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Changes in the mortgage market post 4.5 limit on loan to income ratios

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1 Executive Summary

1.1. Background

The June 2014 Financial Stability Report noted that the recovery in the UK housing market over that year was linked to a rise in the share of mortgages extended at high loan to income (LTI) ratios (Bank of England (2014)). Increased household indebtedness may be associated with a higher probability of household defaults, which cause economic instability and the risk of financial crisis. It may also be associated with a sharp fall in consumer spending after a negative shock, leading to subdued economic activity and macroeconomic volatility. In June 2014 the Financial Policy Committee (FPC) recommended that the Financial Conduct Authority (FCA) and the Prudential Regulation Authority (PRA) '*ensure that mortgage lenders do not extend more than 15% of their total number of new residential mortgages at Loan to Income ratios at or greater than 4.5*' (Bank of England (2014)). This recommendation is commonly referred to as the 'LTI flow limit'.

The core objective of the LTI flow limit is macro-prudential. It aims to reduce risks of financial instability in the economy by limiting the risk of excessive household leverage and curbing unsustainable credit growth. This in turn should ensure the integrity and good functioning of the UK mortgage market. The LTI flow limit took effect in October 2014 and applies to lenders that extend residential mortgage lending greater than £100 million per year.

1.2. Research questions

According to the November 2016 Financial Stability Report (FSR), since implementation of the recommendation, the allocation of credit across LTI ratios has changed. Lenders increased new mortgages extended at LTI ratios just below 4.5 and restricted lending at LTI ratios above 4.5 (high LTI ratios). This has resulted in 'bunching' below the 4.5 cut-off (Bank of England (2016)).

Using a unique transaction-level mortgage dataset and the difference-in-difference methodology, our objective, in this paper, is to document the changes in consumer outcomes and lenders' market dynamics in response to the recommendation. Our findings will be of interest to a wide community of policy makers and academics to help understand the impact of LTI ratio policies. The paper focuses on the following questions:

1.2.1. Redistribution consequences

a. Is there evidence that high LTI mortgages are originated for bigger loans and as a result are there any borrower compositional changes?

The LTI recommendation imposes a 15% limit on the total *number* of new mortgage sales rather than on their total *value*. This restriction on supply could result in lenders choosing to optimise their credit allocation of high LTI mortgages. Post-implementation, lenders may have incentives to extend high LTI mortgages on bigger loans, because the lender

may wish to: 1) maintain interest income; and/or 2) maintain the level of the total value of new mortgages.

We could expect to see an average increase in the loan size for high LTI mortgages post implementation. This would indicate that lenders may prefer to cater for borrowers with higher income. For example, if borrower A has an income of £10k and a borrower B has income of £20k. For an LTI ratio of 4.5 a lender offers a loan of £45k to borrower A and a loan of £90k to borrower B. To assess whether lenders cater for borrowers with bigger loans, we examine whether there is a change in the average loan size of high LTI mortgages compared to lower LTI mortgages, post implementation of the LTI flow limit.

We also consider whether the composition of borrowers at high LTI ratios has changed post implementation; this may indicate that some types of borrowers were more affected by the policy than others. For example, the FCA Guidance Consultation on the LTI recommendation outlined that young first-time buyers and applicants on sole income may be more affected by the introduction of the LTI flow limit (FCA (2014a)).

1.2.2. Price and market dynamics

a. Are there changes in mortgage price for like-for-like high LTI borrowers?

There are many mechanisms through which the price of high LTI mortgages may have been affected post-implementation. For example, the 15% constraint may have represented a negative supply shock, restricting the number of high LTI mortgages available in the market and driving prices up. Alternatively, the recommendation may have restricted competition among lenders thereby increasing the price for high LTI mortgages. For example, some lenders might have been closer to the limit and therefore had limited capacity to compete in the market for high LTI mortgages. The constraint may have also affected lenders' pricing strategies, for example, because lenders might have changed their risk attitude towards high LTI mortgages. We document whether there is any evidence of a change in mortgage price for like-for-like high LTI borrowers after the LTI flow limit was implemented.

b. Are there are changes in lenders' exposure to high LTI mortgages post-implementation and does the lender proximity to the 15% constraint drive changes in mortgage price?

Before the recommendation, lenders' exposures to high LTI mortgages, measured as the percentage of high LTI sales to their share of all mortgage sales, varied considerably. Some lenders were close to the 15% limit, but other lenders had very low proportions of high LTI mortgage sales. We examine how lenders appear to have changed their exposure to high LTI loans post-implementation and whether changes in mortgage price depends on lender proximity to the 15% constraint.

1.3. Key findings

We use a unique transaction-level dataset covering mortgage transactions from July 2012 to June 2016 to test these research questions. These are our key findings:

1.3.1. Redistribution consequences

a. The loan size for high LTI mortgages has increased and the borrower composition has changed.

The average loan size for high LTI mortgages increased by 4-7% post implementation of the LTI flow limit. For a given LTI ratio, an increase in the average loan size suggests that lenders migrated towards borrowers with higher incomes. Our results show that this change occurred at the 4.5 cut-off, which could be attributed to the FPC recommendation.

There were also changes in the composition of the high LTI borrowers. Our results indicate that these changes are also associated with the FPC 4.5 cut-off. Specifically, above the 4.5 cut-off there is:

- an increase in the proportion of home movers;
- a decrease in the proportion of first-time buyers;
- an increase in the proportion of joint income applicants;

These changes in the borrowers composition are consistent with the increase in average loan size for high LTI mortgages. Home movers and joint income applicants are more likely to have higher incomes. The average loan size for home movers, joint income applicants, first-time buyers, and single income applicants, is around £190k, £180k, £150k, and £140k, respectively. We also find evidence that high LTI mortgages have been shifted towards the regions with higher average income and house price, which is also consistent with the increase in average loan size.

1.3.2. Price and market dynamics

a. On average, the mortgage price for high LTI mortgages decreased.

After controlling for borrower, product, and lender characteristics, we find that post-implementation the price for high LTI mortgages on average decreased. The price is measured as either the initial interest rate or the Annual Percentage Rate (APR) based metric, which considers the initial interest rate and the lender fees.

b. Lenders closer to the flow limit reduced their share of high LTI mortgages and those further from the limit increased their share. Additionally, lenders who had been closer to the limit reduced mortgage price on higher LTI lending by more.

Before the recommendation lenders differed in their exposure to high LTI mortgages, measured as the proportion of their number of high LTI mortgage sales to their number of all mortgage sales. After implementation, although the overall proportion of high LTI mortgages to the total number of sales in the market stays around 10%, lenders' individual exposure to high LTI mortgages changed. Some lenders, whose share of high LTI mortgages had been closer to the 15% limit, reduced their proportion of high LTI. In contrast, some lenders that previously had a low share of high LTI mortgages increased their proportion of them. We find that lenders proximity to the 15% constraint is correlated with how strong there is a fall in mortgage price for high LTI mortgages.

1.4. Relation to the literature

This paper contributes to the literature on macroprudential tools, including maximum limits on loan-to-value (LTV), loan-to-income (LTI) and debt-to-income (DTI) ratios. Policy ratio limits (for example, maximum LTV of 85% in Sweden and 90% in Norway) are designed to protect consumers from excessive household leverage and to curb house price

appreciation; this highlights their financial stability objective. Theoretical literature has evaluated the impact of these policies and the consensus is that they restrict credit, reduce household leverage and improve loan performance (e.g. Allen and Garletti (2010)). However, there are few empirical assessments of housing macroprudential policies. Our paper is closely related to DeFusco et al (2017) analysis of the impacts of the U.S. mortgage market policy restricting excessive household leverage (DTI). Their paper evaluated the Dodd-Frank 'Ability-to-Repay' rule and its effect on the price and availability of credit in the US mortgage market.

By looking at the changes in mortgage performance our paper also contributes to the literatures on broader consumer protection (Campbell et al. (2011); Posner and Weyl (2013); Jambulapati and Stavins (2014); and Agarwal et al. (2015)). It also contributes to the literature on ex-post evaluation by looking at the changes in the UK mortgage market post-implementation of the FPC recommendation (Agarwal et al. (2012); and Agarwal et al. (2015)).

2 Policy Background

In July 2014 the FPC recommended that the FCA and the PRA '*ensure that mortgage lenders do not extend more than 15% of their total number of new residential mortgages at Loan to Income ratios at or greater than 4.5*' (Bank of England (2014)). The recommendation took effect on 1 October 2014. The FCA Guidance Consultation outlines details of the policy, but here we highlight the main aspects relevant for our research purpose (FCA (2014a)).

Not all mortgage products are in scope of the recommendation. Some categories of mortgages are excluded from the total number of mortgages completed or the percentage of mortgages completed with an LTI ratio of 4.5 or higher. Both internal and external remortgages, as well as ported products, with no increase in principal are excluded from the LTI flow limit, because they do not constitute an increase in indebtedness. Remortgages with an increase in principal are included. Non-regulated mortgages at the time of the publication of the recommendation, that is, second charge mortgages and buy-to-let mortgages, are exempt from the rule. Lifetime mortgages and equity release products are excluded, because they do not conform to this measure.

Not all mortgage lenders are in scope of the recommendation. A size threshold condition means that only large lenders qualify for the policy. The recommendation stipulates that lenders who completed more than 300 regulated mortgage contracts (excluding remortgaging with no increase in principal, lifetime mortgages, and other mortgages excluded) worth more than £100 million in 4 consecutive quarters preceding 1 October 2014 (ie from Q4 2013 to Q3 2014) are subject to the recommendation on the date the policy came into effect (ie lenders in scope on the date the policy came into effect (Condition A)).

Lenders could move in and out scope after the recommendation applies. Post-implementation of the recommendation, mortgage lenders are monitored on whether they continue to meet the size threshold of selling per annum more than 300 regulated contracts worth more than £100 million. Mortgage lenders that were not subject to the recommendation at the outset of the recommendation could move in scope if they sold over 2 consecutive rolling periods of 4 quarters more than 300 regulated contracts worth £100 million per year. They would become subject to the recommendation 2 quarters after satisfying the size threshold. Similarly, if a lender stopped selling more than £100 million worth of mortgages or sold less than 300 regulated contracts per annum over 2 consecutive rolling periods of 4 quarters, it would exit the recommendation (Condition B).

For a diagrammatic explanation of Condition A and Condition B and a worked example refer to the FCA Guidance Consultation (FCA(2014a)).

Our analysis of the Product Sales Data (PSD) regulatory returns shows that 36 mortgage lenders became subject to the recommendation from 1 October 2014 and remained in scope for the period we analyse (ie until June 2016). These 36 mortgage lenders represented 98% of high LTI mortgage lending over our data period. 10 lenders dipped in and out of the recommendation as per the Condition B. 148 mortgage lenders have never been in scope of the recommendation. Those lenders outside the scope of the recommendation account for less than 1% of all mortgage sales.

The limit applies to the number of mortgages, not the value of the mortgages. Regardless of when a mortgage offer may have been made, all mortgages at an LTI at or above 4.5 completed after 1 October 2014 were counted towards the 15% limit. The 15% limit applies to the number of mortgages completed (volumes) not to the value of mortgages completed (pound sterling basis). The limit applies at the regulated entity level, but lenders are allowed to allocate all or part of its high LTI allowance to any other regulated entity within the same group as stated in the FCA Finalised Guidance (FCA (2014b)).

The PRA does not stipulate any explicit regulatory cost associated with exceeding 15% threshold, but the FCA Guidance Consultation (FCA (2014a)) states that '*if a firm exceeds 15% or more of its total number of new residential mortgages at LTI ratios at or greater than 4.5, we may, on our own initiative, require the firm to stop entering into high LTI mortgage contracts*'.

The recommendation changed in January 2017 to accommodate seasonality. That is, firms that extend less than 15% of their total number of residential mortgages at LTI at or above 4.5 in one quarter were allowed carry over any un-used lending capacity to subsequent quarters. However, as discussed in the FCA Finalised Guidance (FCA (2017)), lenders are still not allowed to extend more than 15% of their total number of new residential mortgages at LTI at or above 4.5 over 4 consecutive quarters.

3 Data and summary statistics

3.1. Data description

The main data source for our research is Product Sales Data (PSD001). All lenders selling regulated first-charge mortgage contracts in the UK must complete this template on a quarterly basis. The dataset includes information collected at point of origination on product characteristics like: loan amount, value of the property, mortgage term, variable vs. fixed rate, initial interest rates and borrower characteristics including age, income, employment status. We complement PSD001 data with information from additional data sources. Missing interest rates are replaced with interest rates from the Product Sales Data (PSD007), which contains information on mortgage performance for all existing mortgage balances since 2015. Additional borrower characteristics like mortgage performance, credit scores, information on property type are obtained from the Credit Reference Agency data. The Credit Reference Agency data covers mortgage products available in the market from July 2012 to June 2016. Finally, where possible, the data is matched to the MoneyFacts mortgage product dataset. This includes product characteristics, borrowers' eligibility criteria, and products' effective date. The MoneyFacts dataset at our disposal covers mortgage products in the market available from 11 October 2011 to 30 November 2016.

3.2. Sample

The period of the combined dataset is from July 2012 to June 2016. Non-standard and non-regulated mortgage products are excluded from our research sample. Examples of non-standard and non-regulated mortgages are buy-to-let, lifetime mortgages, business loans and bridging loans. Mortgage products that are not subject to the recommendation are also excluded from the analysis; these are re-mortgages without an increase in principal. Excluded mortgages account for 15% of the total number of originated mortgages.

This research focuses on those mortgage lenders that have always been in scope of the recommendation. They account for about 95% of all mortgage sales and 98% of all high LTI mortgage sales over the period analysed. This 98% proportion has not changed overtime suggesting that high LTI mortgage lending has not shifted (or 'leaked') from lenders in scope of the recommendation to those outside scope. Within this sample of mortgage lenders, around 10% of all mortgage sales were at or above the 4.5 LTI ratio cut-off.

3.3. Summary statistics

Table 1 presents descriptive statistics on borrowers' main characteristics before and after implementation of the recommendation, grouped by LTI bucket.[1] The difference in composition of borrowers across different LTI buckets could be driven by various factors including regional discrepancies in income and house prices, bank internal risk policies, and regulatory environment.

The summary statistics indicate that borrowers with LTI ratios at and above 5 are very different in comparison to borrowers with lower LTI ratios and we separate these borrowers into different buckets. There are anecdotal and data evidence that some lenders have internal LTI limits. Some lenders do not lend above LTI ratios of around 4.7-4.8 and so for borrowers with LTI ratios between 4.5 and 5, we separate them into 2 buckets, [4.5-4.7) LTI bucket and [4.7-5) LTI bucket.[2]

Borrower characteristics in the LTI >=5 bucket: They are more likely to be home movers and higher income borrowers. Interestingly, the proportion of joint income borrowers is noticeably lower in this LTI bucket, suggesting that a lot of high LTI loans could be high income individuals. Mortgages in the >=5 LTI bucket have on average lower LTVs (in the mid-to-high 60p.p. compared to lower 70p.p. for all other LTI buckets) and pay lower interest rates. These individuals also take much larger loans and have higher mortgage payment to income ratio. Their credit scores are higher, which suggests that on average banks offer extremely high LTI mortgages to consumers that have lower credit risk. We find that the relationship between LTV and LTI is nonlinear- mortgages with higher LTI ratio are associated with lower LTV ratios (**Figure A in Annex**).

