain cross-sectional differences in lending responses to liquidity risk. Cross-sectional differences in the transmission of liquidity risk into lending across global banks are more strongly associated with banks' organizational liquidity management strategies, as reflected in outstanding internal borrowing or lending within banking organizations. This result is economically important, as global banks with greater focus on internal liquidity management are able to lend between 11 and 87 percent (depending on the type of lending) more than their counterparts with smaller levels of internal borrowing and lending during periods of liquidity stress.

Finally, a relaxation of balance sheet constraints may have occurred for some institutions during the global financial crisis, when the Federal Reserve established several facilities to reduce liquidity strains. The role of balance sheet constraints for both types of banks changes when U.S. banks access the Term Auction Facility (TAF), as well as the discount window. In all regression specifications, in periods of liquidity stress, the roles of cross-sectional differences in bank balance sheets are diminished when liquidity risk conditions deteriorate substantially and banks access official sector liquidity. In global banks, we also find that the U.S. banks' net borrowing from their foreign affiliates increased relatively more for those banks that ex ante relied more on their affiliates, and relatively less so for those with higher Tier 1 capital ratios. During the crisis period and when institutions were borrowing from official facilities, ex ante net internal borrowing was no longer a significant driver of cross-sectional differences in growth in domestic lending, foreign lending, credit, and cross-border lending. During this same time frame, net internal borrowing from foreign affiliates declined more for institutions with more Tier 1 capital and was relatively larger for those banks that ex ante relied more on their affiliates.

Overall, our empirical model explains observed changes in domestic loan and credit growth, as well as changes in internal capital market positions, but does not capture much of the cross-border lending growth rates of U.S. banks. The drivers of these changes differ across domestic and global U.S. banks. In all cases, cross-border lending activity and internal borrowing and lending activity tend to be more volatile than domestic lending and lending conducted through U.S. banks' affiliate offices abroad. Another finding is that differences across banks in cross-border lending are sensitive to more of the bank balance sheet characteristics than any of the other forms of lending.

I. Data and Stylized Facts for the United States

Bank-Level Data

The primary data for our empirical analysis is a panel data set containing bank balance sheet and other financial information. We obtain income statement, balance sheet, and selected off-balance sheet data on bank holding companies from the FR Y-9C form filed quarterly as part of regulatory reporting in the United States. We use the Federal Financial Institutions Examination Council (FFIEC) 009 form for detailed information on U.S. bank holding companies' claims on foreign residents in order to determine if these banks have foreign affiliates.[1]

We work with a sample of U.S. banks active between 2006 and 2012.[2] The analysis concentrates only on larger U.S. banks (those with more than $10 billion in assets in constant 2012 dollars) and we distinguish between banks with claims booked through foreign affiliates (global banks) and those without such claims (domestic banks).[3] Both types of banks can lend to both domestic borrowers and foreign borrowers through cross-border transactions. In the case of global banks, lending to foreign residents also can be arranged through their foreign affiliates, with the latter taking the form of subsidiaries or branches established outside of the United States.

Dependent Variables

For each bank indexed by i, we compute the following dependent variables for our main empirical specifications: the change in loans during the quarter t divided by beginning of period $t-1$ assets ($\Delta Loans_t^i$), and the change in credit extension at t, which is the sum of loans plus undrawn commitments divided by the sum of total assets plus undrawn commitments at the beginning of the quarter ($\Delta Credit_t^i$). We present a detailed description of the construction of each variable used in the empirical analysis in the Appendix. Given our focus on the domestic and international transmission of liquidity risks, we also subdivide loans according to the domestic or foreign residence of the borrower. This residency split is available only for commercial and industrial (C&I) loans, which represent about 20 percent of the loans of large banks without foreign affiliates and of banks with foreign affiliates. Lending to foreign counterparties can take the form of cross-border claims (lending from an office outside of the country where the borrower resides) or foreign office claims (local lending from the foreign office), with the latter

[1]While sometimes referred to as "loans" in the text, claims are actually more broadly defined to include loans and other types of similar assets. A detailed description of this item can be found here: www.ffiec.gov/forms009_009a.htm.

[2]We begin in 2006 due to data availability issues. The FFIEC 009 reporting form, a primary data source in our analysis, was modified in 2006, adding some items to our analysis that were not previously available. Hereafter, we use interchangeably the terms "bank holding company" and "bank," recognizing that the commercial banks represent only a portion of the holding company.

[3]We further refine the sample by dropping nonbank financial institutions that report the FFIEC 009 and reporters that were added in the first quarter of 2009, and drop observations where the quarterly change in real total assets is greater than 10 percent to account for changes in organizational structure (such as mergers).

possible only when the bank has branches or subsidiaries established outside of the United States. In addition, we add a dependent variable relevant for global banks, which is the change in net borrowing (liabilities minus claims) between the lead commercial banking office of a bank holding company and its affiliates ($\Delta NetDueTo_t^i$), which are mainly foreign and limited domestic offices established as Edge corporations and International Banking Facilities. This variable captures internal liquidity management within the banking organization. The loan variables are scaled by the beginning of period total assets. Each dependent variable is winsorized at the 1st and 99th percentiles.

