



BANK OF ENGLAND

Working Paper No. 424  
How did the crisis in international  
funding markets affect bank lending?  
Balance sheet evidence from the  
United Kingdom

Shekhar Aiyar

April 2011



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

Shekhar Aiyar<sup>(1)</sup>

### 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 underexamined, 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 data set, created from detailed and confidential balance sheet data reported by individual banks quarterly to the Bank of England. I find that the shock to foreign funding caused a substantial pullback in domestic lending. The results are derived using a range of instruments to correct for endogeneity and omitted variable bias. Foreign subsidiaries and branches 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, transmission mechanism, bank lending, instrumental variables.

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

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## Summary

How did problems originating in one asset class in one country propagate internationally, sparking the Great Recession? A standard stylised explanation relies on the globalisation of the banking system, and has two parts. First, stress in the US banking system (and others directly exposed to US mortgages/structured products) spread internationally through international funding markets. Second, this shock to the foreign funding of various countries' banking systems was transmitted domestically through a reduction in credit supply. While there is a substantial empirical literature documenting the first step above, evidence on the second step is rather slim. This paper tests the transmission to domestic lending of the shock to UK-resident banks' external funding during the crisis.

As a global financial centre, the United Kingdom hosts a large and heterogeneous set of banks, some of which are UK-owned, but many of which are branches or subsidiaries of banks headquartered in other countries. During the financial crisis, these UK-resident banks were subject to an unprecedented shock to foreign funding, with an aggregate fall in external liabilities of about 24% (by way of comparison, the previous largest fall was 9%, during the ERM crisis). This study examines the transmission of this shock to domestic lending. It uses a novel data set, created from detailed and confidential balance sheet data—reported quarterly to the Bank of England—on about 140 UK-resident banks.

The study aims to estimate the impact of the change in a bank's external liabilities on its domestic lending during the crisis. But in principle, of course, causation between these variables can run in both directions, and moreover, domestic lending can be affected by a host of factors that are omitted from the study. To ensure accurate identification of the causation *from* the change in external liabilities *to* the change in domestic lending, an econometric technique called instrumental variables is used. Provided that certain statistical conditions—which are mostly verifiable in the data—are satisfied, this technique circumvents the problems of reverse causality and omitted variables.

The main finding is that each 1% reduction in banks' external funding caused a 0.5% to 0.6 % contraction in domestic lending, a substantial impact. Given the large shock to banks' external funding that actually occurred, it is likely that this was a crucial channel for transmitting the financial shock to the real economy. The estimated relationship is robust to a wide range of specifications and sensitivity tests. Foreign subsidiaries and branches on average 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. There is little evidence that foreign assets buffered domestic lending against shocks to foreign liabilities.

The transmission of the external shock to different sub-components of domestic lending is also explored. Evidence is found that the shock caused a significant cutback in lending to businesses, to other banks, and to other financial institutions, with the caveat that these subsamples of the data are smaller and noisier. But no evidence is found 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 mortgage securities back onto their balance sheets, a development which would tend to increase reported bank lending to households.

## 1 Introduction

In 2009 output contracted in all but 3 of the 33 countries classified as advanced economies by the IMF, with the severity of the contraction among these countries bearing no obvious relationship with direct exposure to the US mortgage market.<sup>1</sup> Rose and Spiegel (2009) conclude, from an exhaustive investigation of country-specific exposures to a range of US assets, that the degree of such exposures played no significant role in the incidence of the crisis. How then did problems originating in one asset class in one country propagate internationally, sparking the Great Recession?

A standard stylised explanation relies on the globalisation of the banking system, and has two parts. First, stress in the US banking system (and others directly exposed to US mortgages/structured products) spread to foreign banks through funding markets, both secured and unsecured. Second, this shock to the foreign funding of various countries' banking systems was transmitted domestically through a reduction in credit supply. While there is a substantial empirical literature documenting the first step above, evidence on the second step is rather slim. This may be because of the identification problem that arises when weak bank credit is observed jointly with weak domestic demand.