Borrower characteristics in the LTI buckets between 4.5 and 5: On average, they are similar to the borrowers in the LTI buckets just below 4.5. However, before the recommendation these borrowers have slightly lower average income and larger average loans. These borrowers pay on average lower initial interest rate than borrowers just below 4.5 cut-off, though their average loan to value ratio and credit scores are not very different. High LTI mortgages are not necessarily riskier. For example, on average they have the same or lower LTV, credit score and interest rates.

Trends before and after implementation of the LTI recommendation: There are some clear trends when we compare borrower characteristics before and after implementation of the recommendation. Most notably, for all LTI buckets at or above 4.5, the proportion of mortgages to home movers rises but the proportion of mortgages to first-time buyers falls. This phenomenon does not occur for mortgages in LTI buckets below 4.5. Post-implementation the proportion of joint income applicants rises across all LTI buckets, except for a small 1% decrease for bucket LTI=>5.

Table 1 also highlights that over our sample period for all LTI buckets the average mortgage term increases by around 7-13 months, the loan value increases and the

[1] The table focuses on selected borrower characteristics. We looked at other borrower and product characteristics and these summary statistics are available on request.

[2] For example, https://www.moneymarketing.co.uk/borrowers-face-mass-confusion-as-mmr-and-lti-cap-conflict/. Data tabulation also shows that some lenders have not originated mortgages above a certain LTI thresholds.

average initial interest rate falls. Some of these findings could be symptomatic of more general trends in housing markets and not related to the implementation of the LTI recommendation. We collect evidence that suggests whether this is the case in the following sections of the paper.

Regional evidence: Table A in the Annex presents the summary statistics on borrower characteristics, before and after the recommendation, by different LTI buckets and by UK statistical region (9 regions in England plus Wales, Scotland and Northern Ireland).

Some of the broader trends described above are also present in the regional findings. The LTI=>5 bucket has the lowest LTV ratios, both before and after implementation (except for Northern Ireland). And in most cases the proportion of joint income applicants is lower for the 4.5-4.7 LTI bucket and above, compared to the lower buckets (except for Northern Ireland and North East).

There are also indications of regional differences. Post implementation, lending shifted from first-time buyers (FTB) to home movers (HM) for LTI buckets at or above 4.5. This is very evident in southern UK regions (eg Greater London, South East, Eastern, South West, West Midlands, and East Midlands) and partially evident in two other regions (North West; and Yorkshire and the Humber). [3] The southern UK regions have noticeably more mortgage transactions compared to other regions, which suggests that national findings are probably dominated by these regions.

In the following section, we will discuss the distributional impacts post implementation, and also test how the aggregate composition of the borrowers across LTI ratios have changed.

[3] Greater London; South East; Eastern; South West; West Midlands; East Midlands are among the regions with the highest ratio of median house price to median gross annual earnings. ONS statistics on the ratio is available at: https://www.ons.gov.uk/peoplepopulationandcommunity/housing/datasets/ratioofhousepricetoresidencebasedearningslowerquartileandmedian (accessed in February 2018).

Table 1: Summary statistics on consumer features before and after the recommendation by different LTI buckets

LTI buckets	[3.5-3.7)		[3.7-4)		[4-4.3)		[4.3-4.5)		[4.5-4.7)		[4.7-5)		>=5	
Before/after recommendation	before	after	before	after	before	after	before	after	before	after	before	after	before	after
Proportion of home movers	43%	41%	42%	40%	40%	40%	39%	39%	39%	44%	38%	45%	45%	52%
Proportion of first-time buyers	41%	41%	44%	44%	46%	46%	49%	48%	48%	43%	51%	42%	40%	32%
Proportion of remortgagors	15%	17%	13%	15%	12%	13%	11%	12%	12%	13%	10%	12%	13%	15%
Age	36	35	35	35	34	34	34	33	34	34	33	33	35	34
Total gross income	49,049	53,753	47,067	52,143	45,229	50,098	43,784	48,248	41,951	48,953	40,408	47,660	44,343	47,271
Proportion of joint income applicants	54%	59%	50%	57%	46%	55%	48%	52%	33%	46%	26%	40%	40%	39%
Mortgage term	314	321	321	331	330	340	335	348	340	350	348	356	338	350
LTV	75%	75%	75%	76%	75%	76%	75%	74%	74%	73%	72%	71%	67%	66%
Loan value	176,469	193,399	181,016	200,654	187,382	207,647	192,760	212,520	192,747	224,921	196,108	230,828	235,359	243,624
Interest rate	3.27	2.86	3.26	2.88	3.21	2.81	3.13	2.71	3.15	2.57	3.07	2.48	2.92	2.34
Credit Score	473	478	472	477	471	477	470	477	468	477	466	477	473	478
Initial payment	873	895	880	910	892	917	900	916	894	945	890	948	1071	1004
Initial payment to income ratio	22%	20%	23%	21%	24%	22%	25%	23%	26%	23%	26%	24%	29%	26%
Number of observations	25,501	27,913	34,423	40,061	28,821	34,443	17,105	21,273	11,400	13,127	15,638	15,844	7,146	3,627

Based on mortgages originated in a 6-month window that ends 6 months before the announcement of the policy, ie originated between July 2013 to December 2013, and mortgages originated in a 6-month window that starts 6 months after implementation of the policy, ie originated between April 2015 to September 2015.

4 Redistribution consequences

The 15% limit on the number of high LTI mortgages could have triggered changes in credit allocation across LTI buckets. According to July 2016 Financial Stability Report, there is evidence of these changes happening since the implementation of the recommendation (Bank of England (2016)). On the one hand, the number of high LTI mortgages decreased, ie lenders might have started rejecting high LTI borrowers. On the other hand, the number of high LTI mortgages just below the 4.5 cut-off increased, ie lenders might have started shifting borrowers from just above to just below the FPC cut-off. If lenders rejected high LTI borrowers or shifted them below cut-off non-randomly, we are likely to observe distributional changes for high LTI mortgages.

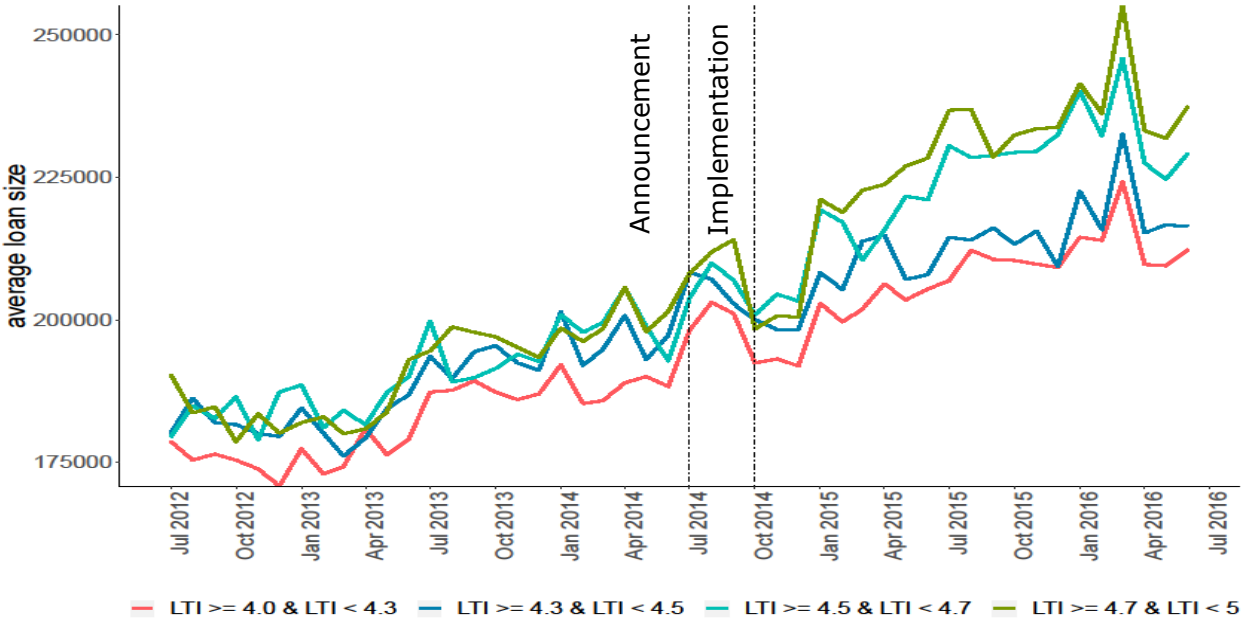
The recommendation imposes the 15% limit on the total *number* of sales rather than the total *value* of sales. Post-implementation, lenders may have incentives to lend high LTI mortgages for bigger loans, catering for borrowers with higher incomes. This strategy could reduce the impact of the 15% limit, because lenders could start substituting smaller loans with bigger loans to maintain interest income and/or the total value of new mortgages.

Figure 1 shows the average loan size before and after implementation of the recommendation for the LTI buckets [4,4.3), [4.3,4.5), [4.5,4.7), [4.7,5). Before the recommendation, the affected (ie LTI buckets [4.5-4.7) and [4.7-5)) and unaffected (ie [4-4.3) and [4.3-4.5)) buckets were moving in parallel. After implementation, there is a noticeable increase in the unconditional average loan size for the LTI buckets above the 4.5 cut-off in comparison to the trend of the average loan size for the LTI buckets below the 4.5 cut-off.

This increase in average loan size for high LTI mortgages implies that these mortgages were originated for bigger loans. For a given LTI ratio a bigger loan would be originated for a borrower with a bigger income. As the 4.5 LTI cut-off applies universally to all types of borrowers, some groups of borrowers with smaller incomes are more likely to be affected the most. For a given LTI ratio, a loan size for joint income applicants is more likely to be bigger. Sole income applicants may be more likely to be affected by the recommendation. Given the upward sloping income profiles over age, younger borrowers may be more likely to have smaller incomes and more likely to be affected by the recommendation. The first- time buyers (FTB) may be more likely to be affected by the recommendation than home movers (HM) or re-mortgagors with an increase in principle (RMTG). Before implementation of the recommendation the average income for home movers is £55,000 the average income for joint income applicants is £61,000.

Given the regional heterogeneity of income and house prices, we might see regional distributional shifts. For example, an increase in number of high LTI mortgage sales in the regions with higher income.

Figure 1. Average loan size before and after the implementation of the recommendation



The average loan size before and after the implementation of the recommendation on winsorised sample of loan values has the same pattern.

4.1. Is there evidence that high LTI mortgages are originated for bigger loans and as a result are there any compositional changes?

In this section, we use an econometric approach to determine whether high LTI mortgages are originated for bigger loans, and if so, whether there are corresponding changes in borrowers' composition or regional shifts. We are also interested in whether ex-ante risk characteristics, such as payment-to-income ratio, credit score, and LTV, have changed since the implementation of the LTI flow limit.

4.1.1. Research design and results

To formally test the changes in the outcome variable after implementation of the policy we use the difference-in-difference (DD) methodology. This compares loans in the affected buckets (LTI ratio at and above 4.5) and loans in the unaffected buckets (LTI ratio below 4.5) before and after the implementation of the recommendation.

We choose mortgages with LTI ratios [4.5, 4.7) as the treatment group and mortgages with LTI ratios [3.5, 3.7) as the control group. As has been discussed above, some lenders do not extend mortgages with LTI ratios above 4.7-4.8. The statistics in **Table 1** suggest that borrowers with LTI ratios above 5 are likely to be a very different group of borrowers. Therefore, we consider LTI bucket [4.5, -4.7) as a treatment group. These LTI buckets will be our baseline case. The recommendation is likely to have changed credit allocation

around the 4.5 threshold. To avoid contamination of the estimates from these manipulations, we do not use LTI buckets close to the 4.5 cut-off as a baseline control group. However, we carry out robustness checks using the buckets just below the 4.5 threshold, because they are more likely to be more similar to the one just below the 4.5 cut-off.

The baseline case represents mortgages originated in a 6-month window that ends 6 months before the announcement of the policy (ie originated between July 2013 to December 2013), and mortgages originated in a 6-month window that starts 6 months after implementation of the policy (ie between April 2015 to September 2015). Both periods are sufficiently far from the implementation date. We also carry out robustness checks using different intervals.

The following model is fitted to the data:

$$y_{it} = \alpha + \beta_0 1[LTI_i = [4.5,4.7)]_i + \beta_1 post_t + \beta_2 1[LTI_i = [4.5,4.7)]_i \times post_t + e_{it} \qquad (Model\ 1)$$

where y_{it} comprises of characteristics that may have changed after the recommendation was implemented. In this section, for example, these characteristics are loan value, gross income, borrower types, age, and ex-ante riskiness characteristics like credit score, payment-to-income ratio and LTV. $1[LTI_i = d]$ is a dummy variable for LTI buckets, which takes value 1 for the treatment LTI bucket $d = [4.5,4.7)$ and 0 for the control LTI bucket $d = [3.5,3.7)$. $Post_t$ is a dummy variable that takes value 0 if a mortgage is originated between July 2013 to December 2013 or 0 if a mortgage is originated between April 2015 to September 2015. The parameters are estimated by the ordinary least squares (OLS) method. It is possible that y_{it} is correlated over time, which means that error terms e_{it} are likely to be serially correlated. In this case, standard errors may lead to serious over-estimation of t-statistics and significance. Bertrand et al (2004) demonstrated importance of using cluster-robust standard errors in the difference-in-difference settings. To account for serial correlation and any area-specific random shocks, we cluster standard errors at a postcode area level in this and all following models. This approach is in line with DeFusco et al (2017). We chose property area level because it strikes a good balance in the bias-variance trade-off that arises: in many estimation problems, larger and fewer clusters have less bias but more variability (Cameron and Miller (2015)). There are around 120 area levels and these areas are quite large.

The β_2 coefficient is the parameter of interest. It measures the difference between the average change in the variables of interest in the treatment group and the average change in the variables of interest in the control group before and after the implementation of the recommendation. The estimates of β_2 coefficients for the baseline case are reported in **Table 2 Col A**.

As robustness checks, the β_2 coefficient is estimated against different time periods before and after the recommendation, using the same control and treatment groups. **Table 2 Col B** shows the estimated β_2 coefficients for a 6-month period that ends just before the announcement of the recommendation (ie from January to June 2014). Here the post-implementation period is the same as in the baseline case. **Table 2 Col C** shows the estimated β_2 coefficients for a different pre-implementation period, which is a 12-month period that ends just before implementation of the recommendation (ie from October 2013

to September 2014), and for a different post-implementation period, which starts immediately after implementation of the recommendation (ie from October 2014 to September 2015).

The house price inflation in an environment of stagnating wages could shift borrowers' demand for high LTI mortgages and change borrowers' composition. To avoid this compounding effect from the house price inflation, **Table 2 Col D** shows the estimated β_2 coefficients for a sample of English regions that experienced low house price inflation and low ratio of median house price to gross annual earnings. These regions are North East, North West, Yorkshire and The Humber, East Midlands, and West Midlands.[4] The Model **Error! Reference source not found.** is estimated for the baseline sample.

