Identifying credit substitution channels

SUMMARY

What kinds of credit substitution, if any, occur when changes to banks' minimum capital requirements induce them to change their willingness to supply credit? The question is of first-order importance given the emergence of 'macro-prudential' policy regimes in the wake of the global financial crisis, under which regulatory tools – in particular, minimum capital ratio requirements for banks – will be employed to control the supply of bank credit as part of the effort to improve the resilience of the financial system. Regulatory efforts to influence the aggregate supply of credit may be thwarted to some degree by 'leakages', as other credit suppliers substitute for the variation induced in the supply of credit by regulated banks. Credit substitution could occur through foreign banks operating domestic branches that are not subject to capital regulation by the domestic supervisor, or through bond and stock markets. The UK experience for the period 1998–2007 is ideally suited to address these questions, given its unique regulatory history (UK bank regulators imposed bank-specific and time-varying capital requirements on regulated banks), the substantial presence of both domestically regulated and foreign regulated banks, and the UK's deep capital markets. In this study we show that foreign-regulated branches are indeed an important source of credit substitution. Leakage by foreign regulated branches can occur either as a result of competition between branches and regulated banks that are parts of separate banking groups, or because a foreign banking group shifts loans from its UK-regulated subsidiary to its affiliated branch, which is not subject to UK capital regulation. Our results suggest the presence of both channels is important, but the responsiveness of affiliated branches is substantially stronger (roughly twice as strong). We do not find any evidence for leakages through capital markets. That result may reflect the possibility that under non-crisis conditions loan substitution through unregulated banks enjoys informational, monitoring and cost advantages over substitution via securities markets. This evidence has important policy implications: (1) because significant leakages result from interbank competition, in addition to loan transfers within affiliated entities of the same banking groups, forcing foreign banks to consolidate their

Economic Policy January 2014 Printed in Great Britain

operations in each country into either a foreign branch or a foreign subsidiary will not solve the leakage problem; and (2) international cooperation will be necessary to prevent regulatory arbitrage between domestically regulated banks and foreign branches.

— Shekhar Aiyar, Charles W. Calomiris and Tomasz Wieladek

Identifying channels of credit substitution when bank capital requirements are varied

Shekhar Aiyar, Charles W. Calomiris and Tomasz Wieladek

1. INTRODUCTION

It is well understood that shocks to banks' capital positions can induce changes in their supply of credit. An important instance of such a shock is a binding regulatory change in minimum capital requirements. But the impact on *aggregate* credit supply depends on the availability and elasticity of alternative sources of credit. Plentiful and highly elastic substitute sources of credit could significantly dampen the credit supply impact of varying minimum capital requirements. Identifying and quantifying the channels through which such credit substitution might operate assumes particular importance in light of the new regulatory focus on 'macro-prudential' policies.

An important long-term consequence of the global financial crisis of 2007–2009 has been the decision by many countries to implement a formalized macro-prudential regulatory framework alongside traditional time-invariant 'micro-prudential' regulations. Macro-prudential regulation takes the macroeconomic state of the financial system and the economy into account when setting regulatory requirements to ensure banks' safety and soundness. It also seeks to achieve the new objective of limiting 'systemic risk' by strengthening the resiliency of banks in dealing with large shocks and reducing the likelihood of such shocks.

The Managing Editor in charge of this paper was Refet Gürkaynak.

Economic Policy January 2014 pp. 45–77 Printed in Great Britain

One goal of macro-prudential policy is to limit systemic risk by raising capital requirements in response to lending-fuelled booms, whether at an economy-wide or sectoral level, so that banks will be able to weather adverse shocks from a sudden change in market conditions. The raising of capital requirements has two effects on financial resilience: First, it improves the capital position of banks. Second, to the extent that the capital requirement increase reduces the aggregate supply of credit, it may prevent credit-driven asset bubbles from forming in the first place.[1]

Macro-prudential regulation can also increase financial resilience during recessions. When many financial institutions simultaneously experience a large loss due to a severe recession, a decline in housing prices, or sovereign stress, credit supply contraction by banks in response to that common shock can magnify the recession and the size of bank losses. So long as banks' capital ratios are sufficiently high at the beginning of the recession, a reduction in required capital can mitigate the contraction of aggregate bank credit, and limit systemic risk in the financial system.

The potentially stabilizing effects of capital requirement changes, through their effects on aggregate credit supply, are closely related to a large literature in macroeconomics that recognizes the relationship between the supply of credit and macroeconomic activity, which is part of an even larger literature on the so-called 'financial accelerator'. Banks, like other firms, generally find retained earnings and debt to be the least costly sources of funding; raising equity in the market is costlier than either of those alternatives because of adverse-selection costs attendant to the negative signalling that comes from inviting new stockholders to purchase equity. Those adverse-selection costs lead to negative announcement effects on issuers' stock prices, and to substantial investment banking fees paid to mitigate those price declines. In contrast, debt issues – which are senior claims on firms' cash flows – do not produce negative signals about firms' prospects. The implication, for banks and non-financial firms alike, is that it is cheaper to fund the purchase of assets with retained earnings and debt issues than with equity raised in the market. Because firms and banks have limited debt capacity, however, sometimes their only option is either to raise equity or reduce their asset purchases. That implies that losses of equity for banks or other firms (e.g., negative cash flows, or declines in the value of assets), or increases in equity capital requirements for banks, tend to reduce investments by affected firms, and lending by affected banks.[2]

[1] See Galati and Moessner (2011) for a review of thinking about macro-prudential policy.

[2] The high cost of equity finance can also be motivated by *ex post* information costs (costly state verification), which can be mitigated through debt contracting (see Diamond, 1984 and Gale and Hellwig, 1985 for applications to banks). Early contributions to the literature include Myers and Majluf (1984), James (1987), Bernanke and Blinder (1988), Bernanke and Lown (1991) and Gertler and Gilchrist (1993, 1994); for a more recent contribution, see Adrian *et al.* (2012). Because the evidence in Aiyar *et al.* (2014a, 2014b) shows that capital ratio requirements affect the supply of bank credit, this evidence also lends support to macroeconomic models that include bank capital, and more broadly, banks' ability to supply credit, as an important contributor to business cycles. In these models, bank credit plays an active role, both as a source of shocks and as a magnifier of other shocks that affect banks' capital and financial health.

Not all of the systemically stabilizing effects of macro-prudential policy depend on the control of aggregate credit supply. As already noted, raising capital requirements during an asset pricing bubble will improve the financial resilience of banks through its effects on banks' capital ratios even if the regulatory change fails to slow the growth in the aggregate supply of credit. More generally, macro-prudential regulation can be used to stabilize banks and insulate them from the effects of errors in the measurement of risk contained in micro-prudential rules that fail to adjust properly to changing macroeconomic circumstances. For example, if risk weights used by banks under the Basel rules (which reflect banks' perceptions of risks at any point in time) tend to underestimate risk in some states of the world, increasing capital requirements in those states of the world can be justified as a corrective policy. Nevertheless, control over aggregate credit supply is a potentially important part of the toolkit of macro-prudential regulation.

Macro-prudential policies have been implemented by some countries in the past, but these were the exceptions rather than the rule. Spain, for example, adopted pro-cyclical provisioning requirements, which forced banks to increase their loan provisioning during good times, and then draw down their provisioning levels during recessions (Jimenez *et al.*, 2011). Higher provisioning effectively raises the amount of capital needed to stand behind loans temporarily, and thereby slows loan growth during booms; the relaxation of provisioning requirements during recessions reduces the amount of capital relative to loans that banks had to maintain, and thereby reduces the rate of contraction in loan growth during recessions. Other countries eschewed formalized macro-prudential rules, but employed discretionary macro-prudential policies. For example, Colombia followed an ad hoc macro-prudential regime, in which the central bank and other regulators reacted to a lending boom with increases in capital requirements, provisioning requirements, and liquidity requirements beginning in 2007, and were able to successful slow banking system loan growth and achieve a soft landing in 2008.

Prior to the crisis, the notion that credit growth, asset price growth, or other indicators of financial fragility should prompt changes in capital and liquidity requirements generally was greeted with scepticism. Many macroeconomists argued that it is difficult to identify asset pricing bubbles *ex ante* with any confidence. Furthermore, the impact of changes in capital requirements on bank credit growth was little understood (Galati and Moessner, 2011) . Policymakers interested in macro-prudential interventions had to advocate policy actions based on little evidence about the magnitude of the impact of those measures.

The costly financial collapse of 2007–2009, and the severe recession that has accompanied it, have created a new consensus in favour of macro-prudential regulation. That consensus emerged out of a generally shared belief that the US mortgage boom and bust of 1999–2010 reflected, among other things, a macroeconomic environment that was too conducive to housing-related risk taking. The combination of loose monetary policy, global current account imbalances, aggressive government

policies promoting homeownership, and prudential regulatory standards that underestimated housing finance risk are generally regarded as contributors to overly generous credit and housing price growth beyond sustainable levels. Under Basel III, the countries participating in setting the Basel regulatory standards agreed that minimum capital ratio requirements should vary in a pro-cyclical manner. That goal is currently being implemented, within the Basel Committee and by a number of regional and national regulators, through the establishment of macro-prudential policy guidelines for varying banks' minimum capital ratios according to warning signs of overheating or recession.

Given that a central channel of macro-prudential regulation is the use of capital ratio requirements to control the aggregate supply of credit as a means of limiting systemic risk and maintaining financial resilience, policymakers need to gauge the extent to which capital requirement changes on regulated banks affect the aggregate supply of credit. Aiyar *et al.* (2014a) identify three necessary conditions that must be satisfied in order for time-varying minimum capital requirements to affect the aggregate supply of credit. First, equity (the key variable of interest in bank capital regulation) must be a relatively costly source of bank finance. Second, minimum capital requirements must have binding effects on banks' choice of capital ratios.[3] And third, when an increase (decrease) in banks' minimum capital requirements diminishes (increases) the supply of credit by banks subject to capital regulation, alternative sources of credit must not fully offset the change in aggregate credit supply. Although there is a substantial body of theoretical and empirical evidence consistent with these assumptions, as a qualitative matter, it is challenging to derive reliable empirical estimates of the elasticity of credit supply with respect to changes in capital requirements. The two key challenges are identifying the effects of capital requirement changes on regulated banks, and measuring the size of 'leakages' – the extent to which non-regulated forms of credit offset changes in the supply of credit from regulated institutions. With respect to the first challenge, using different datasets, methodologies and time periods for the UK, Aiyar *et al.* (2014a), Bridges *et al.* (2013), Francis and Osborne (2012) and Noss and Tofano (2012) find an average lending contraction by regulated banks facing an increase in capital requirements of around 7%, 5.7%, 5% and 7% following a 100 basis point increase in the minimum capital ratio requirement, respectively.