This gap in the literature is important, given the almost universal policy consensus that this was a bank-led recession, ie that the deterioration in the real economy was initiated by a tightening of credit conditions rather than *vice versa*. In a speech given in April 2010, Jean-Claude Trichet summarised 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 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*'<sup>2</sup> Similar diagnoses may be found on the lips of other central bankers and policymakers. Successive *World Economic Outlooks* (WEOs) and

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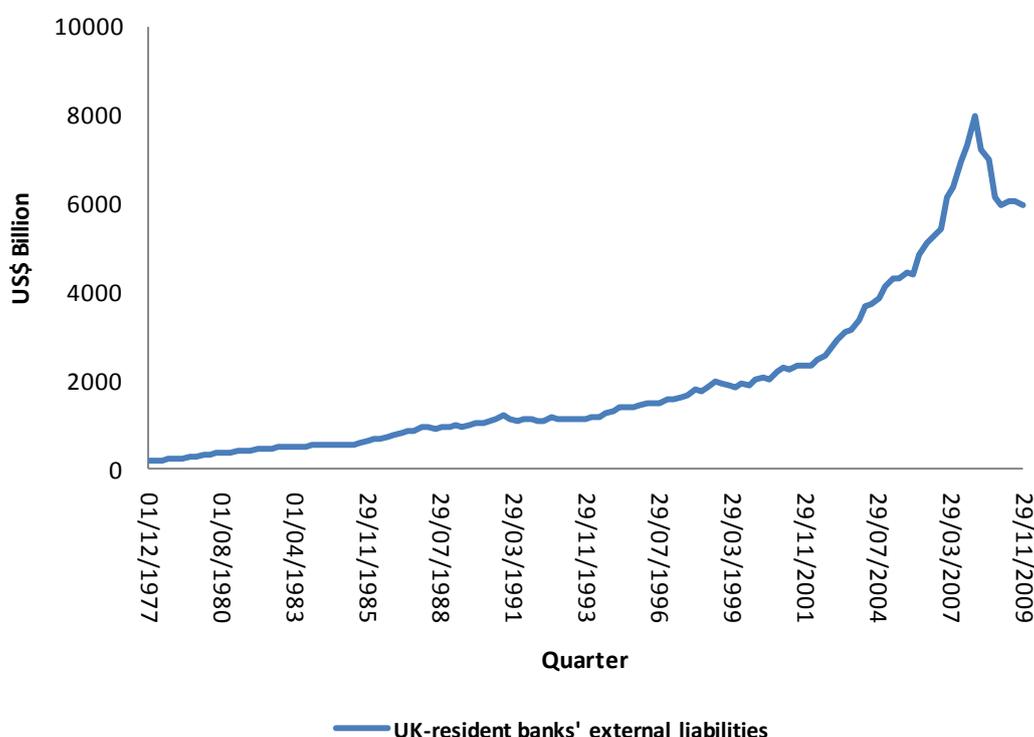
<sup>1</sup> WEO, April 2010.

<sup>2</sup> Trichet (2010).

*Global Financial Stability Reports* (GFSRs) from the IMF have placed the ‘global credit crunch’ at the heart of the recession. In the United Kingdom, several recent issues of the Bank of England’s *Financial Stability Report* have emphasised the impairment of bank credit arising from the liquidity shock.

The UK economy provides an ideal testing ground for the transmission of the external funding shock to banks’ domestic lending. As a global financial centre, it hosts a large and heterogeneous set of banks headquartered in many different countries. Many of these banks—both among those headquartered abroad and those domestically owned—have substantial foreign liabilities, 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 a time series from the Bank for International Settlements (BIS) on the aggregate external liabilities of all UK-resident banks. These liabilities fell by 24% from their peak in end-March 2008 to end-October 2009, when they started stabilising again. By way of comparison, the previous largest six-quarter fall in external liabilities was only 9%, during the ERM crisis in the early 1990s.

**Chart 1: An unprecedented shock to banks' external funding**



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. This study investigates whether and to what extent banks reacted using option (iii), thereby transmitting the financial contagion to the real domestic economy. It uses a novel data set for this purpose, 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 a data set that is rich enough to allow 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 on the change in their domestic lending. Of course, OLS is potentially subject to endogeneity and omitted variable. 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 sizable literature—while not exercising any independent impact on the response variable. Post-estimation tests offer strong support for the validity of the instruments.