Table 2. Changes in average loan value, total gross income and borrower composition

Variable of interest	Col A Baseline specification		Col B Robustness to a different pre-implementation period		Col C Robustness to different pre- and post-implementation period		Col D Robustness to regions with low house price inflation	
Loan value, log	0.0697	***	0.0552	***	0.0424	***	0.0330	***
	(0.009)		(0.0089)		(0.007)		(0.013)	
Gross income, log	0.0702	***	0.0557	***	0.0427	***	0.0337	**
	(0.009)		(0.0089)		(0.007)		(0.01236)	
Proportion of home movers	0.0692	***	0.0590	***	0.0381	***	0.0528	***
	(0.008)		(0.0090)		(0.0066)		(0.0156)	
Proportion of first time buyers	-0.0508	***	-0.0415	***	-0.0212	***	-0.0538	***
	(0.0077)		(0.009)		(0.006)		(0.0140)	
Proportion of re-mortgagors	-0.0148	***	-0.0160	***	-0.0155	***	0.0002	
	(0.006)		(0.006)		(0.005)		(0.0097)	
Proportion of other borrowers	-0.0035	**	-0.0014		-0.0014		0.0009	
	(0.002)		(0.0015)		(0.0010)		(0.0026)	
Age	0.2559	**	0.0679		0.0564		0.6157	**
	(0.1328)		(0.1500)		(0.098)		(0.2377)	
Proportion of joint income applicants	0.0724	***	0.0967	***	0.0678	***	0.0565	***
	(0.008)		(0.0080)		(0.0057)		(0.0113)	
Payment to income ratio	-0.0095	***	-0.0096	***	-0.0073	***	-0.0061	
	(0.0007)		(0.0007)		(0.0004)		(0.0014)	
LTV	-0.0158	***	-0.0068	***	-0.0044	***	-0.0178	***
	(0.0024)		(0.0026)		(0.0017)		(0.0038)	
Credit score	3.4698	***	1.3334		0.7205		2.8002	
	(1.1135)		(1.118)		(0.7496)		(2.321)	

Standard errors are clustered at property postcode area level, in parentheses, *p<0.1; **p<0.05; ***p<0.01. Col A is the baseline case, where mortgages are originated in a 6-month window that ends 6 months before the announcement of the policy (ie from July 2013 to December 2013), and mortgages originated in a 6-month window that starts 6 months after implementation of the policy (ie from April 2015 to September 2015). Col B is a robustness check, where the pre-implementation time period is a 6-month period that ends just before the announcement of the recommendation (ie from January 2014 to June 2014) and the post-implementation period is the same as in the baseline case. Col C is a robustness check, where the pre-implementation time period is a 12-month period that ends just before implementation of the recommendation (ie from October 2013 to October

[4] ONS statistics on house prices and housing affordability are available at https://www.ons.gov.uk/economy/inflationandpriceindices/bulletins/housepriceindex/december2017#house-price-index-by-uk-local-authority-district; https://www.ons.gov.uk/peoplepopulationandcommunity/housing/bulletins/housingaffordabilityinenglandandwales/2017

2014), and the post-implementation time period starts immediately after implementation of the recommendation (ie from October 2014 to September 2015). Col D is a robustness check on a sample of regions that experienced low house price inflation. The model is estimated for the baseline sample.

The results in Col A, Col B and Col C in **Table 1** suggest that unconditional average loan size has increased by around 4-7% for the treatment LTI bucket [4.5,4.7) relative to the control LTI bucket [3.5,3.7) after the implementation took effect. Prior to the recommendation, an average loan size for LTI bucket [4.5-4.7) was around £190,000. An increase by 4-7% implies that the average loan size post implementation for high LTI mortgages, in this case in the LTI bucket [4.5, 4.7), increase by £7,600-£13,300.

As expected, the unconditional gross income has also increased similarly to the unconditional loan size by around 4-7%. For an average gross income of £40,000 it is an increase of £1,600-£2,100 per year.

The estimates of β_2 coefficient for different borrower characteristics suggest that there have been changes after the implementation of the recommendation for the treatment LTI bucket in comparison to the control bucket. The proportion of home movers increased by about 4-7%, the proportion of joint income applicants increased by about 6-10%, and the proportion of first-time buyers decreased by about 2-5%.

Like the robustness checks for the unconditional changes in the average loan size, the β_2 coefficient is estimated against different time periods before and after the recommendation and for English regions that experienced low house price inflation and low ratio of median house price to gross annual earnings. **Table 2 Col B, Col C, Col D** suggest that the results on joint income applicants, home movers, and first-time buyers are robust. Other characteristics are either not robust or the changes are not economically meaningful. For example, credit risk characteristics like credit score, payment to income and LTV in the treatment group in comparison to the control group, though in some cases statistically significant, have changed only marginally after the recommendation took effect.

The results of **Table 2** shows that there are changes in the composition of home movers and first-time buyers, as well as joint income applicants. However, to provide evidence that changes in the borrowers' composition are related to the LTI 4.5 cut-off rather than other changes in the market, we should expect that changes will show at the 4.5 cut-off point. If instead there are other market-wide impacts on borrower composition, then we should expect any changes to vary smoothly for all LTI buckets. In line with DeFusco et al (2017), we fit the following flexible DD specification:

$$y_{it} = \alpha + \beta_0 \mathrm{Post_t} + \sum_{d=3.3}^{>5} [\beta_1^d 1[\mathrm{LTI_i} = \mathrm{d}] + \beta_2^d 1[\mathrm{LTI_i} = \mathrm{d}] \times \mathrm{Post_t}] + \mathrm{e_{it}} \qquad (Model\ 2)$$

In this specification a dummy for LTI bucket [3, 3.3) is omitted so that the coefficients β_1^{d} estimate the d-specific LTI bucket change in the variable of interest relative to the loans in the omitted LTI bucket after the implementation of the policy. The model is estimated using OLS. Standard errors are clustered at postcode area level.

The results of this model are summarised in **Figure 2**, which plots β_2^{d} coefficient estimates (the coefficient for the interaction term between LTI bucket and the Post dummy) from the flexible DD specification and its 95% confidence interval. The coefficient of the baseline

LTI bucket [3, 3.3) is normalised to 0. All coefficients can be interpreted as the change in the variable of interest for a given LTI bucket following the implementation of the FPC recommendation relative to the LTI bucket [3, 3.3).

The **Figure 2A** makes clear that an economically significant increase in the proportion of home movers occurs for mortgages above the FPC 4.5 LTI cut-off. **Figure 2B** shows that there is an economically significant decrease in the proportion of first-time buyers and **Figure 2D** shows an economically significant increase in the proportion of joint income applicants for mortgages above the FPC cut-off of 4.5. **Figure 2C** shows no change in the proportion of people remortgaging above the FPC 4.5 LTI cut-off. This is in line with the findings of the simple DD approach of Model 1. These results are also robust to different time window, from the pre-implementation period of January 2014 to June 2014 and from the post-implementation period of October 2014 to September 2015. **Figure 2** shows that after implementation of the FPC recommendation, the changes in proportions of home movers, first-time buyers and joint income applicants are associated with the FPC 4.5 cut-off.

These changes in borrowers' composition are consistent with the increase in average loan size for high LTI mortgages. However, the results might not be entirely driven by the fact that these categories of borrowers (ie FTB, and single income applicants) have lower income. It could be that, even conditional on the same income and other characteristics, some groups are being offered fewer mortgages, possibly because they are perceived as riskier. To disentangle these two stories, we would need to compare borrowers that differ only in the variables of interest. This conditional analysis is outside the scope of this paper. Instead we check whether income alone could explain the compositional changes, by including it as a regressor in the baseline specification (ie Model 1). Once we include the income variable, our results show that the coefficient β_2^d for the variables of interest became smaller in absolute levels but remain statistically significant.

Furthermore, we can provide evidence that the changes in the borrowers' composition are related to the time when the FPC recommendation was introduced. This shows that the changes in the market are related to the recommendation. We plotted unconditional averages over time for the baseline control and treatment groups for selected outcomes (this is to check whether the parallel trend assumption holds which is the main assumption for the DD methodology proposed above). **Figure B in the Annex** shows that the assumption holds for loan value, proportions of home movers, first-time buyers and joint income applicants.

The test on parallel trends controls for an overall time trend and will take into account any UK specific changes in house price. However, to further check sensitivity of the above results to house prices, we run the parallel trends test on loan value and the flexible DD specification on borrowers' composition using a sample of regions with the low house price inflation (results are reported in **Figure C** and **Figure D** in the Annex). The previous findings are robust, ie the average loan size increases after the implementation of the recommendation and there are changes in the borrowers' composition beyond the 4.5 cut-off.

4.1.2. Regional analysis

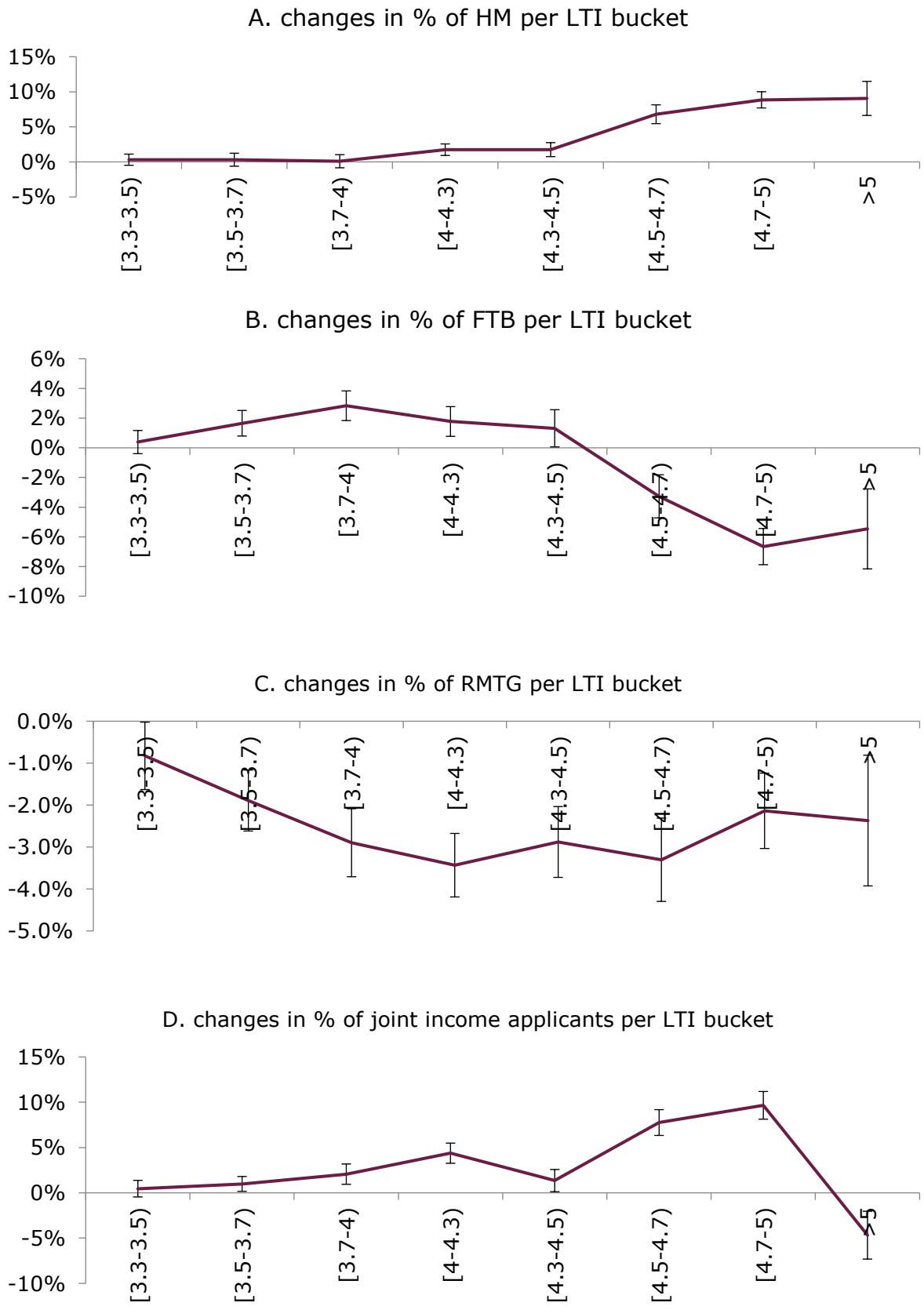
Here we explore evidence of regional heterogeneity post implementation of the recommendation. **Figure 3** shows the number of sales over time for the baseline control and treatment groups (LTI buckets [4.5, 4.7) and [3.5, 3.7)) by regions. As expected the highest sales of high LTI mortgages are in the regions of the highest average house price[5]. Interestingly, after implementation of the recommendation, the number of sales in London and the South East, which have the highest average house price in the UK and the highest ratio of median house price to median gross annual earnings, increased faster for the treatment group than for the control group. [6]

Apart from level changes, we also examined whether there is regional heterogeneity in the compositional changes of high LTIs borrowers. We provide the descriptive statistics in **Table A in the Annex.** These are categorised by region and LTI bucket, before and after the recommendation is implemented. As previously discussed in Section 3.3, the summary statistics indicate that changes in composition of high LTI borrowers might differ by regions.

[5] ONS statistics on house price index is available at
https://www.ons.gov.uk/economy/inflationandpriceindices/bulletins/housepriceindex/november2017

[6] ONS statistics on house price index is available at
https://www.ons.gov.uk/economy/inflationandpriceindices/bulletins/housepriceindex/2015-09-15

Figure 2 Flexible DD estimates of the changes in borrowers' composition



All coefficients can be interpreted as the change in the variable of interest for a given LTI bucket following the implementation of the FPC recommendation relative to the LTI bucket [3, 3.3). An economically significant change in the proportion of home movers, first-time buyers and joint income applicants happens at the FPC 4.5 cut-off. This shows that changes in the composition of borrowers are related to the LTI 4.5 cut-off rather than other changes in the market. According to the flexible DD results on loan value and gross income (in logs) an increase for the treatment groups happens at 4.5 cut-off.

4.2. Discussion

The increase in unconditional average loan size for high LTI mortgages is consistent with our observed changes in borrower composition. There are different mechanisms of how these changes may have happened, and we discuss a few in this section.

We showed that there are changes in the proportions of different types of borrowers for high LTI mortgages. However, we want to know whether it also resulted in changes in absolute levels, ie changes in number of a certain type of borrowers for high LTI mortgages. **Figure E in the Annex** shows that the number of mortgages sold with LTI bucket [3.5, 3.7) (control group) and the number of mortgages with LTI bucket [4.5, 4.7) (treatment group) move in parallel before and after the intervention. The increase in the proportion of home movers and joint income applicants between the treatment and the control groups could be interpreted as an increase in the number of such borrowers. The decrease in the proportion of first-time buyers could be interpreted as a decrease in number of such borrowers. There is some evidence that high LTI mortgages are extended more to home movers and joint income applicants and less to first-time buyers, which is partially driven by income differences between these groups.

