Mortgage Pricing and Monetary Policy*

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Abstract

Using the universe of U.K. mortgages originated during 2010-2014, we provide new evidence on lenders' mortgage pricing and how unconventional monetary policy may have affected it. Specifically, we show that lenders seek to segment the market by offering two-part tariffs composed of interest rates and origination fees, and that this two-part pricing has become more prevalent during recent periods of unconventional monetary policy, such as U.K.'s Funding for Lending Scheme. To understand the effects of lenders' pricing strategies on market equilibrium, we develop and estimate a structural model of mortgage choice and lender competition in which borrowers may have different elasticities to rates and fees. We use the estimated model to decompose the effect of unconventional monetary policy on mortgage pricing, as well as to compute the contribution of two-part pricing to lenders' profits and borrowers' surplus.

PRELIMINARY AND INCOMPLETE

COMMENTS WELCOME

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1 Introduction

Housing constitutes a main driver of business cycle dynamics and mortgage debt represents households' largest liability. In the aftermath of the Great Recession, governments and central banks around the world have sought to stimulate the economy through policies specifically designed to revamp the credit and housing markets. These include the various "credit easing" large asset purchase programmes, such as the Maturity Extension Programme and QE3 by the U.S. Federal Reserve, the Targeted Longer-term Refinancing Operations by the European Central Bank, and the Funds for Lending Scheme by the Bank of England, among others. A common goal of these unconventional monetary policies was to "enhance the functioning of the monetary policy transmission mechanism by supporting lending to the real economy" (ECB press release, 5 June 2014).

Stimulating the housing market via changes in credit conditions could be a powerful way to affect consumption and ultimately boost GDP. However, the literature as identified several frictions in the mortgage market that can impair the transmission of shocks and policies to the real economy. These include product design (Greenwald, 2018; Agarwal et al., 2017a,c), fixed versus adjustable rate contracts (Di Maggio et al., 2017; Garriga et al., 2017), household indebtedness (Cloyne et al., 2017; Baker, 2018), and market concentration (Scharfstein and Sunderam, 2016; Xiao, 2018).

This paper explores a novel channel that can affect the transmission of unconventional monetary policy to the housing sector: price discrimination through two-part tariffs composed of origination fees and interest rates. The price-discrimination literature shows that menus of products with high-fees/low-rates and with low-fees/high-rates allow sellers to segment heterogeneous buyers and to extract surplus from them (Wilson, 1993). In mortgage markets, lenders may observe some of this heterogeneity, but perhaps they do not want to/cannot directly condition their prices on some observable characteristics—e.g., gender or income. However, if this heterogeneity leads borrowers to select different loan amounts, two-part pricing is an indirect tool to price this heterogeneity. For example, richer individuals may

borrow larger amounts and, for large loans, high-fees/low-rates mortgages are cheaper than low-fees/high-rates mortgages.

We provide descriptive evidence on how lenders use this two-part pricing in the U.K. mortgage market and how unconventional monetary policy may have affected their pricing strategy. Moreover, we develop and estimate a structural demand-and-supply model with rich borrower heterogeneity to quantify the effect of unconventional monetary policy on lending rates, the total cost of borrowing, and lenders' profits. Finally, we use the estimated model to compute the welfare costs and benefits of unconventional monetary policies across lenders and borrowers in the absence of this two-part pricing strategy.

Our analysis exploits the universe of mortgages in the UK in 2010-2014. These data allow us to provide new evidence on pricing strategies in the mortgage market and how lenders segment the market with different combinations of interest rates and origination fees. We document two main facts: (i) during our sample period, lenders increased the number of combinations of rates and fees for each product type, most notably by offering many mortgages with zero fees; and (ii) on average, lenders ask for a 30-basis-points higher interest rates on mortgage products with £1000-lower origination fees. Overall, these data patterns suggest that lenders are more-actively seeking to price discriminate across borrowers using two-part tariffs over time.

The descriptive evidence motivates us to understand how borrowers choose among rate-fee pairs, and how lenders pricing depends on their funding costs. To understand these issues, we develop and estimate a model of mortgage choice and lender competition. On the demand side, borrowers, who may have different elasticities to interest rates and origination fees, make a discrete choice of the optimal product and a continuous choice of the optimal loan amount. On the supply side, lenders offer differentiated mortgage products and maximize expected profits by setting interest rates and origination fees on their mortgage products.

We identify the demand side using variation in product characteristics and borrower choices. We address endogeneity problem from the simultaneous nature of the discrete-continuous choice and from omitted variables correlated with the endogenous prices employing

a two-steps procedure. In the first step, we estimate the joint likelihood of the discrete-continuous problem with a rich set of product-market fixed effects that allow us to fully account for selection and endogeneity in mortgage pricing. In the second step, we regress the estimated product-market fixed effects on exogenous product characteristics and instrument endogenous rates with cost-shifters. We identify the supply side parameters using variation in product characteristics that affects marginal costs via default and interest-rate risks. Most notably, we exploit variation from the Bank of England Funding for Lending Scheme (FLS) to estimate the effect of unconventional monetary policy on lenders marginal costs.

We find that borrowers are less elastic to fees than to rates.

The estimated structural model allows us to quantity the effects of the Funding for Lending Scheme on household borrowing costs and lenders' profits and how two-part pricing with rates and fees affect lenders' profits and borrowers' surplus.

Literature review. This paper aims to contribute to three, quite distinct strands of literature. First, the strand of research on estimating the effects of monetary policies through credit markets and mortgages in particular.

Second, the literature on mortgages design and, more generally, consumer financial products (Agarwal et al., 2017b; Crawford et al., 2018; Buchak et al., 2018b; Egan et al., 2017; Hastings et al., 2017; Koijen and Yogo, 2016).