Balance Sheet Characteristics

The balance sheet characteristics identified by CMST as potentially influencing cross-sectional variation in liquidity conditions for individual banks include: the share of a bank's asset portfolio that is illiquid ($IlliquidAssets_{t-1}^i$), the ratio of unused commitments to commitments plus assets ($Commitments_{t-1}^i$), the share of the balance sheet financed with core deposits ($CoreDeposits_{t-1}^i$), the regulatory Tier 1 risk-based capital to asset ratio ($Tier1Capital_{t-1}^i$), and the Net Due To position relative to total liabilities ($NetDueTo_{t-1}^i$). As in CMST, all specifications include the log of total assets ($Assets_{t-1}^i$) as a control variable without taking a definitive position on the economic interpretation of this term.

Data on Funding Costs

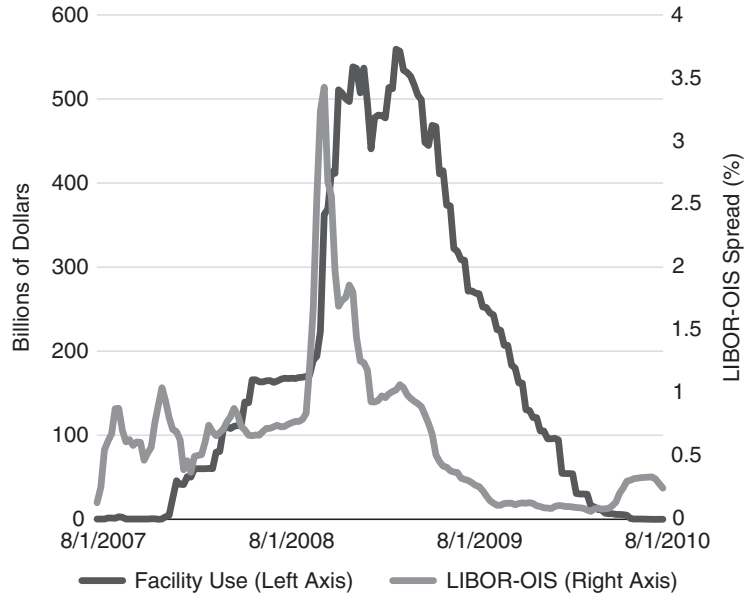
Our measures of aggregate liquidity strains in financial markets are the rates that banks use when lending to one another, known as interbank spreads (such as the London interbank offered rate over the overnight indexed swap, the Libor-OIS spread).[4] As shown in Figure 1, these spreads spiked during the global financial crisis as U.S. and European banks became less willing to lend to one another and liquidity dried up, especially at maturities beyond a few days.

From late 2007, the Federal Reserve announced a number of extraordinary official liquidity facilities to relieve the strains in U.S. financial markets during the crisis.[5] Figure 1 shows that the amount outstanding at two of these facilities, the TAF and the discount window, increased markedly as liquidity costs for banks increased. Because the cost of funds at official facilities was, at times, lower than private market rates, we allow for a different balance-sheet response of individual banks to aggregate prices of liquidity during the periods when the respective banks tap official sector facilities. Thus, our analysis incorporates quarterly bank-specific information on when each institution accessed the TAF and the discount window.

[4]The Libor-OIS spread is calculated as the average, within a quarter, difference between the three-month U.S. dollar Libor and the OIS rate for Federal Funds. An alternative measure is the TED spread, used in CMST. Results are largely unchanged if that measure is used as the proxy for aggregate liquidity risks.

[5]The full set of credit and liquidity measures is provided at www.federalreserve.gov/monetarypolicy/bst.htm

Figure 1. Libor-OIS Spread and Access to the Federal Reserve's Discount Window and the Term Auction Facility (TAF)



Stylized Facts

Table 1 reports the summary statistics of select banks' financial statement items over the period 2006:Q1 through 2012:Q4. Data are reported at the bank holding company level, covering 95 banks each for up to 28 quarters, and yielding a total of 1,920 bank-quarter observations which span 1,415 observations for nonglobal banks and 505 observations for banks with foreign affiliates. The global banks are fewer in number, have a larger median size, and rely less on core deposits as a source of funding. Global banks are exposed to larger contingent loan demand shocks, as the ratio of unused commitments to total credit is larger, and actively borrow and lend internationally within their broader organization, with liquidity management through internal capital markets reflected in the Net Due To rows. These differences across the banks with and without foreign affiliates will prove to be important in explaining cross-sectional variation in the lending effects of liquidity shocks. In addition, cross-border claims and flows associated with internal liquidity management are more volatile than both domestic lending and the claims extended by foreign offices of U.S. banks.

