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Identifying the transmission channels of credit supply shocks to household debt: price and non-price effects

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Abstract

Using matched microdata for the UK, I estimate two distinct channels via which credit supply shocks affect mortgage debt: one that operates through price conditions in credit markets; and another that operates through non-price credit conditions and affects the quantity of credit supplied by lenders. I find substantial heterogeneity in the different channels by age, financial situation, borrower type and income. Young households and home-owners respond exclusively to non-price credit conditions, in particular to changes in the supply of riskier lending. First-time buyers, middle-income households and middle-aged borrowers increase debt following shocks to either type of credit conditions. Debt responses of financially constrained borrowers are amplified by a simultaneous loosening in mortgage spreads and in credit availability at high loan to value or high loan to income ratios. In aggregate, household leverage responds more strongly to supply shocks that change the quantity of credit, as they affect households across the distribution, both at the intensive and at the extensive margin. But a loosening in price and non-price credit conditions simultaneously or a contraction in multiple price indicators at a time can also fuel rapid credit growth.

Key words: Household finance, bank lending, credit conditions, mortgages.

JEL classification: D14, E44, G21, G51, O16.

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1 Introduction

Mortgage credit growth is an important predictor of financial crises (Mian et al. [2017a]; Mian and Sufi [2011]; Jorda et al. [2016]; Aikman et al. [2014]; Aikman et al. [2018]). Rapid increases in leverage can make households more vulnerable to financial shocks and can affect how they respond to economic instability. A large body of research has attributed the growth in mortgage credit before 2007 to an expansion in credit supply that made credit cheaper and more widely available (Mian and Sufi [2018]; Mian et al. [2017b]; Justiniano et al. [2019]; Greenwald [2018]; Favara and Imbs [2015]). This literature argues that credit supply shocks to foreign capital, financial deregulation or lenders' behavioral biases, led to an exogenous relaxation in the credit conditions at which households could borrow. It finds that loosening in credit conditions related to mortgage spreads or to aggregate credit availability can explain observed patterns in house prices and household debt during 2000-07 in the US.

The existing literature does not distinguish between the effects of credit supply shocks operating through the price of credit and the effects of supply shocks operating through the quantity of credit. Additionally, the existing literature has not considered the impact of credit supply shocks affecting price and non-price credit conditions simultaneously, which may amplify household debt responses compared to individual effects. Identifying these effects can help researchers and policymakers understand the contribution of different propagation channels of credit supply shocks to household debt.

In this paper I match lenders' responses to the Credit Conditions Survey in the UK with loan-level data to contribute to this literature in a few ways. First, I identify and estimate two distinct channels via which credit supply shocks affect mortgage debt: one that operates through price conditions in credit markets; and another that operates through non-price conditions and affects the quantity of credit supplied by lenders. Price credit conditions, such as mortgage rates and product fees on new mortgages, capture the costs of borrowing for a given loan principal. Non-price credit conditions, such as credit limits or changes in lending at different debt ratios, capture how much credit banks are prepared to extend to different types of borrowers. To identify the variation in price and non-price credit conditions that is due to credit supply shocks, I obtain measures which are unbiased by macroeconomic, bank-level or household-specific factors that drive both loan demand and loan supply.

I find that the intensive margin of mortgage debt responds to changes in both price and non-price credit supply conditions, and that a shock affecting both types of credit conditions simultaneously can amplify the debt effects. For instance, a credit supply shock that decreases mortgage spreads has nearly double the impact on household leverage if it is also accompanied by an increase in the quantity of lending available at higher LTV multiples. The extensive margin responds mainly to changes in the quantity of credit. The price of credit becomes an important driver of the extensive margin only when overall mortgage costs are cut aggressively by banks, with both fees and mortgage spreads loosened at the same time.

Second, I study the extent to which the effect of price and non-price credit conditions is dependent on borrowers' idiosyncratic characteristics. I find substantial heterogeneity in the different channels by age, financial situation, borrower type and income. Debt levels of young households and home-owners respond exclusively to changes in the quantity of credit, particularly to credit availability at high loan-to-value (LTV) and high loan-to-income (LTI) ratios. First time buyers, middle-income households and middle-aged borrowers increase debt in response to loosening in either type of credit supply conditions. However, for first-time buyers and middle-income households, price and non-

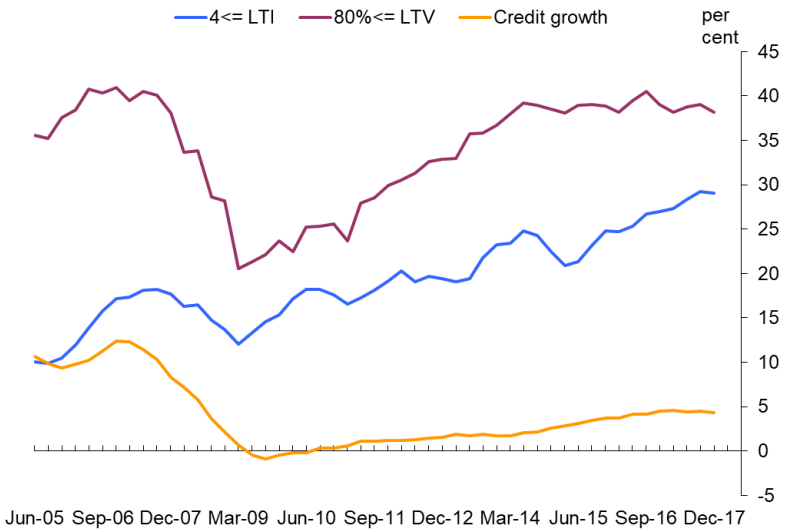
price conditions have a homogeneous effect: i.e. loosening in high-LTV credit availability or in mortgage spreads, increases debt levels by the same amount. In contrast, for middle-aged borrowers, credit supply conditions have a heterogeneous effect: i.e. their debt levels are twice more sensitive to a contraction in mortgage spreads than to a rise in banks' internal LTI limits. Being near collateral or income credit limits, is also a key determinant of debt sensitivity to different credit supply conditions. The number of loans extended to financially constrained borrowers increases following a simultaneous loosening in mortgage spreads and in credit availability at either high LTV or high LTI multiples. This suggests that financially constrained borrowers are restricted in accessing further credit by both credit prices and the supply of riskier loans at banks.

Put together, these results suggest that in aggregate, household leverage responds more strongly to supply shocks that change the quantity rather than the price of credit, as they affect more households across the distribution, both at the intensive and at the extensive margin. Price effects can fuel rapid credit growth only through an aggressive contraction of mortgage pricing indicators (i.e. to both fees and mortgage spreads) or through a simultaneous loosening of both price and non-price credit conditions.

By estimating the elasticity of household debt to changes in price and non-price credit supply conditions, this paper can aid the development of macroprudential policies in two ways. First, it helps identify the credit supply indicators that have the largest impact on household behaviour, which can make policy more targeted and reduce spillovers and unintended consequences. Second, it highlights additional early warning indicators of financial booms, helping researchers and policymakers in estimating financial cycles. The existing empirical literature has mainly focused on the role of mortgage spreads in predicting financial distress. For instance, Mian et al. [2017a] show that a loosening in the price of credit has been correlated with a rise in household debt to GDP and a subsequent economic downturn for 30 countries between 1960 and 2012. However, there are other credit supply conditions that are correlated with household borrowing, whose role has not been examined empirically yet. For example, Figure 1 shows that in the UK, mortgage credit growth is also correlated with non-price credit conditions, such as the number of mortgage loans extended at very high LTI or LTV ratios relative to total mortgage borrowing. In addition, this paper shows that when assessing credit risks, policymakers should not just focus on the dynamics of individual lending criteria in isolation. Interaction effects between different credit supply conditions are crucial too.

This paper is structured as follows. Section 1.1. discusses the related literature. Section 2 describes the data. Section 3 discusses the methodology and the identification of the variation in price and non-price credit conditions that is due to credit supply shocks. Section 4 examines the effect of changes in price and non-price credit supply conditions on the intensive and the extensive margin of debt. Section 5 shows that the effect of price and non-price conditions is dependent on household characteristics. Section 6 concludes.

Figure 1: Lending at high LTI and LTV ratios and mortgage credit growth



Source: FCA Product Sales Database and Bank of England. Note: Credit growth is obtained using the quarterly growth rate of total sterling net secured lending to individuals.

1.1 Related literature

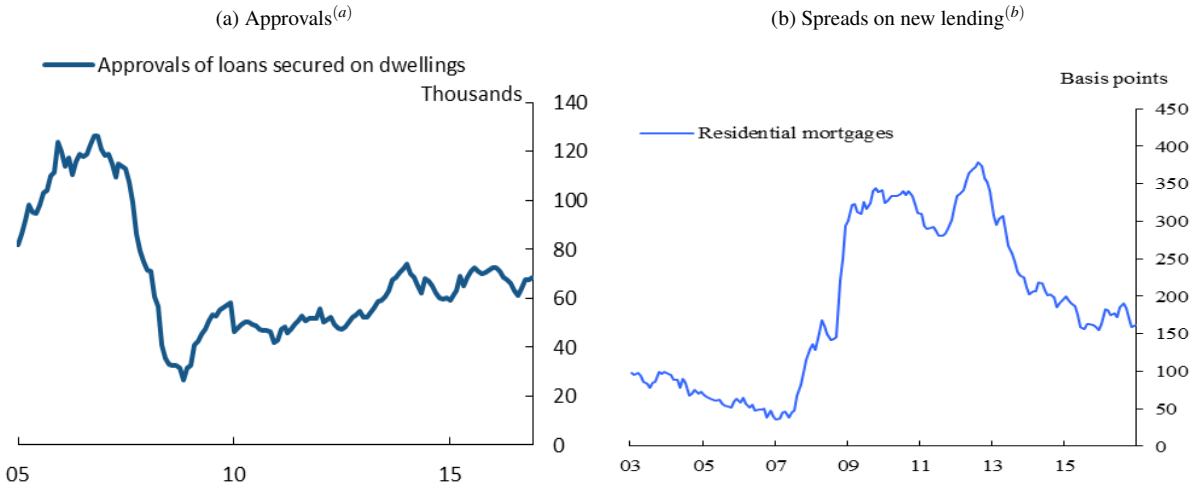
This paper is related to the literature examining the role of credit supply shocks in driving household debt dynamics. This literature finds that the rapid credit growth pre-2007 was fueled by a credit liberalisation which led to loosening in credit availability and in the price of credit (Krishnamurthy and Muir [2017], Mian and Sufi [2009], Mian et al. [2017b], Favara and Imbs [2015]). Credit supply shocks driven by bank competition and changes in banks' risk attitudes have also been identified as key drivers of the financial cycle (Rajan [1994], Ruckes [2004]). These papers show that, as the default probabilities of borrowers decline with improvements in the economic outlook, banks decrease the probability of screening. This leads to intense competition among lenders which promotes cheaper lending and a decrease in credit constraints to marginal borrowers. The loosening in bank credit policy is analogous with a downward shift in the credit supply curve, leading to higher borrowing at lower prices (Mian et al. [2017b], Mian and Sufi [2009]). Hence, if credit growth is fueled by a credit supply shock, the data should show that debt is positively correlated with a relaxation in non-price credit conditions and negatively correlated with the price of credit.