Third, the literature on price discrimination (Miravete, 2002; Verboven, 2002; Agarwal et al., 2017c; McManus, 2007; Luo et al., 2018; Crawford et al., Forthcoming).

Overview. The remainder of the paper is organized as follows. Section 2 describes the data sources and provides motivating evidence and empirical facts in the UK mortgage market. Section 3 describes the Funding for Lending scheme and provides reduced-form evidence on the effects on the scheme on mortgage rates and fees. Section 4 develops the demand and supply model. Section 5 describes the estimation approach and the identification strategy. Section 6 describes the estimates from the counterfactual exercises. Section 7 concludes.

2 Data and Motivating Patterns

Our analysis combines different sources of data that we introduce in this Section. We begin by describing salient features of the supply side exploiting a rich dataset that reports the universe of contracts offered by all lenders in the U.K. mortgage market. We use these data to show how lenders use two-part pricing with interest rates and origination fees to segment the market. Finally, we present descriptive statistics on the choice sets of mortgage products over the sample that we will use in Section (5) to estimate our structural equilibrium model of the mortgage market.

2.1 Mortgage Products and Pricing

The first dataset that we exploit is the Moneyfacts Residential Mortgage Analyzer, which reports the near universe of mortgage products offered in the U.K. Moneyfacts is the U.K. leading provider of personal finance data through monthly coverage of the thousands of mortgage, savings, credit card, personal loan, business banking, life, pension and investment products offered by virtually every Bank and Building Society in the U.K. financial industry.

For each lender and mortgage product, we observe multiple characteristics, including loan-to-value (LTV) band, maximum advance and loan-to-income ratio, borrower type (i.e., first-time buyer, home-mover, or remortgager), rate type (i.e. fixed versus adjustable rate), fixed-term duration, maturity, initial interest rate and, crucial for our analysis, the origination fee. We define a product type as a combination of three features: (i) interest rate type with fixation period; (ii) lender; and (iii) maximum loan-to-value ratio. This definition builds on the fact that U.K. mortgage pricing depends essentially on two key variables: the loan-to-value, which captures default risk, and the fixation period, which captures interest rate risk (Best et al., 2018; Benetton, 2018).[1] We define a product as the combination of a product type and a pair of associated rate/fees.

[1] A regression of the loan-level rate on interacted product type-month fixed effects and the corresponding fee explain more than 90 percent of the variation.

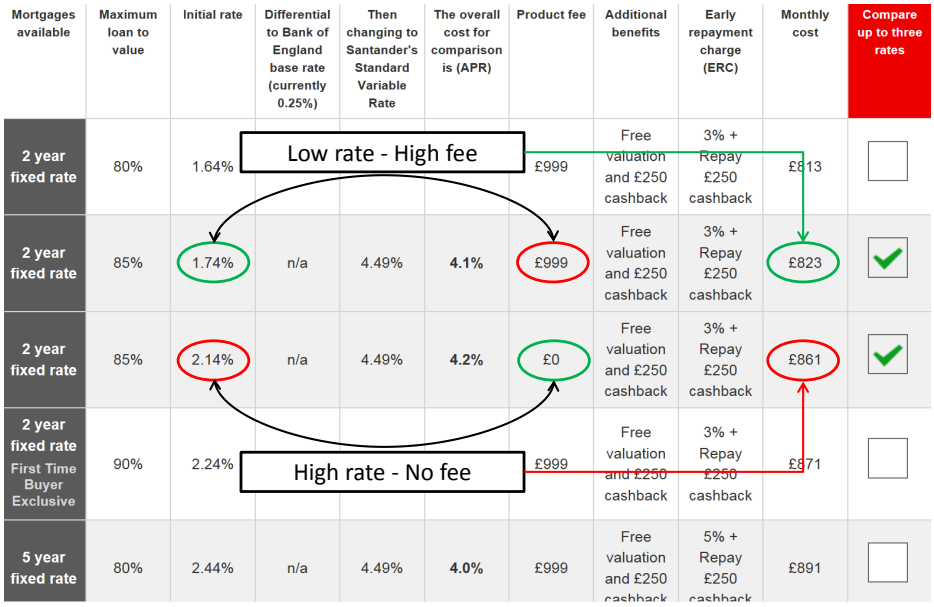
Table 1: Summary Statistics from Moneyfacts

	mean	sd	p50	min	max
Panel A: Products					
Products by month (#)	2560.66	484.61	2531.00	1538.00	3558.00
Product types by month (#)	919.17	124.42	924.00	642.00	1117.00
Products by type/month (#)	2.79	2.48	2.00	1.00	24.00
Lenders by month (#)	18.17	0.59	18.00	17.00	19.00
Products by lender/month (#)	140.93	104.95	114.00	10.00	720.00
Product types by lender/month (#)	50.59	15.65	50.00	6.00	87.00
Panel B: Prices					
Rate (%)	3.85	1.08	3.74	1.49	6.99
Fee (£)	702.33	551.84	875.00	0.00	2999.00

Note: Summary statistics of the main variables used in the analysis. Sample: 2010-2014. Source: Moneyfacts Residential Mortgage Analyzer.

Table 1 illustrates the richness of this dataset. Panel A reports the number of total products and product types, per month and per lender. Panel B reports initial rates and origination fees. The first two columns report average values and standard deviations, the next three columns report median, minimum, and maximum values.