II. Empirical Method and Regression Results

Regression Specification

As described in detail in Buch and Goldberg (2015), we explore the effect of banks' funding conditions on bank loan growth and credit extension.

Table 1. Summary Statistics for Large U.S. Bank-holding Companies, 2006Q1 to 2012Q4

Variable	All Banks ($n = 95$)			With Foreign Affiliates ($n = 27$)			Without Foreign Affiliates ($n = 73$)		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
Balance sheet data (for each bank *i* and quarter *t*)									
Observations	1,920			505			1,415		
Dependent variables									
ΔLoans/Assets (%)	0.45	0.49	2.23	0.09	0.10	2.24	0.58	0.58	2.22
ΔCredit/(Assets+Commitments) (%)	0.39	0.49	2.56	–0.03	0.18	2.73	0.54	0.55	2.48
ΔDomestic C&I Loans/Assets (%)	0.17	0.10	0.74	0.12	0.09	0.74	0.18	0.11	0.74
ΔForeign C&I Loans/Assets (%)	0.01	0.00	0.10	0.02	0.00	0.17	0.00	0.00	0.06
ΔCross-Border Claims/Assets (%)				0.14	0.01	1.19			
ΔForeign-Office Claims/Assets (%)				0.18	0.01	0.90			
ΔNet Due To (Head Office)/Assets (%)				0.06	0.00	1.54			
Independent variables									
Illiquid Assets/Assets (%)	72.86	78.15	16.13	66.28	75.32	18.28	75.20	78.75	14.60
Commitments Ratio (%)	21.82	20.53	11.69	27.40	27.48	10.90	19.82	19.02	11.32
Log Real Assets	17.54	17.03	1.46	18.96	18.89	1.60	17.04	16.72	1.01
Core Deposits/Liabilities (%)	60.65	65.24	19.63	47.82	51.47	21.46	65.23	67.85	16.70
Tier1 Capital/RWA (%)	12.27	11.00	9.49	11.24	10.90	2.90	12.64	11.05	10.90
Net Due To (Head Office)/Liabilities (%)	5.78	3.56	8.62	5.78	3.56	8.62			
Facility Use	0.17	0.00	0.37	0.19	0.00	0.39	0.16	0.00	0.37

This table reports summary statistics for growth in loans, credit, net due to (head office), and domestic and foreign C&I lending as well as levels of other balance sheet characteristics and central bank facility use. The data are quarterly from 2006:Q1 to 2012:Q4. Beginning-of-quarter assets are used to standardize most of the growth variables: Assets and commitments, together, are used to standardize growth in credit. The panel is restricted to bank holding companies with greater than $10 billion in total assets (2012 prices) during its final quarter in the sample. On a quarterly basis, banks are split into subgroups: *banks with foreign affiliates* and *banks without foreign affiliates*. Banks are judged to have a foreign affiliate if they report positive aggregate foreign-office claims in the FFIEC 009. Banks that report zero foreign-office claims or do not report the FFIEC 009 are considered not to have a foreign affiliate. The net due to (or due from) variable, reported in the FFIEC 031, measures from the perspective of a bank's head office total net internal lending (or borrowing) vis-à-vis all its international offices. Facility use is a dummy variable indicating whether or not a bank accessed the Federal Reserve's Term Auction Facility and discount window in a particular quarter. Growth variables are winsorized at the 1st and 99th percentiles.

The regression specification is:

$$\Delta Y_t^i = \gamma^i + \mu_t + \left(\beta^0 + \beta^1 LIB\_OIS_t\right) X_{t-1}^i + \left(\alpha^0 + \alpha^1 LIB\_OIS_t \cdot X_{t-1}^i\right) F_t^i + \epsilon_t^i, \quad (1)$$

where ΔY_t^i is the set of dependent variables described in the section "Dependent variables." X_{t-1}^i is a vector of control variables that captures the degree to which a bank is exposed to liquidity risk through ex ante balance sheet characteristics and market access, as defined in the section "Dependent variables." The interaction between these terms and the Libor-OIS spread (LIB_OIS_t) through β reflects the sensitivity of intermediary credit extension to funding risks in accordance with balance sheet composition. The baseline regression model includes bank and time fixed effects, γ^i and μ_t, respectively.[6] F_t^i is a dummy variable capturing use of official sector liquidity by bank *i* at time *t*.