In contrast, a different strand of literature argues that debt is fueled by a feedback mechanism between collateral posted for secured borrowing and shocks to agents' wealth (e.g. Bernanke and Gertler [1989], Kiyotaki and Moore [1997], Kaplan et al. [2017], Cloyne et al. [2019], Favilukis et al. [2012]). In these papers, collateral appreciation due to a positive shock to net worth or to real estate valuations facilitates more borrowing for given credit conditions. Hence, credit growth is a consequence of changes in the quality of borrowers - i.e. the demand side - and not because of shocks to credit availability - i.e. the supply side. Standard demand and supply analysis suggests that, absent any shocks to bank credit policy - i.e. to the supply side - financial intermediaries will tighten their price terms as a result of the increase in credit demand. Hence, if credit demand factors drive the credit cycle, then all else equal, the price of credit should rise as household debt increases, as shown by Justiniano et al. [2019].

Simple descriptive statistics seem to indicate that the pre-2007 boom in mortgage borrowing in the UK is consistent with a relaxation of credit standards driven by credit supply shocks, rather than credit demand. Figure 2 shows that,

as the quantity of lending available at financial institutions increased in the run-up to the financial crisis, the average price of new lending decreased.

Figure 2: Quantity and price of new lending



(a) Source: Bank of England. Note: Data are for monthly number of house purchase approvals covering sterling lending by UK MFIs and other lenders to UK individuals. Approvals secured on dwellings are measured net of cancellations. See: Bank of England Database
(b) Sources: Bank of England, Bloomberg, FCA Product Sales Data and Bank calculations. Note: the residential mortgage lending spread is a weighted average of quoted mortgage rates over risk-free rates, using 90% LTV two-year fixed rate mortgages and 75% LTV tracker, two and five-year fixed-rate mortgages. Spreads are taken relative to gilt yields of matching maturity for fixed-rate products. Spreads are taken relative to Bank Rate for the tracker product. Weights based on relative volumes of new lending.

Identifying the variation in non-financial debt due to credit supply shocks has remained a challenge. Since the financial crisis, the approach to identifying credit supply shocks using data on commercial lenders' assessment of credit conditions, has been gaining traction. For instance, Bassett et al. [2014] use bank responses to the Fed's Loan Officer Opinion Survey to identify the impact of changes in loan approvals driven by credit supply shocks on aggregate macroeconomic outcomes. Using the same dataset, Lown and Morgan [2002] and Lown and Morgan [2006] use a VAR approach to investigate how changes in overall credit availability affect bank lending and output dynamics and how they interact with monetary policy shocks. They proxy bank credit supply using an aggregated measure of how many commercial banks' report loosening or tightening in loan approvals every quarter. Ciccarelli et al. [2015] replicate the analysis for the EU. Using bank lending surveys for the Euro Area and a VAR model they show that credit supply restrictions, proxied by tighter credit conditions standards reported by commercial banks, affect household and business loans, GDP growth and inflation. They argue that credit supply shocks that affect credit conditions at banks are driven by banks' changes in balance sheet strength and competition. In the UK, Corugedo and Muellbauer [2006] use both aggregate and microdata on household credit, economic and demographic factors to construct a time-varying credit supply conditions index driven by credit supply shocks. However, these papers focus on the aggregate macroeconomic implications of supply shocks to credit conditions, without explicitly distinguishing the effect of price and non-price credit conditions on household debt. To advance this literature, I match lenders' responses to the Credit Conditions Survey with loan-level data, to estimate both the price and the non-price effects of credit supply shocks on the distribution of household debt.

2 Data

I use loan-level data, containing the universe of the mortgage product sales in the UK, at a quarterly frequency. These data are collected by the UK's Financial Conduct Authority (FCA) and has information on all completed owner-occupied household mortgage product originations from April 2005, but does not include commercial or buy-to-let mortgages. The data include a range of information about the mortgage such as the loan size, the date the mortgage became active, the house price appraisal, the interest rate charged during the origination period, whether the interest rate is fixed or variable, the end date of the initial duration (i.e. the time at which the higher reset rate starts applying), whether mortgage payments include amortization, and the mortgage term over which the full loan will be repaid. The data also include a number of borrower characteristics such as age, gross income, and whether the income is solely or jointly earned, whether the borrower is a refinancier, a first-time buyer or home-mover.

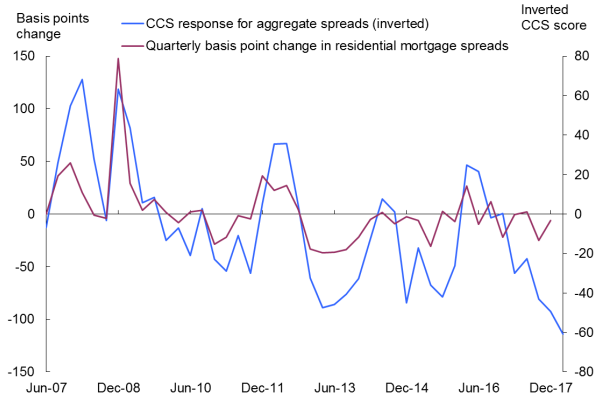
The data on credit conditions come from the Bank of England's Credit Conditions Survey (CCS), which asks major UK lenders (with at least 1% market share) about the conditions in the mortgage market. The survey is intended to assess trends in credit demand and terms and conditions on credit supply on a quarterly basis from the second quarter of 2007. Each lender assesses how credit conditions have changes relative to the previous 3 months, by choosing one of the following five answers (or variations of them): 'up a lot', 'up a little', 'same', 'down a little', 'down a lot'. Each response is then assigned a symmetric score ranging from -100 to 100, in increments of 50. Positive scores indicate that lenders reported demand and credit availability to be higher than over the previous three-month period, or that the terms and conditions on which credit was provided became cheaper or looser.

The CCS provides data on how the following credit condition indicators have changed relative to three months ago: spreads on overall mortgage borrowing, fees on new mortgage products, credit availability to borrowers with LTV ratios above 75% (referred to as high LTV credit thereafter), credit availability to borrowers with LTV ratios below 75% (referred to as low LTV credit thereafter), the maximum LTI limits imposed internally by banks, and the proportion of total loan applications approved each quarter. For example, to assess changes in loan approvals, the CCS asks lenders the following question: "How has the proportion of household loan applications being approved changed over the latest 3 months relative to the previous 3 months?". These credit conditions indicators capture different aspects of easiness in credit markets. Mortgage spreads and fees convey information about the price of borrowing for a given quantity of credit. The remaining indicators provide information on non-price credit conditions in credit markets, since they inform about changes in the quantity of credit that banks are prepared to offer.

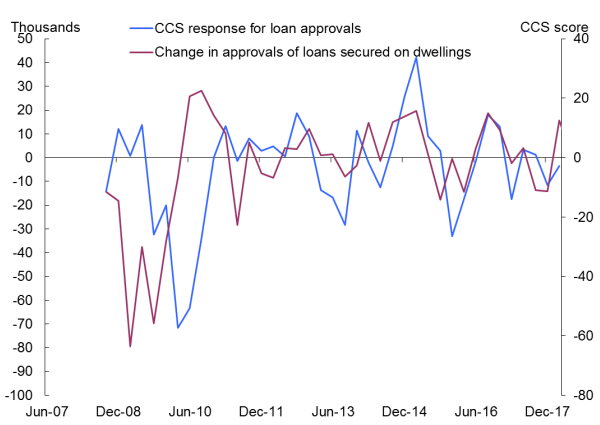
The usefulness of qualitative credit condition indicators depends on how informative they are about current conditions. Figure 3 plots the indicators from the Credit Conditions Survey against their closest counterpart in the actual data. The data series include quarterly changes in aggregate spreads, mortgage loan approvals, the proportion of loans with high LTI or LTV multiples and the proportion of loans with LTV ratios below 75%. The charts show a significant correlation between most of the CCS indicators and the actual data. The correlation is particularly strong for aggregate spreads, with a correlation coefficient of 0.7. The weakest correlation coefficient, of 0.1, is for loan approvals and is driven by the fact that pre-2010, the data seems to lead the CCS response. As a result, the strength of the correlation increases to 0.37 from 2010 onward, when the data and the CCS indicator become better aligned. The correlation coefficient for the rest of the indicators ranges between 0.26 and 0.43.

Figure 3: Informative content of the CCS indicators

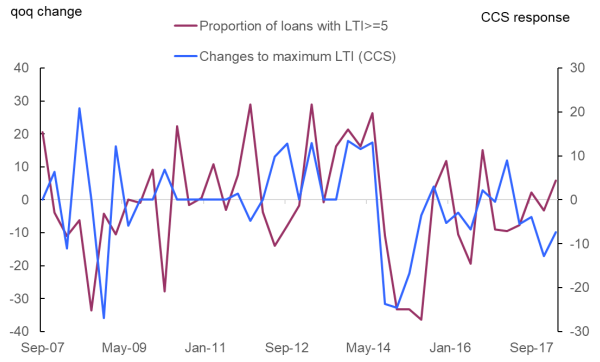
(a) Aggregate spreads[(a)]



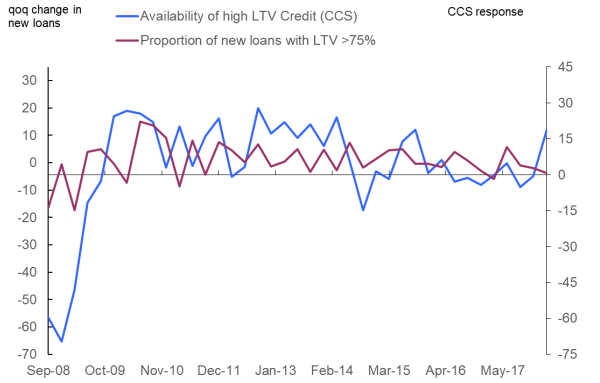
(b) Loan approvals



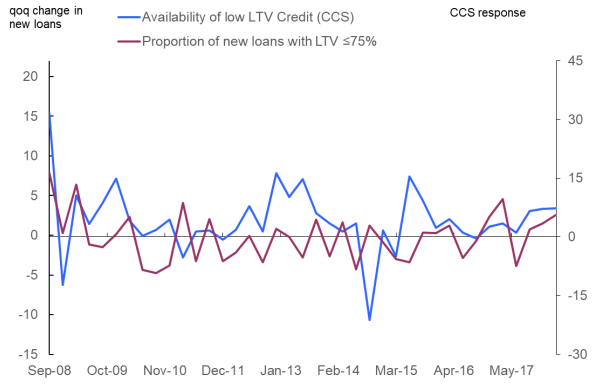
(c) Lending at high LTI



(d) Lending at high LTV multiples



(e) Lending at low LTV multiples



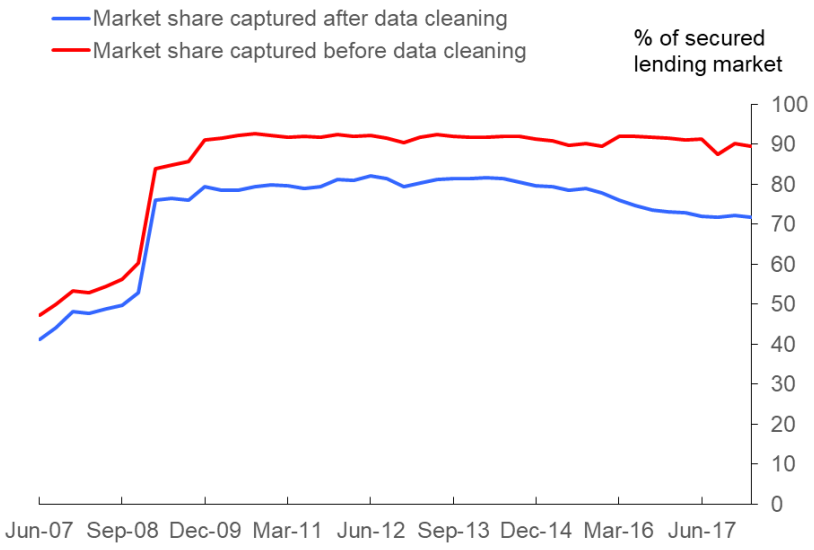
Source: Product Sales Database, Credit Conditions Survey and Bank of England data.
(a) The lending spreads represent the premium over risk free rate, captured as either the Bank rate or gilt yields.