One mechanism that reduces the number of borrower type for high LTI mortgages is lenders' direct credit rationing, either on extensive or intensive margins. The July 2016 Financial Stability Report (Bank of England (2016)) sets out evidence of redistribution of mortgages across LTI ratios, which suggests that there could be rationing of credit. Intensive credit rationing means that borrowers get smaller loans than they applied for. Extensive credit rationing means that borrowers are rejected for a loan. Rationing could make borrowers buy a smaller house, postpone their purchase until they accumulate a larger deposit, or re-apply with a different lender. Unfortunately, we do not have rejection or application data to analyse lenders credit rationing behaviour.

A second mechanism is that intermediaries may steer certain type of borrowers towards high LTI mortgages after implementation of the recommendation. We compared the redistribution results between intermediated and direct sales and they seem similar across the 2 categories.

A third mechanism is that lenders may change the menu choice, offering high LTI mortgage to certain type of borrowers. Some lenders have explicit LTI limits. For example, according to Mortgage Strategy (2017), for Barclays' "…*applicants with incomes of less than £55,000 will get income multiples of up to 4.49 x income*…". In many cases there is a lack of transparency around LTI limits for mortgage products and it is difficult to pin down changes in menu choice from available data (FCA (2018)).

The changes in average loan size and composition of borrowers for high LTI mortgages raise interesting questions. For example, whether these changes are driven solely by the 15% limit being set on the volume rather than value of sales, and whether the redistribution consequences could be mitigated if the 15% limit was instead set on the value of sales.

Figure 3 Number of sales in the baseline control and treatment groups by regions[7]

[7] The high house price regions also have the highest ratio of median house price to gross annual earnings.

5 Price and market dynamics

5.1. Are there changes in mortgage prices for like-for-like high LTI borrowers?

In addition to the distributional effects, the 15% constraint may have changed market dynamics and prices for high LTI mortgages. For example, the 15% constraint may have represented a negative supply shock, restricting the number of high LTI mortgages available to borrowers, and so may have increased prices. And, if the recommendation restricted competition among lenders, this could also lead to increased prices. On the other hand, the 15% constraint might not have been binding at all, and so mortgage prices might have been unaffected. The recommendation may have also changed lenders' pricing strategies. In this section, we document whether there are any changes in the mortgage price for like-for-like high LTI borrowers and changes in the market dynamics.

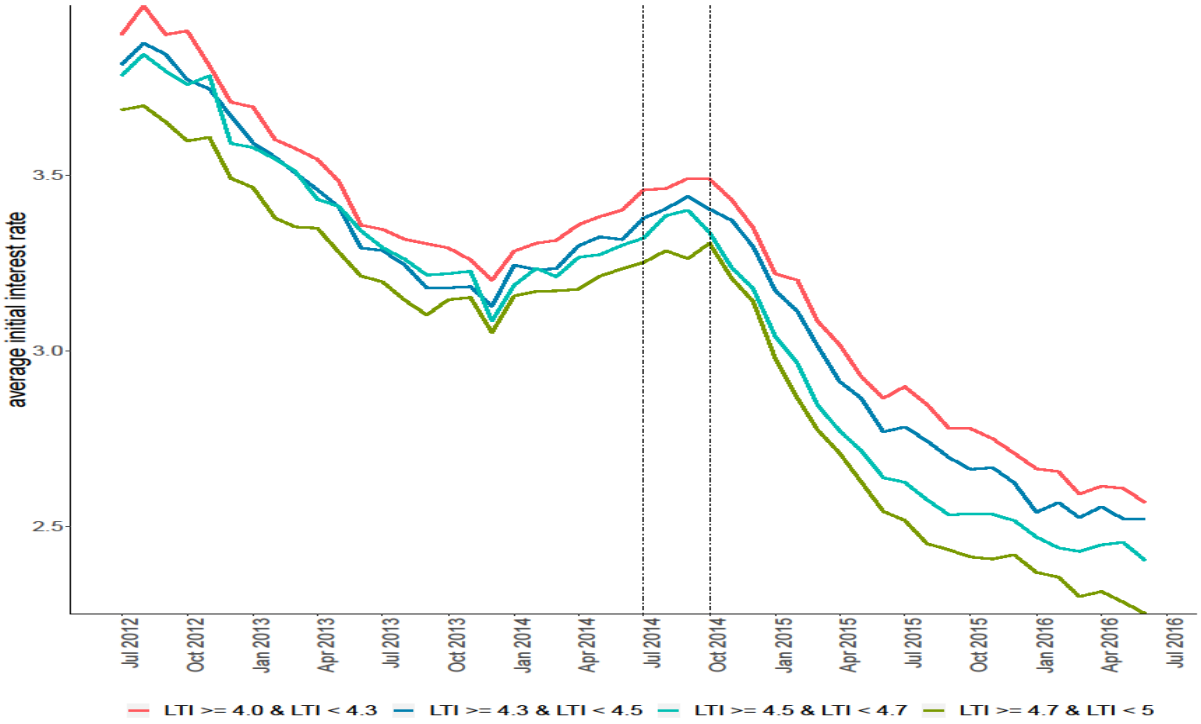
Figure 4 shows the average initial interest rate before and after implementation of the recommendation for the LTI buckets [4,4.3), [4.3,4.5), [4.5,4.7), [4.7,5). After implementation of the recommendation, there is a decrease in the unconditional average interest rate for the LTI buckets above the 4.5 cut-off in comparison to the trend of the average interest rate for the LTI buckets below the 4.5 cut-off. The figure also confirms that affected and unaffected buckets were moving in parallel before the announcement of the recommendation in July 2014, after which the trends diverge.

To assess how mortgage prices changed for like-for-like high LTI borrowers we can use a DD methodology that compares loans above 4.5 LTI and below 4.5 LTI before and after the implementation of the recommendation. Our baseline specification is a simple DD regression estimated at transaction level over the entire sample period. The following baseline regression model is estimated:

$$r_{itpk} = \alpha + \beta_1\ 1[LTI_i = [4.5,4.7)] + \beta_2\ 1[LTI_i = [4.5,4.7)] \times Post_t + X_i'\gamma + \gamma_k + \rho_p + \delta_t + \rho_p \times \delta_t + e_{it}\ (Model\ 3)$$

where r_{it} is the initial interest rate on loan i originated in month t. $1[LTI_i = d]$ is a dummy variable for LTI buckets, which takes the value of 1 for the LTI bucket d = [4.5,4.7) and 0 for the LTI bucket d = [3.5,3.7). $Post_t$ is the dummy variable takes the value of 1 if a mortgage is originated after October 2014 or 0 if before. e_{it} are error terms.

Figure 4. Average initial interest rate before and after the recommendation



The specification controls for borrower and product characteristics (X_i') – these are LTV bands, borrower age, credit score, whether a mortgage is issued based on single or joint income application, employment status of the main borrower, mortgage terms, and loan value. It also controls for time trends (δ_t is origination fixed effects) to account for any time varying changes in the market, for time invariant geographical factors (γ_k), and for factors that are specific to a lender (ρ_p). The model also includes an interaction term between credit score and LTV bands. The model is estimated using OLS. Standard errors are clustered at postcode area level.

We are interested in the coefficients β_2 , which estimates a change in an interest rate specific to the LTI bucket d relative to the control group of mortgages. To see if the price of mortgages with LTIs above 4.5 changed, we used different control groups as a robustness check. These groups are mortgages with LTI between [4.3, 4.5), [4, 4.3), [3.7, 4). The model is run on 2-year fixed mortgages, the most popular product in the market.

The DD methodology relies on the assumption of parallel trends for the control and the treatment groups before any intervention. We plot unconditional average initial interest rate over time for the baseline control and treatment groups, which are mortgages with LTI between [3.5, 3.7) and between [4.5, 4.7) respectively. **Figure F in Annex** shows that there is a parallel trend between the 2 groups before the recommendation.

The coefficients of the interaction term $1[\mathrm{LTI}_i = [4.5,4.7)]\times \mathrm{Post}_t$ for 2-year fixed interest rate mortgages is negative and statistically significant (**Table 3**). These results are robust across different control groups. The specification considers fixed effects of lenders, regions and LTV bands, as well as credit and LTV interactions fixed effects. This suggests that after the recommendation was implemented, the interest rate for mortgages with LTI ratio

between 4.5 and 4.7 was lower than the interest rate of mortgages in the control group. These results are statistically significant, and the magnitude of the coefficients suggests that the impact on the initial interest rate is around 6-8bps.

The price of the fixed rate mortgages is not only determined by the initial interest rate but also by the lender fees each consumer pays to set up their mortgage. We run the Model $Model\ 3$ on an APR based measure that calculates the mortgage cost on initial interest rate and lender fees (Belgibayeva and Majer (2018) for details on how this measure is constructed). The results are presented in **Table B in the Annex**. It shows that the APR based measure in the treatment buckets decreased relative to the control buckets after implementation of the recommendation by around 4-7 bps. Results are robust to different control buckets of the LTI.

We also provide supporting evidence that the changes in the initial interest rate for 2-year fixed mortgages are related to the LTI limit recommendation, rather than other changes in the market. Similar to Model $Model\ 3$, we fit the following flexible DD specification:

$$r_{itpk} = \alpha + \sum_{d=3.3}^{>5} [\beta_0^d\, 1[LTI_i = d] + \beta_1^d 1[LTI_i = d] \times Post_t] + \delta_t + X_i'\gamma + \gamma_k + \rho_p + \rho_p \times \delta_t + e_{it} \qquad \text{(Model 4)}$$

In this specification a dummy for LTI bucket [3, 3.3) is omitted so that the coefficients β_1^d estimate the d-specific LTI bucket change in the interest rates relative to the loans in the omitted LTI bucket after the recommendation is implemented.

The results of Model $Modell4$ for the 2-year fixed rate mortgages are summarised in Figure 5, which plots β_1^d coefficients estimates (the coefficient for the interaction term between LTI bucket and the Post dummy) from the flexible DD specification and its 95% confidence interval. The coefficient of the baseline LTI bucket [3, 3.3) is normalised to 0 so that all coefficients can be interpreted as the change in interest rates for a given LTI bucket after the FPC recommendation is implemented relative to the baseline. Figure 5 shows that a significant interest rate shift occurs for mortgages above the FPC LTI limit of 4.5

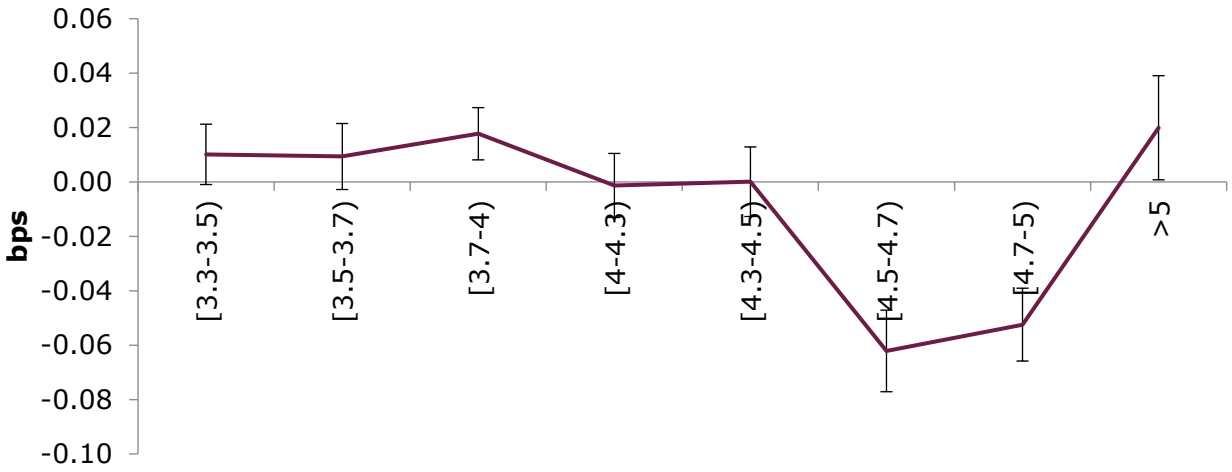
Contrary to expectations that the 15% supply restriction should drive prices up, the analysis shows robust evidence that post-implementation the average price for high LTI mortgages dropped, keeping everything else constant (based on the 2-year fixed mortgages). In the next sub-section, we analyse whether this reduction in price is associated with lenders' exposure to high LTI mortgages before the recommendation and in sub-section 5.3 we discuss alternative drivers.

Table 3. DD specification, 2-year fixed mortgage initial interest rate

Initial interest rate	Baseline: control [3.5, 3.7)		Robustness: control [3.7, 4)		Robustness: control [4-4.3)		Robustness: control [4.3-4.5)	
LTI [4.5;4.7) * Post	-0.0754	***	-0.0799	***	-0.0661	***	-0.0569	***
	(0.0081)		(0.0072)		(0.0070)		(0.0082)	
Year-month Fes	Yes		Yes		Yes		Yes	
Lender Fes	Yes		Yes		Yes		Yes	
Regions Fes	Yes		Yes		Yes		Yes	
LTV Fes	Yes		Yes		Yes		Yes	
LTV*credit score Fes	Yes		Yes		Yes		Yes	
Lender*Year-month Fes	Yes		Yes		Yes		Yes	
Adjusted R-squared	0.68		0.67		0.65		0.65	
Number of observations	108,329		142,512		130,754		96,390	

*p<0.1; **p<0.05; ***p<0.01, standard errors are clustered at property area level. These results are robust to winsorisation.

Figure 5. Flexible DD estimates of the FPC recommendation on interest rates, 2-years fixed mortgages



All coefficients can be interpreted as the change in the variable of interest for a given LTI bucket following the implementation of the FPC recommendation relative to the LTI bucket [3, 3.3). An economically significant change in the initial interest rate happens at the FPC 4.5 cut-off. This shows that changes in the initial interest rate are related to the LTI 4.5 cut-off rather than other changes in the market.

5.2. Are there changes in lenders' exposure to high LTI mortgages and does the lender proximity to the 15% constraint drive changes in mortgage price?

Before the recommendation lenders differed in their proportion of high LTI mortgages[8]. **Figure 6, Panel A** shows that mortgage lenders in scope of the recommendation were either far away from the 15% limit imposed by the FPC policy or very close to it. The figure captures the average exposure of lenders to high LTI mortgages before the recommendation and does not capture whether the 15% limit was binding at the time of announcement or implementation. The share of high LTI mortgages in total sales is averaged over quarters in the period from July 2012 to October 2014.

The 15% constraint may have affected lenders differently, or not at all. For example, mortgage lenders that were closer to the 15% limit before the recommendation could have become more cautious about their exposure to high LTI mortgages once the policy was announced, and subsequently scale back this lending. In contrast, lenders that were further away from the 15% may have interpreted the implementation of a 15% high LTI lending limit as a signal of an acceptable level of risk and increased their exposure to high LTI mortgages. Alternatively, the 15% may not have been binding for some lenders.

