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Capital requirements, risk shifting and the mortgage market

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Abstract

We study the effect of changes to bank-specific capital requirements on mortgage loan supply with a new loan-level dataset containing all mortgages issued in the UK between 2005Q2 and 2007Q2. We find that a rise of a 100 basis points in capital requirements leads to a 5.4% decline in individual loan size by bank. Loans issued by competing banks rise by roughly the same amount, which is indicative of credit substitution. Borrowers with an impaired credit history (verified income) are not (most) affected. This is consistent with origination of riskier loans to grow capital by raising retained earnings. No evidence for credit substitution of non-bank finance companies is found.

Keywords: Capital requirements, loan-level data, mortgage market, credit substitution.

***JEL* classification**: G21, G28.

Non-technical summary

Many countries around the world have reinforced macroprudential and microprudential regulation to increase the resilience of their financial system to socially costly financial crises. One proposed instrument, which is also embedded in Basel III, is a time-varying capital requirement. But, to date, there is little understanding of how this instrument will affect the mortgage loan supply, lenders' preferences for risk, or loan substitution of providers outside the banking system. The UK's banks and building societies were subject to a unique pre-crisis regulatory regime, where capital requirements varied by *institution* and *over time.* A new loan-level database, containing a large set of loan and borrower characteristics on all new mortgages issued in the UK between 2005Q2 to 2007Q2, is also available. By combining these two datasets we can provide the first empirical examination of the impact of time-varying capital requirements.

We examine the effect of changes to a bank's capital requirement on the value of individual household mortgage loans. When confronted with increased capital requirements, the affected bank can choose to contract lending or to raise capital organically by increasing earnings and retaining a greater share of those earnings. One way to achieve the latter in the short run is to lend more to riskier borrowers, who can be charged extra fees and/or higher interest rates. Under Basel I, the regulatory framework during this period, household mortgages were assigned a risk weight of 50% regardless of loan and borrower characteristics. Faced with a rise in the capital requirement, banks were therefore incentivised to reallocate lending towards more profitable high-risk borrowers. To our knowledge, we are the first to formally test for this risk-shifting channel following changes in capital requirements. But the effect on individual banks need not translate to an effect on aggregate loan supply, as substitution of other sources of credit may offset this effect. In the presence of credit substitution, financial policy, if aimed at affecting the loan supply, will be less effective. Finally, we are also first to study whether the size of loans issued by locally competing banks, which were not affected by a rise in capital requirements, and non-bank finance companies, rises in response to the loan contraction by the affected banks, which is indicative of credit substitution.

We find that a rise in an affected bank's capital requirement of 100 basis points, conditional on all observable borrower, loan and balance sheet characteristics, leads to a decline in loan size of about 5.4%. Our results suggest the presence of risk shifting: this loan contraction does not occur for first-time buyers and borrowers with an impaired credit history, but affects those with verified income to a greater extent. Interestingly, locally competing lenders expand the average size of their loans by a quantitatively similar amount. This result is consistent with the idea that locally competing banks may completely offset the loan contraction associated with higher capital requirements on affected banks. On the other hand, there is no evidence for credit substitution from non-bank finance companies.

The findings in this study are based on changes to microprudential capital requirements and are therefore subject to the Lucas Critique, since bank behaviour might change in the presence of macroprudential regulation. Nevertheless, they may offer important lessons for economic policy and theory. Our results suggest that increases in capital requirements intended to make a bank more resilient may also raise the riskiness of a bank's balance sheet by inducing risk shifting behaviour. Furthermore, competition in the local lending market may mute the loan contraction when higher capital requirements are imposed on only a subset of lenders. Awareness of these issues might help both policy makers and researchers to better understand the transmission of both macroprudential and microprudential policies to the mortgage market.

1. Introduction

Current financial reform proposals focus on time-varying capital requirements as an instrument to maintain financial stability and increase the resilience of financial institutions to adverse shocks. Yet the impact and transmission mechanism of these tools is still not well understood (Galati and Moessner, 2013). This should not be surprising, since in the past regulators in most countries imposed a constant capital requirement, by bank and over time, in accordance with the regulatory framework of Basel I. But the UK regulator at the time, the Financial Services Authority (FSA), adjusted individual banks'[1] capital requirements over time to address legal, operational and interest rate risks, which were not accounted for in Basel I. In this paper we exploit this unique regulatory regime to test if changes in bank-level capital requirements affect mortgage loan size with loan-level data on all new mortgages issued in the UK between 2005Q2 and 2007Q2. We also examine if the affected banks shift lending towards riskier borrowers to boost short-term profitability and grow capital through higher retained earnings. Finally, we study whether the size of loans issued by locally competing banks, which were not affected by a rise in capital requirements, and non-bank finance companies, rises in response to the loan contraction by the affected banks, which is indicative of credit substitution.

For capital requirements to affect the aggregate loan supply, three conditions need to be satisfied: (i) bank equity needs to be privately more expensive than bank debt; (ii) capital requirements need to be a binding constraint on a bank's choice of capital structure, and (iii) there needs to be only limited substitution of other sources of finance for bank lending. Condition (i) implies a failure for banks of the Miller-Modigliani (1958) theorem, as otherwise changes in the capital requirement do not need to affect a financial institution's overall cost of funding. But economic theory provides good reasons for why condition (i) should be satisfied, such as asymmetric information (Myers and Majluf, 1984) and the difference in tax treatment between debt and equity.[2] Similarly, empirical work documenting the impact of adverse shocks to bank capital on loan growth, as in

[1] Throughout this paper, we will refer to both building societies and banks as banks.
[2] See Aiyar, Calomiris and Wieladek (2014a) for an extensive discussion of economic theory and empirical evidence in support of the validity of the first assumption.

Bernanke (1983) and Peek and Rosengren (1997, 2000) provides support for this assumption. Several empirical studies, namely Ediz, Michael and Perraudin (1998), Alfon and Bascuñana-Ambrós (2005), Francis and Osborne (2012), Aiyar, Calomiris and Wieladek (2014a) and Bridges, Gregory, Nielsen, Pezzini, Radia and Spaltro (2014), also demonstrate that capital requirements were a binding constraint on banks' choices of capital structure during the 1998-2007 period. This suggests that the second condition is likely to be satisfied as well.

Figure 1 illustrates that banks may choose to cut back risk-weighted assets following a rise in capital requirements if conditions (i) and (ii) hold. Previous work has used the same FSA capital requirements data to test this implication on bank-level private non-financial corporate (PNFC) sector lending instead.[3] Aiyar et al (2014a), Bridges et al (2014) and Francis and Osborne (2012) find a loan contraction of 5.7, 5.6[4] and 5 per cent, following a one hundred basis points increase in capital requirements, respectively. In related work, Jimenez, Peydro, Ongena and Saurina (2015) study the effect of four Dynamic Provisioning changes on lending with a detailed loan-level dataset on loans granted and applied for by firms operating in Spain. The granularity of our dataset allows us to control for loan demand and address issues of reverse causality substantially better than previous studies on bank-level data. Similarly, compared to previous work on loan-level data, we examine the effect of a larger number of changes in capital requirements on individual household mortgage loans.

In theory, higher capital requirements could increase lending at banks with very low or negative net worth, particularly if they help to address the debt overhang problem. Similarly, in the medium-run, improvements in the stability of the banking system that result from higher capital requirements could improve banks' abilities to raise funds in the market and thereby mitigate any decline in short-run loan supply. But given the time period of this study, the short-run loan supply decline effect is expected to dominate.

[3] Bridges et al (2014) is the only other work to consider the impact on mortgage loan growth, but they examine the impact on bank-level, as oppose to loan-level, mortgage lending.

[4] To make their results comparable to the other studies, the authors kindly provided us with a figure that refers to the effect over one year and is a weighted average of their results for the commercial real estate and other PNFC lending categories.

Banks may also choose to raise capital, to satisfy their capital requirement, through greater retaining earnings. Under Basel I, the regulatory framework that applied during the period we study, mortgages were assigned a risk-weight of 50% regardless of loan and borrower characteristics. Faced with a rise in their capital requirement, banks were therefore incentivised to reallocate lending towards more profitable high risk borrowers in order to grow capital via retained earnings.[5] In that case, raising capital requirements could have the perverse effect of making bank balance sheets riskier.[6] Both Furlong (1988) and Sheldon (1996) test for this type of risk shifting behaviour as a result of the introduction of the 1981 leverage ratio in the US and Basel I in Switzerland, respectively. While they do not find any support for risk shifting, Haldane (2013) argues that this could be a result of the interplay with other regulations that were introduced coincidentally. In contrast, our study examines risk shifting in response to changes in bank capital requirements within an otherwise unchanging regulatory framework, meaning that this is a much more powerful test of the risk shifting hypothesis.

But the effect on individual banks need not translate to an effect on aggregate loan supply, as substitution of other sources of credit may offset this effect. In the presence of credit substitution, financial policy, if aimed at affecting the loan supply, will be less effective. Aiyar et al (2014a, b) and Jiminez et al (2015) provide evidence for credit substitution of foreign branches with respect to lending to PNFCs in response to changes to capital requirements and Dynamic Provisioning in the UK and Spain, respectively.

In summary, we contribute to this literature in several important ways. To our knowledge, this is the first paper to examine the impact of changes in capital requirements on mortgage loan size and risk shifting behaviour with loan-level data. We are also the first to formally test whether changes in mortgage loan size issued by banks that were unaffected by changes in capital requirements and non-bank finance companies are consistent with credit substitution in the mortgage market.

[5]Kahane (1977) and Kim and Sontero (1988) both present theoretical model which show that banks are incentivised to take greater risks in the presence of fixed risk weights.
[6] This does not necessarily mean that the bank's balance sheet will become less resilient. Changes in resilience will depend upon whether or not the rise in risky assets is more than offset by the additional capital or not.