The CCS is matched with the loan-level data at a bank and quarter level. Both the loan-level data and the CCS provide information on firms at a group consolidated level[1]. The matched dataset is then cleaned in a few ways. First, three lenders are removed from the matched dataset, due to either missing loan level data prior to 2015 or missing

[1]Mergers, acquisitions and banking splits are already incorporated in the consolidated group over time.

CCS data prior to 2016. Figure 4 shows the share of the regulated secured lending market captured by the matched dataset. Even after the cleaning is applied, the dataset still captures by the end of the sample, a little over 70% of the secured lending market in the UK.

Figure 4: Market share



Source: Credit Conditions Survey, Bank of England

Second, following Favilukis et al. [2012], a four-quarter moving average is constructed for each of the credit condition indicators, as shown in Equation 1. This data manipulation is needed to deal with the high quarterly volatility of CCS indicators, which often leads to short-lived fluctuations in the series. By taking a moving-average I can analyse intended and persistent changes in the short-term trend instead. One source of volatility in the quarterly CCS data comes from the lack of guidance provided to the banks on how they should record changes in credit conditions. Banks have full freedom in how they quantify tighter or looser credit conditions and how they categorise changes as 'a little' or 'a lot'. Hence, this may introduce a source of noise in lenders' responses and it also makes the series incomparable between two different lenders. As a result, the moving-average index captures a consistent trend in credit conditions over the short-run, within an individual bank.

$$CCI_{jt} = \frac{CCI_{jt} + CCI_{jt-1} + CCI_{jt-2} + CCI_{jt-3}}{4} \tag{1}$$

where CCI_{jt} captures the change in the indicator relative to three months ago, CCI_{jt-1} captures the change in the last period relative to the previous three months ago (i.e. changes in the indicator between the last 3 and 6 months ago), CCI_{jt-2} captures the change in the last two periods relative to the previous three months (i.e. changes in the indicator between the previous 6 and 9 months), and CCI_{jt-3} captures the change in the last three periods relative to the previous three months (i.e. changes in the indicator between the previous 9 and 12 months).

Finally, I standardise each series at a lender level. For each bank and each credit conditions indicator, I subtract the historical mean from the contemporaneous value and I divide by the bank's standard deviation. This approach ensures that credit conditions are more comparable across lenders and time, since different banks may categorise changes in credit conditions differently. On average across banks, credit conditions tightening or loosening "a lot"

implies a move of 1 to 2 standard deviations from mean. Similarly credit conditions tightening or loosening "a little" implies a move of 0.5 to 1 standard deviation from mean. Table 1 shows for each credit conditions indicator, the average standard deviation across banks, once moving averages have been constructed. For instance, tightening a little corresponds, on average, to a one standard deviation change in fees but a 0.6 standard deviation change in spreads or in credit availability at low LTV ratios. The table shows that the impact of tightening (loosening) a lot or a little varies across different indicators. However, within each indicator, jumping from tightening (loosening) 'a little' to tightening (loosening) 'a lot' is approximately equivalent to a doubling in the standard deviation.

Table 1: Average deviations for standardised data between 2008-2018

	Fees	Aggregate Spreads	High LTV Credit	Low LTV Credit	Max LTI limit	Proportion of Loans Approved
loosening 'a lot'	-	0.8	-	1.9	-	1.5
loosening 'a little'	0.6	0.4	0.5	0.8	0.8	0.5
tightening 'a lot'	-	-1.1	-1.4	-	-	-1.5
tightening 'a little'	-1	-0.6	-0.7	-0.6	-0.8	-0.4

Note: averages shown where at least two observations have been reported over the time period. Averages are calculated once data has been standardised and moving averages have been calculated.

Table 2 shows the average standard deviation in 2008 across banks which tightened their credit conditions. It shows that at the peak of the crisis in 2008, most indicators were tightened around 1 to 1.5 standard deviations. The data also reflects that the credit conditions related to credit availability at high and low LTV rations (i.e. Columns 4 and 5) have not been tightened until the third quarter of 2008. The last column of the table shows that the tightening in credit conditions coincided with a slow-down in household lending. A negative year-on-year growth in number of approvals for secured lending in 2008, coincided with a 0.65 to 1 standard deviation tightening in all credit conditions with the exception of loan approvals, were the magnitude of tightening was smaller, but still substantially negative.

Table 2: Average deviations for standardised data across the banks that reported a tightening

	Fees	Aggregate Spreads	High LTV Credit	Low LTV Credit	Max LTI limit	Proportion of Loans Approved	Approvals for secured lending (yoy growth)[(a)]
2008Q1	-1.36	-0.86	-	-	-1.34	-0.52	-16.3%
2008Q2	-1.08	-1.23	-	-	-1.34	-0.3	-28.3%
2008Q3	-1.36	-1.54	-0.67	-0.82	-	-0.07	-39.6%
2008Q4	-1.01	-1.21	-1.19	-1.42	-0.65	-0.64	-44.7%

(a) Source: Bank of England. The series represents the quarterly number of monetary financial institutions' sterling total approvals for secured lending to individuals not seasonally adjusted. An year-on-year change is reported in the table. Note: Averages are calculated once data has been standardised and moving averages have been calculated.

The descriptive statistics of the matched loan level and credit condition data is shown in Table 3. As it currently stands, my measure of credit conditions is similar to Favilukis et al. [2012], and it is not weighted by the relative importance of different banks in the mortgage market nor is it weighted by the degree of tightening or loosening in credit conditions. That is because, the CCS does not provide data on the strength of credit loosening or tightening over time, only of its breadth and trend.

Table 3: Descriptive statistics, Matched PSD and CCS data (2008 Q1 - 2018 Q1)

Statistic	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Loan Value	161,654	145,494	2,000	85,000	197,997	8,575,000
House Price	276,709	290,817	12,000	146,000	320,000	23,000,000
Interest rate	3.3	1.4	0.02	2.2	4.2	9.7
Income	61,264	96,058	2,000	32,700	68,250	9,524,197
LTV	0.6	0.2	0.01	0.5	0.8	1.2
LTI	2.9	1.1	0.02	2.1	3.7	10.0
mortgage term	22.3	7.9	3	17	28	40
SVR	4.2	0.5	3.7	3.8	4.7	5.7
age	38.9	10.1	21	32	47	92
DSR	0.2	0.1	0.002	0.1	0.2	3.3
Price Credit Indicators						
Fees	0.003	0.5	−2.1	0.02	0.02	2.1
Aggregate spreads	−0.1	0.7	−2.2	−0.5	0.4	1.5
Non-Price Credit Indicators						
High LTV credit	0.04	0.6	−2.7	−0.1	0.3	1.8
Low LTV credit	−0.03	0.5	−1.7	−0.2	−0.2	1.9
Max LTI limit	0.01	0.7	−2.7	0.04	0.04	2.1
Loan approvals	0.1	0.6	−2.1	−0.3	0.1	1.5
Demand Credit Indicator						
Demand secured lending	0.02	0.6	−2.2	−0.3	0.2	1.8

3 Identification and methodology

This section discusses the approach taken to identify the variation in price and non-price credit supply conditions that is due to credit supply shocks. It then discusses the baseline specification used to obtain the intensive and the extensive margin response of mortgage debt to credit supply shocks that operate through the price or the quantity of credit supplied by lenders.

3.1 Identification approach

The main difficulty in assessing the relationship between household leverage and conditions at financial intermediaries is identifying whether it is supply side or demand side shocks that drive changes. Many factors can determine loan demand and loan supply simultaneously. For instance, changes in the economic environment, such as a shock to house prices, may affect spending and net worth of households which may affect credit demand. At the same time, housing shocks may alter bankers' risk appetite by affecting their future economic expectations, leading to changes in the price and the quantity of credit. Identifying changes in credit supply conditions that are due solely to shocks at banks, requires controlling for a wealth of information on household characteristics and the economic environment.

Controlling for regional time-varying macroeconomic dynamics that affect loan demand at banks is achieved by interacting region and time dummies. These region-time fixed effects capture macroeconomic shocks that affect credit demand independently of the behaviour of individual banks, such as house price shocks, monetary policy changes or financial instability.

Additionally, household-level controls capture idiosyncratic factors that may drive individual borrowers' leverage decisions independently of credit supply conditions, such as income, employment or social factors proxied by age. However, accounting for all the idiosyncratic characteristics that drive household behavior is challenging since both

observed and unobserved factors can play a role. As such, it is possible that existing household controls may not remove all the variation in credit conditions that is due to factors other than credit supply shocks. There are two sources of bias that are potentially concerning.

One source of bias could arise from the self-selection of borrowers within banks over time. It is unlikely that households choose banks randomly, as their decision may be influenced by market research. These effects could be time-varying as well. For example, it is possible that over time banks change their portfolio composition to target more closely a certain segment of the market, such as richer borrowers. If advertised, this may incentivise richer households to self-select into these banks. Richer borrowers may require smaller loans even as credit supply is loosened, which may hinder the true effect of supply shocks on household debt. To deal with this, I follow a similar approach to Bassett et al. [2014] and control for bank-level factors correlated with credit demand using the Credit Conditions Survey. Every quarter, lenders assess how demand for secured household lending has changed over the short-term. I consider lenders' assessment of demand for both housing purchase and pure remortgaging[2]. Pure remortgaging may be correlated with unobserved household characteristics, such as borrower's financial savviness, which may determine some borrowers to refinance more frequently than others.

Another important challenge to the identification is the ability to control for major changes in borrower characteristics over time. A key worry is that, in a leverage boom, the quality of borrowers declines gradually over time as prime applicants become more scarce. The change in borrower quality may be correlated with both credit supply conditions and loan demand. For instance, as more borrowers with weaker balance sheets and higher indebtedness levels apply for a loan, banks may change credit supply conditions, such as the price of credit, to reflect increased default risk of borrowers. While the Bassett et al. [2014] approach provides a good measure of demand dynamics, it may still be prone to this source of bias. Similar to this paper, Bassett et al. [2014], does not have data on the quality of loan inquires over time. In the absence of applications data, I use the lagged proportion of loans extended at high debt multiples at each bank, to control for changes in the composition of banks' portfolios over time. A gradual decline in borrowers' quality over time at a bank should be correlated with a higher proportion of that bank's portfolio extended to riskier borrowers. If poorer quality borrowers target banks that increase their risk-appetite over time or if there are fewer low-risk borrowers applying for a loan, then these effects should be reflected in a continuous and persistent increase in banks portfolio allocations to riskier borrowers.