My main finding is 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 subsamples 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 next section briefly reviews some relevant literature. Section 3 describes the data and the estimation strategy. Section 4 provides the main empirical results and Section 5 presents some additional results. Section 6 disaggregates domestic lending by sector. Section 7 concludes.

## **2 Related literature**

There is a voluminous empirical literature on the impact of the financial crisis on banks' funding markets.<sup>3</sup> Gorton and Metrick (2009) trace the genesis of a 'run on repo', ie a systemic bank run which occurred not through the traditional channel of depositors withdrawing their funds, but through the withdrawal of repurchase agreements. They describe how this vast and global short-term market—which provides the main source of funding for investment banks and an increasingly important source of funds for commercial banks—seized up over the crisis. The haircut on collateral in repo markets started increasing around August 2007, escalated substantially between the collapse of Bear Stearns in March 2008 and the collapse of Lehman Brothers in September, and then spiked dramatically after the latter event. With minor variations in timing, the pattern was repeated in the interbank market for unsecured funding, as evidenced by the Libor-OIS spread. As perceptions of counterparty risk increased, banks hoarded liquidity for precautionary motives (Acharya and Merrouche (2010)), further restricting the liquidity available to other banks. Runs also occurred in other funding markets, such as asset-backed commercial

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<sup>3</sup> 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).

paper and structured investment vehicles (Covitz, Liang and Suarez (2009), Carey, Correa and Kotter (2009)). Short-term funding in US dollars came under particular stress, as documented by McGuire and von Peter (2009) and Coffey *et al* (2009).

The literature on the transmission of this funding shock to bank lending is much sketchier, a gap this paper attempts to remedy. The most similar study in aim to this one looks at an emerging economy in an earlier period: Khwaja and Mian (2008) examine bank lending activity in Pakistan subsequent to the nuclear tests of 1998. In the wake of the nuclear tests, capital controls were imposed, generating a shock to dollar-denominated deposits. The authors show that this had a significant impact on bank lending.

Two recent papers examine different aspects of the evolution of bank lending during the financial crisis. Cetorelli and Goldberg (2010) show how the liquidity shock to globalised banks headquartered in advanced countries was transmitted to emerging economies via a reduction in bank credit. They identify three channels: a reduction in direct cross-border lending, a reduction in lending to local affiliates in emerging economies, and a reduction in foreign funding to locally owned banks in emerging economies. Ivashina and Scharfstein (2010) document the fall in syndicated bank lending in the United States 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 real impact of the funding shock via 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.

### 3 Data and estimation strategy

#### 3.1 Data

The United Kingdom'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.<sup>4</sup> It is the world's largest banking sector by asset size. At end-2009, there were over 300 banks resident in the United Kingdom, with total assets amounting to £7.6 trillion, or over 500% of GDP.<sup>5</sup> 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.<sup>6</sup>

As part of the United Kingdom'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,

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<sup>4</sup> 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.

<sup>5</sup> By way of comparison, US-resident banks at end-2009 had assets of US\$11.67 trillion, or £7.19 trillion.

<sup>6</sup> 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).<sup>7</sup> Each category is split into several subcategories, 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 (eg UK-resident bank purchases of commercial paper issued by other UK residents, line item 26F in the BT form, is subdivided into issuance by financial corporations and issuance by non-financial corporations excluding public enterprises). The CL and CC forms are used to report on, respectively, banks' external liabilities and assets, ie 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 timeseries 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 analysed 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.<sup>8</sup> 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.<sup>9</sup> 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.<sup>10</sup> The stock of domestic lending and external liabilities is

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<sup>7</sup> All regulatory forms used in this study can be viewed at [www.bankofengland.co.uk/statistics/reporters/defs/defs.htm](http://www.bankofengland.co.uk/statistics/reporters/defs/defs.htm).

<sup>8</sup> 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.

<sup>9</sup> 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.