The regression specification departs from CMST in allowing the measured effects of liquidity risk through these balance sheet channels to be affected by the intervention of a lender of last resort. The logic is that the use of official liquidity mitigates some of the high costs of private market financing during the crisis, and changes how the otherwise constrained banks might manage their liquidity internally (through their affiliates) and externally (through the interbank market). The potential effect of the official liquidity provision is econometrically captured by the added interaction terms between the X_{t-1}^i variables described above and the measure of central bank intervention F_t^i (Facility). In our U.S.-based study, the indicator variable equals 1 if a bank accessed the TAF or discount window in period *t*. Essentially, this specification controls for the possibility that the effects of private measures of liquidity risk through balance sheet channels are biased indicators of bank-specific liquidity constraints during periods characterized by use of central bank facilities. Formal tests of this sensitivity are via the coefficient α^1 in Equation (1), while the overall sensitivity of the balance sheet to liquidity risk in periods of official sector liquidity use is captured by $\beta^1 + \alpha^1$.

Regression Results

CMST established that diverse balance sheet structures are associated with diverse bank reactions to funding shocks, emphasizing differences across small and large U.S. banks in relevant balance sheet drivers. Our first regression specification, shown in Table 2, column 1, replicates the CMST findings but instead uses our sample of large banks and the longer time period. We then add the refinements that capture more categories of lending, international banking considerations, and the use of official sector liquidity (Table 2, columns 2-5). We then divide the group of large banks into those without foreign affiliates (Table 3, Panel A) and those with foreign affiliates (Table 3, Panel B), also extending further the international dimensions for adjustment to changing liquidity risk conditions. Overall, we provide results for changes in total loans, domestic C&I loans, foreign C&I loans, and credit (Tables 2 and 3, Panel A), and

[6]We also have run alternative specifications excluding bank fixed effects. In those specifications the β's capture both absolute and cross-sectional differences in balance sheet composition.

Table 2. Credit and Lending Effects of Liquidity Risk using Bank-Specific Data: All Large U.S. Banks

Variables	(1) ΔLoans/Assets	(2) ΔLoans/Assets	(3) ΔDomestic C&I Loans/Assets	(4) ΔForeign C&I Loans/Assets	(5) ΔCredit/(Assets+Commitments)
Illiquid Assets	−0.020	−0.021	−0.006	−0.001	−0.005
Illiquid Assets×Libor-OIS	0.007	0.019	0.002	0.000	0.016
Illiquid Assets×Libor-OIS×Facility		−0.029	−0.025**	−0.001	−0.095**
Commitment Ratio	0.038	0.038	0.015**	0.001	−0.039
Commitment Ratio×Libor-OIS	0.026**	0.025**	0.009*	0.000	−0.015
Commitment Ratio×Libor-OIS×Facility		−0.023	−0.029***	−0.001	−0.010
Log Real Assets	−1.806***	−1.814***	−0.372***	−0.032*	−2.346***
Log Real Assets×Libor-OIS	0.075	0.217	0.120**	−0.007	0.269
Log Real Assets×Libor-OIS×Facility		0.198	0.088	0.005	−0.103
Core Deposits	−0.046***	−0.046***	−0.006	0.000	−0.039**
Core Deposits×Libor-OIS	0.017**	0.007	0.006**	0.000	0.014
Core Deposits×Libor-OIS×Facility		0.070***	0.027**	0.000	0.093***
Tier 1/RWA	0.012	0.006	0.000	0.000	−0.002
Tier 1/RWA×Libor-OIS	0.011	0.020	0.007**	0.000	0.017
Tier 1/RWA×Libor-OIS×Facility		−0.014	−0.020**	0.000	−0.058
Facility Use		6.974	2.346	0.060	−2.668
Observations	1,920	1,920	1,920	1,920	1,920
Adjusted *R*-squared	0.22	0.22	0.20	0.02	0.21
Number of banks	95	95	95	95	95
Coefficients on Libor-OIS terms during periods of central bank facility use, all large banks					
Illiquid Assets		−0.010	−0.022**	−0.001	−0.079*
Commitment Ratio		0.002	−0.020**	−0.001	−0.025
Log Real Assets		0.416**	0.208***	−0.002	0.166
Core Deposits		0.077***	0.032***	0.000	0.107***
Tier 1/RWA		0.006	−0.013*	−0.001	−0.041

This table reports the effects of liquidity risk conditions, central bank facility use, and firm characteristics on growth in domestic and foreign C&I lending and credit. Reported separately are the implied marginal effects for periods in which individual institutions used central bank liquidity facilities. Also reported are the linear combination of the coefficients on the respective *LIBOR-OIS* and *LIBOR-OIS×Facility* interaction terms. A detailed description of the balance sheet variables can be found in the Appendix. The LIBOR-OIS is the quarterly average of the daily difference between the London Interbank Offered Rate and the effective federal funds rate. Growth variables are winsorized at the 1st and 99th percentiles. All specifications include bank and time fixed effects. Standard errors are clustered by bank. ***, **, and * respectively indicate significance at the 1, 5, and 10 percent level.