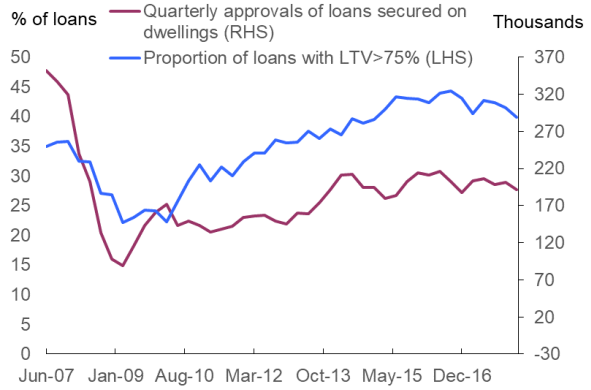
The data does not show a shift in borrower quality after the previous financial crisis. Figure 5 plots the proportion of loans extended to highly indebted borrowers against overall loan approvals.While high LTV borrowing rose by nearly 80% between the trough in 2009Q1 and 2018Q1, overall approvals more than doubled since the peak of the crisis. This suggests that credit has expanded across different types of households, not just the riskier ones. Additionally, Figure 5b shows that the mean income of mortgagors has risen constantly over time, suggesting that credit growth has not necessarily been matched by a decrease in borrowers' quality[3].

[2]Pure remortgaging refers to switching from a standard variable interest rate to a fixed term contract without increase in principal

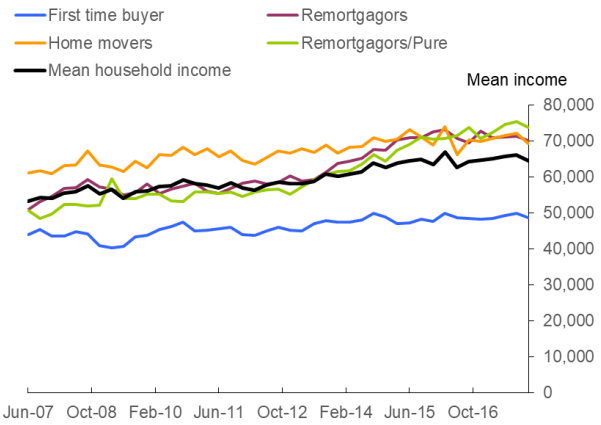
[3]Data from the ONS suggests that since 2011, mean household income has closely followed real household disposable income. See here.

Figure 5: Changes in lending patterns over time

(a) Loan approvals and borrowing at high LTV ratios[a]



(b) Mean borrower income[b]



(a) Source: Product Sales Database and Bank of England. Note: Data for approvals are for monthly number of house purchase approvals covering sterling lending by UK MFIs and other lenders to UK individuals. Approvals secured on dwellings are measured net of cancellations. See: Bank of England Database
(b) Source: Product Sales Database. The chart shows the nominal mean income of mortgagors by housing tenure.

The inclusion of bank-specific, household-specific and macroeconomic variables should provide a clean approach to assess changes in credit supply at individual banks. The remaining fluctuations are likely due to shifts in credit supply, for example from re-assessments of the riskiness of certain types of bank lending, shifts in business strategies, changes in banks' balance sheets or adjustments to changes in bank supervision and regulation.

3.2 Baseline methodology for the intensive margin

The baseline specification used to identify price and non-price effects of credit supply shocks on the intensive margin of mortgage debt is:

$$logL_{rjit} = \sum_{m=1}^{6} \beta_m CCI_{mjt} + \beta_\rho X_{rjit} + \gamma_1 D_{jt}^{HP} + \gamma_2 D_{jt}^{Remo} + \theta_1 PropL_{rjt-1}^{HighLTV} + \theta_2 PropL_{rjt-1}^{HighLTI} + \alpha_j + \delta_{rt} + \varepsilon_{rjit} \quad (2)$$

where r represents the region, j represents the bank, i represents the individual borrower, and t represents time measured at a quarterly level. L represents the loan amount taken out by borrower i. ΔCCI capture the short term trend in each of the six price and non-price indicators detailed above. The short term trend for each CCS indicator is obtained by taking a moving average over the contemporaneous and the three lagged responses, as shown in Equation 1. Controls X, include household-level income; the age bucket of the borrower[4]; the employment status which reports whether the household is salary employed, self-employed, retired or having other type of employment (for instance when the employment status is not clear); and the interest rate at origination, which is a proxy for the riskiness of individual households. D^{HP} and D^{Remo} capture the demand indicators for house purchase and pure refinancing respectively, from the CCS. As they both capture the lenders' own assessment of changes in the short-term trend in demand, both indicators are recorded at a bank and quarter level and the short-term trend is obtained following

[4]Ages of borrowers are reported within a five years bucket. For instance, if a borrower is 32 years old, the age bucket reported in the data is 30-34.

Equation 1. $PropL^{HighLTV}$ and $PropL^{HighLTI}$ capture the lagged proportion of loans extended at LTV ratios at or above 95% or at LTI ratios of 5 or above. Both variables are computed at a quarterly, bank and regional level, by dividing the number of loans with high debt multiples to the total number of loans approved by the bank. By including the proportion of a bank's portfolio allocated to highly indebted households, rather than the absolute numbers, I control for banks' portfolio choices in the past that affect current allocations independently of current credit supply shocks. δ are $region * quarter$ dummies and α represents bank fixed effects.

Bank fixed effects capture time-invariant heterogeneity between different banks. One important source of bank heterogeneity comes from the Credit Conditions Survey itself. Banks use their own judgment when assessing whether credit conditions have changed a little, a lot or insignificantly relative to 3 months ago. Hence, the assessments of tightening or loosening in credit conditions are bank-specific and may not be comparable between different banks. Bank fixed effects account for this unobserved source of bias across different institutions.

The data on refinancing without a capital increase is included. Pure remortgaging, which accounts for nearly 20% of all quarterly lending between 2008-2018, can still be affected by credit supply shocks even if the loan principal decreases mechanically over time. For instance, changes in the price of credit may incentivise a rise in refinancing to take advantage of cheaper products. Hence, excluding these types of contracts from the data may bias the results.

In all specifications, Driscoll-Kraay standard errors are used, with clustering at bank and quarter level.

3.3 Baseline methodology for the extensive margin

Estimating the effect of price and non-price credit supply conditions on the extensive margin is complicated by the absence of application data that provides information on the quality of the entire pool of loan applicants over time. To overcome this problem, I aggregate household loans at a bank-region-quarter level. I then examine the variation in the quarterly volume of loans at each bank and region that is explained by changes in different credit supply conditions. The dependent variable is now the total number of loans approved by each bank. An increase in the number of bank loans indicates a rise in the number of households accessing credit and thus an increase in the extensive margin.

Equation 2 is amended in the following way:

$$\begin{aligned} logNoL_{rjt} = \sum_{m=1}^{6} \beta_m CCI_{mjt} + \beta_\rho X_{rjt} + \gamma_1 D_{jt}^{HP} + \gamma_2 D_{jt}^{Remo} + \\ \theta_1 PropL_{rjt-1}^{HighLTV} + \theta_2 PropL_{rjt-1}^{HighLTI} + \alpha_j + \delta_{rt} + \varepsilon_{rjt} \end{aligned} \tag{3}$$

where NoL is the number of bank loans approved by bank j in region r and quarter t[5]. $PropL^{HighLTV}$ and $PropL^{HighLTI}$ capture, as before, the lagged proportion of high LTV and high LTI loans, calculated as the number of loans extended at high debt multiples relative to the total number of loans at a given bank. Household controls X now include the mean income, mean age and mean loan interest rate for households within a bank, region and quarter. Employment is not included since it is a categorical variable.

[5]Given the panel data structure at a bank level, one could construct a dependent variable that represents the change in the volume of loans between two periods, such that the dependent variable and the *CCI* are both measured in changes. However, maintaining the dependent variable in level terms allows for a better comparison of the impact of *CCI* with the intensive margin. Additionally, measuring the dependent variable in changes would not necessarily ensure maximum consistency with the measurement of credit indicators from the CCS, since these are qualitative indicators and hence units of change are subjective for each bank.

4 Price and non-price transmission channels of credit supply shocks

This section examines the response of the intensive and the extensive margin of mortgage debt to changes in price and non-price credit conditions driven by credit supply shocks.

4.1 The effect of credit supply conditions on the intensive margin

To analyse the effect of credit supply conditions on the intensive margin for household debt, I estimate Equation 2 using OLS. The results are presented in Table 4. Columns 1 and 2 illustrate the impact of using regional rather than aggregate time fixed effects. The most notable difference arises for the maximum LTI indicator, which becomes significant in column 2. This highlights the importance of capturing regional trends in the UK when examining household lending. Analysis by the Bank of England suggests that there is a substantial regional variation in the ratio of house prices to incomes in the UK[6]. In London and the South East, house prices are higher relative to incomes and borrowers tend to have higher LTI ratios compared to households elsewhere in the UK.

Additionally, Table 4 shows that the omission of bank fixed effects produces less economically intuitive results. For instance when bank heterogeneity is not controlled in column 1 and 2, price credit conditions do not matter for household borrowing and a loosening in credit availability at high LTV ratios is significant and negatively correlated with household debt. These unintuitive effects disappear when bank fixed effects are introduced.

In the specification with all the fixed effects present, in column 3, the indicators for changes in spreads and in maximum LTI limits are very significant and have a strong impact on household debt. A positive one standard deviation change in the short-term trend of spreads or maximum LTI limits increases average household borrowing by 2% and 3% respectively, per quarter. A Wald test for the statistical difference in the two coefficient estimates yields a p-value of $2 * 10^{-16}$. This shows that changes in the price and non-price credit supply conditions have a heterogeneous impact on household leverage. This suggests that analysing disaggregated indicators of price and non-price credit conditions can reveal important mechanisms in which credit supply shocks affect borrowing dynamics.

Column 3 also shows that credit availability at LTVs below 75% is negatively correlated with mortgage borrowing. This result is intuitive: increased credit availability at lower LTV multiples may imply lower credit availability to high LTV borrowers, thus leading to a drop in the average loan amount. While this is not a particularly telling indicator of the relationship between credit conditions and household leverage, removing it from the regression would lead to an omitted variable bias since it is clearly correlated with household debt. Additionally, its omission could lead to downward biases in coefficient estimates. As it is a negative confounder, it could cancel out the effect of variables co-moving positively with household debt and negatively with it. This effect indeed happens. Omitting credit availability at low LTV ratios from column 3 lowers the coefficient estimates for the maximum LTI limit and the mortgage spreads.