Figure 6, Panel B shows how lenders' exposure to high LTI mortgages varies after implementation of the recommendation. The period before implementation is from January 2013 to October 2014. Some lenders that were closer to the 15% constraint (measured by volume of sales) reduced the proportion of high LTI loans in their new sales afterwards. Other lenders that were further from the limit increased the proportion of high LTI mortgages in their new sales afterwards.

Here we would like to see whether the fall in mortgage price depended on how constrained lenders were to the 15% policy. We modify Model $\mathrm{Modell4}$ to allow the DD coefficient to vary by lenders' exposure to high LTI loans. In Model $Model\ 5$, we capture the differential impact of the policy on interest rates for those mortgages affected by the LTI limit.

$$r_{itpk} = \alpha + \beta_0\ 1[LTI_i = [4.5,4.7)] + \beta_2\ 1[LTI_i = [4.5,4.7)]\times Post_t + \beta_3\ 1[LTI_i = [4.5,4.7)]\times exposure_p + \beta_4\ Post_t\times exposure_p + \beta_5\ 1[LTI_i = [4.5,4.7)]\times Post_t\times exposure_p + \delta_t + X_i'\gamma + \gamma_k + \rho_p + \rho_p\times\delta_t + \varepsilon_{it} \quad (Model\ 5)$$

β_5 is a triple difference coefficient of the interaction term $1[LTI_i = [4.5,4.7)]\times Post_t\times exposure_p$. It measures whether the difference in the initial interest rate (r_{itpk}), before and after the

[8] To obtain lenders' exposure to high LTI mortgages, for each lender we calculate: a) the share of high LTI mortgages in total sales for each quarter in the period before the LTI recommendation was implemented; and b) average these quarterly values. These values represent lenders' average exposure to high LTI mortgages before the recommendation. The baseline calculations are based on the period from July 2012 to October 2014. Any seasonal variation should be averaged over this period. For robustness, we also calculated the measure over two time periods before the LTI recommendation was implemented (from April 2013 to March 2014; and from January 2013 to July 2014). The pairwise spearman rank correlation between these three measures is high, between 80% and 95%. This means that a lender's exposure to high LTI mortgages relative to other lenders does not vary between the three time periods.

recommendation (Post_t), between the treatment and control groups, depended on lenders' exposure to high LTI mortgages prior the recommendation ($exposure_p$).

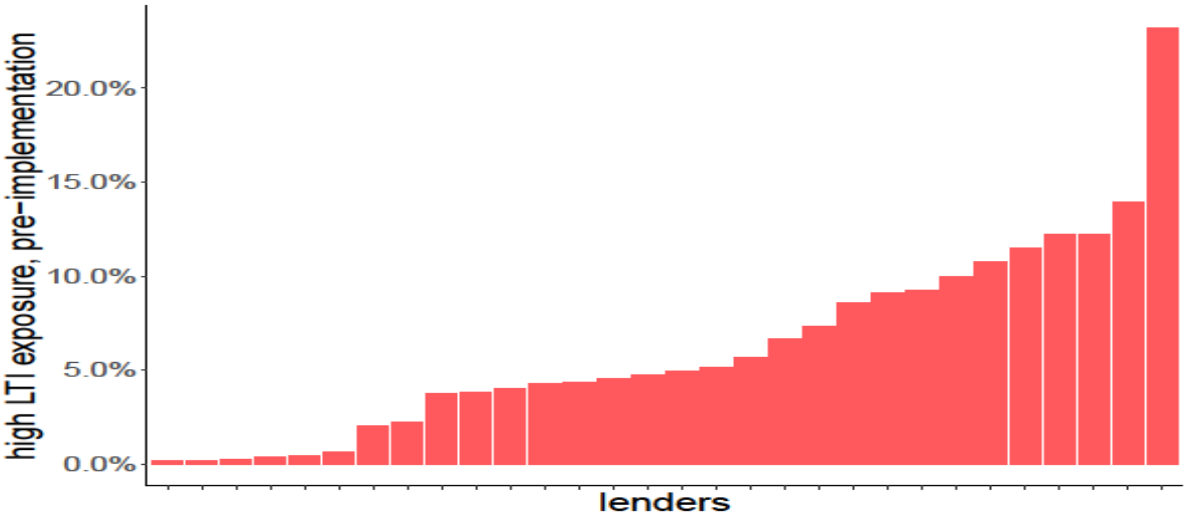
The β_5 coefficients for the 2-year fixed interest rate mortgages is negative and statistically significant (**Table 4**). These results are robust across different control groups, except the baseline case. There is some evidence that after the implementation of the recommendation, the decrease in interest rates for mortgages with LTI ratio between 4.5 and 4.7 relative to the control group is bigger for lenders that were closer to the 15% constraint and constrained by the policy.

Table 4. Triple difference specification, 2-years fixed mortgage initial interest rate

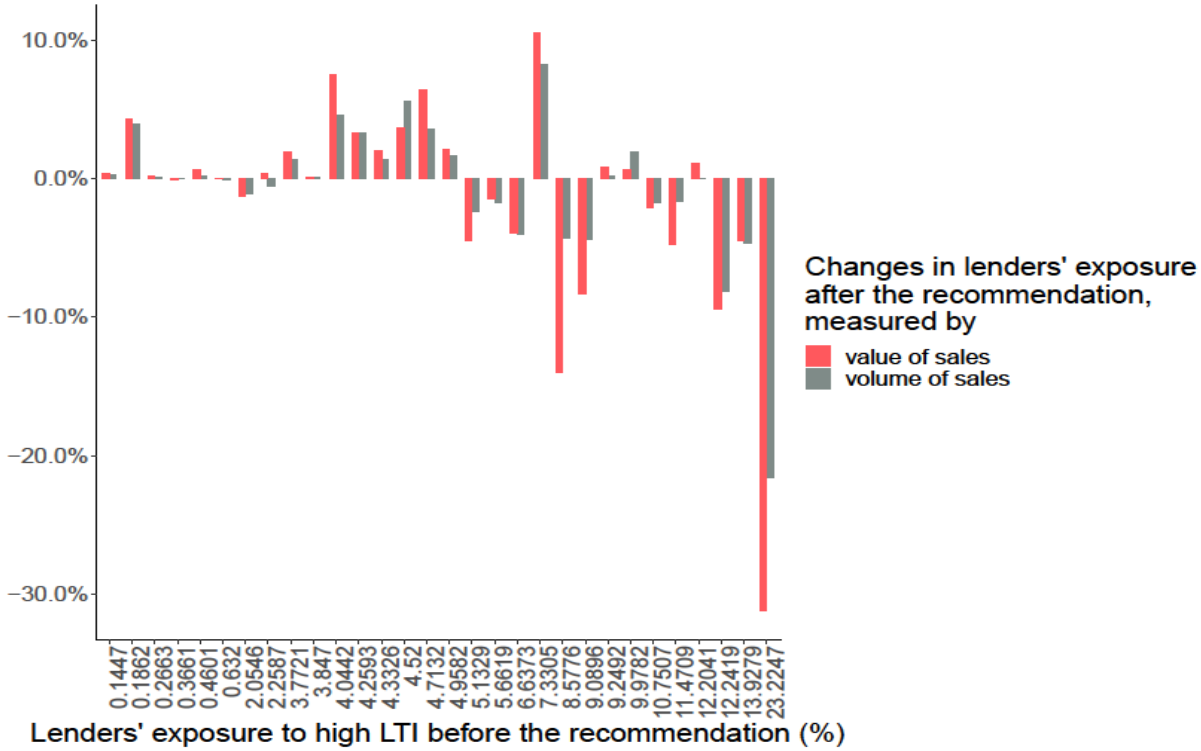
Initial interest rate	control [3.5, 3.7)	control [3.7, 4)	control [4-4.3)	control [4.3-4.5)
LTI [4.5;4.7) * Post	-0.0691 ***	-0.0491 ***	-0.0131	0.0036
	(0.0206)	(0.0174)	(0.0165)	(0.0215)
LTI [4.5;4.7) * Post*exposure	**-0.1672**	**-0.4371** ***	**-0.6259** ***	**-0.6871** ***
	(0.1990)	0.1691	(0.1592)	(0.2022)
LTV Fes	Yes	Yes	Yes	Yes
LTV*credit score FEs	Yes	Yes	Yes	Yes
Year-month FEs	Yes	Yes	Yes	Yes
Lender FEs	Yes	Yes	Yes	Yes
Regions FEs	Yes	Yes	Yes	Yes
Lender*year-month FEs	Yes	Yes	Yes	Yes
Adjusted R-squared	0.68	0.67	0.65	0.65
Number of observations	108,329	142,512	130,754	96,390

Figure 6. Average % of high LTI mortgage sales in total number of sales prior to the recommendation and its changes after the recommendation is implemented.

Panel A



Panel B



The period before implementation is from July 2012 to October 2014, the period after the implementation is from October 2014 to September 2016. % of high LTI mortgages in total number of sales (or in total value of sales) are calculated over each quarter by each lender, these values are then averaged over the quarters before and after the implementation.

5.3. Discussion

In Section 5, we analysed changes in mortgage prices for high LTI mortgages after the recommendation was implemented. The 15% constraint represents a restriction of supply, and such a negative shock should have driven up prices. However, the analysis finds the opposite effect, ie robust evidence that post-implementation prices for high LTI mortgages decreased. In this section, we discuss potential reasons for this.

We looked at the market dynamics and found that post-implementation of the recommendation some lenders whose share of high LTI mortgages had been closer to the 15% limit, reduced their proportion of high LTI mortgages and some lenders that had a low share of high LTI mortgages subsequently increased their proportion of high LTI mortgages. We also found a meaningful relationship between a lender's proximity to the 15% constraint prior to the recommendation and the fall in the mortgage price. Lenders that were closer to the 15% constraint had a larger reduction in the initial interest rate.

The decrease in the price for mortgages could also be explained by other drivers, including changes in competition, lenders' pricing strategies, and unobservable risk characteristics.

We looked at the evolution of market concentration, a proxy for competition, by identifying mortgages of different LTI buckets as a market segment, and calculating the Herfindahl-Hirschman Index (HHI) for each segment. The **Figure 7** shows the calculated HHI, which suggests that the concentration measure for mortgages with LTI bucket [4.3-4.5) and [4.7-5) fell by more compared to mortgages with LTI buckets [4-4.3). The concentration for mortgages with LTI bucket [4.5-4.7) increased. Unfortunately, these patterns cannot be reconciled with the fall in price for high LTI mortgages. If market concentration was related to the reduction in price, we would have seen a reduction in the HHI measure for the segment of mortgages with LTI above 4.5 relative to the segment of mortgage with LTI below 4.5. However, it may also be the case that the threat of increased competition in the high LTI segment, even if there was not a significant decrease in concentration, was the reason for the interest rate changes. This hypothesis needs further investigation.

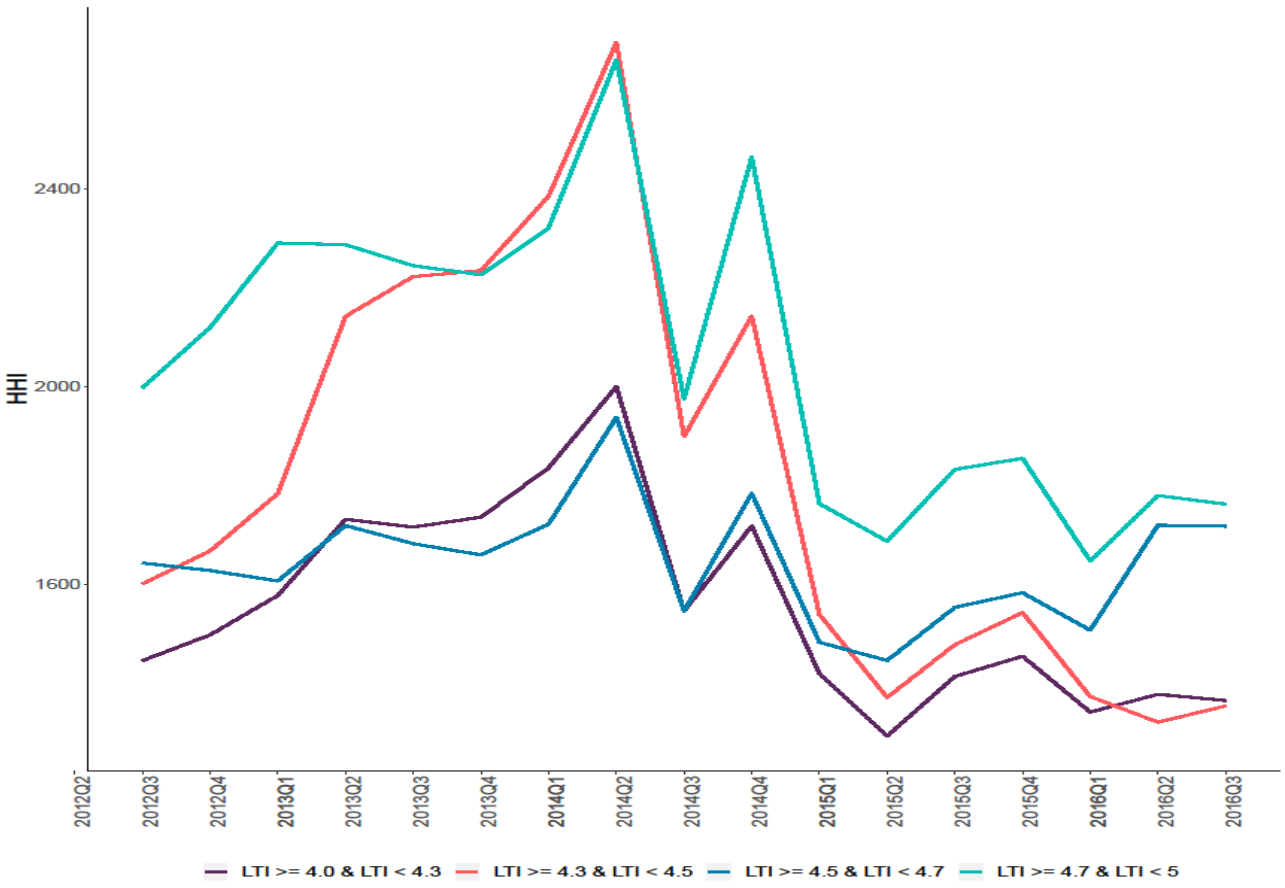
The fall in the price could not be explained by any *observable* risk characteristics or changes in borrower composition. The regression models $\mathrm{Modell4}$ and $Model\ 5$ control for difference in product, borrower, provider and regional characteristics and potential non-linearities, like LTV and credit score buckets, including their interaction effects. If we control for provider and regional characteristics only, omitting product and borrower characteristics, the fall in the initial interest rate is around 16bps compared to 6-8bps in the full models $\mathrm{Modell4}$ and $Model\ 5$. It means that borrower and product characteristics already account for about 10bps reduction in initial interest rate post-implementation of the recommendation.