<sup>10</sup> 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.

measured at the beginning of what is called the ‘shock period’: the period between end-2008 Q1 and end-2009 Q3 during which external liabilities collapsed so dramatically (see Chart 1 above). Changes in the variables of interest are measured as changes over the shock period, and adjusted for exchange rate movements using data on currency composition.<sup>11</sup>

**Table A: Summary statistics**

	Stock 1/			% change		
	Mean	Median	S.D.	Mean	Median	S.D.
<b>£ millions</b>						
<b>External liabilities</b>						
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
<b>Domestic lending</b>						
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
<b>% of total assets</b>						
<b>External liabilities</b>						
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			
<b>Domestic lending</b>						
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

<sup>11</sup> The exchange-rate adjusted change in UK-resident banks’ external liabilities is substantially less than the change in the stock of external liabilities measured in US dollars, because the US dollar appreciated considerably against the pound sterling, and to a lesser extent against the euro during the shock period. Liabilities denominated in US dollars, sterling and euros comprise over 90% of external liabilities.

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. The following simple specification captures the aim of the study.<sup>12</sup>

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

where  $i$  indexes banks;

$\Delta DL$  denotes the change in (log) domestic lending over the shock period;

$\Delta XL$  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  $\gamma$ ).

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

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

<sup>12</sup> The approach employed here relies on cross-sectional heterogeneity in differenced variables. It is preferred to a panel approach mainly because a shock of the magnitude seen in this financial crisis very likely led to a structural break in behavioural relationships, reducing the usefulness of a long time series.

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

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

and

$\Delta TBL_j$  denotes the change in lending by *all* banks to sector  $j$ .

DEMAND is thus an attempt to identify the impact of demand using the heterogeneity of sectoral exposures across banks. All other things equal, banks with large exposures to a sector which experiences a relatively large fall in demand will see domestic lending fall by more than banks with small exposures to that sector: the coefficient on DEMAND should pick up this effect. Of course the control is an imperfect one, since it uses the change in aggregate claims by all banks on a particular sector as a proxy for demand in that sector. This proxy will inevitably be contaminated by supply-side effects (as would any other proxy for demand, such as value-added in each sector).<sup>13</sup> 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 only 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  $\Delta XL$  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 reverse causality. 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

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<sup>13</sup> Considerable effort was expended searching for a sector-specific proxy for demand for loans which did not rely on bank lending data, but no suitable alternative emerged. For example, from the Office for National Statistics (ONS) one may obtain proxies for household demand (final consumption demand by households plus investment in private dwellings) and business demand (business investment). But there is no comparable proxy for demand by the banking sector and the OFI sector. The closest measure is arguably 'operating surplus' or the 'balance of primary income' for those two sectors, but these data are not available on a quarterly basis, and the last year of availability is 2008. More fundamentally, even if it were possible to obtain some measure of value-added by sector from the national statistics, it is not clear that this would be a good proxy for the sector-specific demand for bank loans. It could well be that an identical value added in two different sectors implied a different demand for bank loans, if, say, one sector differentially relied on retained earnings or non-bank finance. Moreover, value-added by sector would also conflate demand and supply effects, eg, a fall in value added might reflect a binding financing constraint rather than a fall in demand.

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 (2009) argue that the run on repo was the chief distinguishing feature of this financial crisis. Raddatz (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, ie ‘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 (2008) 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.<sup>14</sup> 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.

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<sup>14</sup> Further evidence on internal capital markets is contained in Campello (2002) and Ashcraft (2008).