Table 3. Credit and Lending Effects of Liquidity Risk Using Bank-Specific Data

	(1) ΔLoans/Assets	(2) ΔLoans/Assets	(3) ΔDomestic C&I Loans/Assets	(4) ΔForeign C&I Loans/Assets	(5) ΔCredit/(Assets+Commitments)
Panel A: Banks without foreign affiliates					
Illiquid Assets	−0.016	−0.020	−0.006	0.000	−0.012
Illiquid Assets×Libor-OIS	−0.002	0.019	0.003	−0.001	0.024
Illiquid Assets×Libor-OIS×Facility		−0.066	−0.033*	0.000	−0.126**
Commitment Ratio	0.055	0.053	0.021**	−0.001	−0.055
Commitment Ratio×Libor-OIS	0.024*	0.036***	0.011*	0.001	0.010
Commitment Ratio×Libor-OIS×Facility		−0.058*	−0.032***	0.000	−0.022
Log Real Assets	−1.877**	−1.901**	−0.235	0.005	−2.230***
Log Real Assets×Libor-OIS	0.076	0.228	0.088	−0.018***	0.339
Log Real Assets×Libor-OIS×Facility		0.192	0.109	0.016*	0.130
Core Deposits	−0.060***	−0.060***	−0.008*	0.000	−0.049**
Core Deposits×Libor-OIS	0.015	−0.001	0.006**	−0.001***	0.005
Core Deposits×Libor-OIS×Facility		0.076**	0.023*	0.001	0.112***
Tier 1/RWA	0.017	0.010	0.001	0.000	0.006
Tier 1/RWA×Libor-OIS	0.005	0.020	0.008***	−0.001**	0.024
Tier 1/RWA×Libor-OIS×Facility		−0.050	−0.030**	0.000	−0.080
Facility		6.001	3.703*	−0.004	0.988
Observations	1,415	1,415	1,415	1,415	1,415
Adjusted *R*-squared	0.21	0.21	0.16	0.02	0.18
Number of banks	73	73	73	73	73
Coefficients on Libor-OIS terms during periods of central bank facility use, banks without foreign affiliates					
Illiquid Assets		−0.047	−0.030*	−0.001	−0.102*
Commitment Ratio		−0.023	−0.021**	0.000	−0.011
Log Real Assets		0.420	0.197**	−0.002	0.469
Core Deposits		0.076***	0.029**	0.000	0.117***
Tier 1/RWA		−0.030	−0.022	−0.001	−0.056

Table 3: *(Continued)*

	(1) ΔLoans/ Assets	(2) ΔLoans/ Assets	(3) ΔDomestic C&I Loans/ Assets	(4) ΔForeign C&I Loans/Assets	(5) ΔCredit/(Assets +Commitments)	(6) ΔCross-border Claims/Assets	(7) ΔForeign-office Claims/ Assets	(8) ΔNet Due To (Head Office)/ Assets
Panel B: Banks with foreign affiliates								
Illiquid Assets	−0.004	−0.018	0.011	−0.002	0.006	0.010	0.023	0.024
Illiquid Assets×Libor-OIS	0.051*	0.115**	0.012	0.008*	0.088	0.064**	0.034	−0.039
Illiquid Assets×Libor-OIS×Facility		−0.060	−0.029	−0.004	0.025	−0.007	−0.070	−0.043
Commitment Ratio	0.018	0.020	−0.003	−0.003	−0.066	0.022	−0.024*	0.033
Commitment Ratio×Libor-OIS	0.037*	−0.003	−0.002	0.002	−0.100*	0.016	0.006	0.059
Commitment Ratio×Libor-OIS×Facility		0.078**	−0.027**	−0.004	0.128***	0.000	−0.031	−0.015
Log Real Assets	−2.220**	−2.253**	−1.239***	−0.126**	−4.495***	0.108	0.698**	−1.186**
Log Real Assets×Libor-OIS	0.184	0.567	0.146	−0.015	0.821	−0.138	−0.207	−0.419
Log Real Assets×Libor-OIS×Facility		−0.227	−0.109	−0.003	−0.377	0.291	0.015	−0.366
Core Deposits	0.007	0.005	0.004	0.001	0.015	0.002	0.041**	−0.006
Core Deposits×Libor-OIS	0.005	−0.010	0.005	−0.002	0.015	−0.026	−0.009	0.022
Core Deposits×Libor-OIS×Facility		0.050	0.023*	−0.002	−0.023	0.022	0.059*	0.052
Tier 1/RWA	−0.086	−0.129	−0.063*	0.004	−0.212*	0.040	0.096	0.073
Tier 1/RWA×Libor-OIS	0.085	0.159	0.011	−0.016	0.021	0.094	−0.054	−0.290
Tier 1/RWA×Libor-OIS×Facility		0.135	0.128	0.027	1.120***	−0.246	−0.194	−0.426
Facility Use		6.898	−4.750	−0.569	13.874*	12.731	−7.040	−3.502
Net Due to (Head Office)	−0.015	−0.013	−0.011	−0.004	0.007	−0.005	0.043**	−0.241***
Net Due to (Head Office) ×Libor-OIS	0.083**	0.147***	0.043***	0.012***	0.157**	0.065**	0.000	0.019
Net Due to× Libor-OIS×Facility		−0.049	−0.093***	−0.027**	−0.216**	0.010	0.061	0.177
Observations	505	505	505	505	505	502	483	505
Adjusted *R*-squared	0.34	0.33	0.41	0.07	0.39	0.08	0.12	0.26
Number of banks	27	27	27	27	27	27	27	27

