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How did the crisis in international funding markets affect bank lending? Balance sheet evidence from the UK

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Abstract

Evidence abounds on the propagation of financial stresses originating in the US mortgage market to banking systems worldwide through international funding markets. But the transmission of this external funding shock to the real economy via bank lending is surprisingly under-examined, given the central importance ascribed to this channel of contagion by policymakers. This paper provides evidence of this transmission for the UK-resident banking system, the largest in the world by asset size. It uses a novel dataset, created from detailed balance sheet data reported by resident banks quarterly to the Bank of England. It finds that the shock to foreign funding during the financial crisis caused a substantial pullback in domestic lending. A range of instrumental variables are used to correct for endogeneity and omitted variable bias, and the results are robust to various sensitivity tests. Resident subsidiaries and branches of foreign-owned banks reduced lending by a larger amount than domestically-owned banks, while the latter calibrated the reduction in domestic lending more closely to the size of the funding shock.

Key words: Liquidity shock, financial crisis, transmission mechanism, bank lending, instrumental variables.

***JEL* classification**: G01, G2, E3, E5.

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1 Introduction

It is widely accepted that globalized banks were central to the process of transmitting the financial crisis from country to country, and triggering the Great Recession. Contemporary banking systems, especially in advanced economies, are characterised by their web of international linkages, with large claims on and liabilities to non-resident entities. Allen et al (2011) reflect the consensus view when they state that "*Understanding the role of banks in cross-border finance has become an urgent priority....[they] played a leading role in the dynamics of the global crisis of 2007-2009*".

The importance ascribed to globalized banks arises from a standard, two-part narrative that runs roughly as follows. First, stress in the US banking system (and others directly exposed to US mortgages and structured products) spread to banks worldwide through funding markets, both secured and unsecured. Second, this external funding shock to the banking systems of various countries was transmitted domestically through a reduction in credit supply. But while there is a substantial empirical literature documenting the first step above, direct evidence on the second step is relatively slim. This study contributes towards filling that gap.

The literature on the impact of non-monetary shocks on bank lending has a long pedigree. Bernanke (1983) provides evidence that the bank runs and defaults that occurred during the Great Depression caused a reduction in loan supply, and Bernanke and Blinder (1998) model the impact of bank lending on the real economy. A number of papers provide evidence on the real impact of external shocks to bank liquidity. Peek and Rosengren (1997) show that a shock to Japanese banks' liquidity (arising from falling Japanese equity prices) led to a reduction in their lending into the US economy. Khwaja and Mian (2008) document a fall in loans extended by Pakistani banks, in response to an external funding shock (the imposition of capital controls in the wake of the country's 1998 nuclear tests). Schnabl (2011) finds that the liquidity shock to global banks arising from the Russian default in 1998 led to a pullback in lending to Peruvian banks, and that Peruvian banks responded by reducing domestic credit.

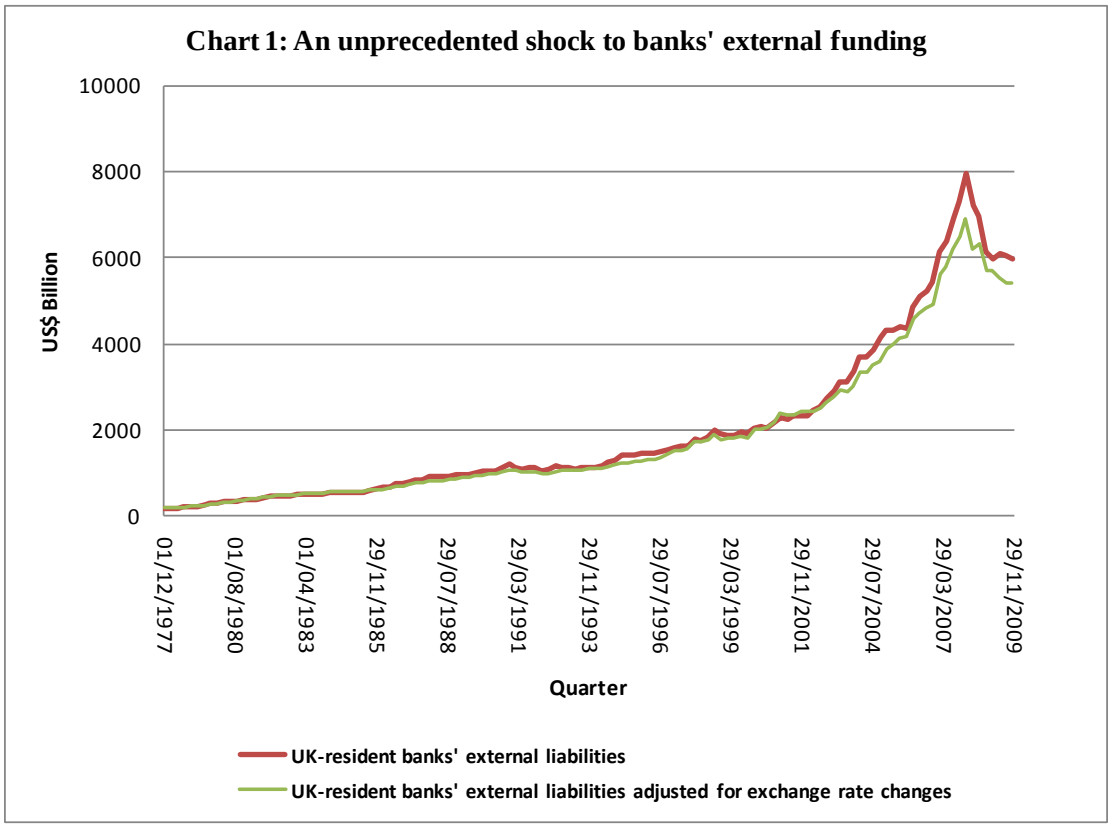
That literature certainly suggests that a cutback in credit supply following a shock to external sources of bank funding is likely to have been an important channel of contagion in the recent crisis. This view is mirrored in the almost universal policy consensus that the Great Recession was a bank-led recession, i.e. that the deterioration in the real economy was initiated by a tightening of international credit conditions rather than vice-versa. In a speech given in April 2010, Jean-Claude Trichet summarized the crisis as follows: *"Given heightened concerns about counterparty risk – which intensified dramatically after the failure of Lehman – cash-rich banks proved unwilling to lend to banks needing liquidity. As a result, the global money market came close to a total freeze. The ensuing decline in banks' ability to raise funds led to a tightening of credit conditions facing enterprises and households."*[1] Similar diagnoses may be found on the lips of other central bankers and policy makers. Successive *World Economic Outlooks* (WEOs) and *Global Financial Stability Reports* (GFSRs) from the IMF have placed the "global credit crunch" at the heart of the recession. In the UK, several recent issues of the Bank of England's *Financial Stability Report* have emphasised the impairment of bank credit arising from the liquidity shock.