Table 2 already showed that ex-ante credit risk characteristics like credit score, payment to income and LTV in the treatment group in comparison to the control group changed only marginally (towards lower risk) after the recommendation took effect. The analysis of ex-post short term performance indicators before and after the recommendation suggest no significant change in short term performance indicators for high LTI mortgages compared to the control group post-implementation (see **Table C in the Annex**, where we use the Model 4 specification, but with the dependent variables being once or twice in arrears within 6 months and 12 months since origination). However, the fall in prices could reflect

changes in unobservable borrowers' characteristics. Lenders could have become very selective and offered high LTI loans to less risky consumers on dimensions *we cannot observe*. This hypothesis matches the lack of transparency in eligibility criteria, which allows lender to choose at their discretion what type of borrowers are approved for high LTI mortgages.

Another potential explanation is that lenders changed their pricing strategies for high LTI mortgages. Accordingly, our analysis indicates a fall in mortgage price.

Figure 7. HHI by LTI buckets



6 Conclusions and limitations with the research

This paper provides evidence of changes in the market for high LTI mortgages post-implementation of the FPC recommendation. We used DD and flexible DD research methodologies and a unique mortgage transaction-level dataset to document changes in the mortgage market after the introduction of the recommendation with a particular focus on consumers. The paper finds that after implementation of the recommendation the average loan size for high LTI mortgages increased by 4-7%. This suggests that lenders originated high LTI loans for borrowers with higher incomes. As a result, we find robust evidence of changes in composition of high LTI borrowers: 1) an increase in the proportion of home movers; 2) a decrease in the proportion of first-time buyers; 3) an increase in the proportion of joint income applicants. After implementation, although the overall proportion of high LTI mortgages to the total number of sales in the market stays around 10%, lenders' individual exposure to high LTI mortgages changed. Some lenders, whose share of high LTI mortgages had been closer to the 15% limit, reduced their proportion of high LTI. In contrast, some lenders that previously had a low share of high LTI mortgages increased their proportion of them. After controlling for borrower, product, and lender characteristics, we find that post-implementation the price for high LTI mortgages on average decreased. The fall in the mortgage price was stronger for lenders that used to be closer to the 15% constraint.

There are some research limitations that might weaken the strength of our findings. We discuss our approach to overcome these limitations.

The main challenge was that other policy interventions were happening at a similar time as the FPC recommendation on LTI, making it difficult to isolate individual policy impacts. The Mortgage Market Review (MMR) rules came into effect in April 2014, 6 months before implementation of the FPC recommendation. The biggest change was that borrowers looking to take out a mortgage now had to undergo an affordability assessment. In addition to the MMR rules, in June 2014 the FPC recommended that mortgage lenders should apply an interest rate stress, when assessing borrowers' affordability (Bank of England (2014)). The affordability assessment may have a much larger effect for borrowers with LTIs of 4.5 and above than for borrowers with lower LTIs. Borrowers' affordability should be tested using reversion rate + 300bps. For a borrower with a 25-year term and a reversion rate of 4%, an LTI of 4.5 would imply a stressed Debt Service Ratio (DSR) of 35-45%. If a borrower has a stressed DSR above 35-40%, it is more likely they will fail the affordability test. Our treatment and control groups might have been affected differently by these changes and it is challenging to establish that the findings in the paper are just because of the FPC recommendation on LTI. However, the flexible DD methodology showed that changes in borrower composition and initial interest rate happened exactly at the 4.5 FPC cut-off. It is also important to note that the changes in payment-to-income ratio, which could serve as a proxy for affordability, before and after the recommendation was implemented, for high LTI mortgages changed only by 1% (**Table 2**).

There could also be an issue of potential endogeneity if, for example, the recommendation were a response to trends already happening with loans at LTI above 4.5. Besley and Case (2000) discussed an example of policy endogeneity. However, one can argue that the FPC recommendation on LTI was exogenous, because it was designed as an "insurance" policy and was not "expected to have a material impact on mortgage lending and housing transactions" (Bank of England (2014)). Nevertheless, this paper tries to address any potential issue of endogeneity by showing that changes in loan value, borrowers' composition and price happen exactly at the 4.5 cut-off (the flexible DD results in **Figure 2**) and at the time the recommendation was implemented (the test on the parallel trend assumption in **Figure B in the Annex**). This is in line with the findings of DeFusco et al (2017), and this paper closely follows their methodology. Similar to the flexible DD approach, and to avoid any contamination of the estimation due to a shift of borrowers from just below 4.5 to just above 4.5, this paper uses buckets further away from the 4.5 cut-off as a control group. We carry out further robustness checks using buckets just below 4.5 cut-off.

The government also launched the help-to-buy (HTB) scheme in October 2013 and restricted it to new mortgages with LTIs below 4.5 from October 2014. The HTB scheme was designed to help first-time buyers to buy a home or home movers with limited equity to move houses. Under the HTB scheme, buyers only needed to provide 5% of a home's value as a deposit. This scheme could have affected our control group of borrowers with LTI ratios below 4.5. That is, borrowers that previously could not afford a mortgage were more likely to enter the HTB scheme and (until October 2014) be borrowers with high LTI and LTV ratio. We checked if the scheme was affecting our findings by choosing a control group of borrowers with LTIs well below 4.5 and crossed checked the results to borrowers with LTIs just below 4.5 (flexible DD approach), and as discussed above the results are robust. Another approach was to re-run the main findings on the data excluding mortgages provided under government initiatives. However, this data field is only available after 2015.

The fast growth in house prices relative to incomes could also have affected distribution of borrowers across LTI buckets. We offset this impact by performing robustness checks on regions with low house price inflation, and by controlling for regional characteristics in our regression analyses.

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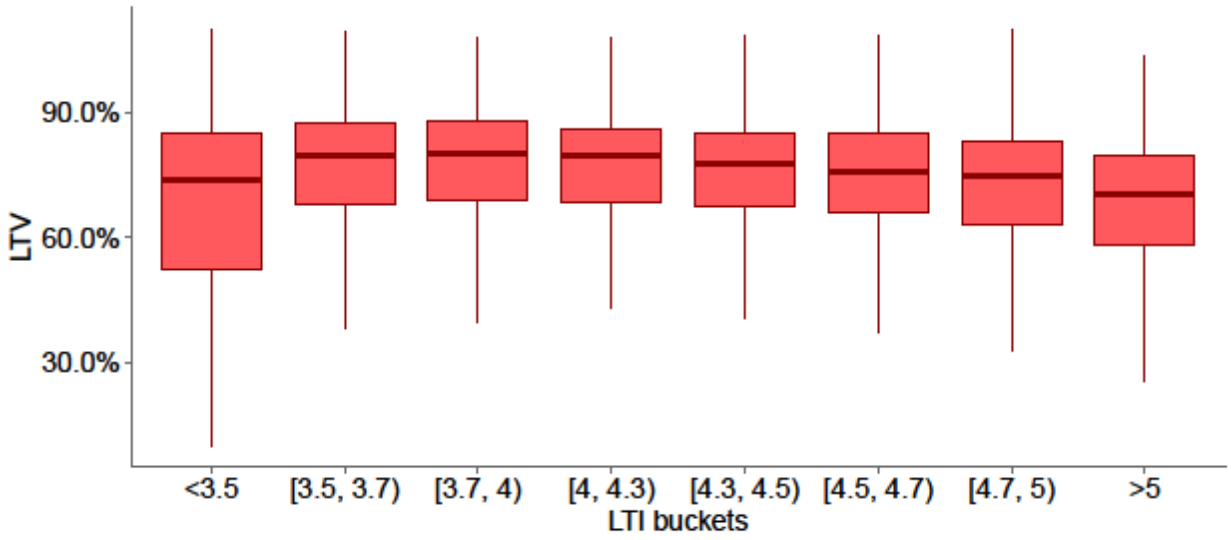
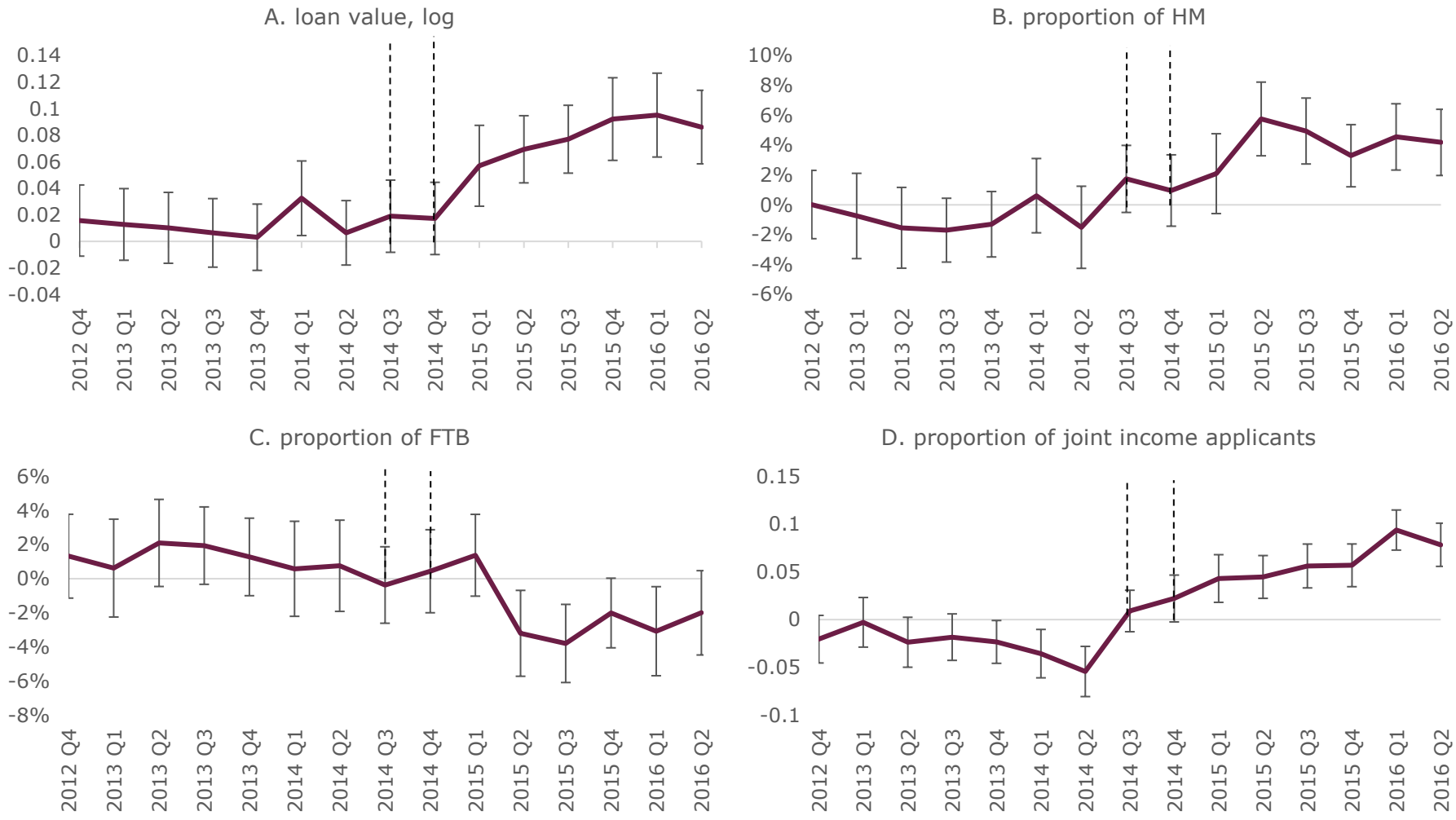
Annex

Figure A. Relationship between LTV and LTI



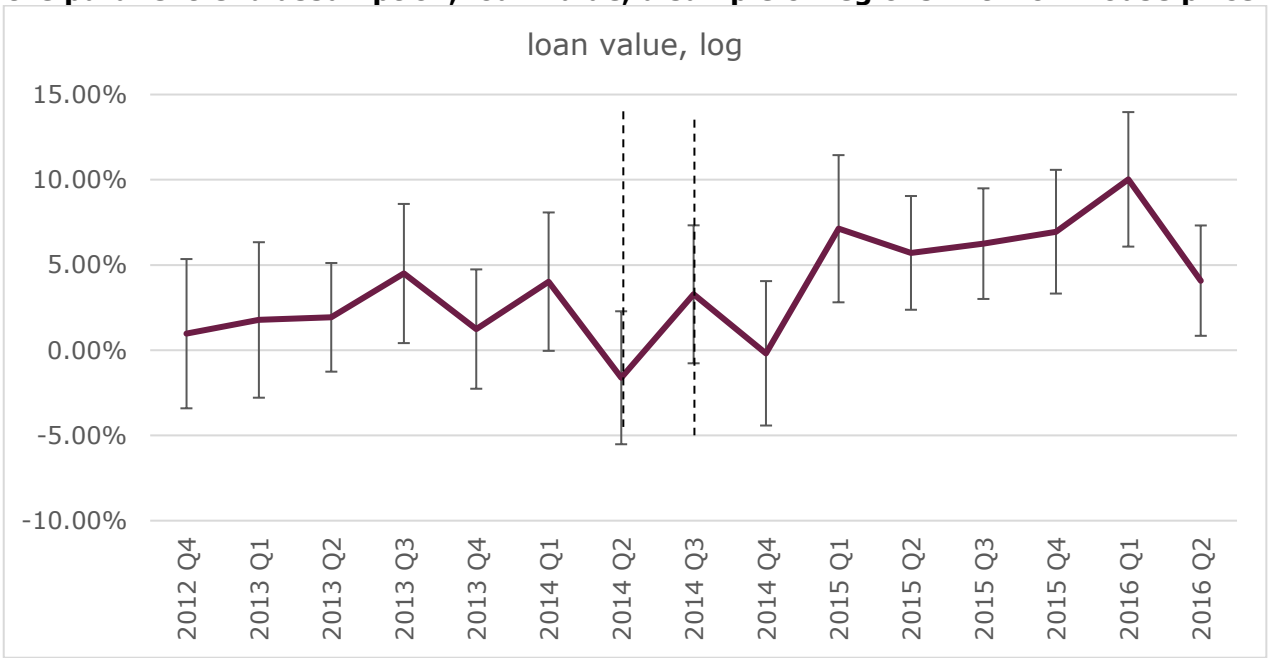
This figure shows distribution of LTVs for different LTI buckets. Relationship between LTI buckers and LTVs are nonlinear. Very high LTI mortgages (above 5) and low LTI mortgages (below 3.5) are associated with lower LTVs. Lenders balance risk of high LTIs with bigger down payment.

Figure B Testing for the parallel trend assumption, selected variables



Baseline specification where LTI bucket d=[4.5,4.7) is a treatment and LTI bucket d=[3.5,3.7) is a control

Figure C Testing for the parallel trend assumption, loan value, a sample of regions with low house price inflation



Baseline specification where LTI bucket d=[4.5,4.7) is a treatment and LTI bucket d=[3.5,3.7) is a control. Regions with the low house price inflation are North East, North West, Yorkshire and The Humber, East Midlands, and West Midlands.