Most of these studies, with the exception of Aiyar *et al.* (2014a), only examine the direct effect of changes in capital requirements on regulated bank lending growth. In general equilibrium, however, a reduction in the supply of regulated sources of credit should be partially offset by other, non-regulated sources of credit supply. Not all potential sources of credit in the financial system are subject to national regulatory

[3] For further discussion of these first two theoretical considerations, see Aiyar *et al.* (2014a), Van den Heuvel (2009), and Van Hoose (2008).

control through minimum bank capital requirements. When a national regulator raises capital requirements that may constrain the loan supply of the banks that it regulates, but other sources of credit supply consequently may face strong incentives to provide substitute funding. As economists, we still know only very little about the importance of such leakages. In some countries (in particular, countries within the European Union), branches of foreign banks are subject to capital regulation by foreign regulators. That means that foreign branches could step in to substitute for declines in credit supply by domestically regulated banks. Of course, other sources of credit supply could also provide substitutes for constrained bank credit, including cross-border credit from non-resident banks, or securities markets through higher amounts of debt and equity issuance. Unless regulators have a clear sense of the extent of leakage through multiple possible channels, they will not be able to gauge the extent to which leakages could interfere with the financial resilience objective of macro-prudential policy.

Regulators are of course aware of the problem of leakage. In particular, they have pledged to find ways to cooperate internationally to coordinate capital requirement policies in the interest of minimizing leakage. Basel III contemplates a reciprocity arrangement whereby foreign regulators of branches located abroad will match changes in the host country's capital requirement over the cycle, up to the 2.5% envisioned under the agreement.

The size and nature of potential leakages, however, remains uncertain. Aiyar *et al.* (2014a) identify important substitution by UK foreign branches in reaction to credit-supply reductions that result from increasing capital requirements on UK-regulated banks. They find that reactions to capital requirement increases by foreign banks' branches offset roughly one-third of the total aggregate credit impact of capital requirement changes. They do not, however, identify the mechanism through which that substitution occurs. It is unclear whether their evidence reflects true interbank competition between domestically regulated banking enterprises and foreign branches, or just a shifting of loans between two related legal entities that operate within the *same* banking group. Houston and Marcus (1997) and Campello (2002), among others, show the importance of internal capital markets within banks, which implies that it may be relatively easy to shift resources among affiliates of the same banking group. The UK-resident financial system includes both subsidiaries and branches of many foreign-owned banking groups.[4] In many cases, a foreign-based banking group may operate both a subsidiary and a branch in the UK. In that case, raising the capital requirement on the subsidiary may simply produce a shift of assets from the subsidiary to the branch.

Understanding the mechanism through which foreign branch leakage occurs is crucial to implementing macro-prudential policy. To the extent that leakage is occurring

[4] See Aiyar (2011, 2012) for a review of the characteristics of the UK-resident banking system.

solely through the movement of loans from foreign bank subsidiaries to their affiliated branches it could be 'plugged' by requiring foreign banks to operate either a branch or a subsidiary, but not both. On the other hand, if the leakages reflect broader competition in lending, then plugging those leakages is more challenging; it requires coordination in the capital regulation of domestically regulated banks and foreign branches.

It is also possible that leakage occurs outside the banking system. Firms that experience reductions in bank credit may seek funding from capital markets. Adrian *et al.* (2012) study the behaviour of publicly traded US firms during the 2007–2009 financial crisis and find that both in the aggregate and at the firm level (for the small percentage of firms with access to public bond markets), bond issuance substituted for the contraction in the supply of bank credit during the crisis. Large, established, relatively low-risk firms with access to public debt markets are at a relative advantage during times of bank credit contraction (see also Gertler and Gilchrist, 1993, 1994; Calomiris *et al.*, 1995). The access of some firms to bond markets, therefore, may substantially weaken the impact of macro-prudential policy on aggregate credit.[5] Unlike leakages from branch lending, leakages from securities offerings cannot be addressed by international coordination of capital standards. What is the relative importance of alternative sources of credit supply other than foreign-headquartered branches? For example, to what extent are securities markets likely to provide substitutes for the constrained supply of bank credit alongside credit growth by foreign branches?

The UK during the period 1998–2007 provides a unique environment for addressing these two key, yet to date unanswered and highly policy-relevant, questions about the nature of leakages as a result of changes in bank minimum capital requirements. The UK regulators set bank-specific capital requirements on the basis of perceived operational and market risks. Cross-sectional differences in capital requirements were large, and changes in bank-specific capital requirements were frequent. As shown in Aiyar *et al.* (2014a, 2014b), bank-specific variation in capital requirements permits the use of panel data on individual banks to gauge the effects of capital requirement changes on credit supply, and the extent to which the branches of foreign banks substitute for loan-supply changes in domestically regulated banks that are caused by changes in capital requirements.

This paper focuses on identifying and comparing the relative strength of different channels of credit substitution in response to changes in banks' minimum capital requirements. With respect to leakages from foreign branches, we identify the extent

[5] Substitution into capital market sources of credit undermines the ability of the macro-prudential regulator to dampen a financial boom, but capital market substitution would not necessarily undermine other macro-prudential objectives. Indeed, to the extent that macro-prudential policy may seek to reduce the banking system's exposure to a common shock, substitution by capital market financing can serve this objective.

to which leakage reflects the behaviour of affiliated branches (those that are part of the same banking group as the subsidiary experiencing the regulatory change), as opposed to interbank competition from unaffiliated branches. To investigate this question, we create a new database that matches branches and subsidiaries with parent institutions. That allows us to explore the extent to which the branches of foreign banks react differently to the loan-supply contractions resulting from changes in regulatory capital requirements imposed on affiliated or unaffiliated UK subsidiaries.

We expect the substitutability of credit supply between regulated subsidiaries and affiliated branches to be greater than between regulated subsidiaries and unaffiliated branches, for several reasons. First, the affiliated branch has a stronger incentive to lend than an unaffiliated branch because it may be able to preserve a valuable lending relationship with relatively little effort on the part of loan officers. Second, the affiliated branch may be able to originate the loan at low transacting cost, by simply transferring the asset from one balance sheet to another. Finally, affiliated branch lenders would enjoy an information advantage about the impending change in regulatory policy toward the affiliated subsidiary. Changes in subsidiary capital requirements were not a matter of public information over our sample period. The affiliated branch would be privy to knowledge of the regulatory policy change affecting its affiliated subsidiary, and that information likely would be shared with the affiliated branch several weeks or months in advance of the change in the requirement.

We also examine whether bond and equity markets substitute for domestically regulated bank credit supply. That is, we seek to identify the new issuance of these instruments in sectors experiencing a contraction (expansion) in bank credit supply as the result of an increase (decrease) in the capital requirements on domestically regulated banks. Our analysis is performed at the sectoral level because our data on bank loans includes the sector but not the identities of individual borrowers. Because we know the sectoral lending mix of each subject bank in our sample, we are able to trace the effect of changes in each bank's minimum capital ratio requirement on the credit available to different sectors.

Although one might expect securities offerings to respond to fluctuations in credit supply, because they offer an alternative means for financing investment, it is also possible that the costs of responding in this way are too large to allow significant credit substitution via this channel. Equity offerings may be quite costly – both in terms of transactions costs and price reactions to offering announcements (Calomiris and Tsoutsoura, 2011) – implying that firms experiencing a contraction in bank credit supply may prefer to contract their investment plans rather than raise equity in response. Bond issues may also be prohibitively costly, due to 'asset substitution' risks that limit many firms' access to the bond market. If bond issuers and bank borrowers within each industry tend to be different firms, then one might find little substitution between bank credit-supply shocks and bond issuance within industries

(Calomiris *et al.*, 1995).[6] On the other hand, as Adrian *et al.* (2012) point out, bond issuers within an industry may substantially increase their bond issuance during times of bank credit stringency to take advantage of their comparative advantage in the cost of finance.

In the remainder of this paper we first briefly review the nature of UK capital regulation under the Financial Services Authority (FSA) during our sample period (Section 2). In Section 3, we develop an empirical strategy for gauging various sources of leakage in response to changes in UK capital regulation – including the lending responses of affiliated and non-affiliated foreign-regulated branches, and of securities issuers – and report our empirical findings regarding these responses. Section 4 concludes.

2. FINANCIAL REGULATION IN THE UK

As an outgrowth of various international banking developments and challenges of the 1970s and 1980s – most obviously, the growth of international bank lending and the disruption to interbank clearing that attended the 1974 failure of Herstadt Bank – bank regulators from the largest developed economies began to meet at the Bank of International Settlements (BIS) in Basel, Switzerland to establish an international standard for supervision and regulation of banks. The resulting agreement, now known as Basel I, was agreed and implemented beginning in 1988. At the core of the agreement was the idea that banks should be subject to a minimum capital requirement of 8% of risk-weighted assets. That is, risk weights are attached to each asset on the bank's balance sheet, and banks must maintain capital equal to at least 8% of the aggregation of these risk-weighted assets. Capital is seen as a buffer used to offset unexpected potential losses from non-performing loans, and thereby preserve bank solvency.

In most countries around the globe, the same, time-invariant capital requirement was applied under Basel I to all institutions within a banking system. But UK regulators regarded the Basel I requirements as incomplete because they did not require capital buffers to absorb losses related to 'legal, reputational or interest rate risk' (Alfon *et al.*, 2005). To provide adequate capital requirements with respect to those risks, UK

[6] Calomiris *et al.* (1995) also examine the degree to which commercial paper substitutes for bank credit. They find that commercial paper issues are among the most established, low-risk debtors, and that the observed negative correlation between bank credit and commercial paper over the business cycle (identified by Kashyap *et al.*, 1993) does not reflect direct substitution between bank credit and commercial paper issues. They show that the aggregate negative correlation between commercial paper and bank credit reflects the role of commercial paper issuers as quasi banks to firms that receive trade credit from commercial paper issuers; when bank credit becomes scarce, commercial paper issuers use commercial paper to fund increases in accounts receivable from other firms, which substitute for the bank credit contraction experienced by the firms increasing their accounts payable. Given the absence of firm-level substitution between commercial paper and bank loans found in Calomiris *et al.* (1995), as well as the lesser importance of commercial paper in the UK and the difficulty of tracking the outstanding amount of commercial paper reliably, we omit commercial paper from our analysis.

regulators supplemented the Basel I accord with bank-specific capital requirements, which were continually assessed and which varied over time.