The first row of Panel A reveals that, in a typical month, there are more than 2,500 residential mortgage products on offer in the U.K. The second row reports that the number of product types per month exceeds 900. We remind that we define a product as the combination of a product type and a pair of associated interest rate/origination fee; the third row reveals that the typical product type exhibits an average of 2.79 multiple fee/rate quotes—e.g., a high-fee/low-rate product, a medium-fee/medium-rate product, and a low-fee/high-rate product. Figure 1, taken by website of a major lender, displays a typical example of a lender offering the same product type—i.e., identical fixed term, maximum LTV, additional benefits and early repayment charges—at two distinct fee/rate quotes. The fourth row reports the number of lenders, which is very stable over our sample, between 17 and 19, with a typical lender offering an average of about 140 products (fifth row) and around 50 product types (sixth row) per month. Finally, the two rows of Panel B describe the large variation in rates and fees. More specifically, the initial interest rates associated



Mortgages available	Maximum loan to value	Initial rate	Differential to Bank of England base rate (currently 0.25%)	Then changing to Santander's Standard Variable Rate	The overall cost for comparison is (APR)	Product fee	Additional benefits	Early repayment charge (ERC)	Monthly cost	Compare up to three rates
2 year fixed rate	80%	1.64%				£999	Free valuation and £250 cashback	3% + Repay £250 cashback	£813	
2 year fixed rate	85%	1.74%	n/a	4.49%	**4.1%**	£999	Free valuation and £250 cashback	3% + Repay £250 cashback	£823	✓
2 year fixed rate	85%	2.14%	n/a	4.49%	**4.2%**	£0	Free valuation and £250 cashback	3% + Repay £250 cashback	£861	✓
2 year fixed rate First Time Buyer Exclusive	90%	2.24%				£999	Free valuation and £250 cashback	3% + Repay £250 cashback	£871	
5 year fixed rate	80%	2.44%	n/a	4.49%	**4.0%**	£999	Free valuation and £250 cashback	5% + Repay £250 cashback	£891	

Figure 1: Product Definition

Note: Snapshot from the website of a large lender on offered mortgages with a fixed initial rate period of two years.

with the products in Panel A vary from about 1.5 percent to 7 percent, with an average of 3.85 percent, whereas the origination fees vary from zero to £2,099, with an average cost of approximately £700.

Figure 2 displays the share of products with a unique fee/rate quote and the share of products with zero fees over the period 2010-2014, uncovering two main trends. First, the share of product types offered with a unique quote has halved over our sample period, declining from more than 15 percent in 2010 to approximately seven percent in 2014. Second, the share of multi-quote products offered with zero fees has more than doubled, steadily increasing from ten percent of the market in 2010 to almost 25 percent in 2014. The growing importance of products with multiple rate-fee pairs documented in Figure 2 suggests that lenders are more-actively seeking to price discriminate across borrowers using a two-part pricing strategy over time. This seems a novel aspect of mortgage pricing to study, for at least two reasons. First, the vast majority of previous studies on mortgage markets

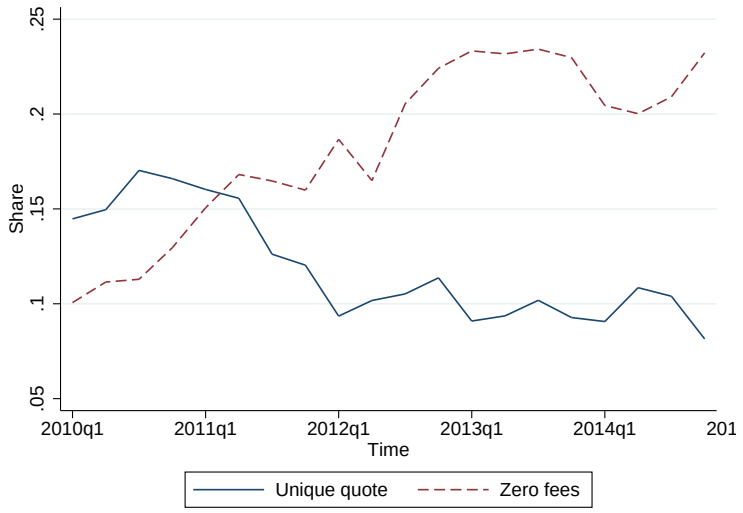


Figure 2: Product Shares

Note: share of products in Moneyfacts with a zero fee and the share of products with a unique quote.

has focused on the interest rate that borrowers pay when taking a mortgage. However, origination fees can represent an important component of the total cost of borrowing, most notably since refinancing is frequent in the U.K. market (Cloyne et al., 2018) and, thus, borrowers may end up paying the origination fee frequently. Looking only at the interest rate may provide an incomplete picture of the mortgage costs for borrowers (as well as of profits for lenders) and, thus, of the transmission mechanism of monetary policy. Second, if borrowers have different elasticities with respect to rates and to fees, lenders can set them strategically and further increase their profits.

We now describe the variation in rates and fees across product types with different LTV bands, as well as the correlation between rates and fees. Specifically, in the panels of Figure 3, we display how initial interest rates (left chart) and origination fees (right chart) vary across maximum LTV bands. Two main patterns emerge. First, there are notable jumps across max LTV bands, especially above 80 percent. This suggest that U.K. lenders seem to price default risk almost exclusively through LTV bands, and not through borrower-specific pricing, as it is instead the case in the U.S. mortgage market. This feature of the U.K. mortgage market motivates us to model borrowers' choice as a discrete-choice among these