One concern when examining different credit supply conditions is the presence of multicollinearity between different indicators. It is possible that banks do not change price and non-price credit conditions in isolation or independently of each other. High correlation between variables would in turn lead to noisy coefficient estimates which would hinder the extraction of a clear signal from each indicator. The covariance between different price and non-price credit conditions indicators within each bank, peaks in absolute terms at around 0.75, which suggests that multicollinearity is not an issue. The highest covariance within the majority of banks is reached between the indicators for loan approvals

[6] See the Bank of England Financial Stability Report, June 2017

Table 4: Baseline intensive marrgin - household level regression

	Dependent variable: log(L)			
	Time FE	Regional Time FE	All FE	Price Interactions
	(1)	(2)	(3)	(4)
Change Fees	−0.001	0.004	−0.012	−0.014*
	(0.024)	(0.024)	(0.008)	(0.008)
Change Spreads	0.009	0.013	0.029**	0.029**
	(0.034)	(0.032)	(0.014)	(0.011)
Change High LTV credit	−0.020**	−0.025***	0.007	0.009
	(0.010)	(0.009)	(0.009)	(0.009)
Change Low LTV credit	0.007	0.012	−0.025***	−0.024***
	(0.010)	(0.010)	(0.007)	(0.007)
Change Max LTI	0.031	0.028*	0.020***	0.021***
	(0.019)	(0.015)	(0.006)	(0.006)
Change Loan Approvals	−0.020	−0.012	0.007	0.008
	(0.013)	(0.013)	(0.008)	(0.009)
Fees*Spreads				0.003
				(0.009)
High LTV credit*Spreads				0.020***
				(0.008)
Low LTV credit*Spreads				−0.009
				(0.009)
Max LTI*Spreads				−0.005
				(0.006)
Loan Approvals*Spreads				−0.0003
				(0.012)
Fixed Effects	Time	Regional Time	Regional Time & Bank	Regional Time & Bank
Controls	*All*	*All*	*All*	*All*
Observations	6,103,175	6,103,175	6,103,175	6,103,175
R^2	0.586	0.606	0.617	0.617

Note: *p<0.1; **p<0.05; ***p<0.01

Driscol-Kraay standard errors in brackets, clustered at bank and quarter level. Controls include household-level income, age bucket, employment status and the loan interest rate at origination.

and either lending above 75% LTV, spreads or maximum LTI limits. In addition, spreads at most banks correlate more closely with lending above 75% LTV and with fees.

To check the impact of correlations between price and non-price credit conditions on debt, I allow spreads to interact with all the other indicators in column 3. The main effects of the indicators on spreads, maximum LTI limits and lending to low LTV multiples maintain their significance and magnitude. However, there are two important differences.

First, fees become statistically significant due to a marginally larger coefficient estimate. A one standard deviation loosening in the short-term trend in fees, lowers the average mortgage loan by approximately 1% per quarter. This negative correlation occurs mechanically. Many households choose to add their fees to the principal of the loan which increases the amount they need to borrow. A reduction in fees leads to a mechanical decrease in borrowing. Rajan and Willison [2018] find that product fees can be a significant fraction of the cost of a mortgage averaging at around 5% of the total mortgage cost over the fixed period and many borrowers cannot afford to pay that amount upfront.

Second, a credit supply shock that simultaneously changes the price and the non-price credit indicators amplifies the effect on household debt. A one standard deviation change over the short term in mortgage spreads increases household debt by nearly 5% per quarter if it is also accompanied by a loosening in high LTV credit availability. This is nearly double than the individual effect of a change in mortgage spreads.

4.2 The effect of credit supply conditions on the extensive margin

To analyse the effect of credit supply conditions on the extensive margin for household debt, I estimate Equation 3 with regional time and bank fixed effects. The regression outputs are shown in Table 5. Column 1 shows that the only statistically significant driver of the number of loans approved by banks is changes in maximum LTI limits. A one standard deviation increase in the maximum LTI ratio accepted by banks, leads to 10% more loans extended to households. A Wald test of coefficient significance suggests that this estimate is statistically different from the coefficient estimates of other non-price credit conditions indicators. The coefficient on spreads, which is a key driver of the size of individual mortgage debt, is statistically insignificant and close to 0.

These results imply that a higher use of credit markets is driven by a loosening in the quantity of lending available at high debt-multiples, and not by changes in the price of credit. This is in line with existing research, which shows that looser credit limits allow financially constrained borrowers to access more credit (e.g. Ingholt [2018], Iacoviello [2015], Millard et al. [2021]).

Introducing interaction terms in column 2 maintains these results with one notable exception. When both types of price credit conditions are loosened simultaneously, the effect on the number of loans extended becomes large and statistically significant. This may occur due to the combined effect of lower fees and mortgage spreads on loans. A loosening in fees reduces the principal borrowed for many households which can marginally improve borrowers' affordability, and in turn, whether they qualify for a loan. When mortgage spreads are also compressed, debt-service-ratios reduce further, making the loan even more affordable.

Annex A investigates whether the relationship between different credit supply conditions and debt is dependent on the overall state of the economy, by splitting the sample in 2010, when the recovery from the financial crisis started to be more apparent.

Table 5: Baseline extensive margin - bank level regression

	Dependent variable: log(Number of bank loans)	
	All FE	Price Interactions
	(1)	(2)
Change Fees	0.092	0.088
	(0.075)	(0.063)
Change Spreads	−0.004	0.015
	(0.066)	(0.068)
Change High LTV credit	0.005	0.017
	(0.054)	(0.056)
Change Low LTV credit	0.020	−0.015
	(0.049)	(0.045)
Change Max LTI	0.107**	0.123**
	(0.054)	(0.053)
Change Loan Approvals	0.057	0.080
	(0.057)	(0.057)
Fees*Spreads		0.162*
		(0.086)
High LTV credit*Spreads		0.016
		(0.060)
Low LTV credit*Spreads		−0.041
		(0.065)
Max LTI*Spreads		−0.058
		(0.058)
Loan Approvals*Spreads		0.037
		(0.076)
Fixed Effects	Regional Time & Bank	Regional Time & Bank
Controls	*All*	*All*
Observations	5,087	5,087
R^2	0.822	0.825

Note: *p<0.1; **p<0.05; ***p<0.01

Driscol-Kraay standard errors in brackets, clustered at bank and quarter level. Controls include mean income, mean age and mean loan interest rates at origination across households within a bank, region and quarter.

5 The distributional effects of price and non-price credit supply conditions

This section examines if the effect of price and non-price conditions is dependent on household characteristics, such as income, age, housing tenure and balance sheet strength.

5.1 Heterogeneity across the income distribution

The maximum amount of debt that borrowers can obtain at banks is conditional on income. For risk-management purposes, many banks have internal limits on the maximum debt-to-income ratios or debt-service ratio at which they are prepared to lend. Hence the lower the borrowers' earnings, the lower the total credit amount they have access to. This is likely to be an issue particularly for low earners whose desired levels of credit are more likely to exceed banks' internal limits. Hence, non-price credit conditions are likely to be important drivers of borrowing decisions for the less wealthy. To check the dependency of effects on income, I assign borrowers into three income quantiles.

Table 6 shows the characteristics of the median borrower across each income quantile bucket. Borrowers in the

lowest income quantile have the lowest median LTV ratio and the highest median LTI ratio. This suggests that credit access for lower earners is more constrained by their incomes rather than by their deposit amount which determines their LTV ratio. As a result, these borrowers are expected to be sensitive to loosening in credit conditions related to credit availability at high LTI multiples.

Table 6: Median household characteristics by income quantile

	Income	LTV	LTI	Interest rate
Quantile 1 - Low earners	£28,200	63%	3.1	3.5%
Quantile 2 - Mid earners	£46,900	70%	2.9	3.1%
Quantile 3 - High earners	£83,000	69%	2.6	2.7%

Note: all values show the median in each quantile bucket.

Table 7 shows the regression results using Equation 2 where all the *CCI* variables have been interacted with the income quantiles. Lower earners (i.e. baseline) are the only category that responds strongly and positively to changes in the quantity of lending supplied at high LTI multiples. A 1 standard deviation loosening in maximum LTI limits, leads to a 2.5% quarterly rise in average borrowing of poorer households. For mid-earners, a one standard deviation increase in loan approvals leads to approximately a 1% rise in the average mortgage debt. Changes to non-price credit conditions affect wealthier borrowers only through changes in credit availability at low LTV ratios which lowers borrowers' debt amounts, as expected[7].

Price credit supply conditions also have a heterogeneous impact across different borrowers. Fees matter only for poorer borrowers. However, a loosening in mortgage spreads drives mortgage borrowing of both mid and high-earners. Since these borrowers have stronger financial positions they are less likely to be quantity constrained when accessing credit markets. Hence, the cost of credit is a main important driver of their borrowing decisions.

5.2 Heterogeneity across borrower types

Housing tenure may also determine how borrowers respond to price and non-price terms. First-time buyers are likely to have different socioeconomic characteristics compared to households who already own a house. The key descriptive statistics by housing tenure are shown in Table 8. The median first-time buyer is younger, poorer and with a substantially higher LTV ratio compared to the median home-owner. Nearly 1 in 4 first-time buyers have LTV ratios of 90% or above and over 60% have LTV ratios above 75%. This suggests that first-time buyers are likely to be financially stretched by their savings, and hence credit availability at high LTV ratios should be a key driver of their borrowing decisions.

[7]The effect of changes in credit availability at low LTV ratios on the average debt level of high earners is obtained by adding the coefficient estimate to that of the baseline, which is the coefficient estimate for low earners: $\frac{\partial Loan}{\partial LowLTVCredit} = [0.014 + (-0.031)] * 100 = -1.7\%$

Table 7: Split by income - intensive margin

	Dependent variable: log(L)
Low earners	
Change Fees	-0.019^{**}
	(0.009)
Change Spreads	0.017
	(0.014)
Change High LTV credit	0.009
	(0.013)
Change Low LTV credit	-0.031^{***}
	(0.007)
Change Max LTI	0.025^{***}
	(0.007)
Change Loan Approvals	0.001
	(0.008)
Mid earners	
Change Fees * Mid	0.005
	(0.009)
Change Spreads * Mid	0.012^{***}
	(0.005)
Change High LTV credit * Mid	0.002
	(0.006)
Change Low LTV credit * Mid	0.002
	(0.005)
Change Max LTI * Mid	-0.007
	(0.005)
Change Loan Appr. * Mid	0.008^{**}
	(0.004)
High earners	
Change Fees * High	0.015
	(0.014)
Change Spreads * High	0.025^{***}
	(0.007)
Change High LTV credit * High	-0.005
	(0.012)
Change Low LTV credit * High	0.014^{**}
	(0.007)
Change Max LTI * High	-0.008
	(0.009)
Change Loan Appr. * High	0.011
	(0.009)
Fixed effects	Regional Time & Bank
Controls	*All*
Observations	6,103,175
R^2	0.617
Note:	*p<0.1; **p<0.05; ***p<0.01

Driscol-Kraay standard errors in brackets, clustered at bank and quarter level. Controls include household-level income, age bucket, employment status and the loan interest rate at origination. Note that the coefficients for mid and high earners show differences relative to baseline.