The results suggest that a rise in an affected banks capital requirement of 100 basis points, conditional on all observable borrower, loan and balance sheet characteristics, leads to a decline in loan size of about 5.4%. We also find evidence for risk shifting: there is no contraction in loan size for borrowers with an impaired credit history or first-time buyers, while borrowers with verified income are affected to a greater extent. In contrast, the size of mortgage loans issued by locally competing lenders rises by an almost identical amount. This suggests that adjustment to higher capital requirements is mostly through the extensive margin and is also consistent with loan substitution in response to changes in their competitors' capital requirements. But we do not find similar evidence for credit substitution of non-bank finance companies.

While the findings from this study are based on changes to individual banks' microprudential capital requirements, they may still offer important lessons for our understanding of how macroprudential policy might affect loan supply. Our results suggest that increases in capital requirements intended to make a bank more resilient may also raise the riskiness of a bank's balance sheet by inducing risk shifting behaviour. Our results also show that competition in the local lending market may mute the loan contraction when higher capital requirements are imposed only a subset of lenders. Changes to regulation introduced after the end of our sample period may, however, mean that our results might be less applicable to macroprudential capital requirements. Banks' use of internal models for setting risk weights on mortgages, introduced under Basel II, may prevent risk shifting, so long as the weights are sufficiently risk-sensitive. The reciprocity clauses in the countercyclical capital buffer, introduced under Basel III, should help to stop foreign branches from substituting for domestic lenders when a national authority increases the buffer rate.[7] But the general principle, documented here, that the financial system may adapt to new regulations in ways that may lead to unintended consequences will also be applicable to Basel III.

[7] Clearly UK capital requirement regulation can only affect UK-regulated banks. In theory, foreign branches, which are not subject to UK capital regulation, could provide a source of credit substitution in response to UK macroprudential capital requirement changes. But in practice the reciprocity clause in Basel III would require the regulator in the foreign branches' home country to match this capital requirement rise on UK lending. This should address loan substitution of foreign banks.

Economic theorists and policy makers may want to keep this in mind when examining the effect of macroprudential instruments on the mortgage market.

The remainder of the paper is structured as follows. Section 2 describes the UK's regulatory regime during the sample period and the data. Section 3 describes the empirical approach to testing each of the proposed hypotheses, presents the results and examines them for robustness. Section 4 concludes.

2. UK capital requirement regulation and data

Bank capital requirements in most countries were set at a fixed value at or above the minimum of 8 per cent of risk-weighted assets since the introduction of Basel I in 1988. But in the UK, regulators set bank-specific capital requirements, otherwise known as minimum trigger ratios[8], to address operational, legal, or interest rate risks, which were not accounted for in Basel I (Francis and Osborne, 2012). Individual banks were subject to different capital requirements over time; requirements were reviewed either on an on-going basis or every 18-36 months. This regulatory regime was first implemented by the Bank of England, with the Financial Services Authority (FSA) taking over in 1997. The FSA based regulatory decisions for banks on a system of guidelines called ARROW (Advanced Risk Responsive Operating frameWork), which covered a wide array of criteria related to operational, management, business as well as many other risks.[9] Indeed, in this high-level review of UK financial regulation prior to the financial crisis of 2008, Lord Turner, the then chief executive of the FSA, concluded that: 'Risk Mitigation Programs set out after ARROW reviews therefore tended to focus more on organisation structures, systems and reporting procedures, than on overall risks in business models' (Turner, 2009). Similarly, the inquiry into the failure of the British bank Northern Rock concluded that 'under ARROW I[10] there was no requirement on supervisory teams to include any developed financial analysis in the material provided to ARROW Panels'[11]

[8] A trigger ratio is the technical term for capital requirement, since regulatory intervention would be triggered if the bank capital to risk-weighted asset ratio fell below this minimum threshold.
[9] The ARROW approach also encompassed prudential risks, but this was not one of the core supervision areas.
[10] Guidelines before their revision in 2006 were referred to as ARROW I, while those thereafter as ARROW II.
[11] Regulatory decisions were made by a panel of supervisors, also referred to as ARROW panels.

(FSA, 2008). Indeed Aiyar et al (2014a) show that, while bank size and writeoffs appear to be important determinants of the level of capital requirements in the cross-section, bank balance sheet variables can typically not predict quarterly time variation in capital requirements. Similarly, Aiyar et al (2014c) estimate a bank panel VAR model on PNFC loan growth and capital requirement changes. They find evidence of causality running from changes in capital requirements to loan growth, but not vice versa. Together, all of this evidence suggests that capital requirement changes within this regulatory framework were mainly determined by factors other than loan growth or credit risk. From an econometric perspective, this provides a suitable environment to examine the effect of changes to institution-specific capital requirements on individual mortgage lending.

We combine a dataset containing mortgage lending, lender-specific Pillar 2 capital requirements, and balance sheet information of bank, building societies and non-bank finance companies. We collect data on a total of 58 regulated banks' mortgage lending and capital requirement changes from the BSD3 form.[12] But banks are not the only source of household mortgage finance in the UK. Building societies, which are owned by their customers, as oppose to external shareholders, made up 16% of all mortgage lending to households. Like banks, building societies were subject to different minimum capital requirements across institutions and time, but the review was only conducted once a year on a rolling basis. Regulatory data for building societies, of which there were 59 during the time period of interest, from the QFS1 form, was provided by the FSA. The third group of mortgage providers are non-bank finance companies, which were not subject to changing capital requirements. Instead, they were subject to a 1% capital requirement for institutions with a capital of greater than 100,000 pound sterling. They made up about 10% of UK mortgage lending during the time period examined here.

Our study covers the time period 2005Q2 to 2007Q2, as loan-level data on mortgages was not collected before then and subsequent data may have been affected by the effects of the global financial crisis on the UK mortgage market, including the failure

[12] Up until 2008Q1, FSA regulatory data were collected by the Bank of England, on behalf of the FSA.

of the bank Northern Rock in 2007Q3. Furthermore, the same overall regulatory capital framework was in place throughout this period. Prior to 2008Q1, UK regulators used Basel I risk weights. Unlike Basel II risk weights, which were adopted after this date, these risk weights were fixed, assigning a weight of 50% to mortgage loans and 100% to PNFC loans, regardless of underlying loan characteristics. The adoption of internal models based (Basel II) risk weights may introduce an additional margin of adjustment following changes in capital requirements (Benford and Nier, 2007). This additional would make the task of understanding the transmission of capital requirements to individual loans even more difficult. For both of these reasons, and to better isolate how changes in capital requirements affect bank behaviour, we choose the sample period to finish in 2007Q2. Regulated institutions were affected by 20 capital requirement changes during this time, all of which are shown in figure 2, with summary statistics provided in table 4. The other lender level balance sheet data were provided by the Bank of England's Statistics and Regulatory Data Division.[13] The control variables we derive from these data are described in greater detail in table 1, with the corresponding summary statistics provided in table 3.

The source of loan-level data is the Product Sales Database (PSD), which starts in April 2005, and during the time period of interest, was collected by the FSA. This includes data on new mortgages issued, retail investments, and home purchase plans. Any financial institution, whether a bank, building society or non-bank finance company, was required to report these data at a quarterly horizon to the FSA, within 20 working days of the end of each quarter. For mortgages, in addition to information about the size of the loan and the value of the property purchased, the database collects important borrower and mortgage contract information. In particular, information on borrower age in years and income in pound sterling is provided. Flexibility of repayment and maturity provide information on the presence of early repayment fees, taking the value of one if that is the case and zero otherwise, and the maturity of the mortgage in years. Purpose of remortgage provides information on whether extra money was raised and if so for what

[13] All banks operating in the United Kingdom are legally required to provide this information to the Bank of England.

purpose. Income verification and impaired credit history indicate if the applicant's income was verified and if they have a bad credit history, taking a value of one if that is the case and zero otherwise. Type of employment indicates if the borrower is employed, self-employed, retired or other. Borrower type provides information on whether the borrower is a first-time buyer, a person moving home, a social tenant[14] or remortgaging their existing home, for example. Greater detail on these variables can be found in the bottom half of table 1. Table 2 shows the mean and the standard deviation of the natural logarithm of loans, the loan-to-value (LTV) ratio and the loan-to-income (LTI) ratio by bank type and selected borrower characteristics for the time period 2005Q2 – 2007Q2. Consistent with economic intuition, individuals whose income status are not verified could therefore be perceived as riskier borrowers, typically obtain mortgages with lower LTV and LTI ratios. Loans with higher maturity tend to have higher LTV and LTI ratios compared to loans with low maturity. Similarly, fixed rate mortgages have higher LTV and LTI ratios compared to standard variable rate (SVR) mortgages. On the other hand, differences in LTV and LTI ratios between employed and self-employed borrowers are negligible. Average LTV ratio is highest for loans to first time buyers compared to other groups of loans presented in table 2. Non-bank finance companies tend to provide mortgages with higher LTV and LTI ratios than either building societies or banks.

House prices in England and Wales rose on around 13 percent between 2005Q2 and 2007Q2. Figure 3 and 4 present the evolution of house price indices and quarterly growth rates during this period, and show a common-trend at the regional level. Figure 5 and 6 display the variation in average and median house prices at the district level and show districts in England and Wales experienced considerable heterogeneity during the period of interest while the market was booming.

[14] In the UK individuals living in social housing, social tenants, have the right to buy the property they live in for a discount from the government, under the Right-to-Buy scheme originally introduced by Prime Minister Margaret Thatcher in the 1980s.

3. Empirical approach and results

In this section we describe the empirical framework to test each of the proposed hypotheses and report the results.