Figure D Flexible DD estimates of the changes in borrowers' composition, a sample of regions with low house price inflation

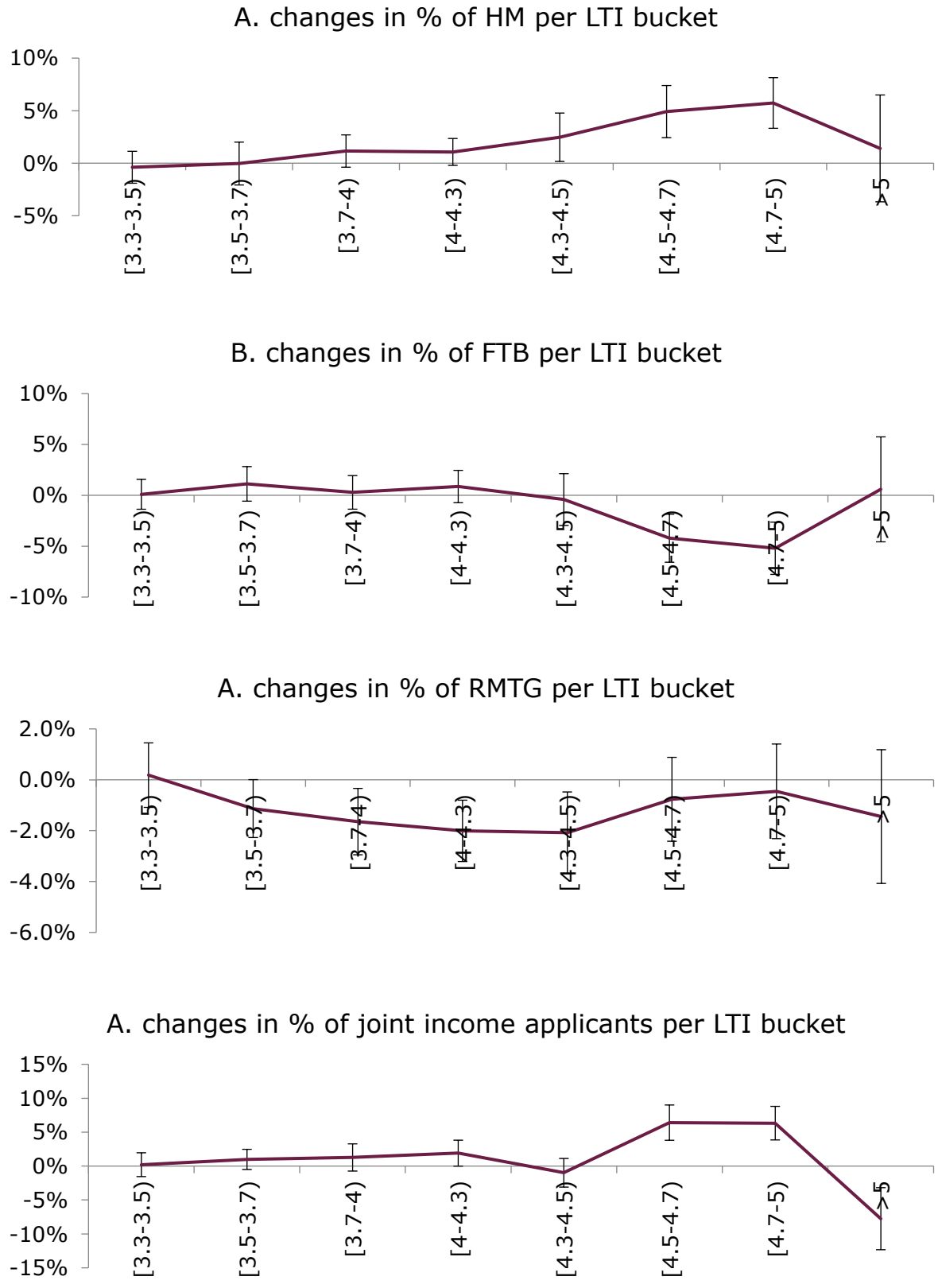


Figure E. Number of sales for the control and treatment buckets

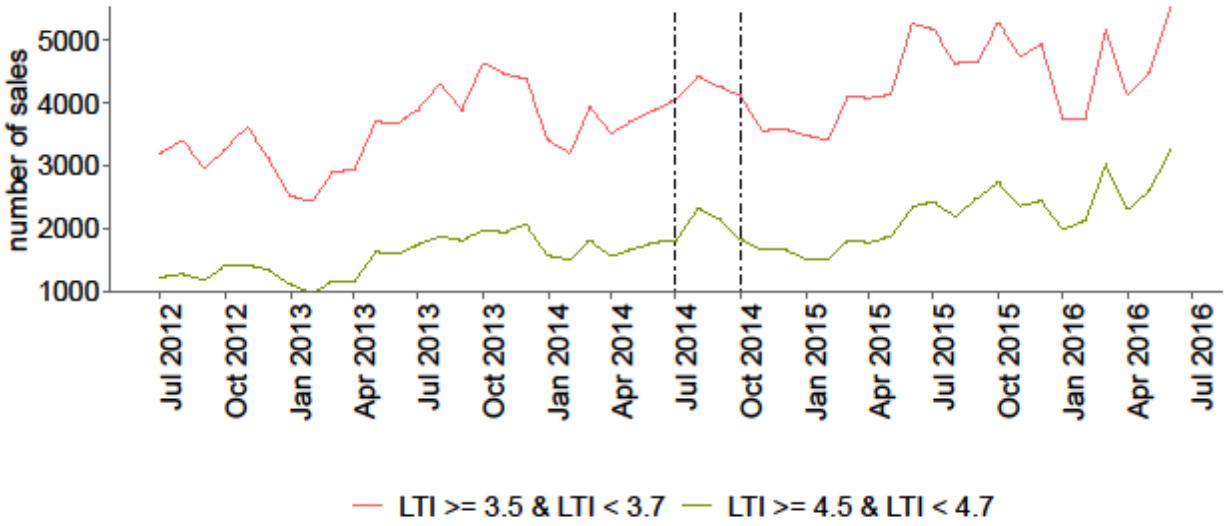
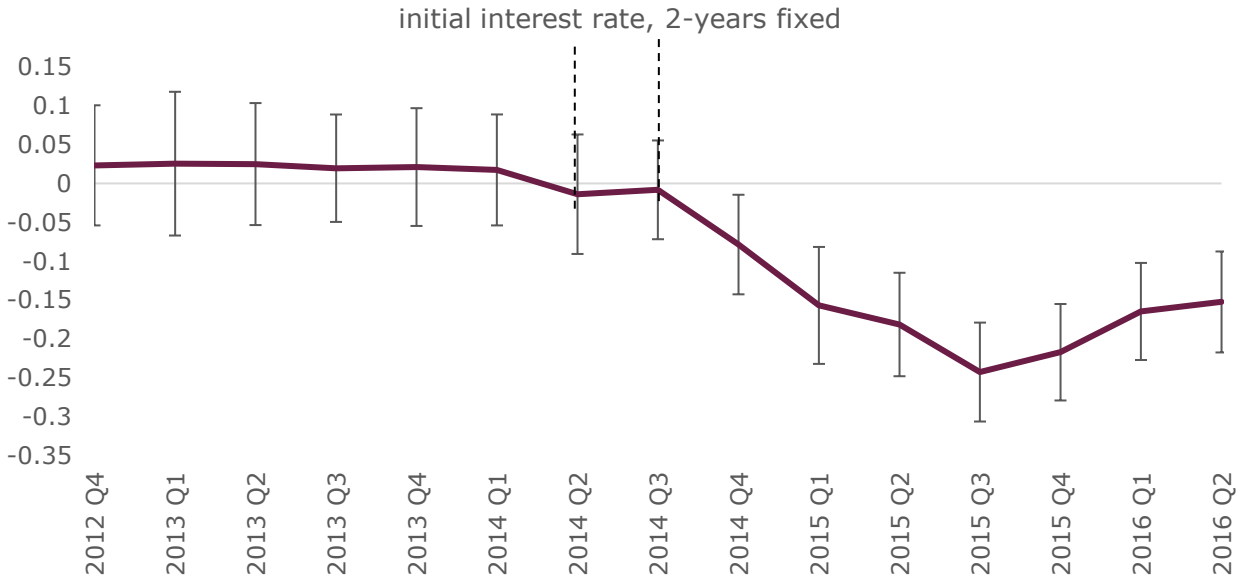


Figure F Testing for the parallel trend assumption, initial interest rate



Baseline specification where LTI bucket d = [4.5,4.7) is a treatment and LTI bucket d = [3.5,3.7) is a control

Table A. Summary statistics by regions

	3.5-3.7		3.7-4		4-4.3		4.3-4.5		4.5-4.7		4.7-5		>=5	
	before	after	before	after	before	after	before	after	before	after	before	after	before	after
Central & Greater London														
Proportion of HM	37%	34%	37%	34%	35%	34%	33%	33%	34%	38%	33%	41%	40%	48%
Proportion of FTB	44%	38%	46%	42%	50%	46%	54%	49%	52%	44%	54%	42%	46%	34%
Proportion of RMTG	17%	26%	16%	22%	14%	18%	12%	17%	13%	17%	11%	16%	13%	18%
Age	36	36	36	36	35	35	34	34	34	34	34	34	34	34
Total gross income	74,416	88,498	70,055	83,521	63,845	74,751	60,590	67,118	57,280	66,443	52,755	63,159	53,982	60,358
Proportion of joint income applicants	58%	62%	53%	61%	49%	59%	51%	57%	37%	48%	29%	43%	38%	41%
Mortgage term	309	309	314	320	322	329	328	336	330	342	337	348	337	348
LTV	71%	68%	72%	70%	72%	70%	72%	69%	71%	68%	69%	66%	64%	61%
Loan value	267,847	318,346	269,475	321,688	264,612	310,035	266,877	295,770	263,261	305,352	255,998	306,137	286,857	308,920
Initial interest rate	3.19	2.45	3.18	2.49	3.16	2.49	3.11	2.42	3.1	2.34	3	2.25	2.88	2.14
Credit score	468	476	466	475	465	473	463	472	462	470	459	472	463	473
Payment to income ratio	22%	20%	23%	21%	24%	22%	25%	22%	26%	23%	26%	23%	29%	25%
Initial payment	1311	1430	1301	1420	1258	1342	1245	1253	1227	1264	1168	1240	1294	1250
Number of observations	6,602	3,558	9,888	6,037	9,756	6,233	6,281	4,719	4,839	3,392	7,573	4,705	4,348	1,307
East Midlands														
Proportion of HM	43%	45%	42%	44%	41%	42%	39%	42%	39%	43%	37%	43%	46%	52%
Proportion of FTB	43%	41%	44%	45%	47%	49%	50%	49%	51%	46%	53%	47%	39%	35%
Proportion of RMTG	13%	13%	13%	11%	11%	9%	10%	9%	10%	11%	10%	10%	12%	11%
Age	35	34	34	34	34	33	33	33	33	33	32	32	35	33
Total gross income	37,605	42,935	34,999	39,784	32,611	37,661	31,704	35,992	29,222	34,626	27,869	33,423	29,920	33,061
Proportion of joint income applicants	48%	59%	42%	52%	36%	48%	35%	45%	20%	34%	16%	29%	28%	30%
Mortgage term	321	328	323	335	332	347	340	355	346	358	358	366	336	351
LTV	78%	78%	77%	79%	77%	79%	76%	77%	76%	77%	75%	76%	72%	72%
Loan value	135,193	154,575	134,456	152,778	135,007	156,033	139,420	158,383	134,225	159,016	135,146	161,486	159,155	171,647
Initial interest rate	3.47	3.02	3.45	3.02	3.38	2.97	3.28	2.81	3.33	2.71	3.26	2.7	3.14	2.61
Credit score	470	477	470	475	467	475	467	473	462	473	463	477	472	477

Payment to income ratio	22%	20%	23%	21%	24%	22%	25%	23%	26%	23%	26%	24%	30%	27%
Initial payment	681	720	670	699	656	695	667	686	632	670	620	674	755	736
Number of observations	3,278	2,280	4,235	3,130	3,089	2,349	1,594	1,263	1,031	685	1,222	704	381	122
	Eastern England													
Proportion of HM	46%	43%	45%	44%	43%	43%	43%	41%	44%	48%	44%	51%	51%	60%
Proportion of FTB	37%	36%	39%	39%	42%	42%	45%	45%	42%	38%	44%	36%	33%	25%
Proportion of RMTG	16%	20%	15%	17%	14%	15%	12%	13%	13%	13%	11%	12%	15%	15%
Age	36	36	35	35	35	34	34	34	34	34	34	34	36	34
Total gross income	51,217	59,464	48,323	55,950	45,323	52,367	43,552	48,731	40,719	49,332	38,565	46,331	40,668	46,698
Proportion of joint income applicants	60%	67%	56%	66%	51%	63%	49%	61%	37%	52%	29%	46%	39%	47%
Mortgage term	314	319	320	331	330	341	334	349	340	353	347	359	338	352
LTV	74%	74%	75%	75%	75%	75%	74%	74%	74%	74%	73%	72%	68%	68%
Loan value	184,334	214,068	185,942	215,333	187,772	217,126	191,615	214,635	187,126	226,638	187,218	224,432	215,249	241,057
Initial interest rate	3.34	2.76	3.32	2.83	3.3	2.78	3.2	2.72	3.25	2.57	3.16	2.48	3.01	2.31
Credit score	478	484	478	482	475	480	475	484	475	482	471	484	477	487
Payment to income ratio	22%	20%	23%	21%	24%	22%	25%	23%	26%	23%	27%	24%	29%	25%
Initial payment	924	986	918	973	904	959	907	924	879	944	866	918	991	988
Number of observations	5,055	3,182	7,162	4,971	5,919	4,529	3,590	2,927	2,296	1,813	3,077	2,173	1,284	481
	North East													
Proportion of HM	43%	39%	41%	41%	36%	44%	32%	36%	35%	47%	35%	39%	47%	47%
Proportion of FTB	43%	49%	45%	49%	52%	46%	56%	56%	56%	47%	54%	53%	32%	41%
Proportion of RMTG	13%	12%	13%	10%	11%	9%	11%	8%	8%	6%	11%	7%	17%	13%
Age	34	33	34	33	33	33	32	31	32	32	32	31	36	34
Total gross income	35,062	37,777	32,309	35,645	30,894	35,058	29,103	31,291	28,232	33,421	26,427	30,454	29,932	29,678
Proportion of joint income applicants	42%	46%	36%	44%	32%	36%	31%	30%	20%	34%	10%	21%	33%	16%
Mortgage term	322	331	327	343	332	352	348	361	348	361	363	369	329	341
LTV	78%	79%	79%	80%	77%	78%	76%	77%	77%	78%	75%	77%	70%	72%
Loan value	126,001	135,818	124,219	136,932	127,920	145,079	128,027	137,766	129,651	153,348	128,191	147,502	160,483	155,055
Initial interest rate	3.49	3.11	3.46	3.1	3.37	2.94	3.27	2.91	3.44	2.87	3.28	2.83	3.23	2.97
Credit score	470	478	470	476	465	473	463	476	464	476	460	477	479	467