This paper investigates how the shock to banks' international funding impacted bank credit supply in a large, non-US, advanced economy during the crisis, thereby providing direct evidence of the transmission channel discussed above. The UK economy provides an ideal testing ground. As a global financial centre, it hosts a large and heterogeneous set of banks, some of which are domestically-owned, but many of which are branches and subsidiaries of banks headquartered in a range of foreign countries. Many of these resident banks have substantial liabilities to non-residents, and are therefore particularly subject to contagion from abroad. And indeed, the shock to external funding that occurred during this crisis was not just large but unprecedented. Chart 1 shows time series from the Bank of International Settlements (BIS) on the aggregate external liabilities of all UK-resident banks, both on an exchange rate-adjusted basis and an unadjusted basis.[2] On an adjusted basis, these

[1] Trichet (2010)

[2] The series showing the stock of exchange rate-adjusted external liabilities is generated by adding quarterly data on exchange rate-adjusted flows to the initial stock.

liabilities fell by 22 percent from their peak in end-March 2008 to end-October 2009 , when they started stabilizing again. By way of comparison, the previous largest 6-quarter fall in external liabilities was only 9 percent, during the ERM crisis in the early 1990s.



From a balance sheet perspective, a bank can react to a shock to external liabilities in any of three ways, or some combination thereof: (i) it can increase its domestic liabilities, that is, borrow more from resident entities, (ii) it can reduce its foreign assets, that is, lend less to non-residents, or (iii) it can reduce its domestic claims, that is, lend less to residents. The focus of investigation here is whether and to what extent banks reacted using option (iii), thereby transmitting the financial contagion to the real domestic economy. A novel dataset is employed, created from the confidential regulatory returns that every UK-resident bank must file quarterly with the Bank of England. These reports contain detailed balance sheet data, providing considerable bank-by-bank heterogeneity in both the external liquidity shock and domestic lending. Exploiting this heterogeneity enables identification of an effect which would usually be difficult to estimate.

The aim is to estimate the impact of the change in banks' external liabilities during the crisis on the change in their domestic lending. OLS is potentially subject to endogeneity and omitted variable bias. Identification is therefore sought by instrumenting the change in banks' external liabilities over the crisis period using three variables. These are: (i) a measure of reliance on wholesale funding, viz. the share of repos in total external liabilities of a bank at the beginning of the crisis; (ii) the share of external liabilities owed to affiliates (as opposed to unaffiliated entities) at the beginning of the crisis; and (iii) a measure of banking system stress in the country in which the bank is headquartered, using the heterogeneity of LIBOR-OIS spreads in different regions of the world. I argue that these instruments are intuitively plausible: all three should be indicative of the size of the funding shock—as attested by a sizeable literature—while not exercising any independent impact on the response variable. Post-estimation tests offer strong support for the validity of the instruments.

The paper is closely related to Cetorelli and Goldberg (2011), who show how the liquidity shock to the banking systems of advanced countries was transmitted to emerging economies via a reduction in bank credit. But of course, contagion was not restricted to transmission from advanced countries to emerging economies. Accordingly, this paper investigates transmission *to* the real economy of a single advanced country arising from a shock to *any* external source of bank liquidity. Because it uses individual bank data, it is able to exploit heterogeneity across banks, rather than relying on cross-country differences.

The study adds to a broader literature on the real impact of the liquidity crisis. Ivashina and Scharfstein (2009) document the fall in syndicated bank lending in the USA during the crisis, providing evidence that this varied according to a bank's access to stable deposit funding and according to exposure to drawdowns on existing lines of credit. Other studies attempt to identify the impact of the funding shock on particular facets of bank lending, such as trade finance (Amiti and Weinstein (2009), Chor and Manova (2009)). A different approach involves the use of survey data: for example Campello, Graham and Harvey (2010) survey CFOs worldwide to ascertain that credit constrained firms planned deeper cuts in employment and investment, drew down on existing credit lines more and sold more assets to fund operations.

The work here takes as an input the shock to banks' international sources of liquidity during the financial crisis, a topic on which there is by now a voluminous empirical literature.[3] Gorton and Metrick (2010) trace the genesis of a "run on repo", i.e. a systemic bank run which occurred not through the traditional channel of depositors withdrawing their funds, but through the withdrawal of repurchase agreements in the vast and global repo market. With minor variations in timing, the pattern was repeated in the inter-bank market for unsecured funding (Acharya and Merrouche (2010)).[4] Short-term funding in US dollars came under particular stress, as documented by McGuire and von Peter (2010) and Coffey, Hrung and Sarkar (2009).

To preview the main results of the paper, I find that a shock to banks' external funding was associated with a substantial contraction in domestic lending. This impact is robust across all deciles of the conditional distribution of the response variable. Foreign subsidiaries and branches reduced lending by a larger amount on average than domestically-owned banks, while the latter calibrated the reduction in domestic lending more closely to the size of the funding shock. There is little evidence that foreign assets buffered domestic lending against shocks to foreign liabilities. I also explore the transmission of the external shock to different sub-components of domestic lending. With the caveat that these sub-samples of the data are smaller and noisier, I find evidence that the shock caused a significant cutback in lending to businesses, to other banks, and to other financial institutions. But I find no evidence for an impact on household lending. This could be because the financial crisis led to the unravelling of the securitisation model of household mortgage lending and caused banks to take mortgages back onto their balance sheets, a development which would tend to increase reported bank lending to households.

The remainder of the paper proceeds as follows. The next section describes the data and estimation strategy. Section 3 provides the main empirical results and section 4 presents some additional results. Section 5 disaggregates domestic lending by sector. Section 6 concludes.

[3] Only a small selection of the literature is described here. Other papers include Eichengreen, Mody, Nedeljkovic and Sarno (2009). A rapidly growing theory literature includes Acharya, Gale and Yorulmazer (2009), Brunnermeir and Pederson (2009), Geanakoplos (2009), Dang, Gorton and Holmstrom (2010) and Pagano and Volpin (2009).

[4] Runs also occurred in other funding markets, such as asset backed commercial paper and structured investment vehicles (Covitz, Lang and Suarez (2009), Carey, Correa and Cotter (2009)).

2 Data and estimation strategy

3.1 Data

The UK's resident banking sector comprises the domestically-incorporated units of UK-owned banks, as well as the subsidiaries and branches of banks headquartered in several other countries.[5] It is the world's largest banking sector by asset size. At end-2009, there were over 300 banks resident in the UK, with total assets amounting to £ 7.6 trillion, or over 500% of GDP.[6] While UK-owned banks are on average larger than foreign branches and subsidiaries, the latter are more numerous, so that the assets of foreign-owned and UK-owned banks are about equal (at 50.5 % and 49.5 % of total assets respectively). Of the foreign-owned banks, European banks have the largest presence, accounting for 27.2 % of total assets, followed by US banks (7.9 %) and Japanese banks (2.4%). There is considerable but not overwhelming concentration in assets; thus the top 10 banks account for about 59.8 % of all banking assets.[7]

As part of the UK's regulatory regime, all resident banks must report detailed balance sheet data to the Bank of England on a quarterly basis. Data are reported on a locational (unconsolidated) basis. Thus the liabilities and assets reported by the London subsidiary of, say, a bank headquartered in New York, pertain only to the balance sheet of the subsidiary, not the balance sheet of the banking group.