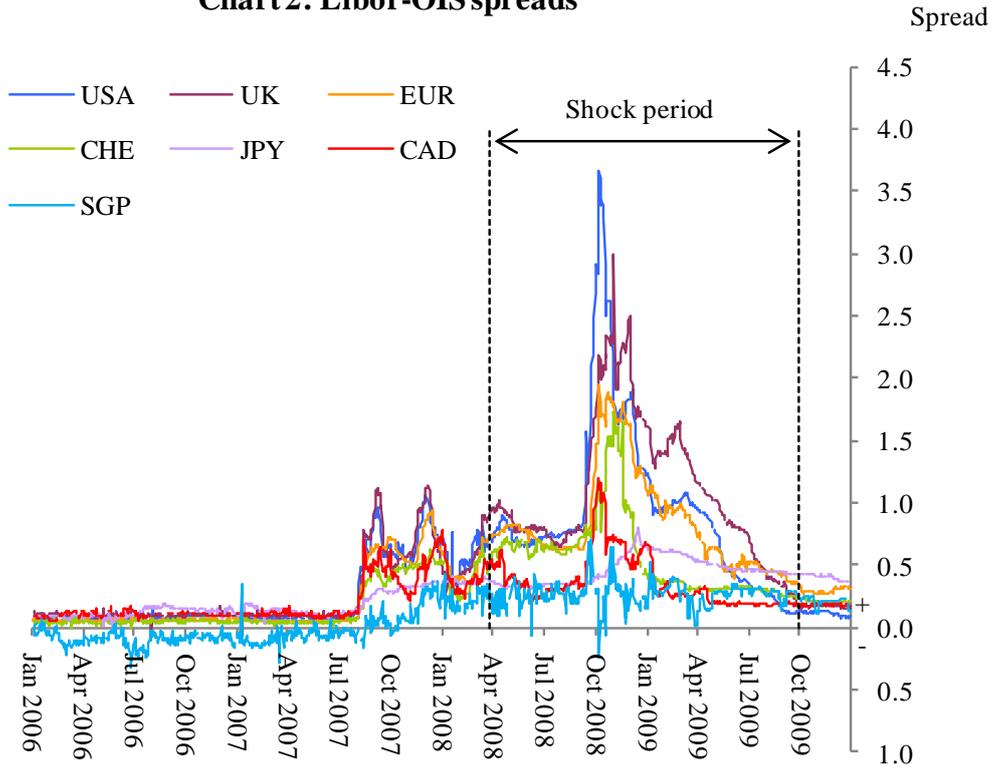
The third instrument is a measure of banking system stress during the shock in the region in which a bank is headquartered. Libor-OIS spreads (or local equivalents) are used to gauge the level of banking system stress.<sup>15</sup> All countries which own sample banks are divided into nine regions: United Kingdom, United States, euro zone, Switzerland, Australia, Canada, Japan, non-Japan Asia and Other. A variable is constructed containing the difference between the average Libor-OIS spread over the shock period and the average over the previous six-quarter period, region by region.<sup>16</sup> 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.

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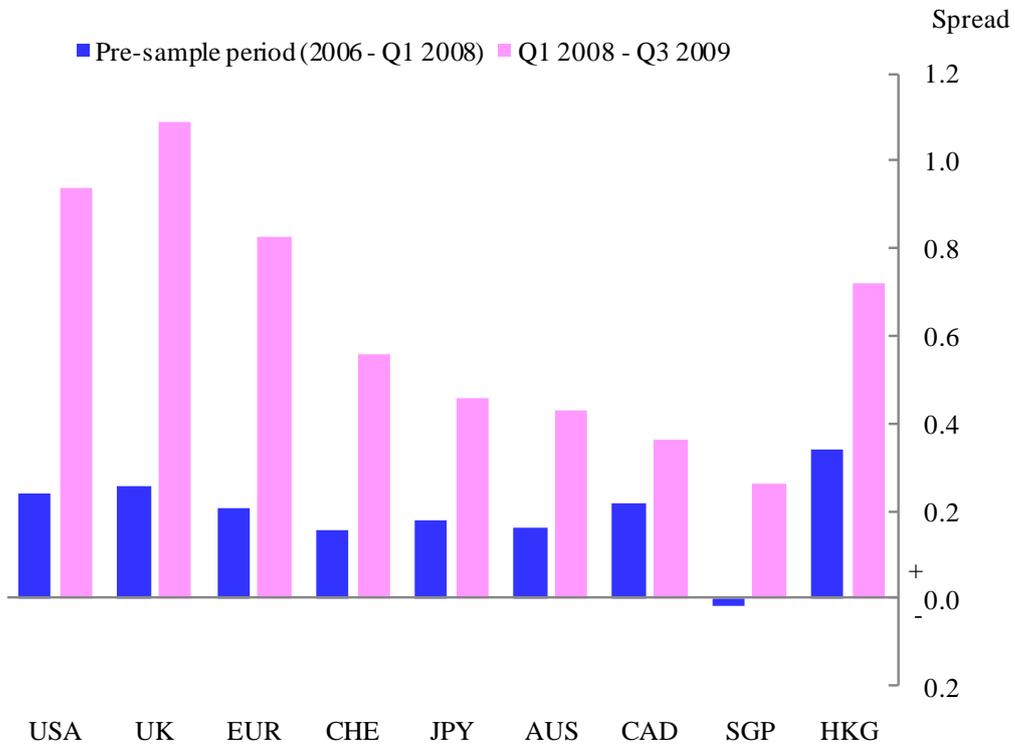
<sup>15</sup> An overnight index swap (OIS) is an interest rate swap in which the floating leg is tied to an index of overnight rates. The two parties agree to exchange, on a given notional amount, the difference between interest accrued on the fixed and floating legs. The fixed rate is a proxy for market 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.