Table 8: Household characteristics by tenure

Borrower type	Income	LTV	LTI	Age bucket	Interest rate	Interest when LTV>75%	Proportion with LTV>75%	Proportion with LTV≥90%
First-time buyers	£39,300	80%	3.3	30 - 34	3.3	3.74	61%	24%
Home - owners	£50,100	62%	2.7	40 - 44	3	3.5	27%	4%

Note: Columns 2-7 show the values at the median. The last two columns show the proportion of all the borrowers within a each type with a given LTV ratio.

To test if mortgage debt responses to supply shocks vary by housing tenure, I modify Equation 2 to interact the *CCI* variables with a dummy indicating if a borrower is a first-time buyer or a home-owner[8]. Table 9 shows that first-time buyers are sensitive to changes in the quantity of credit available at high LTV ratios, as expected. The price of credit also matters to them as it affects their monthly interest repayments as a proportion to income. A one standard deviation increase in either high LTV lending or mortgage spreads over the short-term, raises their average mortgage debt by approximately 4% per quarter. There is no statistical difference between the two coefficient estimates, which suggests a homogeneous effect of price and non-price credit supply conditions on first-time buyers.

Home-owners are insensitive to price credit conditions, but they react to changes in non-price credit supply indicators. First, their average mortgage loan depends negatively on changes in credit availability at high LTV ratios. This result may be driven by portfolio re-allocation effects. When banks become more willing to lend at high LTV multiples, credit is shifted from home-owners to first-time buyers. As shown in Table 8, banks may have more incentives to shift high LTV credit to first-time buyers, since they pay higher interest rates compared to home-movers on products with LTV ratios above 75%. Second, home-owners increase credit demand when banks become more willing to supply loans at high LTI multiples. This suggests that income can remain a constrain on borrowing throughout the life-cycle of households.

5.3 Heterogeneity across borrowers' age

The response of household debt to price and non-price credit supply conditions will also vary with borrowers' age. Table 10 shows that the median young borrower has an LTV ratios nearly 20% higher than the middle middle-aged household, with 63% of all young borrowers having an $LTV \geq 75\%$. This suggests that for young borrowers, constraints on the quantity of debt may be a key driver of how much credit they can access. The median middle-aged borrower has comparable LTI ratios as the median young person, but has an improved LTV ratio. There is no significance difference in the interest rates charged by banks across the life-cycle, particularly for products with high LTV ratios. Hence, older borrowers could be sensitive to both price and non-price credit conditions.

[8]First-time buyers includes council tenants purchasing their house. Home-owners includes households who borrow to move into a different home, remortgagors with an increase in principal, and remortgagors who refinance onto fixed-term contracts without an increase in loan principal.

Table 9: Analysis by borrower type - intensive margin

	Dependent variable: log(L)
First-time buyer	
Change Fees	-0.025^{**}
	(0.010)
Change Spreads	0.037^{**}
	(0.015)
Change High LTV credit	0.038^{*}
	(0.021)
Change Low LTV credit	-0.025^{***}
	(0.009)
Change Max LTI	0.004
	(0.007)
Change Loan Approvals	0.005
	(0.015)
Home-owner	
Change Fees * Home-owner	0.018
	(0.018)
Change Spreads * Home-owner	-0.009
	(0.011)
Change High LTV credit * Home-owner	-0.041^{*}
	(0.022)
Change Low LTV credit * Home-owner	0.0001
	(0.012)
Change Max LTI * Home-owner	0.021^{*}
	(0.012)
Change Loan Appr. * Home-owner	0.004
	(0.017)
Fixed effects	Regional Time & Bank
Controls	*All*
Observations	6,103,175
R^2	0.617
Note:	*p<0.1; **p<0.05; ***p<0.01

Driscol-Kraay standard errors in brackets, clustered at bank and quarter level. Controls include household-level income, age bucket, employment status and the loan interest rate at origination. Note that the coefficients for home-owners show differences relative to baseline.

Table 10: Borrower characteristics by age

Age-bucket	Income	LTV	LTI	Interest rate	Interest when LTV≥75%	Proportion LTV≤75%	Proportion LTV≥90%	% of which are first-time buyers
30 and below	£38,600	80%	3.4	3.5	3.8	37%	23%	65%
31 - 49	£50,500	68%	2.9	3	3.4	66%	8%	17%
50 and above	£45,100	43%	2.1	3	3.6	90%	2%	5%

Note: Columns 2-6 show the values at the median. The last three columns show the proportion of all the borrowers within each age-bucket with a given LTV ratio or who are first-time buyers.

Table 11 shows the results using Equation 2 where the *CCI* measures have been interacted with borrowers' age, split into three age groups: young, aged below 30; middle-aged, between 31 and 49 years old; and older, aged 50 or above. The baseline for regression coefficients in the table is middle-aged borrowers.

The size of debt for young people depends positively and significantly on loosening in credit availability at high debt multiples. A loosening in credit availability at high LTV ratios or an increase in the maximum LTI limits accepted at banks, increases the average debt amount of young borrowers by approximately 2.5% and 0.8% respectively[9]. These results occur because young adults have the lowest median incomes and the highest median LTV ratios out of the three age groups shown in Table 10. As such, they are more likely to be credit constrained by both their earnings and by their lower deposit levels.

Middle-aged households are sensitive to changes in credit availability at very high LTI ratios, as income remains a key determinant of the size of loans. Additionally, the price of credit is also a significant driver of debt decisions for middle-aged borrowers. A contraction in mortgage spreads increases the average size of loans for this age group by nearly twice than a similar shock to maximum LTI limits. A Wald test shows that the coefficient estimates for spreads and maximum LTI credit conditions are statistically different at less than 0.1% level.

The average loan extended to older borrowers is significantly and negatively correlated with changes in mortgage spreads and with credit availability at low LTV ratios (i.e. since $\frac{\partial Loan}{\partial Low\,LTV\,Credit} = 0.024 + (-0.03) = -0.006$). This indicates a potential re-allocation of credit flows to other types of borrowers when price and non-price conditions are loosened.

5.4 Heterogeneity across borrowers' balance sheet strength

The proximity of households to their budget constraints will also affect their borrowing decisions. Credit limits for individual borrowers are determined by a combination of individual characteristics, such as income or savings, and banks' own internal risk management decisions. The latter determines a bank's willingness to supply credit at different LTV and LTI buckets or to households with different levels of credit risk. A credit supply shock will affect credit access of marginal borrowers who sit at a threshold where marginal credit is denied. For instance, those who have to spend a large proportion of their income on mortgage repayments (i.e those with high LTI and implicitly highly

[9]Note that the effect of changes in maximum LTI limits on the average debt level of young households is obtained by adding the coefficient estimate to that of the baseline, which is the middle-aged households: $\frac{\partial Loan}{\partial MaxLTI} = [0.023 + (-0.015)] * 100 = 0.8\%$. The same approach is applied to obtain the effect of changes in credit availability at high LTV ratios.

Table 11: Split by age - intensive margin

	Dependent variable:log(L)
Middle-aged	
Change Fees	−0.008
	(0.010)
Change Spreads	0.040***
	(0.013)
Change High LTV credit	0.007
	(0.008)
Change Low LTV credit	−0.030***
	(0.008)
Change Max LTI	0.023***
	(0.007)
Change Loan Approvals	0.008
	(0.009)
Young	
Change Fees * Young	−0.013
	(0.013)
Change Spreads * Young	−0.007
	(0.008)
Change High LTV credit * Young	0.018*
	(0.011)
Change Low LTV credit * Young	−0.0002
	(0.007)
Change Max LTI * Young	−0.015*
	(0.008)
Change Loan Appr. * Young	0.004
	(0.010)
Older	
Change Fees * Old	−0.012
	(0.012)
Change Spreads * Old	−0.057***
	(0.020)
Change High LTV credit * Old	−0.013
	(0.014)
Change Low LTV credit * Old	0.024*
	(0.012)
Change Max LTI * Old	−0.002
	(0.007)
Change Loan Appr. * Old	−0.007
	(0.021)
Fixed effects	Regional Time & Bank
Controls	*All*
Observations	6,103,175
R^2	0.616
Note:	*p<0.1; **p<0.05; ***p<0.01

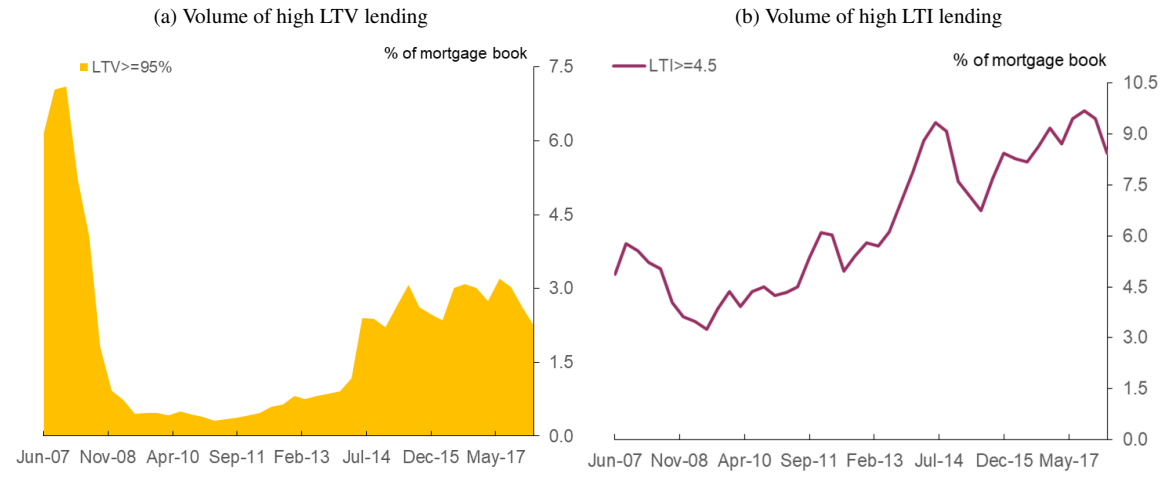
Driscol-Kraay standard errors in brackets, clustered at bank and quarter level. Controls include household-level income, age bucket, employment status and the loan interest rate at origination. Note that the coefficients for young and older households show differences relative to baseline.

income gearing) might be sensitive to changes in mortgage rates and in credit availability at high LTI multiples. That is because, lower interest rates reduce monthly mortgage payments for a a given principal, reducing income gearing. And higher credit supply at high LTI ratios might improve credit access for households closer to their budget constraints, allowing them to expand their balance sheets. Similarly, an increase in banks' willingness to supply loans with high LTV ratios, might allow more borrowers with limited deposit savings to access credit markets.

For borrowers who can increase marginal credit without hitting any binding constraints, looser price credit conditions are more likely to be a key determinant of borrowing decisions, rather than the quantity of credit supply. Cheaper credit is more attractive for consumption smoothing or to increase investment, hence even borrowers further away from their budget constraints may change their marginal leverage demand following credit supply shocks.