The main reporting vehicle for balance sheet information is the BT form, which disaggregates banks' liabilities into 11 broad categories (such as sight deposits, time deposits, etc.) and assets into 13 categories (such as cash, bills and commercial paper,

[5] A "foreign subsidiary" is defined for regulatory purposes as a UK-based company in which a foreign bank holds more than 50% of the nominal value of the share capital, or in which a foreign bank, while holding less than 50% of the share capital, nevertheless controls the composition of the board of directors. A "foreign branch" is any permanent establishment (as defined for UK tax purposes) other than a foreign subsidiary, which has and habitually exercises the authority to negotiate and conclude contracts on behalf of its foreign owner. Subsidiaries are subject to regulation—for example on minimum capital requirements—by the Financial Services Authority (FSA), while branches are not. See Aiyar, Calomiris and Wieladek (2011) for further discussion of the UK banking industry and regulatory differences between institutions.

[6] By way of comparison, US-resident banks at end-2009 had assets of US$ 11.67 trillion, or £ 7.19 trillion.

[7] This is in contrast to the much greater concentration in the assets of UK-*owned* banks on a *consolidated* (banking group) basis: the top 10 UK-owned banks account for over 95% of the consolidated assets of UK-owned banks.

market loans, etc.).[8] Each category is split into several sub-categories, some of which contain information on counterparties. The BE form further disaggregates line items from the BT form, focusing particularly on providing more granular counterparty data. The CL and CC forms are used to report on, respectively, banks' external liabilities and assets, i.e. their funding from and their claims on non-residents.

Using data reported on the BT and BE forms, I construct for each UK-resident bank a time-series for claims on households, on businesses, on other banks and on other financial institutions (OFIs). The sum of claims on these four sectors is defined as domestic lending, which is analyzed in conjunction with data on external liabilities from the CL form. Bank mergers are dealt with by creating a synthetic merged series for the entire period.[9] Banks which started or ceased operations during the period studied, or which reported no external liabilities, or which stopped reporting external liabilities during the period studied, are omitted from the sample.[10] These adjustments yield a sample of 141 banks, of which 17 are UK-owned, 32 are foreign subsidiaries, and 92 are foreign branches. These 141 banks accounted for 92.5 % of the assets of all UK-resident banks at the beginning of the sample period.

Table A below shows some summary statistics for the sample. I focus on domestic lending and external liabilities, the two main variables of interest. Since there are considerable differences by bank type—whether a bank is UK-owned, a subsidiary or a branch—reflecting differences in business models, the summary statistics are disaggregated accordingly.[11]The stock of domestic lending and external liabilities is measured at the beginning of what is called the "shock period": the period between end-Q1 2008 and end-Q3 2009 during which external liabilities collapsed so dramatically (see Chart 1 above). Changes in the variables of interest are measured as

[8] All regulatory forms used in this study can be viewed at http://www.bankofengland.co.uk/statistics/reporters/defs/defs.htm.

[9] As a robustness check, the main regressions in this paper are repeated using a data sample in which merging banks are *not* combined into a single synthetic series. The results are qualitatively unchanged.

[10] Banks are required to report external liabilities using the CL form only if such liabilities exceed £300 million, so a bank could cease to report external liabilities within the period of study if such liabilities fell below this threshold.

[11] Apart from the differences between locally-owned banks, subsidiaries and branches documented here, another significant feature of the UK banking industry is the high degree of concentration in lending, especially to the household sector. This is examined in Section 6.

changes over the shock period, and adjusted for exchange rate movements using data on currency composition.

Table A: Summary statistics

	Stock 1/			% change		
	Mean	**Median**	**S.D.**	**Mean**	**Median**	**S.D.**
		£ millions				
External liabilities						
All banks 2/	23,593	3,245	65,332	-16.1	-15.7	25.9
UK-owned banks	62,436	3,120	131,069	-13.3	-11.4	27.2
Foreign subsidiaries	6,712	1,438	12,753	-20.3	-20.3	27.9
Foreign branches	22,287	5,082	55,740	-15.1	-16.2	25.0
Domestic lending						
All banks	20,434	1,310	69,160	-15.4	-12.6	33.9
UK-owned banks	93,912	6,647	169,303	8.6	10.5	26.0
Foreign subsidiaries	15,515	1,264	41,153	-19.9	-19.6	27.7
Foreign branches	8,568	1,106	24,134	-18.2	-18.3	35.6
		% of total assets				
External liabilities						
All banks	62.7	67.2	24.3			
UK-owned banks	40.8	37.3	29.3			
Foreign subsidiaries	51.4	55.0	25.1			
Foreign branches	70.6	72.7	18.6			
Domestic lending						
All banks	33.6	29.4	23.6			
UK-owned banks	58.1	57.6	26.5			
Foreign subsidiaries	46.6	41.5	20.5			
Foreign branches	24.5	19.8	18.3			

1/ Measured at end-March 2008

2/ The sample comprises 141 UK-resident banks, of which 17 are UK-owned, 32 are foreign subsidiaries, and 92 are foreign branches.

At the beginning of the shock period, UK-resident banks on average had large external liabilities as a share of total liabilities. The ratio was highest for foreign branches, followed by foreign subsidiaries, but even the UK-owned banks sourced more than 40% of their funding from abroad. This pattern was inverted for domestic lending, with UK-owned banks having the largest domestic lending as a share of total assets, followed by subsidiaries and then branches. But even the foreign branches held a substantial fraction of their total assets—about a quarter—in domestic claims.

The shock to external liabilities was very large for all bank types. But it was greatest for foreign subsidiaries, followed by foreign branches and then UK-owned banks. The change in domestic lending was correspondingly large for subsidiaries and branches. UK-owned banks, in contrast, actually expanded their domestic loan book on average over the shock period (but with much variation within the group). These differences in initial conditions, and in the magnitude of the shock, suggest that the response to the shock may also have differed by bank type, an issue which is pursued in section 5.1.

3.2 Estimation

The aim is to examine the impact of a change in banks' external liabilities on its domestic lending over the shock period. Since this is primarily an event study rather than an effort to identify long-run relationships that hold in normal times, the approach employed here relies on cross-sectional heterogeneity in differenced variables.[12] Focusing on cross-sectional heterogeneity over a well-specified shock period has two attractive features in this context. First, it enables the study to abstract from the questions of appropriate lag structure that would arise in a panel context. Second, collapsing the data circumvents the bias introduced by serial correlation in the independent variable (Betrand, Dufflo and Mullainathan (2004)).

The following baseline specification is used.

$$\Delta DL_i = \alpha + \beta_1 \Delta XL_i + \beta_2 DEMAND_i + \gamma' Z_i + \varepsilon_i \qquad (1)$$

where i indexes banks;

ΔDL denotes the change in (log) domestic lending over the shock period;

ΔXL denotes the change in (log) external liabilities over the shock period;

$DEMAND_i$ denotes a bank-specific demand shock; and

Z is a vector of controls (with a corresponding vector of parameters γ).