Coefficients on Libor-OIS terms during periods of central bank facility use, banks with foreign affiliates							
Illiquid Assets	0.055	−0.017	0.004	0.112**	0.058	−0.036	−0.082
Commitment Ratio	0.075**	−0.028*	−0.002	0.028	0.016	−0.025	0.044
Log Real Assets	0.339	0.037	−0.017	0.444	0.153	−0.191	−0.785*
Core Deposits	0.04	0.029**	−0.004	−0.008	−0.005	0.050**	0.074
Tier 1/RWA	0.293	0.139	0.011	1.140***	−0.152	−0.247**	−0.716***
Net Due To (Head Office)	0.097	−0.049*	−0.015	−0.059	0.076	0.061	0.196**

This table reports the effects of liquidity risk conditions, central bank facility use, and firm characteristics on growth in domestic and foreign C&I lending and credit. Reported separately are the implied marginal effects for periods in which individual institutions used central bank liquidity facilities. Panels A and B, respectively, observe samples of banks without and with foreign affiliates, and Panel B includes additional regressions for changes in aggregate cross-border claims, foreign-office claims, and net due to (or net due from). Also reported are the linear combinations of the coefficients on the respective *LIBOR-OIS* and *LIBOR-OIS*×*Facility* interaction terms. A detailed description of the balance sheet variables can be found in the Appendix. The LIBOR-OIS is the quarterly average of the daily difference between the London Interbank Offered Rate and the effective federal funds rate. Growth variables are winsorized at the 1st and 99th percentiles. All specifications include bank and time fixed effects. Standard errors are clustered by bank. ***, **, and * respectively indicate significance at the 1, 5, and 10 percent level.

introduce cross-border claims, foreign office claims, and Net Due To for the global banks with foreign affiliates (Table 3, Panel B). The bottom section of each panel presents the implied marginal effects $\beta^1+\alpha^1$ of liquidity risk priced through the Libor-OIS spread and operating through bank balance sheet channels for those periods in which the individual institutions used central bank liquidity facilities.

U.S. banks' liquidity risk exposure through their balance sheet composition is reflected in changes in their loan growth and credit extended, consistent with CMST (Table 2, column 1). However, our analysis reveals substantive differences in the mechanics of these effects relative to those previously documented. Among large U.S. banks, and for our longer time period, we find that fewer balance sheet characteristics are statistically significant drivers of cross-sectional differences in lending and credit growth responses to liquidity across banks. Moreover, our division of large banks into domestic and global types demonstrates the importance of these fundamental differences in business models for domestic and foreign lending outcomes.

In banks without foreign affiliates, those with higher shares of core deposits in their funding mix, higher Tier 1 capital, and higher commitment ratios, all else equal, are also those that sustain higher growth in domestic lending when liquidity risk rises (Table 3, Panel A, column 3). Ex ante illiquid asset shares do not contribute significant explanatory power to the cross-sectional differences in bank lending for these banks. Even fewer balance sheet characteristics matter for cross-sectional differences in credit and foreign lending growth. During the crisis period when liquidity risk rose and some institutions tapped official sector sources of liquidity, domestic loan growth was supported to a greater degree among those banks with higher core deposits and lower loan commitment and illiquid asset ratios. The size and significance of the effects during these periods are presented in the lower section of Table 3, Panel A.

Comparison of the *R*-squared statistics for these banks shows that the model does much better at capturing variation in total and domestic lending growth (adjusted R^2 of 0.21 and 0.16, respectively) and credit growth (adjusted R^2 of 0.18) than it does for variation in foreign lending growth (adjusted R^2 of 0.02). The bank and time fixed effects account for most of this explanatory power, pointing to commonality in overall patterns of liquidity risk effects across banks.

Next, we conduct a simple exercise to assess the economic magnitude of the balance-sheet-related results in the sample of large banks without foreign affiliates. In particular, we assume an increase of 100 basis points in the Libor-OIS spread and compare its impact on banks located in the 50th percentile and 75th percentile of the distribution of those balance sheet characteristics that significantly affect bank lending. In the first set of results described above, core deposits are significant determinants of both domestic and foreign C&I lending. Using the coefficients on the interaction between core deposits and the Libor-OIS spread (reported in Table 3, Panel A, columns 3 and 4), we find that a bank with a share of core deposits relative to total assets from the 50th percentile of the distribution (at 68 percent) would lend $91 million less in domestic C&I loans compared with a bank with a higher deposit share at the 75th percentile (at 77 percent). This difference represents about 4 percent of total quarterly domestic C&I loans of the

median bank without foreign affiliates.[7] At the same time, banks with a larger share of core deposits on their balance sheets would lend about $21 million less to foreign residents as a result of the increase of 100 basis points in the Libor-OIS spread. These results confirm that the impact of liquidity risks on bank lending outcomes in relation to cross-sectional differences in balance sheet composition is economically important, but mainly through the deposit share distinction in large U.S. banks without foreign affiliates.