3.1 Do capital requirements affect mortgage loan size?

In this section we examine whether changes in capital requirements affect loan size with the following regression equation:

$$\boldsymbol{Loan_{i,j,t} = \alpha_j + \sum_{k=0}^{3} \delta_k KR_{j,t-k} + \varphi BLC_{i,j,t} + \sum_{k=0}^{3} \theta_k Prov_{j,t-k} + \gamma LC_{j,t} + PC_{ht} + e_{i,j,t}} \quad (1)$$

where $LOAN_{i,j,t}$ is the natural logarithm of the loan size for a *new* loan agreed between by borrower *i* and lender *j* at time *t*. $KR_{j,t}$ is the minimum capital requirement ratio[15] for regulated financial institution *j* at time *t*. $Prov_{j,t}$ is the provisions to asset ratio for regulated financial institution *j* at time *t*. $BLC_{i,j,t}$ is a vector of all the borrower and loan characteristics listed in table 1, for individual *i*, borrowing from lender *j* at time *t*. Where borrower and loan characteristics are not binary, they are modelled as additional sets of fixed effects. $LC_{j,t}$ is a vector of lender characteristics for lender *j* at time *t*, all of which are listed in table 1. α_j is a lender fixed effect to account for lender unobservable time-invariant characteristics. PC_{ht} is a vector of district time effects to account for unobservable geographical differences, in particular in loan demand, among the 134 different districts of the UK over time. To avoid perfect multi-colinearity, we drop the first variable from each group of fixed effects. $e_{i,j,t}$ is assumed to be a normally distributed error term. Since the main variable of interest varies by institution and over time, all standard errors are clustered by bank-time. This particular choice of specification is explained in greater detail below.

In this empirical model, capital requirements are assumed to affect the dependent variable contemporaneously and with up to three lags. In the UK, mortgage loan

[15] Aiyar, Calomiris and Wieladek (2014a) point out that in practice, banks were subject to two different capital requirements: the trading book capital requirement; and the banking book capital requirement. Since household lending is in a financial institution's banking book, this is the capital requirement that we focus on.

conditions change at monthly, sometimes weekly, frequency, depending on factors such as the individual institution's balance sheet or general financial market conditions. The FSA's PSD records the loan size and the associated borrower and mortgage characteristics when the purchase of a property is completed. This is typically several weeks, if not months, after the mortgage terms were agreed. For these reasons data recorded in the PSD lags actual mortgage market conditions by several weeks or months. Capital requirements are available only at quarterly frequency. And although financial institutions might start to change loan conditions several months before the implementation of regulatory action, due to anticipation, it is difficult to know precisely when the purchase of a property is completed. Furthermore, due to adjustment costs, it is quite likely that the reaction to changes in capital requirements occurs with a lag. This is why Aiyar et al (2014a, 2014b, 2014c) and Aiyar, Calomiris, Hooley, Korniyenko and Wieladek (2014) include the contemporaneous value as well as three lags of the capital requirement ratio in their exploration of these data. For these reasons, and to maintain comparability to previous work, the minimum capital requirement ratio enters contemporaneously and with three lags here too.[16]

Similarly, the provisions to asset ratio enters model **(1)** contemporaneously and with three lags. Aiyar et al (2014a) and Aiyar et al (2014) both find that the writeoff to risk-weighted asset ratio is an important control variable to control for potential regulatory changes due to deterioration in the quality of the loan portfolio. Unfortunately, writeoffs not are available from the Quarterly Financial Statement form that building societies submit to the FSA, which is why we use provisions instead, since these are available for both banks and building societies. Following the approach in Aiyar et al (2014a-c), the remaining balance sheet variables only enter contemporaneously.[17]

In this study we aim to identify the loan *supply* effect of changes in capital requirements, and hence it is important to control for loan *demand*. This is a challenging

[16] We note that our results are robust to the inclusion of the contemporaneous value alone or the lagged value alone and that the inclusion of shorter lag lengths gives quantitatively similar results.
[17] Another important reason for maintaining the same specification is that this allows a reader to compare estimates across several papers, which is especially important given that the underlying data are not publicly available.

task in most empirical studies. To fully separate loan supply from demand, data on loan applications and outcomes is necessary, such as in Jiminez et al (2015). Since these data are unavailable for the UK, we cannot take this approach. But the geographical information on the loan destination allows us to use geographical time dummies, as in the approach presented in Aiyar et al (2014), to control for loan demand better than most studies of capital requirements with lender level data.[18] The PSD dataset provides detailed geographical information on the property that was purchased with the loan. In the UK, each property is assigned a six-character postcode. Choosing such a narrow geographical area carries the risk that we will run out of degrees of freedom. On the other hand, choosing a very wide geographical area, such as one of the twelve regions in the UK, will result in insufficient granularity to credibly control for loan demand. The Office of National Statistics (ONS) classifies the UK according to the Nomenclature of Units for Territorial Statistics (NUTS).[19] The broadest NUTS classification consists of twelve areas, corresponding to the twelve regions of the UK, while the most detailed classification, level three, classifies the UK into 134 geographical areas, which we refer to as districts for the rest of this paper. This is the most detailed level for which ONS statistics, such as local unemployment rates, are provided. We therefore use district time dummies to control for loan demand in this paper.[20] To the extent that mortgage loan demand shocks only differ across the 134 districts of the UK and the associated time dummies pick those up, the regression estimates on the capital requirement can be thus be interpreted as a supply effect.[21] We report the sum of coefficients on these variables and corresponding F tests, testing the hypothesis that the sum of coefficients is statistically different from zero at conventional levels of significance, in all of the tables. In the presence of lender and time fixed effects, the econometric interpretation of $\sum_{k=0}^{3} \delta_k$ is clear: this sum of coefficients

[18] Kwhaja and Mian (2008) adopt a very similar approach, except that they observe multiple loans for each firm, unlike in this paper.

[19] NUTS was created by the European Office for Statistics (Eurostat) as a single hierarchical classification of spatial units used for statistical production across the European Union.

[20] When more granular time dummies were used, for example based on the first three digits of the postcode, the results were very similar, which suggests that the district level is probably the right level of granularity. These results are available upon request.

[21] If loan demand shocks vary in other dimensions, then the loan supply interpretation will not be right. The results are robust to using more granular time dummies, which suggests that it is unlikely that loan demand shocks vary on a more geographical level. But even if geographical location does not control for loan demand perfectly, the estimates presented in this paper are still more reflective of loan supply than estimates presented in previous papers.

reflects the difference in the loan size of a bank/building society that experienced a change in its capital requirement relative to a bank that did not.[22]

We are not the first to study the impact of minimum capital requirements on lending. Francis and Osborne (2012), Aiyar et al (2014a) and Bridges et al (2014) examine the impact of lender-level changes in capital requirements on lender-level loan growth. In contrast, in addition to the impact on loan size, we can also examine if this effect varies with borrower and loan characteristics. The detail of the dataset decreases the potential for econometric bias arising from the omission of borrower and loan characteristics. The district time effects also allow us to better control for loan demand than in most previous lender-level studies. Finally the dataset contains many thousand loan observations per capital requirement change. Econometric bias from reserve causality is therefore unlikely. In other words, we argue that equation (1) is substantially better identified than the approaches used in previous work. But these econometric benefits come at the cost that we are only able to capture intensive margin (loan size) but not extensive margin (number of loans awarded).

Economic theory has a clear prediction for the sign of the main coefficient of interest, $\sum_{k=0}^{3} \delta_k$. If equity is expensive and capital requirements a binding constraint on an individual bank's choice of capital structure, one would expect a negative loan supply effect following a regulatory action leading to a rise in capital requirements. At loan level, the affected lender can offer the prospective borrower a smaller loan (intensive margin) or reject applications (extensive margin). In the first instance, one would observe a decline in the average individual loan size only. If the bank rejects borrowers with large loan requirements, or offers mortgage products with worse terms to penalise large loans that indeed leads these borrowers to migrate to the competitors, one would observe a decline in the average individual loan size in the second instance, as well. On the other hand, if the bank chooses to reject borrowers with identical loan size to its borrowing

[22] In the dataset, each bank is only subject to one capital requirement change. In the presence of bank fixed effects, this is the same as including a change in the capital requirement. One of the main reasons for including capital requirements in the levels, is that it is not possible to observe a borrower repeatedly, meaning that we cannot express the dependent variable in log changes.

population, no effect would be observed. Unless this last case dominates, the bank would issue a smaller loan on average, and the predicated sign on $\sum_{k=0}^{3} \delta_k$ would therefore be negative. Unfortunately, the PSD does not provide information on loan applications, which means that we cannot formally distinguish between these different adjustment channels. This means that the results in this paper are hence most likely an under-estimate of the total effect.[23] Our examination of loan substitution in the next section suggests that affected banks mainly adjust through the extensive margin.

Table 5 presents estimates of equation (1) for loan size. Column one shows that, once lender and district time fixed effects are included, the estimate of $\boldsymbol{\sum_{k=0}^{3} \delta_k}$ is -.059, implying that if capital requirements rise by 100 basis points, the average loan size issued by the affected bank decreases by about 5.9%. Once provisions are included, the effect now declines to about 4.3%. The inclusion of additional bank balance sheet variables, such as size, core funding, the mortgage to total asset ratio, the liquid to total asset ratio and the return on assets in column six leads to an estimate of 5.4%. Standard errors are clustered by bank and time, though the results remain the same if we only cluster by bank or only cluster by time.