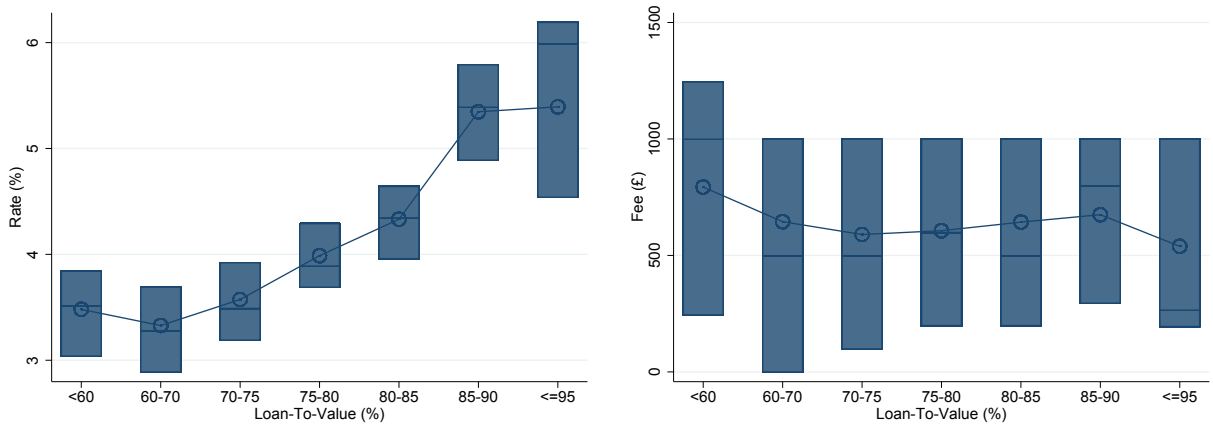


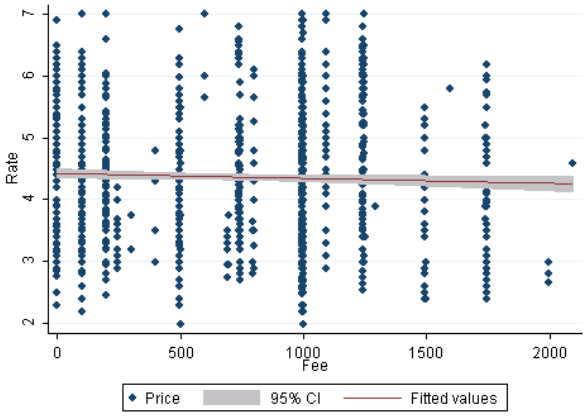
Figure 3: LTV PRICING

Note: The left (right) Panel shows the interquartile range for initial interest rates (origination fees) for all products in each LTV band based on the Moneyfacts dataset.

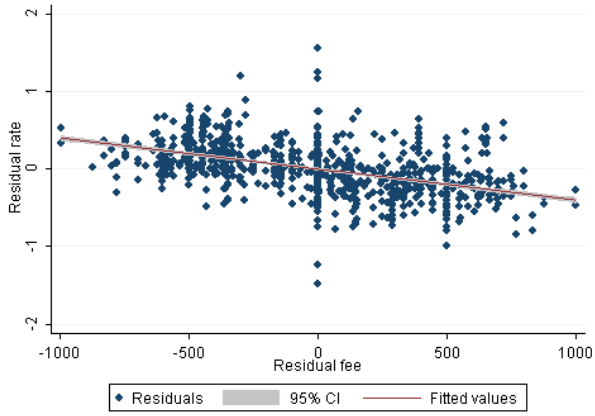
LTV bands, lenders, and other product characteristics. Second, and in sharp contrast to interest rates, origination fees exhibit very limited variation across LTV bands, potentially suggesting that lenders use them mainly to extract consumer surplus. We will explore this hypothesis below, through the lens of an estimated structural model of the U.K. mortgage market in which borrowers are allowed to have different elasticities to interest rates and to origination fees.[2]

In Figure 4, we present the correlation between initial interest rates and origination fees. The left panels displays rates and corresponding fees for all mortgage products in the first (December 2010), middle (December 2012) and last month (December 2014) of our sample. Rates are continuous, while fees often take on discrete values at (almost) round numbers, such as zero, 499-500, 999-1000, and 1250. A negative correlation between rates and fees seems apparent, perhaps more so in 2012 and in 2014 than in 2010. The right panels of Figure 4 display the residual rates and the corresponding residual fees obtained from regressing the product-level rates and fees, respectively, on product type-month fixed effects. The negative correlation between rates and fees becomes sharper within product-type, consistent with the example of Figure 1.

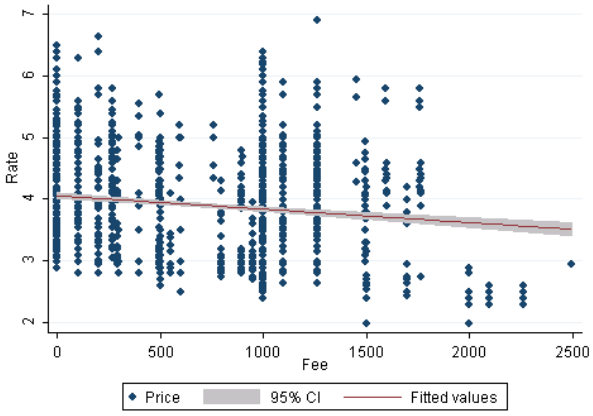
[2]In Figure A1 in Appendix A, we replicate the charts of Figure 3 using data on mortgage *originations* obtained from the Financial Conduct Authority's Product Sales Database.