The motivations associated with variation in UK banks' capital requirements during our sample period were not macro-prudential; that is, they were geared toward bank-specific, rather than systemic, objectives. The UK Financial Services Authority (FSA), which took over regulation from the Bank of England in 1997, used the ARROW (Advanced Risk Responsive Operating frameWork) guidelines to determine whether a financial institution's capital requirement should be changed on the basis of concerns about its own risk position. These guidelines encompass a very wide area of criteria, including environmental risks; customer, product and market risks; business process risks; prudential risks; and management, governance and culture.

High-level reviews of FSA banking supervision in the run-up to the global financial crisis provide some insight on what regulators focused upon the most during the period 1998–2007 when setting minimum capital ratio requirements. It appears that they were more concerned with the managerial and operational aspects of financial institutions rather than balance sheet risks. For example, Lord Turner, the chairman of the FSA, concluded in his review that 'Risk Mitigation Programs set out after ARROW reviews therefore tended to focus more on organization structures, systems and reporting procedures, than on overall risks in business models' (Turner, 2009). Similarly, an inquiry into the failure of the British bank Northern Rock notes that 'Under ARROW I[7] there was no requirement on supervisory teams to include any developed financial analysis in the material provided to ARROW Panels', where developed financial analysis is defined as information on the institutions asset growth relative to its peers, profit growth, the cost to income ratio, the net interest margin and reliance on wholesale funding and securitization (FSA, 2008).

Three studies have examined the extent to which changes in bank-specific capital requirements affected actual capital ratios (Alfon *et al.*, 2005; Francis and Osborne, 2009; Bridges *et al.*, 2013). All find a substantial impact and conclude that capital requirements were binding on capital ratio choices.[8] Aiyar *et al.* (2014a) partition banks into quartiles by the size of the average buffer over the minimum capital

[7] The FSA published revised ARROW guidelines in 2006, called Arrow II. However, financial institutions did not have to submit 'developed financial analysis' as part of the ARROW II either (see p. 28 of www.fsa.gov.uk/pubs/other/nr_report.pdf)

[8] Importantly, binding capital requirements should not be confused with banks always holding capital at the level of the minimum regulatory requirement. Rather, binding capital requirements simply mean that banks adjust their behaviour when the regulatory minimum capital ratio changes. In general, binding capital requirements are perfectly compatible with a capital buffer chosen to minimize the costs of complying with capital requirements. Empirical research has identified substantial heterogeneity with respect to bank responses to capital requirements, and particularly, the extent to which capital requirements bind on banks' choices of capital ratios. In many studies, actual capital ratios respond strongly to changes in capital requirements. But in other studies, there is little observed response, which indicates that in some circumstances market discipline may be the dominant influence on variation in capital ratios (Van Hoose, 2008).

requirement, and show that increases in minimum capital requirements were statistically associated with increases in actual capital ratios in every quartile.

In summary, the UK engaged in a unique policy of requiring highly varying bank-specific minimum capital ratios to UK-regulated banks, and these capital requirements were binding on banks' actual capital ratios. In the determination of bank-specific capital requirements, it appears that loan quality and its consequences for default risk, *per se*, were expected to be covered by the 8% minimum; requirements in excess of that reflected other concerns.

3. EMPIRICAL RESULTS

Our first task is to estimate the extent to which foreign branches react differently to changes in capital requirements imposed on affiliated subsidiaries as opposed to non-affiliated subsidiaries. Data on bank minimum capital requirements and bank lending are taken from the Bank of England.[9] Data on the parent institutions of foreign branches and subsidiaries were hand collected. We define affiliated branches as those that share a common parent institution. Our key dependent variable for banks of all types is the quarter-on-quarter log difference of lending by the bank to private non-financial corporates (PNFCs).

Second, we provide direct evidence on leakages through capital markets. We collect, for each of the 14 sectors on which we have bank lending data, data on equity and bond issuance, and the book and market value of the stock outstanding.[10] Data on corporate bond issuance are from Dealogic. Data on equity issuance are taken from the London Stock Exchange database. We combine these data with our data on sectoral bank lending. We ask whether and how fund raising from the capital markets in a particular sector tends to change in response to changes in minimum capital requirements that affect bank loan supply to that sector.

Table 1 reports summary statistics for our sample of banks, divided into five groups: UK-owned banks, affiliated foreign subsidiaries (subsidiaries of foreign banks operating in the UK which have a common parent with a foreign branch operating in the UK), non-affiliated subsidiaries, affiliated branches, and non-affiliated branches. As Table 1 shows, there is considerable variation in the size of aggregate PNFC lending, expressed in real terms, by bank type. UK-owned banks tend to be larger than banks in the other groups. Affiliated foreign subsidiaries tend to be larger than either non-affiliated subsidiaries or branches. Figure 1a shows a scatter plot of the average exposure (averaged across institutions and time) of affiliated (meaning belonging to the

[9] Banks report lending by sector using Analysis of Lending (AL), available at www.bankofengland.co.uk/statistics/Pages/reporters/defs/default.aspx. Data on minimum capital requirements are taken from the BSD3 form, collected by the Bank of England on behalf of the FSA over our sample period.

[10] We construct a dependent variable that divides new issuance of each type of security by the outstanding amount of that security type. This allows us to obtain a dependent variable that is conceptually close to log differences of real economy lending, which is our dependent variable in the lending regressions we report.

Table 1. Summary statistics

Bank type	UK owned	Affiliated foreign sub	Non-affiliated foreign sub	Affiliated foreign branch	Non-affiliated foreign branch
Bank lending by type (£ millions)					
Mean	20,866.6	8,760.90	824.9	1,164.2	582.1
St Dev	43,105.7	17,717.8	1,513.2	1,213.7	808.5
Min	1.36	4.9	1.02	5.13	3.3
Max	274,139.8	67,806.2	12,451.6	6,071.6	4,218.4
Number of banks	42	16	33	21	96

Variable	BBKR (% of RWA)	DBBKR	Group demand	Ratio
Minimum capital requirements, demand and relative branch size				
Mean	10.41	0.012	0.15	21.1
Std Dev.	1.18	0.225	0.45	40.4
Min	9	−1.50	−1.11	0.001
Max	14.5	1.50	1.06	163

Specification	Group 1	Group 2	Group 3	Group 4
Reference group DBBKR (relevant for Tables 4 and 5)				
Mean	−0.071	−0.0118	−0.077	−0.013
Std Dev.	0.225	0.225	0.225	0.225
Min	−0.44	−0.83	−0.48	−0.83
Max	0.61	1.037	0.56	1.035

Notes: Lending is in millions of pound sterling (real) and comprises lending to the private non-financial companies (PNFCs). BBKR denotes the minimum capital requirement in percent of risk weighted assets for the banking book. DBBKR denotes the quarterly change in BBKR in percent (thus a DBBKR of 1.0 denotes a 100 bp increase in BBKR). Group demand denotes our constructed demand variable for the whole banking group, including all UK-resident entities. Ratio denotes the size of an affiliated branch's loan portfolio relative to the size of its affiliated subsidiary's loan portfolio. The group ordering in the third panel corresponds to the ordering of the regression in Table 4. Note that the demand variable for Tables 4 and 5 takes the same values as the demand variable for Table 2.

same banking group) foreign branches and subsidiaries to 14 different PNFC sectors. Each diamond indicates the exposure of the affiliated foreign branch and subsidiary to one particular sector. A diamond on the 45 degree line indicates that the affiliated branch and foreign subsidiary have identical exposure to that particular sector.

Figure 1b shows the same information but for non-affiliated foreign branches and subsidiaries. The figures show that while there are differences in sectoral specialization between foreign branches and foreign subsidiaries, there is also considerable overlap, thus permitting credit substitution. The main difference in specialization is that branches lend more proportionally to the manufacturing sector, while subsidiaries are relatively more active in commercial real estate; this is true whether the comparison is between affiliated subsidiaries and branches or unaffiliated subsidiaries and branches.

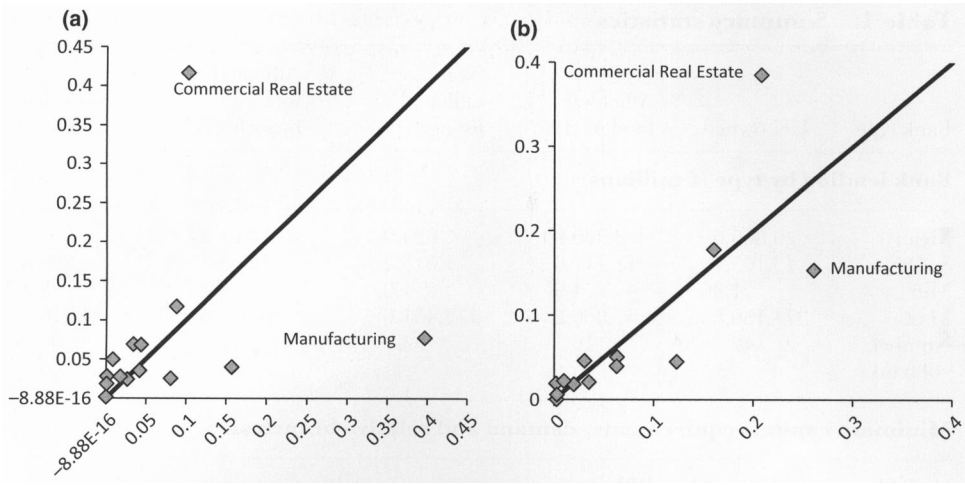

Figure 1. Average exposure of (a) affiliated and (b) non-affiliated branches and subsidiaries to 14 different sectors

Note: In each of the scatter plots above, the average exposure of a foreign branch is on the *Y* axis and the average exposure of a foreign subsidiary on *X* axis. Each grey diamond reflects the average (by time and bank) exposure of the foreign branch (*Y*-axis) and foreign subsidiary (*X*-axis) to one out of 14 PNFC sectors. The black line in each chart is a 45 degree line. A grey diamond on this black line means that both the foreign branch and the subsidiary have identical exposure to that given sector.

Source: Bank of England and authors' calculations.