Payment to income ratio	22%	20%	23%	21%	24%	22%	25%	23%	26%	24%	26%	24%	31%	30%
Initial payment	635	641	616	627	626	645	604	602	620	661	587	630	779	721
Number of observations	1,291	851	1,589	1,021	1,106	700	500	347	346	165	397	191	105	32
	North West													
Proportion of HM	39%	41%	37%	39%	36%	39%	35%	39%	34%	42%	35%	41%	48%	44%
Proportion of FTB	46%	44%	48%	49%	51%	50%	52%	51%	52%	46%	55%	48%	38%	40%
Proportion of RMTG	15%	14%	14%	11%	12%	10%	12%	9%	12%	11%	10%	10%	13%	13%
Age	35	34	34	33	33	33	33	33	33	33	32	32	35	33
Total gross income	36,720	41,489	35,245	39,300	33,428	37,045	31,287	35,123	30,784	35,250	28,412	34,231	31,928	32,165
Proportion of joint income applicants	43%	52%	39%	45%	33%	40%	33%	37%	21%	30%	14%	25%	27%	26%
Mortgage term	316	327	326	338	336	347	339	352	343	351	361	366	332	353
LTV	77%	79%	78%	80%	77%	79%	76%	77%	77%	76%	75%	75%	70%	71%
Loan value	131,990	149,150	135,365	151,048	138,377	153,418	137,601	154,674	141,427	161,857	137,877	165,498	170,696	167,453
Initial interest rate	3.49	3.09	3.48	3.12	3.4	3.01	3.33	2.87	3.34	2.81	3.28	2.76	3.15	2.67
Credit score	464	476	466	470	463	474	463	469	464	474	460	469	476	478
Payment to income ratio	22%	20%	23%	21%	24%	22%	25%	23%	26%	24%	26%	24%	31%	27%
Initial payment	669	703	674	697	672	682	657	676	671	705	625	688	817	705
Number of observations	4,034	2,731	4,942	3,485	3,622	2,576	1,785	1,278	1,205	671	1,400	696	406	165
	Northern Ireland													
Proportion of HM	34%	34%	31%	28%	27%	22%	23%	27%	26%	36%	18%	32%	10%	40%
Proportion of FTB	52%	53%	55%	62%	60%	73%	62%	63%	56%	57%	69%	64%	57%	33%
Proportion of RMTG	11%	13%	10%	10%	7%	5%	7%	10%	7%	7%	6%	4%	2%	27%
Age	34	33	33	33	32	31	31	32	32	32	31	31	31	40
Total gross income	31,321	35,573	29,084	31,999	27,308	27,499	25,485	28,875	24,744	27,989	23,455	25,605	21,762	36,695
Proportion of joint income applicants	36%	44%	34%	31%	36%	23%	31%	24%	37%	12%	26%	13%	89%	40%
Mortgage term	322	328	327	339	335	352	347	362	339	354	351	368	321	296
LTV	78%	81%	78%	81%	78%	82%	77%	77%	77%	79%	75%	75%	78%	79%
Loan value	112,612	128,030	111,609	123,097	112,926	113,752	111,962	126,781	113,733	128,188	113,802	123,585	125,953	202,149
Initial interest rate	3.52	3.14	3.44	3.2	3.4	3.25	3.36	2.86	3.59	2.88	3.35	2.76	4.14	2.82
Credit score	466	462	461	467	450	458	444	458	454	468	453	436	476	473

Payment to income ratio	22%	20%	23%	21%	24%	23%	25%	22%	27%	24%	27%	24%	37%	33%
Initial payment	565	602	546	573	545	518	526	552	568	555	547	516	663	979
Number of observations	470	353	613	404	400	255	199	124	126	74	156	56	168	15
	Scotland													
Proportion of HM	44%	41%	42%	38%	40%	40%	41%	38%	37%	37%	39%	40%	46%	42%
Proportion of FTB	44%	49%	47%	52%	50%	52%	50%	55%	51%	53%	53%	54%	39%	50%
Proportion of RMTG	11%	9%	11%	8%	10%	8%	8%	6%	11%	9%	7%	6%	10%	8%
Age	34	33	34	33	33	33	33	32	33	32	32	31	35	32
Total gross income	39,019	41,469	36,456	38,594	34,767	36,955	33,175	35,575	32,548	34,378	30,009	33,316	29,187	28,175
Proportion of joint income applicants	38%	45%	34%	37%	28%	34%	30%	28%	19%	22%	10%	13%	25%	16%
Mortgage term	317	328	323	337	331	343	340	350	342	350	355	363	326	353
LTV	76%	78%	76%	79%	75%	78%	74%	76%	74%	75%	73%	74%	72%	73%
Loan value	140,297	149,220	140,036	148,372	143,885	153,098	145,891	156,573	149,526	157,844	145,737	161,284	156,378	148,300
Initial interest rate	3.37	3.01	3.29	3.07	3.27	2.96	3.21	2.87	3.19	2.74	3.14	2.65	3.12	2.68
Credit score	470	477	471	475	469	476	468	477	465	474	465	469	469	476
Payment to income ratio	22%	20%	23%	21%	24%	22%	25%	23%	26%	24%	26%	24%	31%	27%
Initial payment	705	690	690	678	693	687	689	688	705	681	657	671	754	623
Number of observations	3,017	2,275	3,594	2,712	2,694	1,994	1,306	981	835	537	991	537	257	118
	South East													
Proportion of HM	46%	43%	45%	42%	44%	43%	42%	41%	43%	47%	43%	50%	52%	61%
Proportion of FTB	35%	33%	38%	37%	40%	41%	45%	44%	42%	38%	45%	36%	32%	24%
Proportion of RMTG	18%	23%	16%	20%	15%	16%	13%	14%	15%	14%	12%	13%	15%	14%
Age	37	37	36	36	36	35	35	34	35	35	34	34	37	35
Total gross income	56,364	65,830	52,823	62,168	49,649	57,583	46,185	53,259	44,547	51,395	41,231	48,938	43,766	46,760
Proportion of joint income applicants	62%	68%	59%	66%	55%	67%	55%	62%	42%	57%	34%	50%	46%	49%
Mortgage term	308	313	316	323	326	337	333	345	335	346	343	354	330	349
LTV	73%	72%	74%	74%	74%	75%	74%	74%	74%	73%	72%	71%	68%	66%
Loan value	202,831	236,775	203,143	239,323	205,663	238,626	203,392	234,686	204,640	236,214	200,066	237,045	231,422	240,094
Initial interest rate	3.3	2.7	3.3	2.75	3.28	2.74	3.19	2.7	3.22	2.52	3.13	2.46	2.95	2.32
Credit score	477	484	476	484	476	482	474	482	472	481	474	483	480	484

Payment to income ratio	22%	20%	23%	21%	24%	22%	25%	23%	26%	23%	27%	24%	29%	25%
Initial payment	1,026	1,099	1,004	1,092	996	1,057	965	1,019	970	997	927	979	1,082	994
Number of observations	5,397	3,283	7,750	4,993	6,861	5,066	4,213	3,379	2,876	2,188	3,951	2,741	1,740	590
	South West													
Proportion of HM	46%	44%	44%	43%	43%	43%	41%	42%	43%	49%	41%	48%	48%	55%
Proportion of FTB	37%	37%	40%	41%	42%	43%	45%	47%	43%	38%	47%	40%	35%	32%
Proportion of RMTG	16%	18%	15%	15%	14%	14%	13%	11%	14%	13%	12%	12%	15%	13%
Age	36	36	36	35	35	34	34	34	35	34	34	33	36	35
Total gross income	45,596	51,091	43,056	48,913	40,273	45,597	38,343	42,916	36,072	42,782	33,900	40,067	34,878	39,070
Proportion of joint income applicants	60%	68%	58%	65%	53%	63%	52%	57%	37%	51%	27%	42%	39%	38%
Mortgage term	312	318	320	330	329	341	336	350	339	354	351	360	340	351
LTV	73%	74%	74%	76%	75%	76%	74%	75%	73%	74%	73%	72%	68%	68%
Loan value	164,035	183,918	165,633	188,244	166,825	189,007	168,758	188,967	165,682	196,498	164,455	193,961	184,979	203,779
Initial interest rate	3.34	2.84	3.34	2.88	3.31	2.84	3.27	2.79	3.27	2.64	3.21	2.57	3.07	2.41
Credit score	478	484	476	482	475	484	475	480	472	484	471	481	478	479
Payment to income ratio	22%	20%	23%	21%	24%	22%	25%	23%	26%	23%	27%	24%	30%	26%
Initial payment	834	863	823	865	814	846	809	822	788	827	765	807	871	859
Number of observations	6,344	4,001	8,930	6,127	7,496	5,415	4,494	3,539	2,922	2,085	3,827	2,384	1,550	461
	Wales													
Proportion of HM	39%	38%	40%	36%	38%	37%	38%	34%	32%	37%	37%	36%	41%	46%
Proportion of FTB	44%	49%	45%	51%	48%	51%	52%	56%	56%	52%	53%	55%	38%	43%
Proportion of RMTG	16%	13%	15%	13%	13%	11%	9%	10%	11%	10%	9%	9%	18%	10%
Age	35	34	34	33	34	33	33	32	33	32	32	32	35	33
Total gross income	34,768	39,857	34,431	37,377	31,619	33,291	30,061	31,389	28,106	30,433	27,451	30,355	28,384	27,546
Proportion of joint income applicants	45%	49%	41%	47%	34%	39%	32%	35%	18%	25%	12%	17%	26%	18%
Mortgage term	324	334	330	344	342	351	351	364	358	361	367	372	338	359
LTV	77%	80%	78%	79%	77%	79%	78%	77%	77%	78%	75%	77%	71%	75%
Loan value	125,066	143,330	132,413	143,851	130,940	137,919	132,184	138,204	129,020	139,872	133,422	147,200	151,577	145,596
Initial interest rate	3.54	3.08	3.49	3.05	3.46	3.03	3.42	2.93	3.44	2.85	3.35	2.83	3.17	2.77
Credit score	467	466	466	474	469	473	465	471	456	462	456	477	466	471

Payment to income ratio	22%	20%	23%	21%	24%	22%	25%	23%	25%	24%	26%	24%	31%	28%
Initial payment	627	663	653	653	633	614	627	593	600	605	611	618	721	616
Number of observations	1,550	947	1,807	1,296	1,336	924	709	432	461	268	595	291	131	61
	West Midlands													
Proportion of HM	43%	43%	41%	39%	39%	40%	38%	40%	35%	42%	34%	42%	45%	47%
Proportion of FTB	43%	43%	47%	49%	49%	50%	51%	50%	53%	48%	57%	49%	42%	41%
Proportion of RMTG	14%	13%	12%	11%	11%	10%	10%	10%	11%	8%	9%	8%	12%	13%
Age	35	35	34	34	34	33	33	33	33	33	32	33	35	33
Total gross income	38,293	44,551	37,399	41,149	34,710	38,232	33,093	36,864	30,638	37,584	28,750	34,889	32,804	32,154
Proportion of joint income applicants	48%	58%	45%	52%	39%	48%	38%	42%	21%	38%	13%	31%	33%	32%
Mortgage term	314	324	322	334	331	344	337	354	342	351	357	358	328	344
LTV	76%	78%	77%	79%	77%	78%	76%	77%	75%	77%	75%	75%	71%	70%
Loan value	137,739	160,213	143,788	158,393	143,706	158,379	145,592	162,271	140,878	172,753	139,499	168,561	174,122	167,965
Initial interest rate	3.41	2.96	3.4	3.03	3.36	2.92	3.29	2.85	3.3	2.76	3.28	2.67	3.13	2.57
Credit score	466	473	467	472	465	472	463	473	462	477	458	472	467	473
Payment to income ratio	22%	20%	23%	21%	24%	22%	25%	23%	26%	24%	27%	24%	30%	27%
Initial payment	696	754	717	727	704	705	697	701	669	745	644	714	842	728
Number of observations	3381	2277	4302	3068	3427	2428	1867	1225	1159	686	1481	782	436	159
	Yorkshire and The Humber													
Proportion of HM	40%	40%	39%	42%	37%	40%	36%	39%	34%	37%	34%	43%	40%	49%
Proportion of FTB	44%	47%	47%	47%	49%	51%	51%	53%	52%	52%	57%	48%	43%	42%
Proportion of RMTG	15%	13%	13%	11%	13%	9%	12%	8%	13%	10%	8%	8%	14%	8%
Age	34	34	34	33	33	32	32	32	32	32	31	32	34	33
Total gross income	36,028	39,704	33,329	37,826	32,233	36,006	30,121	34,717	28,996	33,368	27,373	32,556	28,578	30,564
Proportion of joint income applicants	45%	52%	40%	48%	35%	43%	30%	42%	19%	31%	14%	27%	31%	25%
Mortgage term	320	328	328	338	335	348	344	359	352	353	364	366	338	359
LTV	77%	79%	78%	80%	77%	79%	76%	78%	77%	76%	75%	76%	72%	72%
Loan value	129,627	142,885	128,010	145,432	133,472	149,073	132,555	152,859	133,253	153,249	132,666	157,193	154,083	160,944
Initial interest rate	3.47	3.03	3.45	3.1	3.38	2.99	3.32	2.94	3.33	2.79	3.21	2.73	3.15	2.61
Credit score	468	475	467	475	467	473	464	472	464	478	457	477	475	485

Payment to income ratio	22%	20%	23%	21%	24%	22%	25%	23%	26%	24%	26%	24%	31%	27%
Initial payment	654	667	631	664	647	667	623	667	624	661	603	653	733	694
Number of observations	3248	2175	3955	2818	2868	1974	1447	1059	947	563	1187	584	406	116

Table B. DD specification, 2 years fixed mortgages, APR

APR on incentivised period only	control [3.5, 3.7)	control [3.7, 4)	control [4-4.3)	control [4.3-4.5)
LTI [4.5;4.7) * Post	-0.0522 ***	-0.0760 ***	-0.0571 ***	-0.0437 ***
	0.0083	0.0067	0.0068	0.0074
Year-month FEs	Yes	Yes	Yes	Yes
Lender FEs	Yes	Yes	Yes	Yes
Regions FEs	Yes	Yes	Yes	Yes
LTV FEs	Yes	Yes	Yes	Yes
LTV*credit score FEs	Yes	Yes	Yes	Yes
Lender*Year-month FEs	Yes	Yes	Yes	Yes
Adjusted R-squared	0.68	0.68	0.66	0.66
Number of observations	98,836	130,611	120,346	88,712

*p<0.1; **p<0.05; ***p<0.01, standard errors are clustered at postcode area level. These results are run on winsorised APR

Table C. Regression results, short term performance (6 and 12 months)

Dependent variable	once in arrears in 6m	twice in arrears in 6m	once in arrears in 12m	twice in arrears in 12m
LTI [4.5;4.7) * Post	-0.00086	-0.00012	-0.0014	-0.00032
	(0.00072)	(0.00014)	(0.0012)	(0.00031)
Year-month Fes	Yes	Yes	Yes	Yes
Lender Fes	Yes	Yes	Yes	Yes
Regions Fes	Yes	Yes	Yes	Yes
LTV Fes	Yes	Yes	Yes	Yes
LTV*credit score Fes	Yes	Yes	Yes	Yes
Lender*Year-month Fes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.004	-0.001	0.009	0.001
Number of observations	189,576	189,576	151,953	151,953

*p<0.1; **p<0.05; ***p<0.01, standard errors are clustered at postcode area level.

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