[12] The empirical design is thus similar to Schnabl's (2011) event study of the liquidity shock caused by the 1998 Russian default, and its impact on bank lending in Peru.

Equation (1) attempts to control for bank-specific demand shocks through the term $DEMAND_i$. This is constructed as follows:

$$DEMAND_i = \sum_{j \in J} s_{ij} \Delta TBL_{ij}$$

where j indexes sector and $j \in J =$ {Households, Businesses, Other Banks, OFIs};

s_{ij} denotes bank i's claims on sector j as a ratio of its total domestic claims; and

ΔTBL_{ij} denotes the change in lending by all banks *except* bank i to sector j.

DEMAND thus seeks identification of the impact of demand by exploiting the heterogeneity of sectoral exposures across banks. For each bank, it uses the sectoral exposure pattern of that bank to weight lending growth by all *other* banks across sectors. All other things equal, banks with large exposure to a sector which experiences a relatively large fall in demand will see domestic lending fall by more than banks with small exposure to that sector: the coefficient on DEMAND should pick up this effect. To some extent this proxy for demand conditions may also pick up supply-side effects (as would any other proxy for demand, such as value-added in each sector, which may determine demand for bank loans but would also reflect loan availability). But it will only pick up *aggregate* supply side effects that affect lending by all banks, not supply side effects which are specific to any particular bank. The bank-specific heterogeneity in the variable arises from differential exposures across sectors.

Given the origins of the financial crisis in the US mortgage market, it seems plausible that ΔXL is exogenous. But this needs to be established rather than assumed, so that estimating equation (1) using OLS is potentially subject to the standard problems of omitted variable bias and endogeneity. One or more non-observables might affect both the response variable (the change in domestic lending) and the explanatory variable of interest (the change in external liabilities). Moreover, given the imperfections of the demand control, a relationship between the response and conditioning variable could occur, say, because weak demand generates a fall in the need for external funding.

These issues are addressed by instrumenting the conditioning variable, the change in external liabilities over the shock period. Three instruments are used.

The first instrument is the share of repos—repurchase agreements—in a bank's total external liabilities, immediately prior to the shock. This is a measure of ex-ante reliance on wholesale external funding. As described in the literature review, there is ample evidence showing that the funding shock was transmitted through the repo market, with the haircut on repos increasing to unprecedented levels in the aftermath of the Lehman collapse. Gorton and Metrick (2010) argue that the run on repo was the chief distinguishing feature of this financial crisis. Raddatsz (2010) presents cross-country evidence that banks with more reliance on wholesale funding came under greater stress—as measured by returns—following Lehman. So it is plausible that this instrument should predict the size of the funding shock in the subsequent period. Both the stock nature of the instrument and its time of measurement would suggest that it should not itself be affected by the subsequent change in banks' domestic lending. Moreover, it seems unlikely that it would impact a future change in domestic lending except through the funding shock.

The second instrument is the ex-ante share of external liabilities owed to foreign affiliates, i.e. "within firm" borrowing as opposed to borrowing from unaffiliated firms. There is substantial evidence that globalised banks with foreign affiliates activate internal capital markets in the face of liquidity shocks. A series of papers demonstrate that this smoothing of liquidity operates in both directions. Thus Cetorelli and Goldberg (2009) show that large US banks absorb liquidity from foreign affiliates in the face of domestic shocks, while de Haas and van Lelyveld (2010) show that in a financial crisis, foreign subsidiaries rely on liquidity support from parents to smooth credit supply.[13] Therefore it is likely that banks with a larger share of exposure to foreign affiliates enjoy relatively greater insulation from external liquidity shocks. As with the repo instrument, the share of liabilities to foreign affiliates is measured immediately prior to the shock period.

The third instrument is a measure of banking system stress during the shock in the region in which a bank is headquartered. LIBOR-OIS spreads (or local equivalents)

[13] Further evidence on internal capital markets is contained in Campello (2002) and Ashcraft (2008).

are used to gauge the level of banking system stress.[14] All countries which own sample banks are grouped into one of nine regions: UK, USA, Eurozone, Switzerland, Australia, Canada, Japan, non-Japan Asia and Other. For each rion, a variable is constructed containing the difference between the average LIBOR-OIS spread during the shock period and the average during the previous 6-quarter period.[15] As Charts 2 and 3 below show, while LIBOR-OIS spreads shot up in all regions during the shock, there was considerable heterogeneity in the extent of this upward movement, with Australian, Canadian and Asian banking systems registering a much smaller mean increase than major Western banking systems.

[14] An overnight index swap (OIS) is an interest rate swap in which the floating leg is tied to an index of overnight rates. The two parties agree to exchange, on a given notional amount, the difference between interest accrued on the fixed and floating legs. The fixed rate is a proxy for market expectations of future overnight rates, with minimal credit risk (because of the short maturity of the claim). Therefore the spread against LIBOR provides a measure of credit risk in the interbank market.

[15] Wherever possible, a regional equivalent is used in place of the LIBOR. Thus the EURIBOR is used for the Eurozone, the TIBOR for Japan, the SIBOR for Singapore, the HIBOR for Hong Kong, the CDOR for Canada and the Bank Bill Swap Reference Rate (BBSW) for Australia, with spreads taken over the corresponding overnight index swap (OIS). For the region non-Japan Asia, an average of the SIBOR-OIS and HIBOR-OIS spread is used, while for the residual region Other, an unweighted average of the spreads for all other regions is used.