3.1. Branch leakages

Table 2a reports panel regressions of foreign branch leakages for a sub-sample restricted to affiliated branches. Here we examine the lending response of branches to capital requirement changes imposed on their pairwise affiliated subsidiaries. The dependent variable is real PNFC loan growth by the foreign branch. The independent variable of primary interest is the change in the capital ratio requirement of the affiliated subsidiary (denoted as Subsidiary DBBKR in the table).[11] We include the contemporaneous value and three lags of capital requirement changes. The reported coefficients in Table 2 are the sum of those four coefficients. We control for loan demand by constructing a sectorally weighted measure of employment for the sectors to which the affiliated subsidiary and branch lend.[12] This measure, Group Demand, distinguishes among 14 non-financial sectors receiving loans from banks, and is a composite that combines the sectoral allocation of lending in the subject affiliated branch

[11] To be precise, DBBKR denotes the quarter-on-quarter change in the minimum capital requirement imposed on the banking book of the subject bank.

[12] Although we refer to this as a 'demand' control for convenience, it is more accurate to recognize that this variable captures all influences of the employment growth of a particular sector, including, for example, not only demand for its product, but changes in sectoral costs, including changes in the cost of capital related to changing perceptions of sectoral risk, which could affect the sector-specific cost of capital. Importantly, from our perspective, by controlling for these influences, we isolate the effects of bank-specific changes in capital requirements on the supply of credit.

Table 2a. Affiliated branch leakages with asymmetric responses
Dependent variable: Lending growth of foreign branches

Variables	(1)	(2)	(3)	(4)	(5)
Subsidiary-DBBKR	0.351**	0.373**	0.353**	0.395**	0.358**
	(4.85)	(5.85)	(5.89)	(5.75)	(4.62)
Group demand		0.055	0.111**	0.104**	0.11**
		(1.35)	(6.50)	(7.83)	(6.40)
Subsidiary write-offs			0.027	0.027	0.015
			(0.63)	(0.61)	(0.22)
Real GDP growth				0.038	0.051
				(0.29)	(0.32)
Inflation					0.044
					(0.41)
Constant	0.034	0.055	0.054	0.043	−0.009
	(0.024)	(0.037)	(0.035)	(0.056)	(0.096)
Observations	327	327	311	311	311
R-squared	0.065	0.079	0.112	0.125	0.143
Number of banks	21	21	21	21	21

Notes: Data are quarterly. The dependant variable is the growth rate of PNFC lending by foreign branches. For each regressor, the reported coefficient is the sum of the contemporaneous term and three lags, with the corresponding *F*-statistics provided in parentheses. The sample is restricted to foreign branches with an affiliated UK-resident subsidiary. Subsidiary DBBKR and Subsidiary Write-offs are the quarterly changes in the subsidiary's banking book capital requirement and loan write-offs, and each is expressed as a fraction of risk-weighted assets. To obtain Group Demand, we multiply the Group's (branch and subsidiary as a sum together) portfolio weight with six quarter on six quarter employment growth in the corresponding sector: the Group Demand variable is the sum of these products. Inflation refers to the real GDP deflator. All regressions include bank-specific fixed effects with the specification in the last column also including time fixed effects.

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

and its subsidiary. Specifically, it is defined as follows: we multiply each group's sectoral portfolio weight (obtained by simply summing the branch and subsidiary) with the corresponding six-quarter sectoral employment growth. We also include other macroeconomic controls in our regressions, such as GDP growth and inflation. Changes in the subject bank's loan write-offs are included to control for balance sheet considerations that could, in principle, trigger both regulatory changes and changes in credit supply (although, as noted earlier, the regulatory regime over the sample period was governed mainly by non-balance sheet-related factors).

Table 2a shows that the response by affiliated branches to capital requirement changes at affiliated subsidiaries is positive, large and statistically significant. A coefficient of 0.35 means that when the minimum capital ratio is raised by 100 basis points (i.e. DBBKR = 1), lending growth by the affiliated branch increases by 35%. This is the cumulative response over four quarters.[13] Evaluated at the mean risk-based capital ratio requirement of 10.41 for affiliated subsidiaries, this implies a 3.64 elasticity of lending by foreign branches with respect to changes in the capital requirement of their

[13] Strictly speaking, the cumulative impact on lending growth will differ from these estimates due to compounding.

affiliated subsidiaries.[14] Note that the finding of this leakage itself is evidence that we are correctly identifying responses to exogenous changes in capital regulation, even if our proxy for demand is imperfect.

Table 2b examines whether increases and decreases in minimum capital requirements on subsidiaries have asymmetric effects on lending by affiliated branches. This is done by introducing two separate regressors for increases and decreases in regulatory capital requirements. The results suggest that there is a pronounced asymmetry. A rise in minimum capital requirements drives a large increase in lending by affiliated branches, with the effect being much larger than the estimate obtained without allowing for asymmetric responses (coefficient estimates in the first row of Table 2b are roughly one and a half times as large as the estimates in the first row of Table 2a). But reductions in minimum capital requirements do not appear to generate a corresponding contraction of lending by affiliated branches. This suggests that changes in regula-

Table 2b. Affiliated branch leakages with asymmetric responses
Dependent variable: Lending growth of foreign branches

Variables	(1)	(2)	(3)	(4)	(5)
Subsidiary-DBBKR (positive)	0.567***	0.595***	0.567***	0.619***	0.572***
	(10.98)	(12.58)	(12.14)	(11.34)	(11.48)
Subsidiary-DBBKR (negative)	−0.207	−0.185	−0.163	−0.142	−0.127
	(1.45)	(1.35)	(1.47)	(0.75)	(0.58)
Group demand		0.014	0.0712*	0.0645	0.0710
		(0.10)	(3.312)	(2.940)	(2.677)
Subsidiary write-offs			0.0180	0.0198	0.0103
			(0.316)	(0.404)	(0.120)
Real GDP growth				0.0428	0.0523
				(0.362)	(0.387)
Inflation					0.0379
					(0.333)
Constant	0.0339	0.0555	0.0540	0.0425	−0.00976
	(0.0243)	(0.0371)	(0.0350)	(0.0560)	(0.0959)
Observations	327	327	311	311	311
R-squared	0.117	0.128	0.155	0.168	0.182
Number of banks	21	21	21	21	21

Notes: Data are quarterly. The dependent variable is the growth rate of PNFC lending by foreign branches. For each regressor, the reported coefficient is the sum of the contemporaneous term and three lags, with the corresponding *F*-statistics provided in parentheses. The sample is restricted to foreign branches with an affiliated UK-resident subsidiary. Subsidiary DBBKR and Subsidiary write-offs are the quarterly changes in the subsidiary's banking book capital requirement and loan write-offs, and each is expressed as a fraction of risk-weighted assets. To investigate asymmetric responses to increases and decreases in minimum capital requirements, Subsidiary DBBKR is decomposed into two variables, Subsidiary positive DBKR (which takes the value zero for decreases in capital requirements) and Subsidiary negative DBKR (which takes the value zero for increases in capital requirements). To obtain Group demand, we multiply the group's (branch and subsidiary as a sum together) portfolio weight with six quarter on six quarter employment growth in the corresponding sector: the Group demand variable is the sum of these products. Inflation refers to the real GDP deflator. All regressions include bank-specific fixed effects with the specification in the last column also including time fixed effects.

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

[14] An increase in the minimum capital ratio, from 10.41 to 11.41 is a percentage change of about 9.4%, and 35/9.6 = 3.64.

tory capital requirements over the cycle can have long-lasting effects: a rise in the requirement followed by a subsequent fall in the requirement may cause a long run substitution of lending away from the subsidiary and towards the affiliated branch.

The specifications in Table 2a and 2b do not allow the magnitude of the lending response to vary according to the relative sizes of the affiliated branch and subsidiary. In principle, however, the magnitude should be sensitive to this ratio. When the capital requirement for the affiliated subsidiary is raised, if the parent moves capital from its subsidiary to its branch to preserve its UK lending, then the percentage adjustment of branch lending (the coefficient on DBBKR in the regression) needed to accomplish that transfer of loans from the subsidiary to the branch should be smaller when the affiliated branch is large relative to the affiliated subsidiary.

To capture this effect, the regression reported in column 1 of Table 3 allows the magnitude of the affiliated branch's response to vary with its relative size.[15] We capture that variation by including the size of the loan portfolio of the branch relative to the loan portfolio of the affiliated subsidiary, and by allowing this measure to interact with the change in the capital requirement for the affiliated subsidiary. As expected, we find that the interaction of the ratio and DBBKR is negative and significant, as is the ratio itself. That is, the larger the branch relative to its affiliated subsidiary, the smaller the percentage lending adjustment by the branch in response to a change in the capital requirement of the subsidiary. The remaining columns of Table 3 approach the sensitivity of the lending response with respect to the relative size of the branch in a different way. In columns 2–5, rather than using relative size interactions, we restrict the sample in those regressions using various thresholds of the ratio of branch size to subsidiary size. These thresholds increase from left to right: thus the threshold ratio is 1 in specification (2), 2 in specification (3), 5 in specification (4) and 20 in specification (5). As expected, the higher the threshold relative size of the branch, the smaller the size of the estimated coefficient on the capital requirement change for the affiliated subsidiary. The estimated coefficient declines monotonically from 0.66 to 0.47 as the sample becomes decreasingly restrictive.

Table 4 expands the analysis to compare the response of branches to affiliated subsidiaries – what might be called 'within-firm leakages' – with the response of branches to unaffiliated regulated banks. An affiliated branch's response to its own affiliated subsidiary's minimum capital requirements is captured by the variable Subsidiary DBBKR, as before. A branch's response to a reference group of *all* banks experiencing a change in regulatory capital requirements is captured by the coefficient on Reference DBBKR. We define the reference group in two

[15] Note that Table 3, and subsequent tables, do not allow for asymmetric responses to increases and decreases in the minimum capital requirement, despite the evidence of Table 2b that the lending response is asymmetric. Once we introduce further ways in which to 'slice' the data – relative size in Table 3, within-firm versus cross-firm effects in Tables 4 and 5 – sub-sample sizes become small and many degrees of freedom are lost; and the results on asymmetric lending responses cease to be robust.