To check if these channels are present in the data, I examine how credit conditions affect the extensive margin of debt extended at high LTV and high LTI levels. I then compare it with the volume of debt extended to borrowers with low levels of debt relative to their incomes or house value. The challenge is to define a threshold for high LTI and LTV mortgages that proxies the level where borrowers get closer to their budget constraints. The ideal measure is one which captures the proximity to the households' budget constraints while also exhibiting sufficient variation over time. Two such measures are the volume of lending at $LTV \geq 95\%$ and at $LTI \geq 4.5$. Both of these ratios reflect debt multiples above which lending has historically been more constrained. Figure 6 shows that lending at $LTV \geq 95\%$ has been very volatile since the 2007 financial crisis, and it was substantially reduced after the bust. Hence, borrowers with 5% deposits or less can be locked down of credit markets during financial shocks and may even be constrained in how much credit they can access during good times. Similarly, the volume of lending with $LTI \geq 4.5$ is monitored closely by banks in the UK as is triggers supervisory attention. Following recommendations from the Financial Policy Committee, commercial banks are not allowed to extend more than 15% of their portfolio to borrowers with LTI multiples above 4.5[10]. As a result, borrowers with lower levels of income relative to mortgage debt are more likely to face constraints in accessing credit markets.

Figure 6: Volume of new mortgages with high-debt multiples



Source: FCA Product Sales Database (PSD). The Product Sales Database includes regulated mortgages only.

[10]See the Bank of England, Financial Stability Report from June 2014, https://www.bankofengland.co.uk/-/media/boe/files/financial-stability-report/2014/june-2014.pdf

Table 12 shows the results using Equation 3 amended in two ways. First, the *CCS* variables are interacted with mortgage spreads to allow for dependencies between price and non-price credit supply conditions. These dependencies may be important for borrowers close to their budget constraint whose increased credit risk may lead to marginal credit being available only at very high costs. Second, the dependent variable is the number of loans extended at a given debt multiple, divided by the total volume of loans issued by a bank in a given quarter and region[11].

Table 12: Split by borrower indebtedness - extensive margin (bank level)

	Dependent variable:			
	Loans with LTV$\geq$ 0.95	Loans with LTV<0.6	Loans with LTI$\geq$ 4.5	Loans with LTI<3
	(1)	(2)	(3)	(4)
Change Fees	0.002*	0.024***	−0.003	0.012**
	(0.001)	(0.006)	(0.002)	(0.006)
Change Spreads	−0.002*	0.005	0.005**	−0.008
	(0.001)	(0.012)	(0.002)	(0.007)
Change High LTV credit	−0.001	−0.004	0.003	−0.003
	(0.001)	(0.008)	(0.002)	(0.007)
Change Low LTV credit	0.001	0.024***	−0.004	0.018***
	(0.001)	(0.005)	(0.003)	(0.006)
Change Max LTI	−0.0001	−0.018***	0.001	−0.002
	(0.001)	(0.005)	(0.002)	(0.004)
Change Loan Approvals	0.0004	−0.005	0.0005	−0.005
	(0.001)	(0.007)	(0.002)	(0.006)
Fees*Spreads	−0.002	−0.003	0.003	−0.012
	(0.002)	(0.008)	(0.002)	(0.008)
High LTV credit*Spreads	0.004***	−0.004	−0.001	0.004
	(0.001)	(0.008)	(0.001)	(0.006)
Low LTV credit*Spreads	0.001	−0.015	−0.002	0.001
	(0.002)	(0.009)	(0.003)	(0.007)
Max LTI*Spreads	0.002*	−0.002	0.004***	−0.011***
	(0.001)	(0.005)	(0.001)	(0.004)
Loan Approvals*Spreads	−0.006***	−0.004	0.003**	−0.006
	(0.002)	(0.010)	(0.001)	(0.006)
Fixed effects	Regional Time & Bank	Regional Time & Bank	Regional Time & Bank	Regional Time & Bank
Controls	*All*	*All*	*All*	*All*
Observations	5,087	5,087	5,087	5,087
R^2	0.712	0.758	0.612	0.760

Note: *p<0.1; **p<0.05; ***p<0.01

Driscol-Kraay standard errors in brackets, clustered at bank and quarter level. In each column, the dependent variable is the number of loans extended at high debt multiples divided by the total volume of loans issued by a bank in a given quarter and region. Controls include mean income, mean age and mean loan interest rates at origination across households within a bank, region and quarter.

Column 1 shows that the proportion of bank loans issued at $LTV \geq 95\%$ increases when fees on new mortgages are reduced by banks, since it allows borrowers to use the relief from lower fees to increase their loan principal.

[11]The dependent variable becomes the share of bank loans extended at high debt multiples. Using the share of high-debt loans at a bank is more desirable than using the absolute number because it is more easily interpretable when logs cannot be taken. That is because, the number of high-debt loans at banks is 0 in some regions and quarters. By transforming the dependent variable into to shares, one can easily interpret the coefficient on credit conditions as the percentage change in the dependent variable. Appendix B looks at the results when applying an inverse hyperbolic sine transformation of the absolute number, instead of transforming it in shares.

The interaction term between mortgage spreads and credit availability at high-LTV multiples is positive, although the economic impact of changes in these two credit conditions simultaneously is a little above 0. However, the positive coefficient suggests that highly-indebted borrowers can benefit from a contraction in spreads if it is accompanied by a relaxation in their credit quantity constraints.

The proportion of new loans issued to borrowers with very conservative LTV ratios in Column 2, is positively correlated with product fees and with low LTV lending. A one standard deviation reduction in either credit indicator, increases the volume of new loans issued to low-leveraged households by about 2%. Although the coefficient on mortgage spreads is also positive, its statistical effect is missing. This may arise because borrowers with stronger balance sheets already have access to products with lower interest rates, hence a further marginal loosening in spreads is unlikely to provide them with significant incentives to lever up. For instance, borrowers with LTV ratios below 60% pay on average an interest rate of 3.2%, compared to borrowers with LTV ratios above 85% who pay on average 4% in interest. Finally, a rise in high LTI credit availability results in a lower proportion of banks' portfolios being allocated to lower risk borrowers. A one standard deviation increase in maximum LTI limits decreases the volume of loans extended to low-LTV households by nearly 2%.

The correlation between credit supply conditions and high income gearing is explored in Columns 3 and 4. The effect of mortgage spreads on the proportion of loans extended at $LTI \geq 4.5$ is positive and statistically significant. That is because having high LTI ratios also implies that households have to spend a large proportion of their income on monthly mortgage repayments. A reduction in interest rates mechanically reduces households income gearing, all else constant, thus loosening borrowers' budget constraints. A one standard deviation loosening in mortgage spreads increases the volume of loans to highly indebted households by 0.5% if it occurs in isolation, and by around 1% if it occurs simultaneously with a loosening in banks' maximum LTI limits. An expansion in loan approvals also matters for the volume of loans extended to highly indebted households if it is accompanied by a reduction in mortgage rates. This suggests that supply shocks that loosen price and non-price credit conditions simultaneously, increase banks' allocation to riskier borrowers. The proportion of loans allocated to borrower with low income gearing in Column 4 (i.e. with $LTI < 3$) are positively correlated with a loosening in fees and in credit availability at low-LTV credit.

There are two potential issues with the analysis above. First, by including the lagged proportion of loans with $LTV \geq 95\%$ and $LTI \geq 5$ as control variables (as shown in Equation 3), the model now includes a lagged dependent variable in Column 1, and a near lagged dependent variable in Column 3, given the strong autocorrelation between the proportion of loans issued at $LTI \geq 4.5$ and those issued at $LTI \geq 5$. This may be problematic for two reasons. On one hand, the inclusion of both lagged dependent variables and period dummies can absorb a substantial amount of time variation in the model. On the other hand, including a simple lagged dependent variable may miss-estimate the true form of the persistence in banks' portfolio allocations. As a result, this approach could bias the coefficients of all the independent variables downwards if it wrongly assumes an identical persistent effect in all the independent variables (Plümper et al. [2005]). However, by allowing the lagged dependent variables in the model, I can control better for serial correlation in banks' portfolio allocations. Banks' portfolio decisions are unlikely to fluctuate significantly between two quarters, for instance due to transaction costs or profitability implications in re-optimising loan portfolios. Nonetheless, Annex B recreates the results in Table 12 once I remove the lagged proportion of loans issued at $LTV \geq 95\%$ and $LTI \geq 5$. As expected, the coefficient estimates are generally higher, but the direction of estimates remains

broadly unchanged.

Second, the effect of credit supply conditions may be underestimated by having the dependent variables in ratios rather than levels. That is because ratios can remain unchanged if a credit supply shock leads to all mortgage products in a bank's portfolio increasing in a proportional way. In such a scenario, changes in credit supply indicators may increase the extensive margin in absolute terms (i.e. by increasing the number of mortgages to marginal borrowers), but not in a proportional way. However, a simple log transformation of the level cannot be applied since the number of loans to highly indebted borrowers can be nearly 0 in the data, particularly in the recovery period after the 2008 crisis. An inverse hyperbolic sine is used in Annex C as an alternative transformation. The results are consistent to those in Table 12.

6 Conclusion

In this paper, I use bank and household level micro-data to examine how changes in price and non-price credit supply conditions at banks affect mortgage lending in the UK. To identify the variation in credit supply conditions that is due to credit supply shocks, I obtain indicators of credit conditions which are uncontaminated by macroeconomic, bank-level or household-specific factors that can affect loan demand and supply simultaneously.

I show that changes to both price and non-price credit supply indicators matter for household debt dynamics. I find that the intensive margin of mortgage debt responds to changes in both price and non-price credit supply conditions and that a shock affecting both types of credit conditions simultaneously, amplifies the debt effects. The extensive margin however, responds mainly to changes in the quantity of credit. The price of credit becomes an important driver of extensive margin only when overall mortgage costs are cut aggressively by banks, with both fees and mortgage spreads loosened at the same time.

I also show the distributional implications of price and non-price credit supply conditions on household debt. I find substantial heterogeneity across households' life-cycle characteristics and balance-sheet strength. Young and home-owners respond exclusively to changes in the quantity of credit, particularly to credit availability at high LTV and high LTI ratios. Debt levels of first time buyers, middle-income households and middle-aged borrowers are sensitive to either type of credit supply conditions. Proximity to budget constraints is also a key determinant of households' sensitivity to different credit supply conditions. Borrowers closer to collateral or income constraints increase the quantity of debt demanded following a simultaneous loosening in mortgage spreads and credit availability at high LTV or high LTI multiples.

These results suggest that a reduction in the quantity of credit available in the economy, notably at high LTV or high LTI lending, would in turn constrain leverage and risk-taking, as it would affect a wide range of households across the intensive and the extensive margin. Additionally, evidence of aggressive contraction in overall mortgage pricing at banks (i.e. to both fees and mortgage spreads) or a simultaneous loosening of price and non-price credit conditions could be early warning indicators of rapid credit growth.

While this paper shows that changes in price and non-price credit supply conditions at banks can have different implication on mortgage debt, further research is needed to identify the nature of credit supply shocks that fuel these changes in credit conditions. This is important to understand the financial system dynamics that drive mortgage debt accumulation.

Appendix

A. Symmetry of the impact of credit supply conditions across time

The relationship between credit supply conditions and debt may be dependent on the overall state of the economy, even after demand factors are controlled for. For instance, it is possible that banks change credit supply conditions with a different frequency in the aftermath of financial downturns compared to normal times. Uncertainty about future profitability following a bust is one example why banks may be less willing to translate positive credit supply shocks into changes in credit conditions and hoard funds instead. Additionally the elasticity of debt out of changes in credit supply conditions may be larger immediately after a crisis, compared to other periods. That is because, after financial distress, credit supply may dry up, reducing credit access for households who use borrowing to smooth consumption or invest. As such, when credit supply loosens again, households may be in a rush to borrow to compensate for lost opportunities, compared to normal times when credit access is more widely available and hence marginal improvements in credit supply are less valuable.