Chart 2: LIBOR-OIS spreads

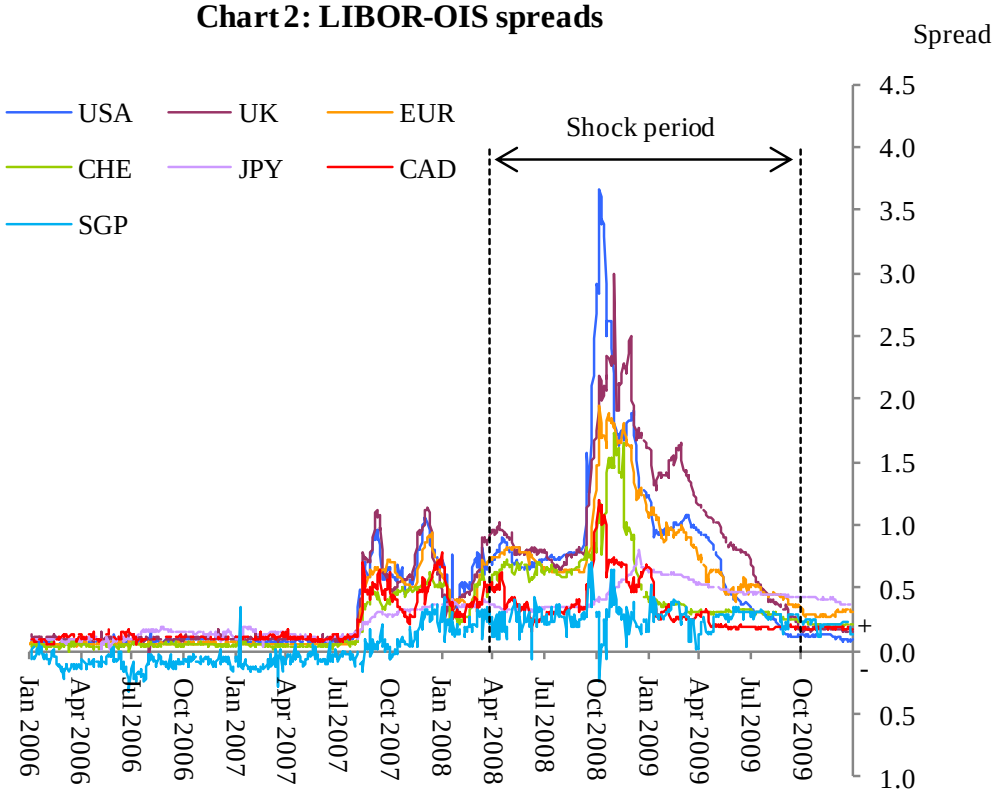
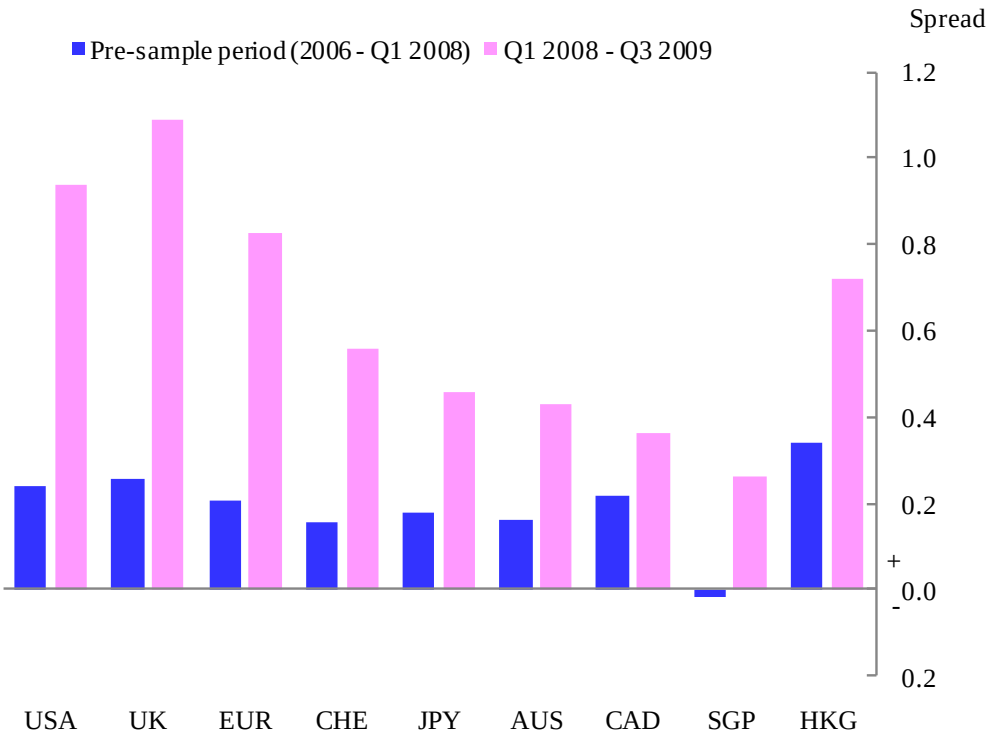


Chart 3: Mean LIBOR-OIS spreads



The LIBOR-OIS spread measures counterparty risk among participating banks.[16] The heterogeneity of counterparty risk among different banking systems during the crisis is well documented; see, for example, Genberg, Hui, Wong and Chung (2009) and Baba and Packer (2009). The divergence by region in the mean increase of the LIBOR-OIS spread provides a measure of this heterogeneity. Other things equal, a greater increase in counterparty risk in a particular banking system should be associated with a greater withdrawal of interbank liquidity.

4 Main Results

Table B presents the results of 2SLS estimation using the instruments described above.

[16] See Taylor and Williams (2008) for evidence that the LIBOR-OIS spread indeed provides a measure of counterparty risk among banks. In particular, they refute the hypothesis that the spread also picks-up liquidity constraints.

Table B: Impact of change in external liabilities on change in domestic lending [(a)]

Dependent variable: ΔDL	1 **2SLS**	2 **2SLS**	3 **2SLS**	4 **2SLS**
ΔXL	.55**	0.59**	.65**	.60**
	0.27	0.25	0.28	0.28
DEMAND		.035***		.032***
		0.009		0.01
Size controls	No	No	Yes	Yes
N	141	141	141	141
Underidentification (H0: Not identified)				
K-P Wald rank LM-statistic	10.3	11.83	9.3	10.12
p-value	0.012	0.008	0.02	0.01
Overidentifying restrictions (H0: Instruments uncorrelated with error process)				
Sargan chi-squared statistic	0.35	0.17	0.12	0.071
p-value	0.84	0.92	0.94	0.96
Weak instruments (H0: Instruments are weak)				
K-P rank Wald F-statistic	10.23	12.46	9.74	10.25
10% critical value (Stock and Yogo)	9.1	9.1	9.1	9.1

(a) Heteroskedasticity-robust standard errors reported below coefficients. *, ** and *** denote 1%, 5% and 10% levels of significance respectively. These conventions apply to all following tables of regression results. Size controls include total bank assets prior to the shock period, and total external liabilities prior to the shock period.

Column 2 estimates equation (1). A fall in external liabilities of 1 percent leads to a reduction in domestic lending of about 0.6 percent, a substantial impact. Demand shocks, proxied by bank-specific sectoral exposures, exert a significant independent effect on domestic lending, with the expected sign. If the instruments used are valid, including or excluding the demand shock variable should have little impact on the co-efficient of interest. This is confirmed by column 1, where DEMAND is omitted from the specification; the co-efficient on ΔXL remains significant and of a very similar magnitude.

Columns 3 and 4 introduce two controls relating to the size of the bank's balance sheet and external operations. The first is total assets immediately prior to the crisis, and the second is total external liabilities immediately prior to the crisis. Both variables are significant with the expected signs (positive and negative, respectively). They are retained as controls for subsequent regressions tabulated in this paper, but not individually reported, since they make no significant difference to the estimate of

the parameters of interest (as can be seen by comparing columns 3 and 4 with columns 1 and 2).

A comprehensive set of post-estimation tests of instrument validity is reported for each regression. The Kleinbergen-Paap rank LM-statistic tests for identification (Kleinbergen and Paap (2006)): the null hypothesis that the instruments are uncorrelated with the endogenous regressor is strongly rejected. Because three instruments are used for a single endogenous regressor, it is possible to conduct Sargan-Hansen tests of overidentifying restrictions. Under all specifications above, the null hypothesis that the exclusion restriction is valid—i.e. that the instruments are uncorrelated with the error term of the structural equation (1)—cannot be rejected. Moreover, p-values indicate that the Sargan statistic lies far to the left of the rejection zone. Finally, the Kleinberg-Paap rank Wald F-statistic indicates that the instruments used are sufficiently strong.[17]

On the basis of strong support from post-estimation tests and the intuitive appeal of the instruments used, I conclude that the impact of the external funding shock on banks' domestic lending is well identified and substantial. This is the paper's central result.