The regression specifications for the U.S. global banks, shown in Table 3, Panel B, cover a broader set of lending aggregates reflecting the possibility of intrabank lending internationally and alternative forms of lending to foreign customers. One important observation is that these regression specifications explain approximately 40 percent of the time series and cross-sectional variation in domestic C&I lending and credit growth, but only about 10 percent of the variation in C&I lending to foreign resident borrowers, total cross-border lending, and lending by affiliate offices. This weak fit arises despite the important role that foreign lending plays in global banks' balance sheets (for example, global banks' C&I lending to nonresidents represents about 25 percent of their total C&I lending). Another key observation is that the balance sheet characteristics that matter for adjustment to liquidity risk changes are sharply different for the sample of global banks. Specifically, internal liquidity management is the single, consistently significant driver of cross-sectional differences in loan growth by global banks in response to changing liquidity risk. Those global banks with higher net borrowing from affiliated entities had consistently stronger loan growth (total, domestic, foreign, cross-border, credit) when liquidity risks increased. The change in aggregated claims extended by the foreign branches and subsidiaries of these banks are not significantly differentiated according to these same U.S. bank balance sheet features.

Another interesting result is the way in which drivers of cross-sectional differences across the large global banks change when the global banks access official sector liquidity. Tier 1 capital ratios gain importance, with higher capitalized banks lending and supporting credit to a greater degree than less capitalized banks. When official liquidity is in use, larger banks that have more Tier 1 capital reduce net borrowing from foreign affiliates to a greater degree. The observation that higher internal capital market borrowing is used to support loan growth in global banks is consistent with evidence provided by Cetorelli and Goldberg (2012b and 2015c): the official liquidity provision may have helped insulate adverse international transmission to affiliated firms and the markets they serve.

In terms of economic magnitudes, we replicate the quantitative analysis described previously but instead use information on the U.S. banks with foreign affiliates. In particular, we compare the difference in lending growth of a bank in

[7]To arrive at this dollar amount, we multiply the growth rate given by the product of the coefficient on the interaction term from Table 3 and the difference in the share of deposits of banks in the selected percentiles, by the total assets of the median bank in the sample of financial institutions that do not have any foreign affiliates.

the 75th percentile of the Net Due To distribution (a ratio of Net Due To over Total Liabilities of 6.6 percent) to a bank in the 50th percentile (a ratio of 3.6 percent) when there is a 100 basis point increase in the Libor-OIS spread. Banks in the higher part of the distribution support their quarterly domestic C&I lending by about $1,900 million more and support foreign C&I lending by $531 million more. These sizable differences in lending represent about 11 and 87 percent of the lending done by the median bank in each category.

III. Concluding Remarks

This paper is part of a broader cross-country initiative through the International Banking Research Network to better understand the movement of international capital flows through banks. We demonstrate that the distinct business models of large U.S. banks are associated with differentiated balance sheet drivers of cross-sectional variation in loan growth in response to changing liquidity risk conditions. Large U.S. banks without foreign affiliates have loan growth rates that differ cross-sectionally in line with their reliance on core deposits for funding, their regulatory Tier 1 capital and their outstanding credit commitments. Large U.S. global banks have loan growth rates that differ mainly in relation to their use of liquidity management within their broader organization and internationally. Banks that tend to borrow more from their own affiliates also have more stable lending and credit growth as liquidity risk conditions worsen.

We also find that different characteristics of banks matter for cross-sectional lending variation during more extreme liquidity risk conditions and when banks access official liquidity facilities. For the domestically oriented banks, those with higher core deposits and lower commitments and illiquid assets still attained relatively higher domestic lending and credit growth. For the global banks, banks with more Tier 1 capital and less credit commitments relied relatively less on borrowing from their affiliates during these times. The ex ante reliance of the institutions on internal liquidity management became less important for cross-sectional distinctions across banks in lending to domestic and foreign customers. In this sense, we observe the official sector liquidity support as having contained some adverse liquidity risk effects on the real domestic economy and on transmission abroad through U.S. global banks.