Of course, lenders could grow capital organically by increasing earnings and retaining a greater share of those earnings, rather than contracting lending. One way to achieve this goal in the short run is to lend more to riskier borrowers, who can be charged extra fees and/or higher interest rates. This was a particularly attractive margin of adjustment under Basel I because the risk weight assigned to mortgage loans was the same for all mortgages regardless of borrower and loan characteristics. In other words, in the presence of risk shifting, high (low) risk borrowers should be affected relatively less (more) by an increase in capital requirements. Previous empirical work by Furlong (1989) and Sheldon (1996) does not find any evidence for this type of risk shifting following the introduction of the 1981 US leverage ratio and Basel I in Switzerland, respectively. Yet, as

[23] It is possible that, while cutting back on loans to borrowers with large loan requirements, banks may expand loans to borrowers with smaller loan requirements. In this case, the estimates presented here would be over-estimates of the total effect.

argued by Haldane (2013), this could be due to the coincident move to 'a much more complex regulatory framework'.

We examine risk shifting in table 6. In particular, we interact the capital requirement ratio coefficients with several borrower and loan characteristics. Column one shows estimates for a regression model where the capital requirement ratio is interacted with a dummy variable that take the value of one if the individual is a first time buyer. Interestingly, this coefficient is statistically significant, positive and of almost equal size to the coefficient on KR. The sum of the KR coefficient and this interaction term is approximately zero, which suggests that first time buyers, who typically tend to be riskier borrowers, are not affected by the loan contraction. Though the coefficients are quantitatively smaller, a similar pattern applies to individuals who are self-employed and have an impaired credit history, which are examined in the regression in column two. Conversely column three suggests that individuals whose incomes have been verified during the mortgage application process obtain a smaller loan, or greater loan contraction, following a 100 basis points rise in capital requirements. It is worth noting that while KR coefficient becomes positive and statistically significant, the sum with the interaction term still indicates a loan contraction of about 7% for borrowers whose incomes where verified.[24] Similarly, borrowers who take out interest-only mortgages are also less affected by the loan contraction, perhaps because these products may be more profitable for the issuing bank. This suggests that the only the group of borrowers with verified incomes is subject to loan contraction, but other types of borrowers are either not or less affected. All of these findings are consistent with risk shifting following an increase in capital requirements. Finally, all of the interaction terms are included in column five. This suggests that borrowers who are first-time buyers, self-employed or have an impaired credit history are less affected, while those with verified income experience the largest credit contraction following a rise in capital requirements. Overall, this evidence seems to

[24] Dropping the dummy variables for low and high income from the regression does not make a difference to this result.

be consistent with the idea that lenders reallocated lending from low risk to high risk borrowers following an increase in their capital requirements.[25]

Despite the anecdotal and econometric evidence in section II, one worry in the interpretation of these results is that causality runs from risk to the capital requirement change rather than the other way around. One way to address this issue is to include bank-time effects, rather than district time effects, to control for bias from omitting a variable at bank-level, including those related to the factors behind the regulatory change. The estimates from this exercise are presented in column 6 of table 6. This clearly shows that all of the coefficients on the KR interaction terms change very little. This is another piece of evidence to confirm that bias from omitting variables or endogeneity does not seem to affect the estimates in this application significantly.

The findings in this section suggests that affected lenders cut back average mortgage loan size by about 5.4% following a 100 basis point rise in capital requirements. This effect varies by borrower and loan type. In particular, individuals who are first-time buyers, have an impaired credit history or are self-employed are less affected by the loan contraction associated with a rise in capital requirements. On the other hand, borrowers with verified incomes are affected the most. While this pattern may appear counter-intuitive initially, it is important to keep in mind that lenders can choose to raise capital through greater retained earnings, which could be achieved through a reallocation of lending towards higher risk, more highly profitable, borrowers. The results presented here are consistent with this type of risk shifting.

3.2. Do unaffected lenders partially offset the loan contraction associated with capital requirement policy?

One of the conditions for capital requirements policy to affect the *aggregate* credit supply and systemic credit risk is the limited substitution of alternative sources of finance. Aiyar et al (2014a, 2014b) and Jiminez et al (2015) provide evidence that foreign branches

[25] The corresponding F-tests to examine whether a sum is significantly different from zero are available from the author upon request.

expand PNFC lending in response to changes in capital requirements and Dynamic Provisioning in the UK and Spain, respectively. But no previous work has studied this issue in the mortgage market. In this section we examine if lending from either regulated lenders that were not subject to changes in capital requirements (referred to as 'unaffected' lenders subsequently) or non-bank finance companies is consistent with loan substitution. I.e. do borrowers migrate to unaffected or non-bank lenders following changes in capital requirements on regulated institutions? For ease of exposition, we focus on the loan response of unaffected banks first and discuss non-bank finance companies thereafter.

Here we examine whether, and to what extent, the size of mortgage loans that unaffected lenders and non-bank finance companies issue, reacts to changes in capital requirements on competing financial institutions. The challenge in this task is, of course, to relate capital requirements of affected lenders to lending decisions by unaffected lenders. We create a reference capital requirement for this purpose. The idea behind this approach is that unaffected institutions should respond the most in geographical areas in which they have an established presence and compete actively with lenders affected by capital requirement changes. This is constructed in the following way: $RefKR_{q,t} = \sum_m \left(\frac{initial\ period\ lending\ by\ lender\ m\ to\ area\ q}{initial\ period\ lending\ by\ all\ lenders\ to\ area\ q}\right) KR_{m,t}$. In other words, we take the exposure[26] of a lender to a geographical area, multiply it by the corresponding capital requirement and then sum across lenders to obtain the reference group capital requirement. In the presence of credit substitution, an increase $RefKR_{q,t}$ should lead to larger loans issued by lender *j*.

An important choice in constructing the reference capital requirement is the granularity of geographical area. The PSD provides geographical information on the location of the property at both post code and regional level. Choosing a narrow geographical area, such as at the post code level, carries the risk that not all relevant

[26] We use lending in 2005Q2 to construct the exposure of an institution to a given area throughout. In other words, the exposure is time invariant. One could also use a time-varying exposure, but then the exposure might be affected by the capital requirement change. Similarly, the reference capital requirement might then change for reasons unrelated to actual capital requirement changes. For these reasons we prefer to use time-invariant exposure.

lenders that actively compete with the affected bank, and hence are available to borrowers, will be picked up by the reference capital requirement. On the other hand, choosing a very wide geographical area, such as one of the twelve regions in the United Kingdom, will probably lead to the inclusion of lenders that are not competing with the affected bank. We use the district level, as before. While this choice is, of course, to a certain extent arbitrary, this classification appears to have the right degree of granularity: the size of geographical area included in the classification makes the risk of excluding banks that compete in the local mortgage market and including those who do not seem small.

At loan-level, credit substitution can occur through the extensive margin only. If, as a result of capital requirement changes, bank one rejects loan applications with large loan requirements or only offers mortgage products with terms that penalise large loans, then the affected borrowers can migrate to bank two, within the same local area. So long as the loan requirement is large compared to that of bank two's borrowing population, this would lead to an increase in bank two's average loan size in response to a rise in bank one's capital requirement.[27] But if the loan requirements of migrating borrowers are similar to bank two's borrowing population, bank two's average loan size will stay unchanged. The PSD only allows us observe actual loan outcomes as oppose to loan applications. It is therefore not possible to know if unaffected banks' borrowers originally applied for a loan from a bank affected by an increase in capital requirements but were rejected. In practice this means that we can only test for the type of loan substitution described in the first, but not second, case. Formally, we test for this second type of loan substitution with the following regression model:

$$\boldsymbol{Loan_{i,j,t} = \alpha_j + \sum_{k=0}^{3} \sigma_k RefKR_{q,t-k} + \gamma RefLC_{j,t} + \gamma LC_{j,t} + \varphi BLC_{i,j,t} + PC_{ht} + e_{i,j,t}} \qquad \textbf{(2)}$$

where $Loan_{i,j,t}$ is the logarithm of the loan size for a *new* loan taken out by borrower *i* from lender *j*, who was not subject to the rise in capital requirements, at time

[27] This implication relies on the assumption that when banks adjust mortgages in response to changes in capital requirements, they prefer to cut back on a few large loans, as oppose to many small ones. Given that the affected lenders will want to avoid losing market share and valuable relationships, the former is perhaps more plausible.

t. $RefKR_{q,t}$ is the reference capital requirement in area q that the loan was made in at time *t*. Since the horizon at which borrowers switch from an affected to an unaffected lender is unclear, we use the contemporaneous value of the capital requirement together with three lags, as in model (1). $RefLC_{j,t}$ are the corresponding reference affected lender balance sheet control variables, including provisions, used in model (1). $BLC_{i,j,t}$ is a vector of all the borrower and loan characteristics listed in table 1, for individual *i*, borrowing from lender *j* at time *t*. Where borrower and loan characteristics take values that are not binary, they are modelled as additional sets of fixed effects. $LC_{j,t}$ is a vector of lender characteristics for lender *j* at time *t*, all of which are listed in table 1. α_j is a lender fixed effect to account for lender unobservable time-invariant characteristics. Since the main variable of interest, the reference capital requirement only varies at district level, PC_{ht} is now a vector of region time effects to account for unobservable geographical differences, in particular in loan demand, among the twelve regions of the UK over time. To avoid perfect multi-colinearity, we drop the first variable from each group of fixed effects. $e_{i,j,t}$ is assumed to be a normally distributed error term.

In the presence of lender *j* fixed and region time effects, $\sum_{k=0}^{3}\sigma_k$ can be interpreted as the sum of coefficients on the difference between lender *j's* time-invariant capital requirement and the reference capital requirement. The presence of region time effects allows us to control for demand and interpret this sum of coefficients as a *loan supply* effect.