[17] The Cragg-Donald Wald statistic is more conventionally used to test for weakness of instruments, but is invalid under heteroskedasticity-robust standard errors. Critical values are from Stock and Yogo (2005). As a further robustness check, I estimate, but do not report, the regressions in Table B using limited information maximum likelihood (LIML). Again, the validity of the instruments is strongly supported.

Table C: 2SLS and OLS

Dependent variable: ΔDL	1 **2SLS**	2 **OLS**
ΔXL	.60**	.51***
	0.28	0.09
DEMAND	.032***	.034***
	0.01	0.01
Size controls	Yes	Yes
N	141	141
R-squared		0.27
Exogeneity of explanatory variable (H0: Variable is exogenous)		
Difference-in-Sargan statistic	0.14	
p-value	0.71	

It is now possible to re-examine whether the external funding shock in equation (1) was indeed exogenous, by comparing an OLS estimate with the 2SLS estimate above.

A comparison of columns 1 and 2 in Table C reveals no significant difference between the OLS estimates and the instrumental variables estimates. *Provided* that the instruments used are valid, this suggests that the funding shock was indeed exogenous. A formal test of the exogeneity of ΔXL is provided by the Difference-in-Sargan statistic. This is constructed as the difference of two Sargan-Hansen statistics, one in which the suspect regressor is treated as endogenous, and one in which the suspect regressor is treated as exogenous. Under the null hypothesis that the regressor is actually exogenous, the statistic is distributed as chi-squared with one degree of freedom.[18]The null cannot be rejected at conventional levels of significance, and the p-value indicates that the statistic lies far to the left of the rejection zone.

Given the exogeneity of ΔXL, OLS is preferred to the 2SLS estimator since it is more efficient. Accordingly, OLS is employed for the remainder of this paper. Before exploring various interactions with the funding shock, I check that the estimated relationship is robust to outliers, and whether the relationship is driven by particular

[18] The test is a heteroskedasticity-robust variant of a Hausman test, to which it is numerically equivalent under homoskedastic errors.

sub-samples of the data. This is an important concern in an economy in which there is much concentration of lending among certain banks, a point that is elaborated in Section 6, where domestic lending is disaggregated on a sectoral basis.

Table D: Median impact on change in domestic lending

	1	**2**
Dependant variable: ΔDL	**OLS**	**Median Regression**
ΔXL	.51***	.55***
	0.09	0.1
DEMAND	.034***	.031***
	0.01	0.01
Size controls	Yes	Yes
N	141	141
R-squared	0.27	0.21

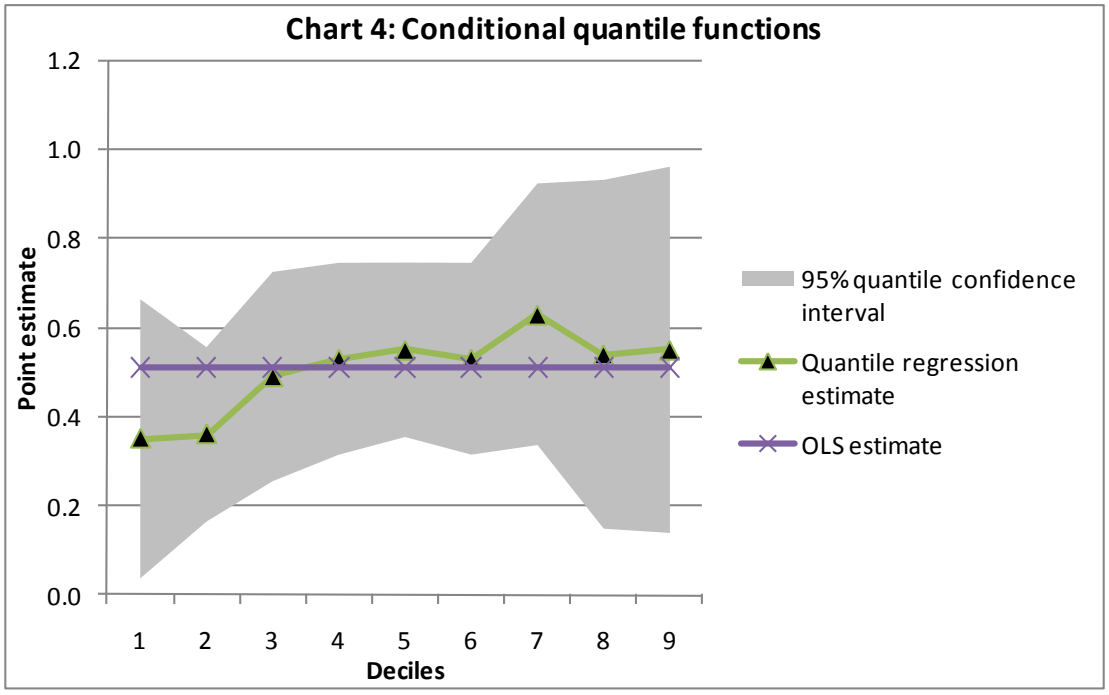


Table D compares the OLS specification against a median regression. Since the latter attaches less weight to outliers, the close correspondence between the two estimates is reassuring. Chart 4 shows point estimates from a family of quantile regressions. Although there is some variation in these estimates across different deciles of the

conditional distribution of the response variable, all estimates are significant. Moreover the 95 percent confidence interval for each decile encompasses the OLS estimate. This assuages concerns about influential observations or sub-samples driving the results.

5 Some further empirical investigations

5.1 What role is played by institutional structure?

The summary statistics presented earlier showed that foreign-owned banks sourced a greater proportion (in the case of foreign branches, a far greater proportion) of their funding from abroad than domestically-owned banks. And the shock to their foreign funding was proportionately larger than for UK-owned banks. These heterogeneous initial conditions suggest that the response to the shock may differ by bank type. In addition, there are numerous theoretical reasons why the credit supply response of domestically-owned banks faced with a financial crisis or economic downturn may differ from the response of a foreign-owned bank (see de Haas and Lelyveld (2006) for a summary). Most importantly, foreign-owned banks may not consider lending in the host country to be a core business activity to the same extent as credit extension in their home country. This may induce them to extend credit on a "transaction-by-transaction basis" in the host country, implying a more volatile pattern of lending relative to a "through-the-cycle" model. Moreover, the differences in institutional structure between subsidiaries and branches—independent capitalization, location of regulator, legal relationship with the parent bank, etc.—might indicate differential responses to a crisis.[19] And, as noted earlier, in the UK branches rely on external funding to a greater extent than subsidiaries and lend less domestically.