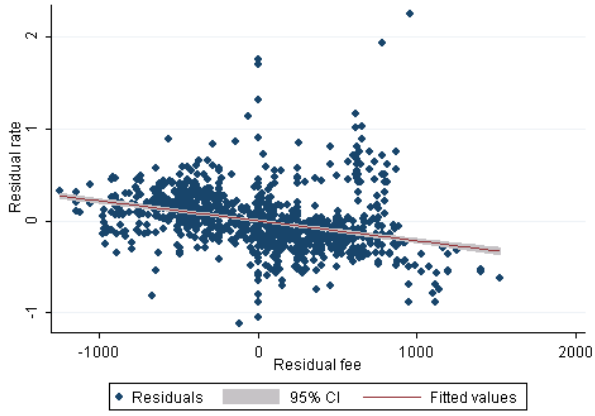
(a) Raw data, December 2010



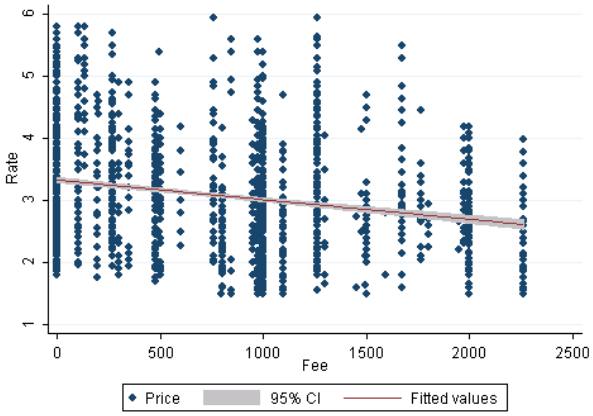
(b) Residuals, December 2010



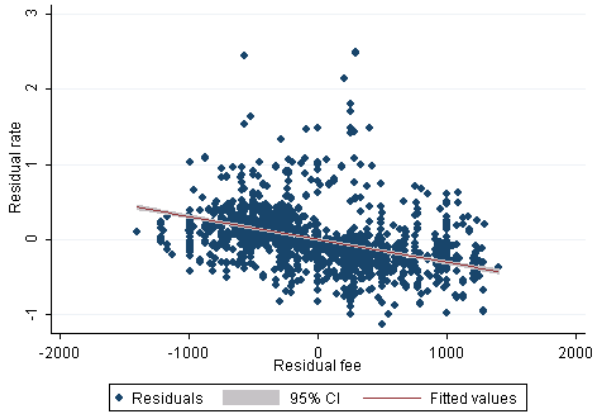
(c) Raw Data, December 2012



(d) Residuals, December 2012



(e) Raw Data, December 2014



(f) Residuals, December 2014

Figure 4: Relation between Rates and Fees

Note: Panels (a), (c) and (e) show the correlation between rates and fees in December 2010, 2012, and 2014 respectively. Panels (b), (d) and (f) show the correlation between the residual rates and fees in December 2010, 2012 and 2014 respectively. The residuals are computed regressing the product-level rates and fees on product type-month fixed effects.

Table 2: Relation Rates-Fees

Panel A: Continuous Fees

	Baseline	Heterogeneity								
		(Fix)	(Var)	(<75)	(>75)	(Big 6)	(Other)	(FTB)	(HM)	(RMGT)
Fee (.000)	-0.281***	-0.297***	-0.228***	-0.279***	-0.296***	-0.283***	-0.279***	-0.274***	-0.288***	-0.280***
	(0.011)	(0.011)	(0.023)	(0.012)	(0.016)	(0.015)	(0.014)	(0.016)	(0.015)	(0.015)
Product-Time	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.94	0.95	0.90	0.92	0.95	0.95	0.93	0.95	0.94	0.93
Observations	158648	115662	42986	137358	21290	68790	89858	55611	53734	49303

Panel B: Zero-fee Indicator Variable

	Baseline	Heterogeneity								
		(Fix)	(Var)	(<75)	(>75)	(Big 6)	(Other)	(FTB)	(HM)	(RMGT)
Zero fees	0.332***	0.337***	0.315***	0.338***	0.285***	0.349***	0.321***	0.328***	0.339***	0.329***
	(0.012)	(0.013)	(0.020)	(0.013)	(0.019)	(0.012)	(0.017)	(0.016)	(0.016)	(0.015)
Product-Time	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.93	0.94	0.90	0.91	0.94	0.95	0.92	0.94	0.93	0.93
Observations	158648	115662	42986	137358	21290	68790	89858	55611	53734	49303

Note: Panel A reports the estimates from equation (1) using as explanatory continuous variable the level of fees. Panel B reports the estimates from equation (1) using as explanatory indicator variable a dummy for products with zero fees. Standard errors are double clustered at the product and time level. Source: MoneyFacts dataset.

To quantify more formally the magnitude of the negative relation between rates and fees, we run the following regression on MoneyFacts data:

$$r_{jkt} = \alpha f_{jkt} + \gamma_{kt} + \epsilon_{jkt}, \tag{1}$$

where r_{jkt} is the interest rate of product j, product-type k at time t, f_{jkt} is the corresponding fee, γ_{kt} are product type-time fixed effects, and ϵ_{jkt} are unobservables. The coefficient of interest is α, which measures the within product type-time rate of substitution between initial interest rates and origination fees. We estimate two specifications of (1): one with the fees in level as a continuous variable; another one with an indicator variable equal to one for products with no fees and zero otherwise.

We report the coefficient estimates in Table 2. In Panel A, we show the baseline model with continuous fees. The first column shows that a £1,000-higher origination fee corresponds to a 28-basis-point-lower interest rate within product type. The other columns report coefficients obtained on different subsamples of the data, e.g. for different product

types (depending on the interest rate type, maximum loan-to-value, lender) and for different borrower types (first-time buyer, home mover, and remortgager). The result is remarkably stable across subsamples. In Panel B of Table 2, we report the coefficient estimates of equation (1) when we use as explanatory variable an indicator variable equal to one for products with no fees and zero otherwise. The estimates imply that a product with zero fees tends to be offered at an interest rate that is on average 33 basis point higher than an identical product type but with a positive fee. All estimates on different subsamples show very limited hetereogeneity.