Economic theory gives clear predictions about the sign of $\sum_{k=0}^{3}\sigma_k$. When capital requirements of locally competing banks increase, the affected banks can either offer smaller loans to all borrowers or stop lending to borrowers with large mortgage requirements. In the case of the latter, these borrowers may turn to local competitors who would be willing to lend to them instead. If this type of loan substitution operates, then, conditional on all other observable characteristics, one would expect the sign of $\sum_{k=0}^{3}\sigma_k$ to be positive. In other words, one would expect that lenders which were not affected by an increase in their capital requirement, to provide loan substitution to offset the local credit contraction.

Despite all of the evidence to the contrary, there will always be a worry that the estimates of the capital requirement impact in regression model (1) might be subject to endogeneity bias. But this is clearly not the case with regression model (2), since, according to the ARROW guide, regulators did not take into account the reaction of the competitors when setting individual bank capital requirements.

Table 7 present estimates of model (2). The standard errors in all of the specifications are clustered by bank-time, though the results are robust to alternative assumptions on the standard errors of the model. Column one of table 7 reports estimates of $\sum_{k=0}^{3} \sigma_k$, controlling for unaffected lender and postcode time fixed effects, as well as all of the mortgage and borrower characteristics listed in table 1. Columns two and three add balance sheet control variables. Columns four and five include instead reference group balance sheet variables and bank time effects. Regardless of specification, $\sum_{k=0}^{3} \sigma_k$ is always positive and statistically significant with a value of between .042 and .056. Unaffected lenders thus increase the size of the mortgages they issue by between 4.2% and 5.6% following an increase in the capital requirement of a locally competing institution. Quantitatively, these numbers are very similar to the loan contraction by an affected bank of between 4.3% and 5.9% documented in table 5, but with the opposite sign. Given that the average logarithm of the loan size in both of these groups is almost identical, this suggests that the loan contraction as a result of an increase in capital requirements is completely offset by a competing institution.

Since banks can adjust by both rejecting applications and reducing individual loan size, it is difficult to compare the impact documented here to those in previous studies using bank-level data without further assumptions. The impact could be larger or smaller, depending on the whether the bank chooses to approve more or less loan applications. But the average loan size in locally competing institutions rises by roughly the same amount as the loan contraction by banks affected by the capital requirement change, which is consistent with stronger credit substitution than documented in previous work.[28] The closest study to ours, Aiyar et al (2014b), finds that PNFC loan substitution of foreign branches can offset the loan contraction associated with higher capital requirements by only 43%. Given the more standardised nature of mortgages and hence much cheaper cost of switching providers, relative to PNFC loans, this greater degree of substitution should not be surprising.

Table 8 estimates model **(2)** for non-bank finance companies. In other words, the dependent variable, together with all of the loan and borrower characteristics, now refers to loans issued by non-bank finance companies. The summary statistics in table 4 suggest that, compared to the sample overall, these lenders typically lend to higher LTV borrowers. Whether or not they provide a source of credit substitution is an important economic policy question. The estimate of $\sum_{k=0}^{3} \sigma_k$ in column one has the right sign and is statistically significant. But this is not robust to adding additional explanatory variables to the model in the remaining specifications in table 8. This suggests that non-bank finance companies did not provide a source of credit substitution in response to an increase in capital requirements on regulated lenders. This should not be surprising as most of the local loan contraction seems to have been offset by those banks and building societies that did not experience an increase in their capital requirement.

In summary, the results presented in this section suggest that locally competing and unaffected banks and building societies expand their loan supply in response to the loan contraction associated with an increase in the capital requirements of affected lenders. Quantitatively, the size of the loan expansion is almost identical to the contraction associated with the increase in capital requirements. This is consistent with the idea that most of the adjustment in response to higher capital requirement is through the extensive margin. Given the almost identical average log loan size in both the affected

[28] As the average log loan size in both unaffected and affected banks is almost identical. This means that similar coefficient magnitudes in both the direct impact and loan substitution regressions suggest a greater degree of loan substitution (closer to complete substitution) than in previous work.

and unaffected group of banks, these results are also indicative of large degree of credit substitution. But no evidence of credit substitution of non-bank finance companies.

4. Conclusion

Countries around the world have introduced macroprudential regulation to increase the resilience of the financial system to socially costly financial crises. One proposed instrument, which is also embedded in Basel III, is a time-varying capital requirement. But, to date, there is little understanding of how this instrument will affect the mortgage loan supply, lenders' preferences for risk, or loan substitution of providers outside the banking system. The UK's unique regulatory regime pre-crisis, where banks and building societies were subject to individual and time-varying capital requirements, together with a new loan-level database, containing a large set of loan and borrower characteristics on all new mortgages issued in the UK between 2005Q2 to 2007Q2, allows us to provide the first empirical examination of these important issues.

Economic theory suggests that if an increase in capital requirements is binding and the Miller-Modgliani (1958) theorem fails, then the affected bank will either need to raise capital or reduce risk-weighted assets to satisfy the new requirement. Previous work, such as Aiyar et al (2014a), Francis and Osborne (2012) and Bridges et al (2014), test this last implication with regard to PNFC lending. In contrast, we examine the effect of changes to a bank's capital requirement on the value of individual household mortgage loans, the granularity of which allows us to better control for loan demand and address issues of reverse causality. The affected bank may also choose to raise capital by increasing retained earnings. Under Basel I, the regulatory framework during this period, household mortgages were assigned a risk weight of 50% regardless of their individual characteristics. Faced with a rise in the capital requirement, banks were therefore incentivised to reallocate lending towards more profitable high risk borrowers to grow capital via retained earnings. To our knowledge, we are the first to formally test for this risk shifting channel following changes in capital requirements. Finally, we are also the first to examine mortgage loan substitution of lenders that were unaffected by changes in capital requirements and non-bank finance companies.

We find that a rise in an affected banks capital requirement of about 100 basis points leads to a decline in loan size of about 5.4%. Our results suggest the presence of risk shifting: this loan contraction does not occur for first-time buyers and borrowers with an impaired credit history, but does for those with verified income are affected to a greater extent. Interestingly, locally competing lenders expand the average size of their loans by a quantitatively similar amount. This result is consistent with the idea that locally competing banks may completely offset the loan contraction associated with higher capital requirements on affected banks. On the other hand, there is no evidence for credit substitution of non-bank finance companies.

The findings in this study are based on changes to microprudential capital requirements and are therefore subject to the Lucas Critique, since bank behaviour might change in the presence of macroprudential regulation. But they may nevertheless offer important lessons for economic policy and theory. The results are consistent with risk shifting, which means that rises in capital requirements intended to make a bank more resilient may also raise the amount of risk on the balance sheet. Furthermore, competition in local lending markets may mute the loan contraction, associated with greater capital requirements on an individual institution, entirely. Basel II and Basel III will address some of these issues. Clearly, when the change in the capital requirement is at the level of the banking system, rather than individual institutions, loan substitution of competing institutions is likely to be smaller. The reciprocity clause in Basel III would also help to stop substitution by foreign branches. And the internal-model determined risk weights may help to address risk shifting, so long the weights vary with the degree of risk. Nevertheless, our study illustrates the adaptability of the financial system and hence the potential for unintended consequences, following the introduction of new financial regulations. Awareness of these issues will help both policy makers and researchers to better understand the transmission of macroprudential policies to the mortgage market.

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Table 1

Bank Level Variables			
Variable	**Definition**	**Source**	**Notes**
KR – Banking Book capital requirement ratio	FSA-set minimum ratio for capital-to-risk weighted assets (RWA) for the banking book.	BSD3/ QFS	BSD3 provides this information for Banks. QFS provides it for Building societies.
Size of Household in Total Lending	AL18/AL19	AL	AL 18 – Household lending to UK residents AL 19 – Total lending to UK residents
Size	Natural log of (BT40)	BT	BT40 – Total Assets
Liquidity	(BT21+ BT32D)/BT40	BT	BT21 - Cash BT32D – Holdings of Government Stock
Core Funding	(BT2H +BT3H)/BT40	BT	BT2H – Retail Sight Deposits BT3H – Retail Time Deposits
Provisions	PL20B/BT40	PL/BT	PL20B – Provisions
Return on Assets	PL15/BT40	PL/BT	PL15 - Profits

Borrower and Mortgage Characteristic Variables - All from FSA PSD		
Variable	**Definition**	**Notes**
loan	Loan size in pound sterling	
Borrower Age	The age of the borrower	
Income verified		Takes value of 1 if income verified, 0 otherwise.
Mortgage Term		Remaining mortgage maturity
Mortgage Payment Protection	Takes value of 1 if payment insurance taken out, 0 otherwise	
Employment Status	Takes distinct numerical value for each status	Status: 1) Employed, 2) Self-employed, 3) Retired or 4) Other.
Borrower type	Takes distinct numerical values for each type	Type: 1) First Time Buyer, 2) Home Mover, 3) Remortgagor, 4) Social tenant, 5) Other, 6)Unknown
Repayment type	Takes distinct numerical value for each type	Type: 1) Capital and Interest 2) Interest only (endowment), 3) Interest only (pension), 4) Interest only (Unknown), 5) Mix of 'capital and interest' and 'interest only' 6) Unkown
Remortgage reason	Takes distinct numerical value for each reason	Reason: 1) No extra money raised, 2) Extra money for home improvement, 3) Extra money for debt consolidation, 4) Extra money for home improvement and debt consolidation, 5) other
Rate Type	Takes distinct numerical value for each rate type	Type: 1) Fixed, 2) Discount, 3) Trackers, 4) Capped, 5) other.