Column 1 of Table E includes a dummy signifying UK-ownership (UOB), as well as a term that interacts UK ownership with the change in external liabilities. Being a domestically owned bank had a large and significant positive impact on domestic lending during the crisis. On the other hand, the positive interaction term suggests a sharper pullback in domestic lending in response to a given shock to external liabilities for a domestically-owned bank.

[19] Cerutti et al (2007) provide useful stylized facts about the characteristics of subsidiaries and branches, together with an analysis of organizational choice.

Table E: The impact of bank type

	1	2
Dependant variable: ΔDL	**OLS**	**OLS**
ΔXL	.45***	.83***
	0.10	0.12
DEMAND	.032***	.033***
	0.01	0.01
UOB	25.98***	
	6.3	
SUB		-26.8***
		6.95
BRN		-26.1***
		6.92
UOB*ΔXL	.38**	
	0.17	
SUB*ΔXL		-.52***
		0.17
BRN*ΔXL		-.32*
		0.19
Constant	3.02	29.6***
	4.56	6.66
Size controls	Yes	Yes
N	141	141
R-squared	0.31	0.32

This result suggests a "head for the exits" impact—a disorderly rush to deleverage—of the financial crisis on foreign-owned banks. That is, foreign-owned banks reduced domestic lending by a large amount irrespective of the size of the actual shock they faced to external liabilities. In contrast, domestically-owned banks calibrated the change in their domestic lending more closely to the size of the external funding shock.

Column 2 replaces the UK-ownership dummy with two dummies signifying whether a bank is a foreign subsidiary (SUB) or a foreign branch (BRN), together with corresponding interaction terms. This corroborates the "head for the exits" phenomenon for both subsidiaries and branches. No evidence is found of substantial

differences in response between subsidiaries and branches. It seems that—however differently they may respond to lesser liquidity shocks or economic downturns—their response was very similar in a financial crisis of this magnitude.

5.2 Does FX-denominated domestic lending respond differently?

If foreign liabilities are incurred primarily to support domestic lending in foreign exchange (FX), then we might expect an external funding shock to disproportionately impact FX-denominated domestic lending. Consistent with this hypothesis, column 1 of Table F provides some (weak) evidence of a smaller intercept term for FX-denominated lending. But the effect disappears once the UK-ownership dummy is introduced. Branches and subsidiaries are more likely to lend in foreign exchange, but the differential impact on domestic lending comes from their institutional structure rather than from the currency denomination of their loans.

Table F: Lending in FX

	1	**2**
Dependant variable: ΔDL	**OLS**	**OLS**
ΔXL	.54***	.45**
	0.15	0.19
DEMAND	.024**	.024**
	0.011	0.012
Fraction of DL in FX (t=0)	-21.5*	-16.79
	12.77	11.59
(Fraction of DL in FX)*ΔXL	-0.8	-0.01
	0.32	0.31
UOB		23.46***
		7.78
UOB*ΔXL		.41**
		0.22
Constant	12.19*	7.68
	4.84	5.20
Size controls	Yes	Yes
N	141	141
R-squared	0.29	0.32

5.3 Do foreign assets buffer the lending response?

To what extent do foreign assets provide a buffer against a shock to external liabilities? In the extreme case, if foreign liabilities were incurred only to fund foreign assets and if these assets could be easily liquidated in the face of a funding shock, foreign assets could, in principle, completely insulate the domestic economy from the shock. This is clearly not the case: as demonstrated by the regressions presented so far, the funding shock to banks was transmitted to domestic lending. But is the strength of the transmission related to the size of a bank's portfolio of foreign assets?

Table G: Are foreign assets a significant buffer?

	1	**2**	**3**
Dependant variable: ΔDL	**OLS**	**OLS**	**OLS**
ΔXL	.56***	.49***	.39***
	0.15	0.10	0.12
DEMAND	.033***	.033***	.031***
	0.01	0.01	0.01
Foreign assets / Total assets (t=0)	-14.72		
	10.74		
(Foreign assets / Total assets)*ΔXL	-0.11		
	0.32		
Foreign assets / Foreign liabilities (t=0)		-6.56**	-4.54
		3.21	3.2
(Foreign assets / Foreign liabilities)*ΔXL		-0.003	0.04
		0.06	0.06
UOB			24.18***
			6.44
UOB*ΔXL			.41**
			0.17
Constant	13.46**	11.98**	6.72
	6.59	5.35	5.66
Size controls	Yes	Yes	Yes
N	141	141	141
R-squared	0.28	0.29	0.33

Column 1 of Table G introduces the ex-ante ratio of foreign assets to total assets as a regressor, together with an interaction term. No evidence of a buffering role is found

by this measure. But this measure is probably less relevant than the one introduced in column 2: the ratio of foreign assets to foreign liabilities (FAFL).

Here, too, the interaction term is insignificant. This may seem surprising, since the buffer effect hypothesized above should drive a significant negative co-efficient on this term. The explanation probably lies in the countervailing impact of what might be called a core business effect. Consider banks whose core business is domestic lending. Other things equal, they will have a small ratio of foreign assets to foreign liabilities. Faced by an external funding shock, these banks will try to cut back first on foreign lending to save core business. This effect would tend to drive a positive interaction term. The fact that the interaction term is found here to be close to zero could indicate that these effects are cancelling each other out.

Column 2 does indicate a lower intercept for banks with large foreign assets relative to foreign liabilities. But this looks very much like the "head for the exits" phenomenon identified for branches and subsidiaries. And indeed, column 3 shows that when a UK-ownership dummy is included in the regression, the co-efficient on FAFL ceases to be significant. Branches and subsidiaries are simply more likely to have a large ratio of foreign assets to foreign liabilities than UK-owned banks.

6 Sectoral components of domestic lending

In this section I decompose domestic lending into its constituent parts—lending to households, lending to businesses, lending to other banks and lending to other financial institutions—and examine separately the impact of the external funding shock on each of these. The evidence presented here is subject to several important caveats. First, the sample of banks which lends to each particular sector is smaller than the full set of banks. Second, and more important, the samples are noisier, because of the concentration of lending in each sector. Finally, I cannot control for demand using the heterogeneity of sectoral exposures across banks as before, since the regressions are now sector-specific.

Table H below illustrates the high degree of concentration in bank lending by sector. The bottom line of the first panel shows the number of banks, in each sector, which

lend to that sector. The second panel restricts the sample to those banks with claims on a particular sector of more than £100 million (measured at the beginning of the shock period). The third panel further restricts the sample to those banks with claims of more than £500 million, and the fourth panel to banks with claims of over £ 1 billion. It is evident that while there is concentration in each sector, the degree of concentration is by far the highest in the household sector. Banks with individual claims of more than £ 1 billion account for over 99 percent of total claims on the household sector (compared with a ratio of 96 to 99 percent for the other sectors). Moreover, there are only 15 such banks in the household sector (compared with 45 to 50 banks in the other three sectors).