In summary, we uncover two main patterns: (i) lenders have increased over time their offer of product types with multiple rate-fee combinations, presumably in an attempt to segment the market and to price discriminate across borrowers using two-part quotes; and (ii) lenders charge approximately a 30-basis-point-higher rate on a mortgage with a £1000-lower origination fee, with almost no heterogeneity across product types.

2.2 Mortgage Choice

The second dataset that we exploit is the Product Sales Database (henceforth PSD) constructed by the Financial Conduct Authority (henceforth FCA). PSD collects all mortgage originations, reporting mortgage contract characteristics: the interest rate, the LTV, the maturity, the loan amount, the lender; the main borrower characteristics: age, income, and borrower type (first-time-buyer, home-mover, remortgager); and property characteristics: the location and transaction price.

Despite the richness of the PSD, it has two limitations for our purposes. First, it reports mortgage fees only since 2015, which is after the introduction of the Bank of England's Funding for Lending Scheme in 2012. We overcome this limitation since PSD reports the main characteristics of each origination, such as the lender, the LTV, and the interest rate, which allow us to match each PSD mortgage to the corresponding mortgage product from MoneyFacts to recover its origination fees. Second, PSD does not report borrowers' choice sets—for example, some mortgage products may be unavailable to some borrowers. We

address this issue by exploiting the choice of borrowers with similar observable characteristics to construct the choice set of each borrower depending on his age, income, region, and quarter. Most notably, we divide borrowers into groups based on the region they bought the house, the quarter in which they obtain the mortgage, and on their income and age (below vs above the median). We assume that a borrower has access to the mortgage products that other borrowers in the same group have chosen. Moreover, to account for differences among borrowers within the same group in unobservable characteristics, such a wealth, we restrict the discrete loan-to-value band choice to the maximum loan-to-value bands just above and just below the band which the chosen product falls into. This additional restriction removes products that were unlikely to belong to borrowers' choice sets because of leverage limits, such as loan-to-income or loan-to-value constraints.

Table 3 reports summary statistics for the 2010-2014 dataset that we use to estimate our model. We focus on first-time-buyers for two main reasons. First, home movers' and remortgagers' *new* mortgage choice is affected by their *existing* mortgages, which we do not observe in our datasets. Second, first-time-buyers are the borrowers with the highest leverage, which makes them potentially more responsive to the monetary stimulus that we focus on in this paper. The estimation sample comprises of approximately 728,000 mortgages, and Panel A reports their main characteristics. The average loan has an amount of about £135K and a maturity of approximately 28 years. The average loan amount on adjustable-rate products is significantly larger than that on fixed-rate products. The average borrower is less than 30 years old and has an income of about £42K (£59K for products with variable rates). The average LTV is about 82 percent and the average loan-to-income is 3.4.

Panel B of Table 3 reports some additional statistics on borrowers' choice sets. Each choice set (namely the combination of product type and a pair of associated rate/fees) features approximately 50 product types and approximately 70 products—i.e., we observe two different rate/fee combinations for approximately 40 percent of product types. The average initial rate in equals 420 percentage points, with adjustable rate deals typically offered at 60 basis points less than fixed rate ones. Products with a maximum LTV above

Table 3: Summary Statistics

	All	Rate		LTV		Lender	
		Fix	Var	Low	High	Big 6	Others
Panel A: Choices							
Loan amount (£, 000)	134.78	131.08	174.47	137.75	128.92	133.81	161.23
Maturity (years)	28.85	29.05	26.73	28.30	29.93	28.85	28.74
Gross income (£, 000)	41.55	39.94	58.82	42.04	40.59	41.12	53.22
Age (years)	30.08	29.90	32.00	30.51	29.23	30.08	30.00
Loan-to-value	82.42	82.60	80.51	78.66	89.86	82.41	82.84
Loan-to-income	3.45	3.47	3.24	3.52	3.31	3.46	3.22
Initial rate (%)	4.31	4.36	3.68	3.86	5.16	4.31	4.04
Fees (£) (%)	723.60	740.15	545.94	762.02	647.75	726.49	645.39
Panel B: Choice-set							
Initial rate (%)	4.20	4.36	3.71	3.85	5.09	4.22	4.07
Fees (£) (%)	661.72	664.68	652.22	702.04	560.69	656.39	719.53
Product type identifier	55.27	42.31	12.99	39.80	15.47	51.34	4.11
Product identifier	62.57	47.72	14.89	44.72	17.85	57.29	5.53

Note: Summary statistics for the main variables used in the analysis.

75 percent are associated with a significantly higher interest rate than products with lower maximum LTVs, as we documented in Figure 3. The origination fee amounts to approximately £660 on average, though deals with maximum LTV above 75 percent typically demand a significantly lower origination fee.

Overall, Table 3 exhibits a large heterogeneity in borrowers' choices, suggesting a large heterogeneity in borrowers' preferences. This heterogeneity also accounts for borrowers' choices between high-fee and low-fee products, as theory predicts; for example, Figure 5 shows that the fraction of borrowers choosing no-fee products declines as borrowers' loan amounts increase. Thus, the model that we develop in Section 4 will feature rich observable and unobservable borrower heterogeneity to capture their choice of mortgage product from lenders' menus.