Table 3. Taking account of size ratios in affiliated branch leakages
Dependent variable: Lending growth of foreign branches

Variables	(1)	(2)	(3)	(4)	(5)
Subsidiary-DBBKR	0.434***	0.664***	0.624***	0.603***	0.467***
	(7.89)	(18.25)	(23.46)	(16.21)	(8.04)
Group demand	0.08**	0.14**	0.114**	0.13**	0.104**
	(6.51)	(6.55)	(9.397)	(7.62)	(7.27)
Subsidiary write-offs	−0.015	−0.133	−0.050	−0.018	−0.023
	(0.232)	(0.317)	(0.043)	(0.005)	(0.159)
Real GDP	0.037	0.27***	0.23***	0.21***	0.098
	(0.19)	(23.94)	(15.55)	(8.80)	(0.99)
Inflation	0.035	0.089	0.066	0.13	0.039
	(0.28)	(2.35)	(0.80)	(1.96)	(0.35)
Ratio	0.0013**				
	(7.25)				
Ratio*DBBKR	−0.0085**				
	(5.93)				
Constant	0.023	−0.111**	−0.069	−0.124	−0.002
	(0.076)	(0.048)	(0.083)	(0.098)	(0.092)
Observations	311	161	190	217	244
R-squared	0.26	0.35	0.33	0.29	0.22
Number of banks	21	11	12	16	16

Notes: Data are quarterly. The dependent variable is the growth rate of PNFC lending by foreign branches. For each regressor, the reported coefficient is the sum of the contemporaneous term and three lags, with the corresponding *F*-statistics provided in parentheses. The sample is restricted to foreign branches with an affiliated UK-resident subsidiary. Subsidiary DBBKR and Subsidiary Write-offs are the quarterly changes in the subsidiary's banking book capital requirement and loan write-offs, and each is expressed as a fraction of risk-weighted assets. To obtain Group Demand, we multiply the Group's (branch and subsidiary as a sum together) portfolio weight with six quarter on six quarter employment growth in the corresponding sector: the Group Demand variable is the sum of these products. Inflation refers to the real GDP deflator. Ratio denotes the size of an affiliated branch's loan portfolio relative to the size of its affiliated subsidiary's loan portfolio. Specifications 2, 3, 4 and 5 are estimated subject to the restriction that Ratio <1, < 2, < 5 and < 20, respectively. All regressions include bank-specific effects.

***$p < 0.01$, **$p < 0.05$, * $p < 0.1$

different ways. In column 1, $Reference\ DBBKR = \frac{\Sigma_i \Delta BBKR_i}{number\ of\ banks_i}$, which is simply the average change in minimum capital requirements across all regulated banks *i*. In column 2, Reference DBBKR is defined in a branch-specific way; the idea is that the reference group of regulated banks should be weighted to favour banks that specialize in lending to similar sectors as the subject foreign branch. Thus $Reference\ DBBKR = \left\{ \left(\frac{Lending\ by\ branch\ j\ to\ sector\ q}{branch\ j\ to\ all\ sectors} \right) \Delta BBKR_q \right\}$, where $\Delta BBKR_q$ is the change in capital requirements aggregated to sector level.[16] Columns 3–4 repeat 1–2, but restrict the reference group to regulated banks that do not operate an affiliated branch.

The coefficients on Subsidiary DBBKR and Reference DBBKR are both positive and statistically significant, indicating that credit substitution by foreign branches occurs both with respect to changes in the minimum capital requirements of affili-

[16] See Aiyar *et al.* (2014a) for further discussion of reference groups and their construction.

Table 4. Comparing affiliated and non-affiliated branch leakages
Dependent variable: Lending growth of foreign branches

Variables	(1)	(2)	(3)	(4)
Subsidiary-DBBKR	0.27*	0.30**	0.28**	0.32**
	(3.721)	(4.627)	(3.930)	(4.887)
Group demand	0.12***	0.12***	0.12***	0.12***
	(7.81)	(9.72)	(8.47)	(9.89)
Unaffiliated branch demand	0.062***	0.062***	0.060**	0.061**
	(7.21)	(6.97)	(6.64)	(6.72)
Subsidiary write-offs	−0.017	−0.009	−0.027	−0.007
	(0.15)	(0.04)	(0.38)	(0.03)
Real GDP	0.00013	−0.0038	−0.041	−0.0041
	(1.21e-05)	(0.0106)	(1.133)	(0.0113)
Inflation	0.0176	−0.0123	−0.0216	−0.0114
	(0.428)	(0.197)	(0.625)	(0.173)
Reference-DBBKR	0.19***	0.24***	0.23***	0.20***
	(14.80)	(14.56)	(17.94)	(9.55)
Constant	−0.015	0.0013	0.046	−0.0015
	(0.035)	(0.037)	(0.039)	(0.038)
Observations	1,999	1,999	1,999	1,999
R-squared	0.043	0.041	0.040	0.041
Number of banks	117	117	117	117

Notes: Data are quarterly. The dependent variable is the growth rate of PNFC lending by foreign branches. For each regressor, the reported coefficient is the sum of the contemporaneous term and three lags, with the corresponding *F*-statistics provided in parentheses. Subsidiary DBBKR and Subsidiary write-offs are the quarterly changes in the subsidiary's banking book capital requirement and loan write-offs, and each is expressed as a fraction of risk-weighted assets. To obtain Group demand, we multiply the group's (branch and subsidiary as a sum together) portfolio weight with six quarter on six quarter employment growth in the corresponding sector: the Group demand variable is the sum of these products. Group demand is the measure of demand shocks for branches with affiliated subsidiaries. For branches that operate without an affiliated subsidiary, the measure of demand is called Unaffiliated branch demand; its construction is identical to Group demand, except that the portfolio weights are taken for the unaffiliated branch alone, rather than the banking group. Inflation refers to the real GDP deflator. All regressions include bank-specific effects. Reference DBBKR in specifications (1) and (2) is defined as the change in average DBBKR and the change in branch-specific DBBKR respectively, where the reference group includes all regulated banks except the affiliated subsidiary of the given branch. Specifications (3) and (4) repeat this exercise, but the reference group now excludes any subsidiary that has an affiliated branch. To make the coefficient magnitudes of the reference groups comparable, in this table we standardize the standard deviation of the Reference DBBKR to that of the Subsidiary DBBKR.

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

ated subsidiaries and with respect to the changes in the minimum capital requirements of non-affiliated banks. The coefficient on Subsidiary DBBKR is similar to the magnitudes obtained in Table 2a; it implies that in response to a 100 basis point rise in the capital requirement of an affiliated subsidiary, an affiliated branch's lending increases by about 30%. In order to compare the magnitudes of the coefficients on Subsidiary DBBKR and Reference DBBKR, Table 4 standardizes the measures of Subsidiary DBBKR and Reference DBBKR so that the two measures have identical standard deviations. The lending reaction by a foreign branch to a capital ratio requirement change occurring in its own affiliated subsidiary is larger than its reaction to a similar capital ratio requirement change occurring in a reference group of unaffiliated banks: the difference between the two magnitudes ranges from 22% to 60% depending on the specification used. In other words, 'within-firm' leakages are

stronger than leakages across non-affiliated banks. This supports our prior from Section 1: banks within the same banking group enjoy some combination of informational and transactional advantages over unaffiliated banks, or have a relatively strong incentive to preserve an existing lending relationship.

Table 5 is similar to Table 4, but here we also allow the lending response of an affiliated branch to a capital ratio requirement change, occurring in its affiliated subsidiary, to vary with the size of the branch relative to the subsidiary. As in Table 3, both the Ratio and the interaction of the Ratio and DBBKR are negative and highly

Table 5. Comparing affiliated and non-affiliated branch leakages
Dependent variable: Lending growth of foreign branches

Variables	(1)	(2)	(3)	(4)
Subsidiary-DBBKR	0.40***	0.43***	0.40***	0.46***
	(10.19)	(12.19)	(10.15)	(12.23)
Group demand	0.084**	0.089**	0.09**	0.09**
	(5.068)	(6.541)	(5.754)	(6.659)
Unaffiliated branch demand	0.063***	0.063***	0.06**	0.062***
	(7.35)	(7.16)	(6.84)	(6.96)
Subsidiary write-offs	−0.00741	1.31e-05	−0.0182	0.000802
	(0.0304)	(1.03e-07)	(0.178)	(0.000362)
Real GDP	0.0158	0.0144	−0.0253	0.0133
	(0.209)	(0.177)	(0.50)	(0.14)
Inflation	0.0209	−0.0108	−0.0202	−0.0109
	(0.622)	(0.153)	(0.558)	(0.159)
Reference-DBBKR	0.19***	0.24***	0.23***	0.21***
	(14.95)	(14.52)	(17.96)	(11.01)
Ratio	−4.32e-05	−0.0000227	−3.88e-05	−2.23e-05
	(0.174)	(0.046)	(0.138)	(0.0440)
Ratio*DBBKR	−0.0062*	−0.0064**	−0.0060*	−0.0067**
	(3.694)	(4.015)	(3.276)	(4.124)
Constant	−0.0260	−0.0113	0.0369	−0.0121
	(0.0334)	(0.0356)	(0.0364)	(0.0365)
Observations	1,999	1,999	1,999	1,999
R-squared	0.054	0.053	0.051	0.052
Number of banks	117	117	117	117

Notes: Data are quarterly. The dependent variable is the growth rate of PNFC lending by foreign branches. For each regressor, the reported coefficient is the sum of the contemporaneous term and three lags, with the corresponding *F*-statistics provided in parentheses. Subsidiary DBBKR and Subsidiary write-offs are the quarterly changes in the subsidiary's banking book capital requirement and loan write-offs, and each is expressed as a fraction of risk-weighted assets. Group demand is the measure of demand shocks for branches with affiliated subsidiaries: we multiply the group's (branch and subsidiary as a sum together) portfolio weight with six quarter on six quarter employment growth in the corresponding sector. Group demand is the sum of these products. For branches that operate without an affiliated subsidiary, the measure of demand is called Unaffiliated branch demand; its construction is identical to Group demand, except that the portfolio weights are taken for the unaffiliated branch alone, rather than the banking group. Inflation refers to the real GDP deflator. All regressions include bank-specific effects. Reference DBBKR in specifications (1) and (2) is defined as the change in average DBBKR and the change in branch-specific DBBKR respectively, where the reference group includes all regulated banks except the affiliated subsidiary of the given branch. Specifications (3) and (4) repeat this exercise, but the reference group now excludes any subsidiary that has an affiliated branch. Ratio denotes the size of an affiliated branch's loan portfolio relative to the size of its affiliated subsidiary's loan portfolio. To make the coefficient magnitudes of the reference groups comparable, in this table we standardize the standard deviation of the Reference DBBKR to that of the Subsidiary DBBKR.