<sup>16</sup> Wherever possible, a regional equivalent is used in place of the Libor. Thus the Euribor is used for the euro zone, 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 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.<sup>17</sup> 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.

**Table B: Impact of change in external liabilities on change in domestic lending**<sup>(a)</sup>

Dependent variable: $\Delta DL$	1	2	3	4
	2SLS	2SLS	2SLS	2SLS
$\Delta XL$	.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
<b>Underidentification (H0: Not identified)</b>				
A-P chi-squared statistic	31.57	38.76	30.53	32.34
p-value	0.00	0.00	0.00	0.00
<b>Overidentifying restrictions (H0: Instruments uncorrelated with error process)</b>				
Sargan chi-squared statistic	0.35	0.17	0.12	0.071
p-value	0.84	0.92	0.94	0.96
<b>Weak instruments (H0: Instruments are weak)</b>				
K-P Wald rank 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.

<sup>17</sup> 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.

Column 2 estimates equation (1). A fall in external liabilities of 1% leads to a reduction in domestic lending of about 0.6%, 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 coefficient of interest. This is confirmed by column 1, where DEMAND is omitted from the specification; the coefficient on  $\Delta XL$  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 Angrist-Pischke statistic strongly rejects underidentification. 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—ie 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 statistic indicates that the instruments used are sufficiently strong.<sup>18</sup>

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<sup>18</sup> As a further robustness check, I estimate, but do not report, the regressions in Table B using limited information maximum likelihood (LIML). See Stock and Yogo (2005). Again, the validity of the instruments is strongly supported.

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.

**Table C: 2SLS and OLS**

Dependent variable: $\Delta DL$	1 2SLS	2 OLS
$\Delta XL$	.60**	.51***
	0.28	0.09
DEMAND	.032***	.034***
	0.01	0.01
Size controls	Yes	Yes
N	141	141
R-squared		0.27
<b>Exogeneity of explanatory variable (H0: Variable is exogenous)</b>		
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  $\Delta XL$  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.<sup>19</sup> 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.

<sup>19</sup> The test is a heteroskedasticity-robust variant of a Hausman test, to which it is numerically equivalent under homoskedastic errors.

Given the exogeneity of  $\Delta XL$ , OLS is preferred to the 2SLS estimator since it is a more efficient estimator. 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 subsamples 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**