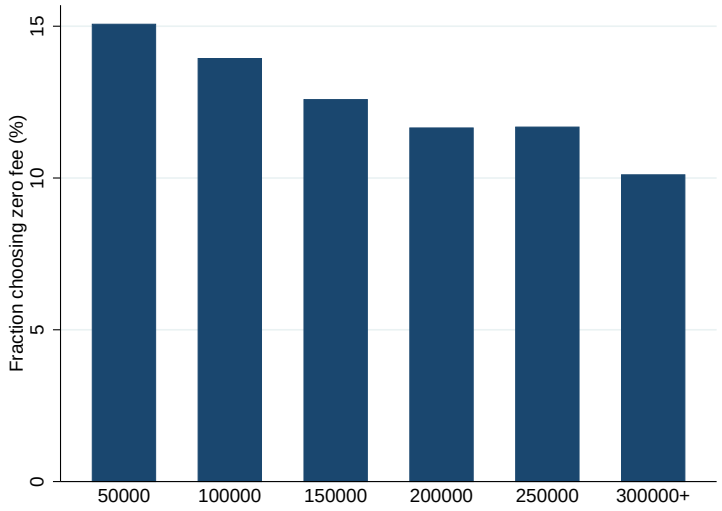


Figure 5: Fraction of borrowers choosing no-fee products for different loan size bands.

3 The Funding For Lending Scheme

A main goal of our analysis is to study how mortgage pricing, especially origination fees, affects the transmission of monetary policy. While this question is also relevant for conventional interest rate policies, it is particular salient for the large number of unconventional interventions that dominated the responses of central banks around the world to the financial crisis and that has been popularized under the heading of 'credit easing'. A case in point is the U.K. Funding for Lending Scheme (henceforth FLS), whose main features and impact on mortgage pricing we describe in this section.

3.1 Institutional Background and Lenders' Funding Costs

On June 14th, 2012, Governor Mervyn King announced the introduction of the Bank of England and HM Treasury FLS programme, which officially started on July 13th, 2012. The scheme was part of the larger monetary stimulus package that the Bank of England pursued since the onset of the Financial Crisis, along the lines of similar programs by other central

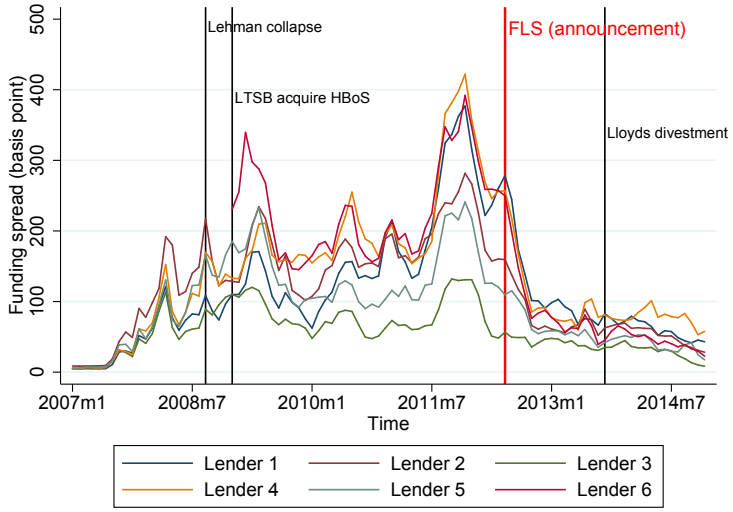


Figure 6: Funding costs

Source: Bank of England.

banks (Borio and Zabai, 2016).[3]

The timing of FLS followed an intensification of the European Sovereign Debt Crisis and an increase in banks' funding costs for the major UK lenders, which in turn led to an increase in loan rates. Figure 6 displays funding costs for the six (anonymized) largest U.K. lenders.[4] Black vertical lines denote key banking events, whereas the red vertical line marks the announcement of the FLS. The time series of these funding costs display two large increases: one during the Great Recession in 2007-09 and one during the intensification of the European Sovereign Debt Crisis in 2011-2012. After the FLS announcement, lenders' funding spreads decreased considerably; by the second half of 2013, the level and dispersion of the funding spreads were close to those prevailing before the financial crisis.

The FLS programme provides direct funding to banks and building societies for an extended period at lower rates than prevailing on the market, with the stated goal of

[3]The Bank of England cut interest rate to 0.5 percent in March 2009 and from September 2009 to July 2012 purchased a total of £375 billion in assets, mainly U.K. government securities, but also smaller quantities of high-quality corporate bonds.

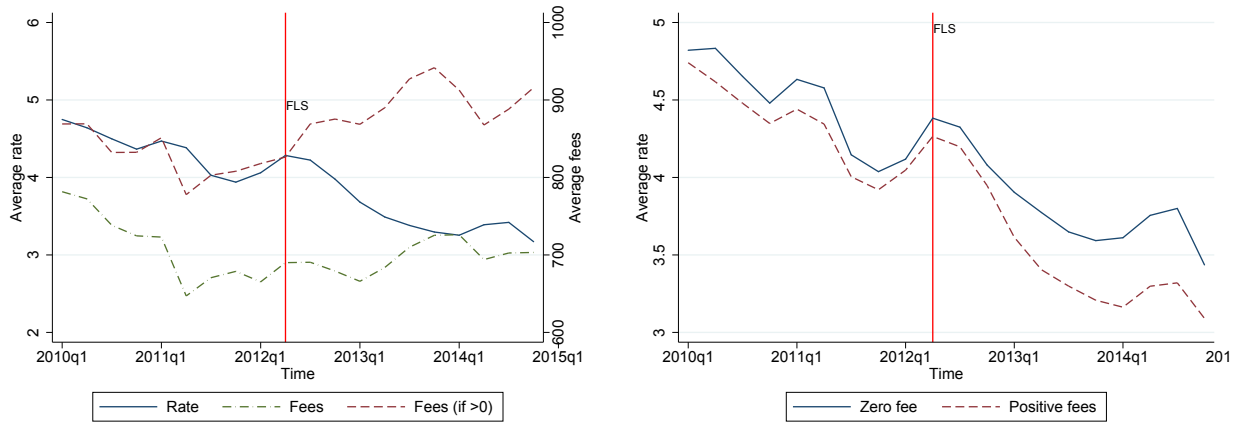
[4]More formally, Figure 6 reports the constant maturity secondary market spreads to mid-swaps for the largest U.K. lenders' five-year euro-denominated senior unsecured bonds (or a suitable proxy when unavailable) as constructed in the Bank of England Credit Conditions Review 2017Q3 (chapter 1, chart 1.2).