Table 2 – Loan size, LTV and LTI ratios by Lender and Borrower

Type	Log Loan Size			LTV Ratio (%)			LTI Ratio (%)			Number of observations
	Mean	St. Dev.	Median	Mean	St. Dev.	Median	Mean	St. Dev.	Median	
Whole sample	11.48	.77	11.54	63.07	25.53	67.86	2.74	1.12	2.79	5643636
Bank	11.47	.78	11.54	62.24	25.73	66.56	2.73	1.14	2.78	5255982
Non-bank finance	11.58	.61	11.61	74.29	19.54	80.66	2.92	0.79	2.95	387654
Employed	11.45	.73	11.51	63.97	25.22	68.45	2.77	1.12	2.82	4441747
Self-Employed	11.77	.75	11.81	64.27	23.80	70.42	2.69	1.07	2.73	953690
Income verified	11.44	.81	11.52	66.03	26.92	73.68	2.81	1.19	2.88	3259770
Income unverified	11.53	.70	11.57	59.03	22.89	61.99	2.65	1.00	2.69	2383866
Impaired Credit History	11.47	.58	11.47	71.94	19.03	75.92	2.88	0.88	2.89	228964

Type	Log Loan Size			LTV Ratio (%)			LTI Ratio (%)			Number of observations
	Mean	St. Dev.	Median	Mean	St. Dev.	Median	Mean	St. Dev.	Median	
First Time Buyer	11.61	.49	11.62	83.22	17.87	90	3.26	0.94	3.24	902382
High income	12.11	.69	12.18	66.91	23.48	73.44	2.41	1.04	2.47	1389991
Low income	10.9	.62	11.02	55.72	26.55	55.84	3.03	1.23	3.05	1389570
High maturity	11.58	.58	11.63	79.78	20.16	87.59	3.37	1.03	3.38	801352
Low maturity	11.18	.90	11.19	44.26	24.21	40.82	2.11	1.10	2.02	1329774
Flexible mortgage	11.38	.90	11.51	59.59	28.09	63.76	2.57	1.19	2.67	2156059
Interest-only	11.77	.78	11.83	66.76	25.44	74.93	2.89	1.15	2.95	1607659
Fixed i-rate mortgage	11.46	.76	11.54	64.91	25.41	70.55	2.81	1.11	2.88	3779917
SVR mortgage	11.33	.87	11.38	55.04	27.58	54.91	2.47	1.34	2.38	250158

Note: The term ‘Bank’ in the table above refers to banks and building societies together as in the rest of this paper only.

Table 3 – Balance Sheet Data Description

Variable	Mean	St. Dev.	Median	25th	75th
KR	10.07	1.38	10	8	11
Size	8.91	2.42	8.96	7.16	10.74
Liquid Assets	0.011	0.024	0.001	0.00	.01
Core Funding	0.42	0.23	0.43	0.24	0.55
Fraction of Mortgage Asset on Balance sheet	0.45	0.31	0.39	0.21	0.71
Return on Assets	0.0033	0.006	0.0026	0.001	.004

Table 4 – Description of Changes in Capital Requirements

	Number of Changes	Mean	Standard Deviation
Capital Requirement increase	8	-0.89	0.67
Capital Requirement decline	12	0.81	0.47

Table 5 – The Impact of Capital Requirements on Loan Size

Dependent Variable: Log of Loan Size						
	1	2	3	4	5	6
KR	-0.059**	-0.043*	-0.049**	-0.055**	-0.055**	-0.054**
	(5.05)	(3.26)	(3.86)	(5.64)	(5.98)	(5.58)
Provisions		-0.12**	-0.11**	-0.11**	-0.10**	-0.10**
		(6.43)	(5.79)	(6.23)	(6.26)	(6.32)
Corefund			-0.00724**	-0.00719**	-0.00861***	-0.00864***
			(0.00285)	(0.00287)	(0.00302)	(0.00298)
Size				0.0240	0.0447	0.0441
				(0.0381)	(0.0345)	(0.0340)
Mortfrac					0.00510	0.00502
					(0.00523)	(0.00523)
Liquidity					-1.052*	-1.057*
					(0.574)	(0.579)
ROA						-0.157
						(2.053)
Borrower Controls	YES	YES	YES	YES	YES	YES
Bank Fixed Effects	YES	YES	YES	YES	YES	YES
District time effects	YES	YES	YES	YES	YES	YES
Observations	4,199,686	4,199,686	4,199,686	4,199,686	4,199,686	4,199,686
R-squared	0.628	0.628	0.628	0.628	0.628	0.628

This table presents results from panel regressions of regulated financial institutions. The dependent variable is the logarithm of loans provided to an individual borrower. All specifications include bank fixed effects and district time effects. We use the contemporaneous and three lags of each of the first two variables: the level of the capital requirement ratio and the provisions to total asset ratio. We report the sum of coefficients and F-statistics in parenthesis for these variables. The bank balance sheet control variables are: size, defined as log of total assets; the fraction of retail to total liabilities; the fraction of mortgage to total assets; the fraction of liquid to total assets; and profits divided by total assets. All of these enter contemporaneously. For these variables, t statistics are reported in parenthesis below. Borrower and loan characteristics include: 1) Borrower age; 2) Binary dummy variables for the following types of interest rate: Fixed rate, Discounted variable rate, Tracker, Capped rate, Standard variable rate or Other; 3) Term of mortgage in years; 4) Binary dummy variables for the method of repayment: Capital and interest; Interest only (endowment); Interest only (ISA); Interest only (pension); Interest only (type unknown); Mix of capital and interest and interest only; Unknown; 5) Binary dummy variables for the purpose of remortgage; No extra money raised; Extra money for home improvements; Extra money for debt consolidation; Extra money for home improvements and debt consolidation; 6) A dummy variable for mortgage protection payment insurance; 7) A dummy variable for income verification; 8) Binary dummy variables for type of employment: Employed; Self-employed; Retired; Other; Unknown; 9) A dummy variable for impaired credit history; 10) Binary dummy variables for the borrower type: 1) First Time Buyer; 2) Home Mover; 3) Remortgagor; 4) Social tenant; 5) Other; 6) Unknown. For statistical significance, we use the following convention throughout: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered by bank-time.

Table 6 – The Impact of Capital Requirements on Loan Supply by Borrower and Loan Characteristic

Dependent Variable: Log of Loan Size						
	1	2	3	4	5	6
KR	-0.054**	-0.061***	0.055*	-0.054**	0.059*	
	(4.40)	(6.96)	(3.37)	(5.78)	(3.83)	
KR*Self Employed		0.027***			0.021***	0.02***
		(31.74)			(14.30)	(13.9)
KR*Impaired Credit		0.039***			0.047***	0.049***
		(11.06)			(13.32)	(14.23)
KR*First Time Buyer	0.049**				0.072***	0.07***
	(5.58)				(8.05)	(7.95)
KR*High Income			0.00489		0.00496	0.0063*
			(1.22)		(2.06)	(3.59)
KR*Low Income			0.0074		0.014	0.012
			(0.84)		(2.25)	(1.76)
KR*Income Verified			-0.126***		-0.13***	-0.14***
			(19.05)		(17.63)	(17.22)
KR*High Maturity					0.046***	0.048***
					(30.65)	(30.98)
KR*Low Maturity					-0.007	-0.008
					(0.65)	(0.97)
KR*Flexible					-0.016	-0.015
					(2.17)	(2.12)
KR*Fixed Interest Rate				0.00123	-0.011**	-0.01**
				(0.06)	(4.97)	(4.41)
KR*Interest Only				0.021***	0.024	0.026
				(10.59)	(11.29)	(12.69)
KR*SVR				0.0156	0.045**	0.041**
				(0.75)	(5.25)	(4.79)
Balance Sheet Controls	YES	YES	YES	YES	YES	YES
Borrower Controls	YES	YES	YES	YES	YES	YES
Bank Fixed Effects	YES	YES	YES	YES	YES	YES
District Time Effects	YES	YES	YES	YES	YES	
Bank Time Effects						YES
R-squared	0.633	0.629	0.632	0.629	0.639	0.640

This table presents results from panel regressions of regulated financial institutions. The dependent variable is the logarithm of loans provided to an individual borrower. The main explanatory variable is the capital requirement ratio, which enters contemporaneously and with three lags. This variable is interacted with the several binary dummy variables which reflect the following borrower/loan characteristics: 1) Self Employment; 2) Impaired credit history; 3) First Time Buyer; 4) High/Low Income/Maturity if borrower income/maturity is above/below the 75/25% of the relevant distribution; 5) Flexible mortgage features; 6) Income verification; 7) Interest only mortgage; 8) Fixed interest rate mortgage; 9) Standard variable rate mortgage. We report the sum of coefficients and F-statistics in parenthesis for all of these variables. The remainder of the model specification is identical to column four in table 5. For statistical significance, we use the following convention throughout: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered by bank-time.