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

statistically significant. The effects are of similar magnitudes to those reported in Table 3. Moreover, accounting for the relative branch size allows more precise estimation of the main coefficients of interest: the lending response to changes in minimum capital requirements, both for the branch's affiliated subsidiary and for a reference group of unaffiliated banks (all these coefficients are now significant at the 1% level). Intra-group leakages are approximately twice as great as leakages across non-affiliated banks in these more tightly estimated specifications.

3.2. Aggregating branch leakages

What macro-prudential policymakers are most interested in, of course, is the total size of leakage in the macroeconomy, and the extent to which that total is the result of affiliated or interbank leakages. Knowing the composition is important because the policy tools that would deal with either source of leakage are distinct, as we discuss further below.

We can arrive at an aggregate estimate of leakage by computing the sizes of both affiliated and interbank leakages implied by our estimated effects. To do so, we begin with the gross effect (before taking into account any leakages) of a one percentage point across-the-board increase in capital requirements for all UK-regulated banks (that is, an increase by one percentage point of the minimum capital ratio requirement). In Aiyar *et al.* (2014a) we estimated a gross effect of a 5.7% loan supply contraction following a one percentage point rise in capital requirements.[17] Table 1 gives the average size of UK owned banks, affiliated and unaffiliated foreign subsidiaries. Weighting by each type of UK-regulated bank implies an average UK-regulated bank size of 11,944.4 million, meaning that a one percentage point across the board rise in capital requirements will produce an average loan supply contraction of 680.81 million. Table 1 shows that the total number of UK-regulated banks is 89 (43 UK-owned, 30 non-affiliated foreign subs, and 16 affiliated foreign subs). Thus, the total gross contraction in lending from a one percentage point increase in capital requirements is 680.8 million × 89 = 60,593.8 million.

Aggregate leakages from foreign branches can be computed using the coefficients in either Table 4 or 5, combined with information about the number and average sizes of affiliated and non-affiliated foreign branches. For computational ease, we employ the coefficients in Table 4 to gauge the overall size and composition of leakages. The results of these computations are summarized in Table 6. Table 4, column 2 suggests that the reaction of the average non-affiliated branch to a one percentage point change in capital requirements in its *reference group* is 0.24. Multiplied by the average size of the unaffiliated branch, 582.1, this yields an average leakage of 139.7 million for each of the 96 non-affiliated branches, implying a total leakage for this group of 139.7 × 96 = 13,411.6, or 22.1% of the gross contraction in lending.

[17] To be precise, the estimate comes from an updated version of the original working paper.

Table 6. Aggregate branch leakages

	Unaffiliated branches	Affiliated branches	
		Intra-group	Cross group
Average bank lending	582.1	1,164.2	1,164.2
Average leakage per bank	139.7	372.5	232.8
Number of banks	96	21	21
Total leakage in percentage of loan contraction	22.1	12.9	8.1

Note: In response to a 100 bp increase in minimum capital requirements, loan supply by FSA-regulated banks is estimated to contract by 5.7%, or £60,594 million. This table shows different types of leakages arising from the partially offsetting response of foreign branches.

For affiliated branches, it is important to take into account both the response with respect to its affiliated subsidiary and the interbank leakage. From Table 4, column 4 one can see that the reaction of an affiliated branch, following a one percentage point rise in the capital requirement of the affiliated subsidiary is 0.32, which multiplied by the average size, 1164.22, gives an average leakage of 372.5 million, which when multiplied by the 21 affiliated branches, implies a total affiliated leakage of 7,823.5 million, or 12.9% of the gross contraction in lending. Finally, to obtain the average leakage for the interbank reaction of affiliated branches, one needs to multiply by the average size of the affiliated branch, with its reaction to changes in the reference group made up of unaffiliated subsidiaries and regulated banks (0.2 from column 4 in Table 4), which gives 232.8. The total response of affiliated branches to increases in the capital requirements of non-affiliated UK-regulated banks, therefore, is 232.8 × 21 = 4,889 million, or 8.1% of the gross contraction in lending (Table 6).

In summary, the total loan-supply leakage associated with the responses of foreign branches to an increase in capital requirements is 22.1% + 12.9% + 8.1% = 43.1%. Of the 43.1% total leakage, 12.9% (just under one-third) reflects the responses of affiliated branches to the capital requirement increases of their affiliated subsidiaries; over two-thirds of the total leakage reflects interbank responses, either by branches without affiliates or by branches with affiliates. The total leakage estimate provided here is somewhat higher than the 32% leakage estimate reported in Aiyar *et al.* (2014a). The estimate reported here, of course, is more precisely calculated because it is able to take account of the differences between affiliated and interbank responses.

3.3. Capital market leakages

Our next task is to measure the leakage from securities offerings. Our analysis exploits sectoral-level loan-supply consequences from capital requirement changes. That is, we first compute the implied sectoral-level capital requirements that apply to each of the 28 non-financial sectors that borrow from banks, by aggregating across banks using their weighted capital requirements, using each bank's sectoral lending share to derive sectoral changes in minimum bank capital ratio require-

Table 7. Capital market summary statistics

Summary statistics relevant for regression Tables 9 and 10					
	Corp bond issuance/ book value	Equity issuance/ book value	DBBKR	BBKR	Employment growth
Mean	0.0033	0.08	–0.005	9.12	–0.002
Std Dev.	0.0098	0.58	0.068	0.17	0.026
Min	0	0	–0.32	8.64	–0.21
Max	0.13	9.6	0.28	10.18	0.16

	External fin	Regulated bank share	Branch share	Corp bond share	Equity share
Mean	–3.82	0.27	0.08	0.448	0.205
Std Dev.	2.28	0.27	0.098	0.326	0.206
Min	–10.3	0.009	0.003	0	0
Max	–1.1	0.908	0.494	0.97	0.902

Table 8. Correlation between regulated bank lending growth, equity and corporate bond issuance

	CBOND	EQUITY	Regulated bank lending growth
CBOND	1		
EQUITY	0.0171	1	
Regulated bank lending growth	0.0194	0.008	1

Notes: This table reports the correlation matrix among the following three variables: Corporate bond issuance {at time t}/Stock outstanding {at time $t-1$}; Equity issuance {at time t}/Book value outstanding {at time $t-1$}; Regulated bank lending growth. All of the variables are aggregated to the sector level.

ments. We then regress the new sectoral issuances of stock to total book value outstanding, and bonds to total market[18] value outstanding, on this constructed measure of changes in sectoral capital requirements.

Table 7 reports summary statistics for the frequency and magnitudes of capital requirement changes, and securities issuances of both kinds, by sector, over the sample period. Note that securities issuance is measured in gross terms, while loan growth over the sample is a net concept (which incorporates loan retirements); thus, our measures of issuance, by construction, will potentially exaggerate the relative importance of securities offerings relative to loans as sources of funding to a sector.

Table 8 computes simple correlations between sectoral loan growth and sectoral bond and equity issuance. The coefficients are negative, but extremely small. Tables 9 and 10 report various regressions for bond and equity issuance, respectively. We include sectoral employment growth to capture demand variation. We vary the regression specifications by including various combinations of interaction variables

[18] Though book value would be preferable for corporate bonds as well, to our knowledge, this is not easily available with the sectoral break down that is necessary for our study.

Table 9. Corporate bond issuance regression
Dependent variable: Sectoral corporate bond issuance

Variables	(1)	(2)	(3)	(4)
DBBKR	0.011	0.012	0.007	0.003
	(1.35)	(1.37)	(0.15)	(0.01)
Employment growth		–0.0185	–0.029	–0.029
		(0.47)	(0.39)	(0.38)
DBBKR*External Fin			–0.0017	–0.0019
			(0.05)	(0.06)
DBBKR*Reg Bank Share				0.0077
				(0.04)
DBBKR*Branch Share				–0.0437
				(0.07)
DBBKR*Corp bond share				0.0162
				(0.26)
Constant	0.00275***	0.00271***	0.00303***	0.00303***
	(4.88e–05)	(4.07e–05)	(8.17e–05)	(8.99e–05)
Observations	884	884	782	782
R-squared	0.002	0.002	0.005	0.009
Number of id	26	26	23	23

Notes: Data are quarterly. The dependent variable is corporate bond issuance {at time t}/stock outstanding {at time $t-1$} by sector. For each regressor, the reported coefficient is the sum of the contemporaneous term and three lags, with the corresponding *F*-statistics provided in parentheses. DBBKR is the sector-level aggregated change in the banking book capital requirement. Employment growth is quarterly employment growth by sector. External Fin is the external finance requirement for each sector, defined as in Rajan and Zingales (1998). Reg Bank Share, Branch Share and Corp Bond Share are, respectively, the shares of regulated banks (UK-owned + foreign subsidiaries), foreign branches, and corporate bonds in total finance for that sector, which is defined as the sum of the stock of total bank lending, corporate bonds and equity outstanding in that sector. All specifications include sector fixed effects.

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

with DBBKR, on the theory that the degree of substitution between capital market issuance and bank lending may vary according to certain sectoral characteristics (the tendency for firms to require external financing, as measured by Rajan and Zingales, 1998, and the average sectoral reliance on bonds, foreign branch funding, or funding from banks other than foreign branches).

We find no evidence of any connection between implied sectoral changes in bank minimum capital requirements and capital market offerings. None of the estimated coefficients in either of the regression tables is statistically significant. Our results stand in contrast to Adrian *et al.* (2012), who find that in the US, there was considerable substitution of bond finance for bank loans during the financial crisis of 2007–2009. In the aggregate, during the credit crunch associated with the recent financial crisis, a substantial increase in UK bond issuance is also apparent. Bond issuance was higher in each year from 2009 to 2012 than it had been on average for 2003–2008.[19] This contrasting evidence suggests that during 'normal' times, when a common shock is not simultaneously affecting a wide swathe of the banking system, the main channel of credit substitution is between regulated banks and foreign branches, consistent with

[19] See Bank of England (2012).