APPENDIX

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Table A1. Construction of Variables

Variable Name	Report Form Description	Source	Notes
Dependent variables			
ΔLoans/Assets$_{(t-1)}$	[Δ(Loans and leases held for sale+Loans and leases, net of unearned income and allowance for loan and lease losses)/Assets]×100	FR Y9-C	All Δ constructions are the difference between t and $t-1$ values. All growth variables and balance sheet ratios are calculated as percentages.
ΔCredit/(Assets+Commitments)$_{(t-1)}$	[Δ(All unused commitments+Loans and leases held for sale+Loans and leases, net of unearned income and allowance for loan and lease losses) / (Assets+All unused commitments)]×100	FR Y9-C	
ΔDomestic C&I Loans/Assets$_{(t-1)}$	[Δ(Commercial and industrial loans to U.S. addressees)/Assets]×100	FR Y9-C	
ΔForeign C&I Loans/Assets$_{(t-1)}$	[Δ(Commercial and industrial loans to non-U.S. addressees)/Assets]×100	FR Y9-C	
ΔCross-Border Claims/Assets$_{(t-1)}$	[Δ(Cross-border claims on banks, public, and other) /Assets]×100	FFIEC 009, FR Y9-C	Cross-border claims are evaluated on an immediate counterparty basis
ΔForeign-Office Claims/Assets$_{(t-1)}$	[Δ[(Foreign-office claims on local residents in nonlocal currency: banks, public, and other) +(Foreign-office claims on local residents in local currency)]/Assets]×100	FFIEC 009, FR Y9-C	Foreign-office claims are evaluated on an immediate counterparty basis
ΔNet Due To (Head Office)/Assets$_{(t-1)}$	[Δ(Net due to own foreign offices, edge and agreement subsidiaries, and IBFs−Net due from own foreign offices, edge and agreement subsidiaries, and IBFs) /Assets]×100	FFIEC 031, FR Y9-C	From the perspective of the commercial bank head office vis-á-vis own foreign offices, edge and agreement subsidiaries, and IBFs.

Table A1: (*Continued*)

Variable Name	Report Form Description	Source	Notes
Independent variables			
Illiquid Assets$_{(t-1)}$/Assets$_{(t-1)}$	{[Loans held for sale+Loans net of unearned income and allowances for loan & lease losses (A. L.L.)+Held-to-maturity MBS, ABS, and structured financial products (amortized cost) +Available-for-sale MBS, ABS, and structured financial products (fair value)]/Assets}×100	FR Y9-C	Structured financial products available on the FR Y9-C report form starting 2009:Q2.
Commitments Ratio$_{(t-1)}$	[All unused commitments/(Assets+All unused commitments)]×100	FR Y9-C	
Log Real Assets$_{(t-1)}$	Log [Total assets×(GDP Deflator$_{2012}$/GDP Deflator)]	FR Y9-C, BEA	Nominal assets are converted to real values (2012 dollars). The GDP implicit price deflator series is from the Bureau of Economic Analysis.
Core Deposits$_{(t-1)}$/Liabilities$_{(t-1)}$	{[Total transaction accounts+Savings deposits (MMDAs, and so on)+Total time deposit accounts with balances less than $100,000]/ Liabilities}×100	FR Y9-C	
Tier 1 Capital$_{(t-1)}$/RWA$_{(t-1)}$	[Tier 1 risk-based capital/Risk-weighted assets (net of allowances and other deductions)] ×100	FR Y9-C	
Net Due To (Head Office)$_{(t-1)}$/Liabilities$_{(t-1)}$	[(Net due to own foreign offices, edge and agreement subsidiaries, and IBFs−Net due from own foreign offices, edge and agreement subsidiaries, and IBFs)/Liabilities]×100	FFIEC 031, FR Y9-C	From the perspective of the commercial bank head office vis-á-vis own foreign offices, edge and agreement subsidiaries, and IBFs.

REFERENCES

Buch, Claudia M. and Linda Goldberg, 2015, "International Banking and Liquidity Risk Management: Lessons from Across Countries," *International Monetary Fund Economic Review*, Vol. 63, No. 3, pp. 377–410.

Cetorelli, Nicola and Linda Goldberg, 2012a, "Banking Globalization and Monetary Transmission," *Journal of Finance*, Vol. 67, No. 5, pp. 1811–43.

——— , 2012b, "Follow the Money: Quantifying Domestic Effects of Foreign Bank Shocks in the Great Recession," *American Economic Review*, Vol. 102, No. 3, pp. 213–18.

——— , 2012c, "Liquidity Management of U.S. Global Banks: Internal Capital Markets in the Great Recession," *Journal of International Economics*, Vol. 88, No. 2, pp. 299–311.

Cornett, Marcia, Jamie McNutt, Philip Strahan, and Hassan Tehranian, 2011, "Liquidity Risk Management and Credit Supply in the Financial Crisis," *Journal of Financial Economics*, Vol. 101, No. 2, pp. 297–312.

Kashyap, Anil and Jeremy Stein, 2000, "What Do A Million Observations on Banks Say About the Transmission of Monetary Policy?," *American Economic Review*, Vol. 90, No. 3, pp. 407–28.