Table 7 – The Impact of Reference Capital Requirements on Unaffected Lender Loan Supply

	Dependent Variable: Log of Loan Size				
	1	2	3	4	5
Reference KR	0.054***	0.055***	0.056***	0.045***	0.042**
	(12.23)	(11.11)	(12.20)	(7.96)	(6.50)
Reference Provisions				0.071**	-0.0299
				(6.18)	(0.087)
Provisions		-0.047	-0.012	-0.012	
		(1.56)	(0.11)	(0.11)	
Reference Size					-0.0987**
					(0.0424)
Reference Corefund					-0.00714
					(0.00634)
Reference Mortfrac					0.0101
					(0.00792)
Reference Liquidity					-4.690**
					(2.378)
Reference ROA					-8.652
					(10.55)
Size			-0.0508	-0.0508	
			(0.1000)	(0.0996)	
Corefund			-0.00422	-0.00421	
			(0.00334)	(0.00333)	
Mortfrac			-0.000413	-0.000358	
			(0.00572)	(0.00571)	
Liquidity			-0.932*	-0.931*	
			(0.542)	(0.541)	
ROA			1.802	1.794	
			(2.694)	(2.680)	
Borrower Controls	YES	YES	YES	YES	YES
Bank Fixed Effects	YES	YES	YES	YES	YES
Region Time Effects	YES	YES	YES	YES	
Bank Time Effects					YES
Observations	2,595,485	2,431,239	2,431,239	2,431,239	2,431,239
R-squared	0.583	0.579	0.579	0.579	0.581

This table presents regression results of the reference capital requirement on lending by regulated lenders which were not subject to a change in capital requirements, which we refer to as unaffected lenders below. The dependent variable is the logarithm of loans provided to an individual borrower. We use the contemporaneous and three lags of each of the first three variables: the reference capital requirement ratio, the reference provisions to total asset ratio and the provisions to total asset ratio. We report the sum of coefficients and F-statistics in parenthesis for these variables. For all other variables, t-statistics are reported in parenthesis below the coefficients. The reference capital requirement is the implied capital requirement for a given geographical area. It is calculated by multiplying the capital requirement of each affected bank with its 2005 Q2 exposure to district q, and the summing across banks to obtain the reference capital requirement. See the main text for more details. All variables preceded by the work 'Reference' are defined in an analogous way. See the footnote of table 5 for a detailed description of the lender balance sheet, borrower and loan characteristics. For statistical significance, we use the following convention throughout: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered by bank-time.

Table 8 – The Impact of Reference Capital Requirements on Non-Bank Finance Companies` Loan Supply

Dependent Variable: Log of Loan Size				
	1	2	3	4
Reference KR	0.026**	0.02	0.017	0.005
	(4.73)	(1.70)	(1.13)	(1.20)
Reference Provisions		0.0305	0.0595	0.078
		(1.33)	(1.43)	(1.70)
Reference Size			0.0347*	0.0354***
			(0.0202)	(0.00896)
Reference Corefund			-0.00932*	-0.0120***
			(0.00494)	(0.00304)
Reference Mortfrac			0.0135**	0.0156***
			(0.00543)	(0.00276)
Reference Liquidity			-2.188	-2.928***
			(1.508)	(0.506)
Reference ROA			0.284	0.114
			(7.228)	(3.068)
Borrower Controls	YES	YES	YES	YES
Bank Fixed Effects	YES	YES	YES	YES
Region Time Effects	YES	YES	YES	
Bank Time Effects				YES
Observations	293,763	293,763	293,763	293,763
R-squared	0.856	0.856	0.856	0.857

This table presents regression results of the reference capital requirement on lending by non-bank finance companies. The dependent variable is the logarithm of loans provided to an individual borrower. We use the contemporaneous and three lags of the reference capital requirement ratio provisions and report the sum of coefficients and F-statistics in parenthesis for these variables. For all other variables, t-statistics are reported in parenthesis below the coefficients. The reference capital requirement is the implied capital requirement for a given geographical area. It is calculated by multiplying the capital requirement of each affected bank with its 2005 Q2 exposure to district q, and the summing across banks to obtain the reference capital requirement. See the main text for more details. All variables preceded by the work 'Reference' are defined in an analogous way. See the footnote of table 5 for a detailed description of the lender balance sheet, borrower and loan characteristics. For statistical significance, we use the following convention throughout: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered by bank-time.

Figures

Figure 1

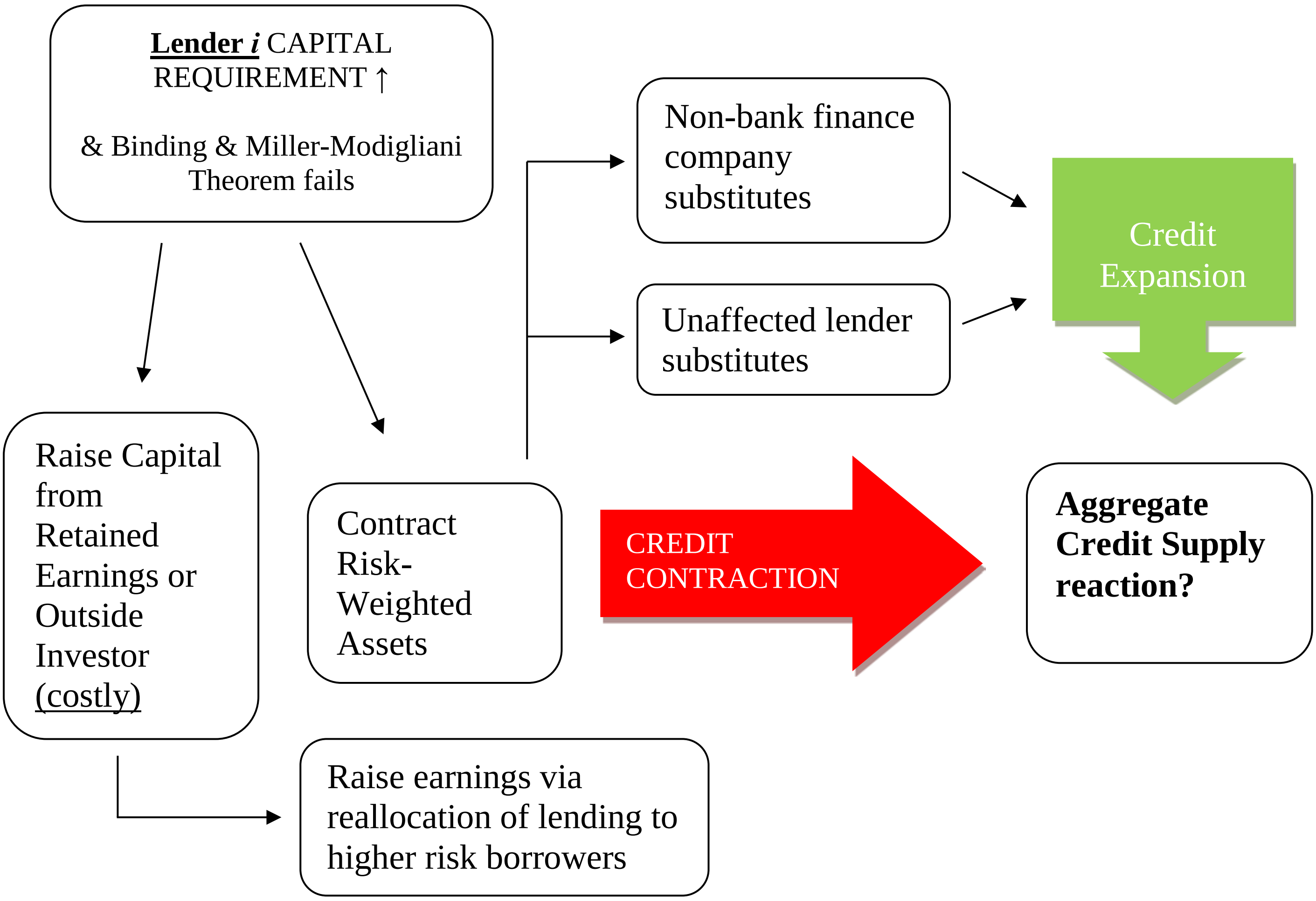
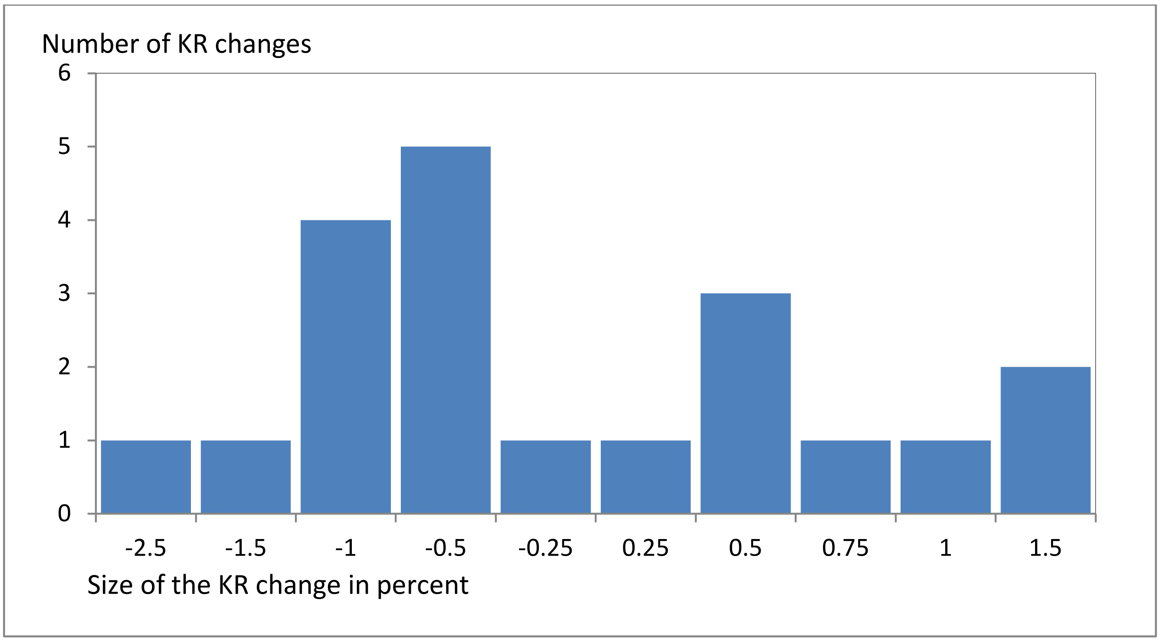