Table 10. Equity issuance regression
Dependent variable: Sectoral equity issuance

Variables	(1)	(2)	(3)	(4)
DBBKR	–0.372	–0.379	–0.579	–1.51
	(0.95)	(0.95)	(1.00)	(1.17)
Employment growth		0.327	0.428	0.39
		(0.64)	(0.59)	(0.59)
DBBKR*External Fin			–0.04	–0.0165
			(0.46)	(0.02)
DBBKR*Reg Bank Share				0.48
				(0.33)
DBBKR*Branch Share				6.465
				(0.78)
DBBKR*Equity share				2.12
				(1.05)
Constant	0.0925***	0.0933***	0.105***	0.105***
	(0.00183)	(0.000954)	(0.000929)	(0.00147)
Observations	884	884	782	782
R-squared	0.001	0.001	0.001	0.003
Number of id	26	26	23	23

Notes: Data are quarterly. The dependent variable is Equity issuance {at time t}/Stock outstanding {at time $t-1$} by sector. For each regressor, the reported coefficient is the sum of the contemporaneous term and three lags, with the corresponding *F*-statistics provided in parentheses. DBBKR is the sector-level aggregated change in the banking book capital requirement. Employment growth is quarterly employment growth by sector. External Fin is the external finance requirement for each sector, defined as in Rajan and Zingales (1998). Reg Bank Share, Branch Share and Equity Share are, respectively, the shares of regulated banks (UK-owned + foreign subsidiaries), foreign branches, and equities in total finance for that sector, which is defined as the sum of the stock of total bank lending, corporate bonds and equity outstanding in that sector. All specifications include sector fixed effects.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

relatively poor substitutability between securities markets and bank loans. As is well known, loans involve more detailed contracting terms than bonds, and are characterized by the use of 'soft' information for screening and monitoring purposes that is neither required nor available in securities markets. Thus our sample period, running from 1998 to 2007, shows limited recourse to security offerings in response to a sectoral rise in capital requirements (and, consequently, a sectoral contraction in credit supply by regulated banks), but a large lending response by foreign branches. However, when most banks in the financial system – including foreign branches – are subject to a massive disruption in common funding markets and face pressures to shrink their balance sheet, the usual channel of credit substitution via foreign branches becomes inaccessible. In such circumstances bond issuance, especially by large firms that already have a history of tapping capital markets, becomes a much more important channel of credit substitution, as documented by Adrian *et al.* (2012).

4. CONCLUSION

In response to the global financial crisis, policymakers have decided to pursue macroprudential regulation, which seeks, among many other things, to vary minimum bank capital ratio requirements over time to maintain the resilience of the financial system

to adverse shocks. An indirect, yet important, channel through which this policy can contribute to systemic financial stability is via its impact on credit supply. But this effect can be subject to leakages from unregulated substitute sources of funding. The recognition of these various potential leakages has prompted national regulators to attempt to coordinate the changes in regulatory capital requirements across countries, both through Basel III and through ongoing European Union initiatives.

Using a unique 1998–2007 UK sample of UK-regulated domestic banks and foreign subsidiaries, foreign-regulated branches operating in the UK, and sectoral-level bond and equity offerings, we examine the relative magnitudes of various sources of leakages. First, with respect to inter-bank leakages, we compare the leakages from affiliated and non-affiliated branches of foreign-regulated banks in responding to the loan-supply effects of changes in capital requirements for UK-regulated banks. We find that branches of foreign banks operating in the UK respond strongly to changes in capital ratio requirements on banks and foreign subsidiaries regulated within the UK. The responses of affiliated branches to changes in capital requirements for their affiliated subsidiaries are roughly twice as large as the responses of non-affiliated branches to changes in capital ratio requirements for an unaffiliated reference group, but both affiliated and non-affiliated branches are significant sources of leakage.

Second, we consider the extent to which securities issuance substitutes for changes in bank lending were prompted by changes in regulatory capital requirements. We find no significant connection between sectoral-level or aggregate changes in bank capital requirements and securities issuance. It appears that – in periods when the domestic and international banking systems are not suffering a systemic crisis – the substitution of bond or equity finance for bank loans is not an important source of leakages. This is consistent with securities offerings being relatively poor substitutes for bank loans (relative to bank loans sourced from a different bank), due to myriad informational and transactional considerations. These results have important implications for macro-prudential policy. First, limited substitution between bank and non-bank sources of funding in non-crisis periods implies that macro-prudential control of aggregate credit through capital requirement changes is a potentially powerful policy tool – one that likely will not be circumvented by capital market substitution.

We find that leakages via parts of the banking system subject to foreign regulators are potentially very large. Foreign branches are able to substitute rapidly and substantially for credit supply contractions by domestically regulated banks that are induced by changes in capital requirements. Third, because leakages from both affiliated and non-affiliated foreign branches are substantial, leakages cannot be plugged simply by requiring foreign banks to choose between operating a subsidiary or a branch; plugging leakages due to foreign branches will require coordination among countries to ensure that foreign bank branches operating in a host country are subject to similar time variation in capital requirements as the domestically regu-

lated banks in the host country. Our results therefore suggest that rigorously implementing the reciprocity principle enshrined in Basel III's counter-cyclical capital buffer (CCB) will be crucial to the success of macro-prudential regulation going forward.[20] However, given the strength of the leakages documented here, the fact that the CCB – and therefore reciprocity – is capped at 2.5% might be regarded as a cause for concern.

Discussion

Ester Faia

Goethe University Frankfurt, CFS and SAFE

The debate on the pros and cons of capital regulation and macro-prudential policies is high on the agenda of policymakers and academics. For this reason empirical evidence shedding light on those issues is timely and appropriate. The authors in this paper analyse the extent to which changes in capital requirements, occurred in the UK during the period 1998–2007, affect the aggregate supply of credit. In the UK bank regulators imposed bank-specific and time-varying capital requirements on regulated banks: the authors asked whether those changes were followed by credit substitution between regulated subsidiaries on the one side and affiliated or unaffiliated branches or via other market instruments (corporate debt) on the other side. They find evidence of credit substitution primarily through the first channel (via affiliated banks).

The historical experience of the UK is particularly well suited to analyse the type of questions at hand. The empirical analysis is rich in robustness checks and the results are informative and novel. I will mainly comment on the implications drawn for macro-prudential policies, whereby I will add general considerations on the appropriate interpretation of those policies.

First, the authors suggest that the existence of credit substitution signals an impaired ability of macro-prudential regulation to control credit growth, hence to curtail risks. This view is not univocal and is restrictive compared to the scope of macro-prudential regulation. The goal of macro-prudential regulation indeed is not that of curbing credit growth: as long as loans are safe their growth or volatility is

[20] Under Basel III the CCB is scheduled to be phased in between 2016 and 2019, although it can be adopted earlier. Reciprocity means that foreign regulators would impose an additional capital charge on UK exposures of foreign branches equivalent to the prevailing level of the CCB determined by UK regulators (and vice-versa). However, reciprocity only extends to the CCB limit of 2.5% of risk-weighted assets. For example, if the domestic regulators of a particular country decided, on macro-prudential grounds, to raise capital requirements by 5% of risk-weighted assets, foreign regulators would only be obliged to raise capital charges on the exposures of foreign branch by 2.5%, leaving them with a significant cost advantage over domestically regulated banks.

not necessarily inefficient. Prudential regulators shall instead identify, through appropriate monitoring, systemically important institutions, namely those that if hit by a shock can have contagious effects on the entire system. If those institutions are monitored and cured credit growth *per se* is not necessarily a concern. Against this background the existence of credit substitutions is actually a sign of banking system resilience, as tightening in capital requirements do not necessarily translate into a widespread credit crunch.

Second, the authors effectively consider micro-prudential instruments (capital requirements on individual banks), whose time-varying nature implies that they might have an effect on the aggregate credit dynamic. This observation calls for a reflection upon the definition of an appropriate framework for macro-prudential policy. Like for any macro policy either the instruments or the objectives must be defined in aggregate terms. The recent developments show that some central banks (for instance the Bank of England) seem to follow the first approach, while others (for instance the ECB) follow the second approach. In my opinion an aggregate capital or leverage requirement might introduce significant distortions as not all banks are alike. The objectives instead shall tackle aggregate externalities, for instance by defining an appropriate systemic risk loss function (Shapley values, CoVaR, etc.). If the second view would prevail future empirical analyses shall also assess the link between changes in capital requirements and an empirical measures of systemic risk.

Third, if we consider prudential regulation as a macro policy we shall not neglect the role of expectations and the double causality with the macroeconomy. Any macro policy is subject to the Lucas critique: any change in policy is anticipated by agents (whether fully rational or not) and through this its intended effects might be neutralized or modified. Policymakers shall therefore take into account agents' expectation formation process and adjust their policy instruments endogenously.

For this reason empirical studies on macro policies have typically been conducted through time series analysis (also in combination with a panel data dimension). This aspect shall also be part of future empirical analysis on macro-prudential regulations to make them fully informative.

Two final aspects deserve attention in future research agendas. First, the authors assume that capital requirements are binding through their entire sample: in a historical perspective one might instead argue that the emergence of securitization in the 90s might have changed the tightness of the requirements. A fully fledged time series dimension might have shed light on this aspect. At last, the authors do not find any evidence of credit substitution with market-based instruments (corporate bonds): to fully identify this effect one shall probably use credit registry data and consider also data on credit demand (firms' applications) alongside data on credit supply (banks' approved applications).

Isabel Schnabel

Johannes Gutenberg University Mainz

One of the cornerstones of macroprudential regulation is the idea that capital requirements should be raised in a boom and lowered in a bust to dampen the expansion of credit in good times and lower the need for deleveraging in bad times. This paper argues that countercyclical capital requirements may be ineffective if there are 'leakages' through foreign banks or capital markets. Based on a detailed dataset of UK domestic and foreign banks, this paper analyses whether there are substitution effects in reaction to rising capital requirements through non-affected banks or capital markets. To answer this question, the paper exploits two interesting institutional features: (1) the imposition of bank-specific capital requirements in the UK over and above the Basel requirements, and (2) the different regulatory treatment of foreign subsidiaries (regulated by the UK regulator) and branches (regulated by home supervisors).

The authors distinguish three channels through which 'leakage' may occur. First, foreign banks may shift lending from the affected subsidiaries to non-affected affiliated branches (the 'regulatory arbitrage' channel). Second, unaffiliated foreign branches may take over business from affected banks (the 'competition' channel). Third, firms may enter capital markets to substitute for bank loans (the 'capital markets' channel).

The paper finds that foreign branches in the UK generally increased their lending in the presence of tighter UK capital requirements. The effect is particularly strong for foreign branches with affiliated UK subsidiaries. There is no evidence of a higher issuance activity in capital markets in response to tighter capital requirements. The paper concludes that macroprudential regulation can only be effective if such 'leakages' are closed, that is, if the compensating behaviour by other (less regulated) agents in the economy is prevented. In light of the results, the paper recommends harmonizing macroprudential capital requirements at the international level to prevent leakages through the foreign bank channel.

The paper deals with an important topic. The need for complementing the traditional microprudential perspective with a macroprudential perspective is one of the main lessons learnt from the recent crisis. However, little is known about the effectiveness of macroprudential regulation. This is one of the few papers trying to shed light on this issue.