To test these hypothesis, I re-run Equation 2 and Equation 3 splitting the sample in 2010 Q2. Loan approvals begin to stabilize in mid-2010 after a persistent fall following the financial crisis. This approach allows me to compare the effects of credit supply conditions on the intensive and the extensive margin in the aftermath of the crisis, with those obtained in more normal periods. The results are shown in Table 13 against those obtained using the full sample.

Examining the impact of credit supply conditions on the intensive margin (Columns 1-3), reveals three notable differences between the sub-sample analysis and the full-sample results. First, the impact of price credit conditions on debt is conditional on the state of the economy. In the immediate aftermath of the crisis, a loosening in spreads has no statistical effect on debt, suggesting that households might have had limited access to credit markets due to restricted quantities of credit supply. Instead, a loosening in fees has a large and negative effect on debt. A one standard deviation reduction in fees, results in nearly 2% average reduction in the principal borrowed. The impact of fees is not significant however in the subsequent period, when the price of credit affects debt decisions solely through mortgage spreads.

Second, half of the non-price credit conditions are state-dependent. The credit indicator on loan approvals is large and statistically significant before 2010Q3 and it is nearly 0 afterwards. This suggests that the elasticity of debt out of supply shocks to overall loan approvals is larger after periods of stress when credit access is sparse. In other words, after periods when the average household has been deprived of credit, leverage will increase at a faster rate compared to periods when credit access is consistently higher. Additionally, credit availability at high LTV lending is negative and significant prior to 2010Q3 and positive but insignificant afterwards. A one standard deviation loosening in high LTV lending, reduces average debt by nearly 2%. This result is unlikely to be driven by the impact of the financial crisis on house prices, since that is controlled by the regional-time fixed effects. Hence these results highlight a lower elasticity of debt out of supply shocks to high LTV credit availability, immediately after the crisis. Put differently, households did not take full advantage of any increased supply in high-debt loans in the aftermath of 2008. As a result, even as high-debt credit became available at banks prior to 2010Q3, borrowers choose to take out lower mortgages instead of borrowing up to the maximum capacity available to them. These results suggest that supply shocks have not been the only reason why credit failed to pick up years after the crisis and that credit demand played a role as well.

The sub-sample results on the extensive margin (Columns 4-6) also reveal more dynamics compared to the full-sample analysis. Fees become an important driver of the volume of loans extended by banks after 2010Q2, but not in the aftermath of the crisis. Additionally, high LTV lending becomes positive and very significant prior to 2010Q2. This shows that a loosening in credit availability at $LTV \geq 75\%$ in the aftermath of the crisis led to an increase in the overall volume of loans. Putting these results together with those on the intensive margin, shows that an increase in high-LTV credit before 2010Q3 led to less credit to more people. This suggests that while borrowers increased access to credit markets following credit supply shocks, they remained conservative about their individual debt levels. Finally, credit supply shocks to loan approvals have a positive effect on the volume of mortgage loans after 2010Q2, but not before.

Table 13: Sub-sample analysis - split in 2010Q2

	Intensive margin regression			**Extensive margin regression**		
	2008-2010Q2	2010Q3-2018	Full-sample	2008-2010Q2	2010Q3-2018	Full-sample
	(1)	(2)	(3)	(4)	(5)	(6)
Change Fees	-0.020^{**}	-0.014	-0.012	-0.089	0.193^{**}	0.092
	(0.009)	(0.010)	(0.008)	(0.093)	(0.077)	(0.075)
Change Spreads	-0.001	0.055^{***}	0.029^{**}	0.018	0.030	-0.004
	(0.008)	(0.011)	(0.014)	(0.069)	(0.048)	(0.066)
Change High LTV credit	-0.018^{**}	0.009	0.007	0.280^{***}	0.077	0.005
	(0.009)	(0.010)	(0.009)	(0.043)	(0.080)	(0.054)
Change Low LTV credit	-0.019^{**}	-0.016^{*}	-0.025^{***}	-0.102	-0.053	0.020
	(0.008)	(0.009)	(0.007)	(0.097)	(0.049)	(0.049)
Change Max LTI	0.021^{***}	0.017^{**}	0.020^{***}	0.128^{**}	0.059	0.107^{**}
	(0.003)	(0.007)	(0.006)	(0.051)	(0.042)	(0.054)
Change Loan Approvals	0.015^{***}	0.004	0.007	-0.032	0.143^{***}	0.057
	(0.004)	(0.014)	(0.008)	(0.034)	(0.050)	(0.057)
Fixed effects	*All*	*All*	*All*	*All*	*All*	*All*
Controls	*All*	*All*	*All*	*All*	*All*	*All*
Observations	1,317,291	4,785,884	6,103,175	1,186	3,901	5,087
R^2	0.562	0.627	0.617	0.878	0.837	0.822

Note: *p<0.1; **p<0.05; ***p<0.01

Driscol-Kraay standard errors in brackets, clustered at bank and quarter level. In Columns 1-3, the dependent variable is *log*(L). In Columns 4-6, the dependent variable is *log*(Number of bank loans). Controls include household income, age and loan interest rates at origination.

B. Impact of excluding the lagged dependent variables

Annex B recreates the results in Table 12 once I remove the lagged proportion of loans issued at $LTV \geq 95\%$ and $LTI \geq 5$ from the list of independent variables. As expected, the coefficient estimates are generally higher, but the direction of estimates remains broadly unchanged.

Table 14: Split by borrower indebtedness with no lagged dependent variables - extensive margin

	Dependent variable:			
	Loans with LTV$\geq$ 0.95	Loans with LTV<0.6	Loans with LTI$\geq$ 4.5	Loans with LTI<3
	(1)	(2)	(3)	(4)
Change Fees	0.003	0.020***	−0.0003	0.009
	(0.002)	(0.007)	(0.002)	(0.006)
Change Spreads	−0.007**	0.005	0.007***	−0.009
	(0.003)	(0.011)	(0.002)	(0.007)
Change High LTV credit	0.001	−0.004	0.002	−0.002
	(0.002)	(0.009)	(0.002)	(0.006)
Change Low LTV credit	−0.001	0.023***	−0.006***	0.020***
	(0.002)	(0.005)	(0.002)	(0.004)
Change Max LTI	0.001	−0.016***	0.001	−0.001
	(0.002)	(0.006)	(0.002)	(0.004)
Change Loan Approvals	−0.001	−0.003	0.001	−0.004
	(0.002)	(0.007)	(0.002)	(0.005)
Fees*Spreads	0.002	−0.0004	0.0002	−0.009
	(0.003)	(0.009)	(0.003)	(0.008)
High LTV credit*Spreads	0.011***	−0.006	−0.002	0.003
	(0.003)	(0.009)	(0.002)	(0.006)
Low LTV credit*Spreads	0.004	−0.014	−0.003	0.0003
	(0.004)	(0.009)	(0.003)	(0.007)
Max LTI*Spreads	−0.002	−0.008	0.003**	−0.012***
	(0.002)	(0.006)	(0.001)	(0.004)
Loan Approvals*Spreads	−0.011**	−0.0004	0.005***	−0.006
	(0.005)	(0.012)	(0.002)	(0.007)
Fixed effects	Regional Time & Bank	Regional Time & Bank	Regional Time & Bank	Regional Time & Bank
Controls	*All*	*All*	*All*	*All*
Observations	5,230	5,230	5,230	5,230
R^2	0.479	0.759	0.548	0.752

Note: *p<0.1; **p<0.05; ***p<0.01

Driscol-Kraay standard errors in brackets, clustered at bank and quarter level. In each column, the dependent variable is the number of loans extended at high debt multiples divided by the total volume of loans issued by a bank in a given quarter and region. The lagged proportion of loans with LTV$\geq$ 0.95 and with LTI$\geq$ 5 have been removed as independent variables. Controls include mean income, mean age and mean loan interest rates at origination across households within a bank, region and quarter.

C. Applying inverse hyperbolic sine transformation

This Annex uses an inverse hyperbolic sine as an alternative transformation for the dependent variable used in Table 12. This allows me to re-run the analysis using the absolute number of mortgage loans extended at high LTV and high LTI ratios as a dependent variable. To reduce the approximation error under the inverse hyperbolic sine, it is important to have dependent variables where the number of observations below 10 is minimised (Bellemare and Wichman [2020]). To increase the number of observations with high-LTV and high-LTI ratios, I split loans by LTV and LTI quartiles. I then assess the impact of credit supply conditions on the number of loans extended to highly levered borrowers (i.e. with both LTV or LTI ratios in the top quartile) or to low-levered borrowers (i.e. with LTV and LTI ratios in the bottom quartile). The results are consistent to those in Table 12. Mortgage lending to the extensive margin (Column 1) responds strongly and positively to changes in credit availability at high debt multiples and to changes in total mortgage costs (i.e. simultaneous changes in fees and spreads). In contrast, mortgage lending at lower debt levels is strongly correlated to changes in product fees.

Table 15: Split by borrower indebtedness - extensive margin

	Top debt quartile	Bottom debt quartile
	(1)	(2)
Change Fees	0.048	0.181***
	(0.068)	(0.069)
Change Spreads	0.041	0.013
	(0.078)	(0.072)
Change High LTV credit	0.024	−0.018
	(0.059)	(0.063)
Change Low LTV credit	−0.053	0.085*
	(0.047)	(0.050)
Change Max LTI	0.141**	0.068
	(0.057)	(0.049)
Change Loan Approvals	0.045	0.039
	(0.059)	(0.064)
Fees*Spreads	0.197**	0.128
	(0.094)	(0.094)
High LTV credit*Spreads	0.027	0.002
	(0.062)	(0.073)
Low LTV credit*Spreads	−0.014	−0.032
	(0.068)	(0.062)
Max LTI*Spreads	−0.048	−0.064
	(0.058)	(0.062)
Loan Approvals*Spreads	0.021	−0.039
	(0.078)	(0.078)
Fixed effects	Regional Time & Bank	Regional Time & Bank
Controls	*All*	*All*
Observations	5,087	5,087
R^2	0.815	0.823

Note: *p<0.1; **p<0.05; ***p<0.01

Driscol-Kraay standard errors in brackets, clustered at bank and quarter level. In each column, the dependent variable is the number of loans extended at high debt multiples divided by the total volume of loans issued by a bank in a given quarter and region. For both columns, the dependent variable is obtained using $log\left(y+\sqrt{1+y^2}\right)$. The dependent variable in column 1 is the number of loans extended to borrowers with either LTV ratios or LTI ratios in the top quartile for a given quarter (i.e. those with high levels of debt on at least one dimension). The dependent variable in column 2 is the number of loans extended to borrowers with both LTV and LTI ratios in the bottom quartile for a given quarter (i.e. those with low levels of debt relative to both income and collateral). Controls include mean income, mean age and mean loan interest rates at origination across households within a bank, region and quarter.

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