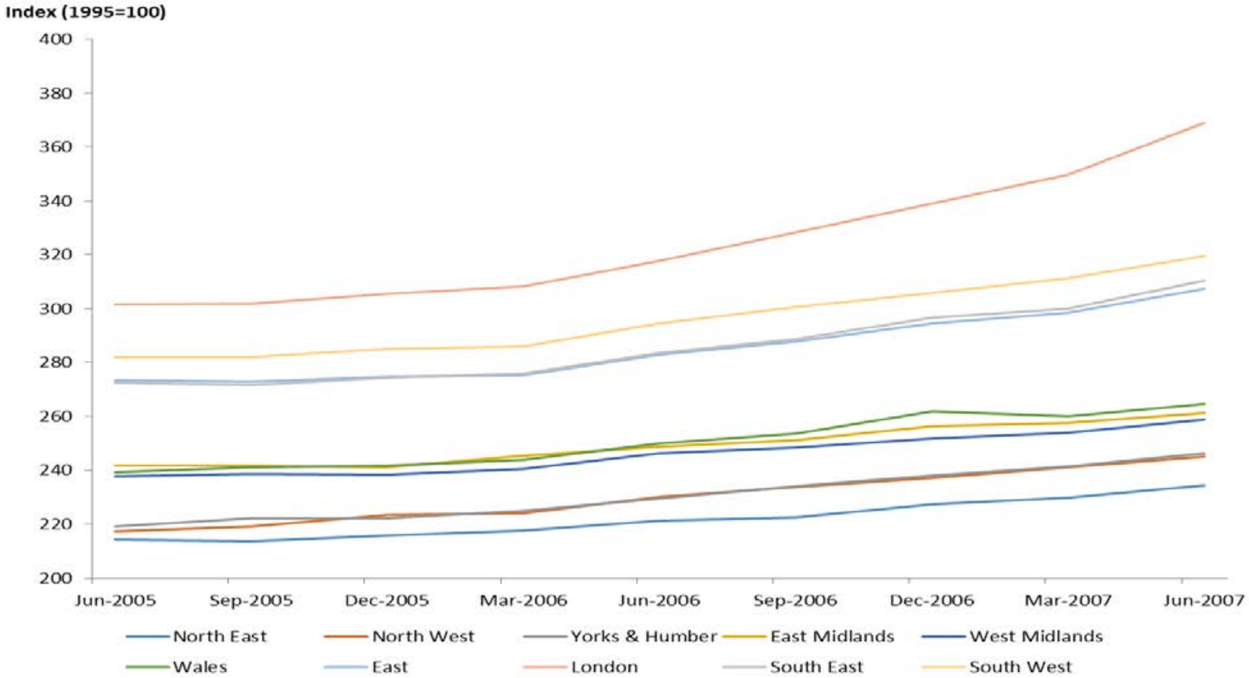
Figure 2: Histogram of changes in capital requirements



Source: Bank of England.

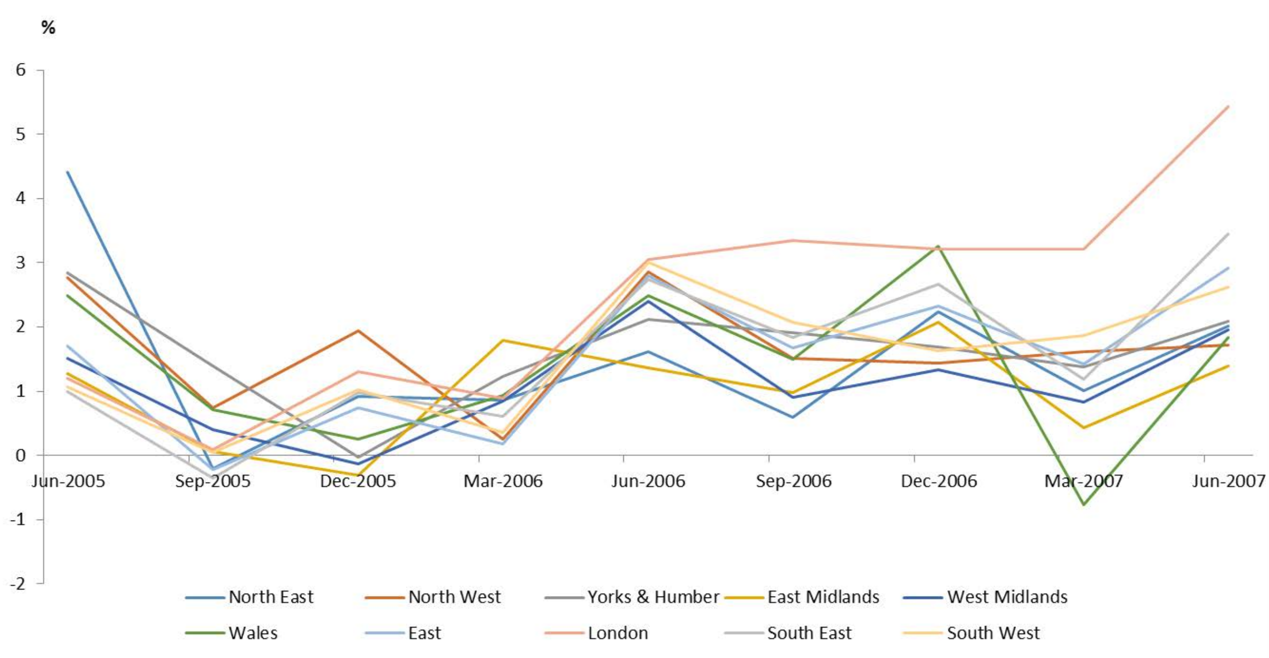
Notes: This chart shows the number of capital requirement changes (x-axis) of a given size (y-axis). This includes all Pillar 2 capital requirement changes on banks and building societies between 2005Q2 – 2007Q2. The size of the change if expressed in percent, meaning that 1 indicates a 100 basis point rise in the capital requirement.

Figure 3: Regional House Price Indices



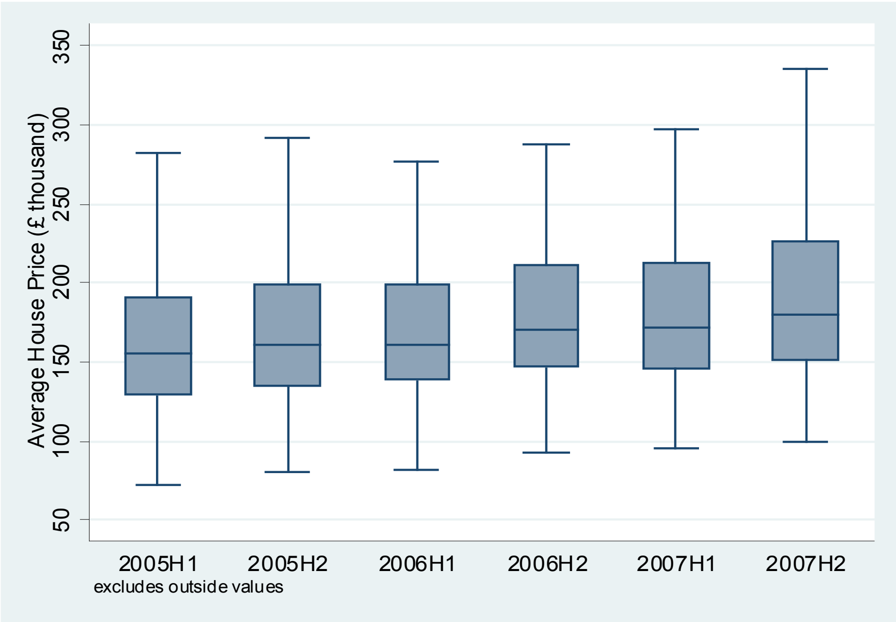
Source: Land Registry.

Figure 4: Quarterly House Price Growth



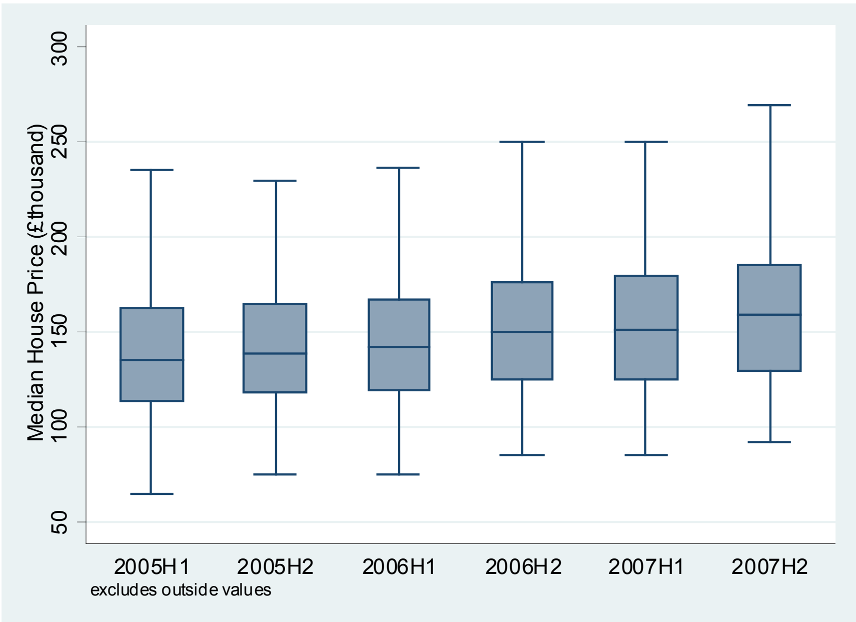
Source: Land Registry.

Figure 5: Average House Prices by Districts



Source: Land Registry. The bottom and top of each box are the first and third quartiles, and the band inside the box is the median.

Figure 6: Median House Prices by Districts



Source: Land Registry. The bottom and top of each box are the first and third quartiles, and the band inside the box is the median.

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