Consistency with macroeconomic developments

The paper's results imply that foreign lending should react less strongly to rising capital requirements than domestic lending because foreign branches would absorb some of the lending by UK-regulated banks (domestic banks and foreign subsidiaries). Somewhat surprisingly, this does not seem to be true in the aggregate. For example, around the end of 2003, there was a sharp increase in average capital requirements of UK banks (see Figure 5 in Aiyar *et al.*, 2012a). At the same time, the growth in lending

to UK businesses slowed down, as expected; however, whereas domestic bank lending still grew at a positive rate, foreign lending growth became negative (see Bank of England, 2009a, p. 9). Hence, there is no indication at the macroeconomic level that foreign lending led to leakage. In fact, foreign lending reacted *more* strongly than domestic lending. Although these are admittedly unconditional results, they cast some doubt on the results found in the paper.

Idiosyncratic versus aggregate changes in capital requirements

Furthermore, the paper argues that the changes in capital requirements analysed in this paper are *idiosyncratic* and are not related to the business cycle. Under such circumstances, the paper's results are highly plausible. There is a lot of scope for leakage within the banking sector if not all banks are hit by higher capital requirements at the same time. For this reason, firms do not have to turn to capital markets for funding: the banks that are not affected by higher capital requirements are happy to substitute for the decrease in lending by affected banks. Hence, the paper's results are in line with expectations. However, macroprudential capital requirements are linked to the cycle and are likely to hit many banks at the same time. It is questionable whether the effects of such a policy can be identified by considering idiosyncratic changes in capital requirements that are not related to the cycle.

Looking again at aggregate numbers, there is evidence of substantial leakage to capital markets in the (global) crisis (which is outside the sample period). In 2009, bank lending collapsed whereas bond and equity issuance soared (Bank of England, 2009b, p. 6). When all banks are subject to shocks at the same time, substitution within the banking sector is difficult, whereas substitution by capital markets becomes more likely.

If one wants to capture the effects of macroprudential regulation, *aggregate* changes in capital requirements are more informative. At the same time, however, such changes are likely to be endogenous, making identification difficult. Using idiosyncratic variation in capital requirements is more credible from an identification perspective, but is less informative about the actual effects of macroprudential regulation.

Policy conclusions

Finally, I would like to discuss policy implications. The paper seems to suggest that leakages are a problem because they limit the effectiveness of macroprudential regulation. I propose a slightly more differentiated conclusion. I certainly agree that leakage from UK-regulated banks to non-UK-regulated banks is undesirable in boom times when macroprudential regulation intends to dampen the cycle. This calls indeed for international coordination of macroprudential policies. It is less clear that leakage to capital markets is undesirable in such circumstances, as it may prevent a further increase in leverage in the banking sector (although aggregate debt expansion may

not be dampened). In a crisis, both types of leakage are desirable because they reduce the need for deleveraging and help to prevent a credit crunch. In some countries, we have seen that foreign banks substituted for domestic lending in the crisis and thereby had a stabilizing effect. Hence, preventing leakages within the banking sector seems to be particularly important in boom times. We should, however, be aware that a prevention of leakage within the banking sector is likely to amplify leakages through capital markets or through the shadow banking sector.

In conclusion, this paper contributes significantly to our understanding of the effects of macroprudential policies, but it also shows the difficulties in judging the effects of policies that are largely untested.

Panel discussion

Ethan Ilzetzki noted that the UK had a pro-cyclical capital requirement ratio prior to the crisis. He subsequently enquired what this implies for the effectiveness of macroprudential regulation given that the UK ultimately observed a significant banking crisis. Frank Westermann wondered whether capital requirements are the best instrument to consider when speaking about the stabilization of lending. He suggested looking at interest rates instead. Alan Taylor referred to liquidity requirements and explained that banks may first attempt to change their balance sheets in other ways than issuing equity when capital requirements are raised. In particular, if banks do not have reserves of liquid securities and other assets, then they will retract their lending which will lead to a fall in credit. Conversely, Taylor argued that if they do possess such assets, then these can be sold and the level of credit may respond less negatively to the rise in the capital requirement. Second, Taylor questioned the future of foreign banks in the UK and asked how the competition channel could end up being affected. Next, Philippine Cour-Thimann asked if the authors also control for regulatory changes in the home countries of the foreign banks. Lastly, Hans-Werner Sinn requested that the authors reinvestigate the various channels through which capital can flow towards investment.

Tomasz Wieladek contended that the analysis contains some macroprudential elements in the sense that the timing of changes is the same across all banks. On the exogeneity of the instruments, he reported that extensive checks were made to confirm the presence of some exogenous variation. Moving on, Wieladek said that doubt surrounding the identifying assumption should be alleviated by the empirical evidence showing the binding nature of the capital requirement ratio over the time period of study. He also noted that in previous work he controlled for capital requirement changes in foreign countries and found nothing new. However, he accepted that it is difficult to control for (relative) changes in regulation abroad given that (banking) regulatory tools other than just capital requirements may exist. On the analysis of asymme-

tries, Wieladek stated that this issue was considered but ultimately deemed not too important. Regarding Ilzetzki's point, Wieladek thought that reciprocities of the idea that credit substitution channels were missing would have attenuated the crisis. Moreover, Wieladek explained that the use of Basel II risk weights by banks from 2007 onwards may have been another reason for the (extent of the) crisis. Ending the discussion, he acknowledged Taylor's comments and revealed that these issues would be addressed in future work.

REFERENCES

Adrian, T., P. Colla, and H. S. Shin (2011). 'Which financial frictions? Parsing the evidence from the financial crisis', Federal Reserve Bank of New York Staff Report No. 528.

Aiyar, S. (2011). 'How did the crisis in international funding markets affect bank lending? Balance sheet evidence from the United Kingdom', Bank of England Working Paper No. 424.

Aiyar, S. (2012). 'From financial crisis to Great Recession: the role of globalized banks', *American Economic Review* 102 (3), 225–230.

Aiyar, S., C. Calomiris and T. Wieladek (2014a). 'Does macro-prudential regulation leak? Evidence from a UK policy experiment', *Journal of Money, Credit and Banking* 46 (1), 181–214.

—— (2014b). 'How does credit supply respond to monetary policy and bank minimum capital requirements?', Bank of England Working Paper (forthcoming).

Alfon, I., I. Argimón and P. Bascuñana-Ambrós (2005). 'How individual capital requirements affect capital ratios in UK banks and building societies', Working Paper 515, Bank of Spain.

Bank of England (2009a). 'Trends in Lending', April.

Bank of England (2009b). 'Trends in Lending', December.

Bank of England (2012). 'Asset purchase facility quarterly report', Q3.

Bernanke, B. S. and A. S. Blinder (1988). 'Credit, money, and aggregate demand', *American Economic Association Papers and Proceedings*, 78, 435–39.

Bernanke, B. S. and C. S. Lown (1991). 'The credit crunch', *Brookings Papers on Economic Activity*, 2, 205–48.

Bridges, J., D. Gregory, M. Nielsen, S. Pezzini, A. Radia and M. Spaltro (2013). 'The impact of capital requirements on bank lending', Bank of England Working Paper (forthcoming).

Calomiris, C.W., C. Himmelberg and P. Wachtel (1995). 'Commercial paper, corporate finance, and the business cycle: a microeconomic approach', *Carnegie-Rochester Series on Public Policy*, 42, 203–50.

Calomiris, C.W. and M. Tsoutsoura (2011). 'Underwriting costs of seasoned equity issues: cross-sectional determinants and technological change, 1980–2008', Working Paper, Columbia Business School.

Campello, M. (2002). 'Internal capital markets in financial conglomerates: evidence from small bank responses to monetary policy', *Journal of Finance*, 57, 2773–805.

Diamond, D. (1984). 'Financial intermediation and delegated monitoring', *Review of Economic Studies*, 51, 393–414.

Francis, W. and M. Osborne (2009). 'Bank regulation, capital and credit supply: measuring the impact of prudential standards', FSA Occasional Paper No. 36.

—— —— (2012). 'Capital requirements and bank behavior in the UK: are there lessons for international capital standards?' *Journal of Banking and Finance*, 36(3), 803–16.

FSA (2008). 'The supervision of Northern Rock: a lessons learned review.' Report, Internal Audit Division, FSA, April 2008.

Gale, D. and M. F. Hellwig (1985). 'Incentive-compatible debt contracts: The one-period problem', *Review of Economic Studies*, 52(4), 647–63.

Galati, G. and R. Moessner (2011). 'Macroprudential policy – a literature review', BIS Working Paper No. 337.

Gertler, M. and S. Gilchrist (1993). 'The role of credit market imperfections in the monetary transmission mechanism: Arguments and evidence', *The Scandinavian Journal of Economics* 95 (1), 43–64.

—— —— (1994). 'Monetary policy, business cycles, and the behavior of small manufacturing firms', *Quarterly Journal of Economics* 109 (2), 309–340.
Houston, J., C. James and D. Marcus (1997). 'Capital market frictions and the role of internal capital markets in banking', *Journal of Financial Economics*, 46, 135–64.
James, C. (1987). 'Some evidence on the uniqueness of bank loans', *Journal of Financial Economics*, 19, 217–35.
Jimenez, G., J. S. Salas, S. Ongena and J. Peydro(2011). 'Macroprudential policy, countercyclical bank capital buffers and credit supply: evidence from the Spanish dynamic provisioning experiment', European Banking Center Discussion Paper.
Kashyap, A., J. Stein and D. Wilcox (1993). 'Monetary policy and credit conditions: evidence from the composition of external finance', *American Economic Review*, 83(1), 78–98.
Myers, S. and N. Majluf (1984). 'Corporate financing and investment decisions when firms have information that investors do not have', *Journal of Financial Economics*, 13, 187–221.
Noss, J. and M. Toffano (2012). 'A structural VAR analysis of UK capital requirement policy', Bank of England Working Paper (forthcoming).
Rajan, R.G. and L. Zingales (1998). 'Financial dependence and growth', *American Economic Review*, 88(3), 559–86.
Turner, A. (2009). 'The Turner Review: A regulatory response to the global banking crisis', Financial Services Authority, March.
Van den Heuvel, S. (2009). 'The welfare cost of bank capital requirements', *Journal of Monetary Economics*, 55(2), 298–320.
Van Hoose, D. (2008). 'Bank capital regulation, economic stability, and monetary policy: what does the academic literature tell us?' *Atlantic Economic Journal*, 36(1), 1–14.