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

**Chart 4: Conditional quantile functions**

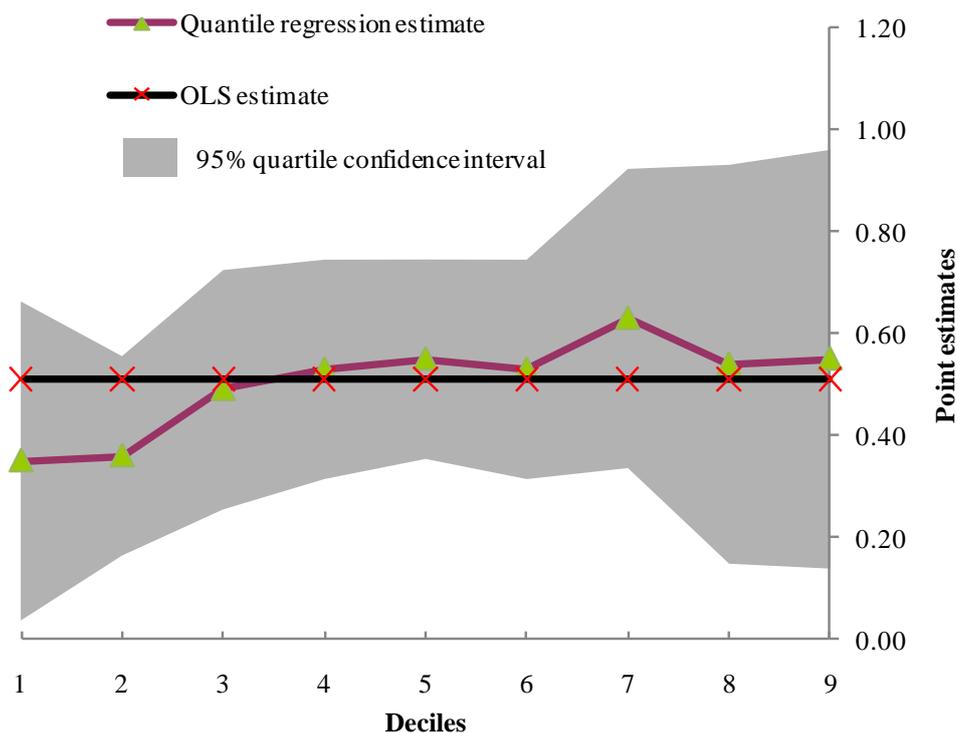


Table D compares the OLS specification against a median regression. Since the latter attaches less weight to outliers, the close correspondence between the two estimates is reassuring. Chart 4 shows point estimates from a family of quantile regressions. Although there is some variation in these estimates across different deciles of the conditional distribution of the response variable, all estimates are significant. Moreover the 95% confidence interval for each decile encompasses the OLS estimate. This allays concerns about influential observations or subsamples 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 capitalisation, location of regulator, legal relationship with the parent bank, etc—might indicate differential

responses to a crisis.<sup>20</sup> And, as noted earlier, in the United Kingdom branches rely on external funding to a greater extent than subsidiaries and lend less domestically.

**Table E: The impact of bank type**

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

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

<sup>20</sup> Cerutti *et al* (2007) provide useful stylised facts about the characteristics of subsidiaries and branches, together with an analysis of organisational choice.

sharper pullback in domestic lending in response to a given shock to external liabilities for a domestically owned bank.

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**

Dependant variable: $\Delta DL$	1 OLS	2 OLS
$\Delta XL$	.54*** 0.15	.45** 0.19
DEMAND	.024** 0.011	.024** 0.012
Fraction of DL in FX (t=0)	-21.5* 12.77	-16.79 11.59
(Fraction of DL in FX)* $\Delta XL$	-0.8 0.32	-0.01 0.31
UOB		23.46*** 7.78
UOB* $\Delta XL$		.41** 0.22
Constant	12.19* 4.84	7.68 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?

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).

**Table G: Are foreign assets a significant buffer?**

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

Here, too, the interaction term is insignificant. This may seem surprising, since the buffer effect hypothesised above should drive a significant negative coefficient 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 coefficient 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% of total claims on the household sector (compared with a ratio of 96% to 99% 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).

**Table H: Sectoral regressions**

		Dependent variable: change in lending to sector			
		Households	Businesses	Other Banks	OFIs
		1	2	3	4
Sample	<b>Full sample</b>				
	$\Delta XL$	-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
	<b>Sectoral lending &gt; £100 m</b>				
	$\Delta XL$	-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
	<b>Sectoral lending &gt; £500 m</b>				
	$\Delta XL$	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
	<b>Sectoral lending &gt; £1000 m</b>				
$\Delta XL$	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	

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 securitised 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.<sup>21</sup> 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 recapitalised 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 I: Quantile regressions on components of domestic lending**  
Dependent variable: change in lending to sector (a)

	Deciles of conditional distribution								
	1	2	3	4	5	6	7	8	9
<b>Businesses</b>									
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
<b>Other Banks</b>									
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
<b>OFIs</b>									
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.

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

<sup>21</sup> The balance sheet data used in this study do not include information on mortgage securitisations, and there is no alternative data source, to the best of my knowledge, with bank-specific information on mortgage securitisations on an unconsolidated basis.

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.

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 conventional wisdom 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 United Kingdom 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 United Kingdom 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 United Kingdom 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, ie reducing lending to resident entities. Thus financial contagion was transmitted to the real economy.

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