The first panel therefore contains a large proportion of banks which lend relatively trivial amounts (and are therefore subject to large percentage changes in lending). This introduces a lot of noise into the sample, and the regression results are correspondingly weak. The second, third and fourth panels—in which the sample is restricted by increasing levels of minimum sectoral claims—are more interesting. They show that the shock to external funding had a substantial impact on lending to businesses, to other banks, and to other financial institutions. Moreover, the third and fourth panels seem to indicate that the transmission was strongest for lending to OFIs, followed by lending to other banks, and then by lending to businesses. I find no evidence for an impact on household lending.

Why is there no statistically significant relationship between the shock to external liabilities and the change in household lending? One obvious explanation is that, because of the high degree of concentration, the sample size in the second, third and fourth panels is too small for reliable statistical inference. But there is probably a more fundamental factor at work. To the extent that the securitisation model of household mortgage lending was unwinding during the shock period—with securitized assets held off balance sheet in special purpose vehicles (SPVs) coming back onto banks' balance sheets— this would appear in the data as an increase in lending to the household sector, offsetting the impact of other falls in lending to the

sector.[20] Moreover, to the extent that the SPVs are domestic, and financed their purchase of the mortgages through a loan from the originating bank, the unwinding of securitisation would also be manifest in the data as a decrease in lending to OFIs, potentially exaggerating the relationship between the change in external liabilities and the change in domestic lending for the OFI sector.

Another possible explanation for the lack of a statistical impact on household lending could be pressure exerted by the government on banks to keep up lending to households and businesses. This pressure may have been especially acute on banks that were recapitalized by the Treasury or accessed special liquidity facilities (see HM Treasury (2008)). However, this explanation is somewhat less promising, because the government was keen to see lending maintained to both households and businesses, and a statistical impact is found for lending to businesses.

Table H: Sectoral regressions

Sample		Dependent variable: change in lending to sector			
		Households	**Businesses**	**Other Banks**	**OFIs**
		1	**2**	**3**	**4**
	Full sample				
	ΔXL	-66.31	-578	1.13*	.50*
		58.36	584	0.59	0.29
	% of total lending	100	100	100	100
	N	122	134	139	130
	Sectoral lending > £100 m				
	ΔXL	-0.28	.53***	.38*	.69***
		0.39	0.17	0.28	0.24
	% of total lending	99.8	99.8	99.8	99.9
	N	27	91	105	73
	Sectoral lending > £500 m				
	ΔXL	0.08	.41***	.50*	.92***
		0.29	0.15	0.29	0.33
	% of total lending	99.6	98.4	99.2	98.8
	N	19	60	70	47
	Sectoral lending > £1000 m				
	ΔXL	0.33	.39**	.79***	1.03***
		0.21	0.18	0.27	0.33
	% of total lending	99.1	96.5	98.6	96.9
	N	15	47	48	40

[20] Unfortunately the balance sheet data used in this study do not include information on mortgage securitisations, and there does not exist, to the best of my knowledge, any alternative data source with bank-specific information on mortgage securitisations on an unconsolidated basis.

In view of the high concentration of bank lending in particular sectors, and the sensitivity of estimates to different sample restrictions, I also examine a family of conditional quantile regressions separately for the business sector, for other banks, and for OFIs. Unlike the quantile regressions for domestic lending as a whole, here there is considerable variation across deciles. Moreover, a number of decile point estimates are insignificant.

Table I: Quantile regressions on components of domestic lending

Dependent variable: change in lending to sector (a)

	Decliles of conditional distribution								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Businesses									
ΔXL	0.02	.51*	.65**	0.38	.46**	.48***	.53***	.48**	.61*
s.e.	0.51	0.29	0.32	0.26	0.18	0.11	0.13	0.22	0.38
Other Banks									
ΔXL	0.11	0.29	.43**	.45**	.39***	.52**	.50*	0.29	-0.42
s.e.	0.22	0.23	0.18	0.18	0.15	0.21	0.30	0.59	1.1
OFIs									
ΔXL	-0.02	.59**	.64*	.77***	1.03**	1.05**	1.14***	1.19***	1.15
s.e.	0.39	0.25	0.34	0.29	0.41	0.42	0.39	0.31	0.79

(a) All regressions exclude banks with sectoral claims of less than £100 million prior to the shock.

Overall, the evidence seems to indicate a substantial impact of the external funding shock on lending to businesses, other banks and OFIs. But the evidence is weaker than for domestic lending taken as a whole, and point estimates are subject to considerable uncertainty.

7 Conclusion

It is by now widely held that a primary international transmission channel of the financial crisis was through a retrenchment of credit by globalised banks facing a funding shock. But the literature on this bank lending channel is surprisingly sketchy. The UK provides a good testing ground for this channel, because of the size and importance of its resident banking sector. The large number of banks operating in the UK and their heterogeneity provide an ideal sample for statistical inference.

This paper has used detailed regulatory bank returns to identify a substantial impact of the external funding shock on the provision of domestic bank credit. This includes not only direct credit provided to the real economy, but also lending to other banks and OFIs, which would be expected to have further knock-on effects on credit provision to the real economy. Quantile regressions suggest that the impact identified is robust to outliers in the data.

I find evidence of a "head for the exits" phenomenon among foreign-owned banks—both branches and subsidiaries—relative to UK-owned banks. That is, the typical branch or subsidiary cut back on domestic lending to a much larger extent than the typical UK-owned bank, irrespective of the size of the shock to external funding. UK-owned banks, on the other hand, calibrated the credit pullback more closely to the size of the funding shock. This is consistent with UK-owned banks regarding lending within the UK as a core business activity to a greater extent than branches and subsidiaries, and with banks acting to preserve core business. To the extent that we can use these results to think about the experience of other countries, this differential response by bank type is relevant to the transmission of the global funding shock to bank lending in countries with smaller banking sectors, and, in particular, a smaller presence of foreign-owned banks. They suggest that while all advanced countries with globalised banks should have seen some transmission to their real economies through the bank lending channel, the impact would be increasing in the share of foreign-owned banks.

There is some evidence that FX-denominated lending was cut back more than sterling lending, but this is probably because foreign-owned banks are more likely to lend in foreign exchange. There is little evidence that foreign assets acted as a significant buffer to protect domestic lending against the external funding shock. Any buffering role was overwhelmed by the core business effect, by which foreign-owned banks—which tend to have a relatively large foreign assets-to-foreign liabilities ratio—pulled back domestic credit more sharply than UK-owned banks.

The evidence of the impact of the funding shock on lending by sector relies on smaller and noisier samples. Nonetheless, a substantial impact is found on lending to

businesses, to other banks, and to OFIs. I find no evidence of an impact on lending to households, perhaps because of the contemporaneous unwinding of the securitisation model of mortgage lending.

Overall, the results lend considerable support to the standard narrative of the global financial crisis and the Great Recession. First, stresses spread from banking systems with direct exposure to US "toxic assets" to secured and unsecured funding markets. This caused a large funding shock to banking systems in various countries, irrespective of direct exposure to US assets, as amply documented in the literature. Second, banks responded to this shock to the liabilities side of their balance sheet by retrenching domestic assets, i.e. reducing lending to resident entities. Thus financial contagion was transmitted to the real economy.

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