promoting lending to households and firms. The scheme incentives operate through both quantities and prices. As for quantities, the amount of funding available varies with the amount that banks lend out as follows. First, each lender can borrow from the Bank of England up to five percent of its existing stock of loans to households and to firms at June 2012. Second, banks can borrow beyond this five percent limit as long as the additional borrowing leads to a net expansion (i.e. net of repayments) of their lending to households and firms over the period July 2012-December 2013. In other words, banks can finance each pound of new lending with a pound from the FLS, facing no constraint on the additional amount that they can borrow for this purpose. As for the scheme incentive on prices, the funding cost depends on the amount that banks lend out. Banks that maintain or expand lending pay an annual fee of 25 basis points for the amount that they borrow from the FLS facilities. Banks that reduce net lending pay an additional fee of 25 basis points for each percentage point of decline in net lending. This fee increases linearly up to a maximum of 150 basis points for banks that reduce net lending by more than five percent.

By the end of 2014, the FLS recorded an aggregate outstanding drawings of more than £4.4 billions, with an associated increase in aggregate lending of about 2.5 percent. All large lenders, with the notable exception of HSBC, participated in the FLS. The scope of the scheme narrowed over time and since February 2014 excluded household loans such as mortgages, amid rising property values. After that, FLS supported loans to small and medium-sized enterprises only. Churm et al. (2012) provides a more-detailed description of the FLS, as well as some evidence on the short-term effects of the scheme on the interest rates that lenders charged to firms and to households.

3.2 Mortgage Pricing around the FLS

We now describe some notable changes in mortgage pricing around the introduction of the FLS programme. Panel (a) of Figure 7 displays the evolution of the average rates (left axis), the average fees for all products and the average fees for only products with positive fees (right axis). Panel (b) displays the average rates for products with positive fees and for



(a) Rates and fees

(b) Rates at different fee levels

Figure 7: FLS and Mortgage Pricing

Note: The left panel displays the average interest rate, the average fee, and the average fee conditional on the fee of the product begin larger than zero. The lower panel shows the average interest rate for product with positive fees and for product with zero fees.

products with zero fees. The vertical line denotes the FLS announcement.

The evidence in Panel (a) suggests that the decline of mortgage rates (blue solid line), which was already ongoing before July 2012, perhaps accelerated after the introduction of the scheme. The average mortgage rate decreased by almost 100 basis points, from approximately 420 points in the second quarter of 2012 to 320 points by the end of 2013. This finding is consistent with lenders passing through their lower funding cost to lower mortgage rates. Average fees display a similar trend to average interest rates before the introduction of FLS, but seem to diverge thereafter. Origination fees do not display a noticeable average change after the introduction of FLS and, if anything, they reveal a gentle increase from below £700 to just above it. However, if we consider only products with strictly positive fees (red dashed line), their average fees increase more markedly after the introduction of FLS, by approximately £100. These patterns lend support to the hypothesis that, in response to the FLS, lenders may have adjusted interest rates downward to attract borrowers, while increasing origination fees for some of their products, possibly to extract consumer surplus and to increase profits.

In Panel (b) of Figure 7, we investigate this hypothesis further by decomposing the decline in the average rate displayed in Panel (a) between products with positive fees (red dashed

line) and products with zero fees (blue solid line). Before the introduction of the FLS, the two rates display a parallel trend, with the no-fee products associated with a higher rate than the positive-fee products, consistent with the evidence reported in Section 2. However, after the beginning of the FLS programme, the gap between the two rates widens: the decline in interest rates is substantially smaller for no-fee products than for positive fee ones, with the difference in rates between the two set of products moving from an average of about 10 basis point in 2012Q2 to an average of around 50 basis points by 2014.

4 A Structural Model of the Mortgage Market

The descriptive evidence of previous sections reports some intriguing pricing patterns. At the same time, it raises several interesting questions. Specifically, how do borrowers choose among rate-fee pairs? How do lenders pricing depends on their funding costs, as well as to borrowers' choices? How would demand (i.e., borrowers' choice) and supply (i.e., lenders' pricing) change if fees were banned?

The goal of the model that wed develop in this section, as well as of the counterfactual analyses of Section 6, is to allow us to answer these questions in a coherent way.

4.1 Household Demand

In each market m, I_m heterogeneous households, indexed by i, choose a mortgage to buy a house. Households choose simultaneously their mortgage product among all lenders, rate types, and maximum loan-to-values available to them (discrete product choice), as well as their loan amount, given their preferences and budget constraint (continuous quantity choice). We assume that each mortgage is represented as a bundle of attributes and that borrowers have preferences over these attributes. The indirect utility for household i taking product j in market m is:

$$V_{ijm} = \bar{V}_{ijm}(Y_i, D_i, X_j, r_{jm}, f_{jm}, A_{ij(l)m}, \zeta_i, \xi_{jm}; \theta_i) + \varepsilon_{ijm}, \tag{2}$$

where Y_i is household income; D_i are other household demographics (e.g., age, location); r_{jm} is the rate and f_{jm} is the origination fee of product j in market m; X_j are time invariant product type characteristics (i.e., rate type, lender and maximum loan-to-value); $A_{ij(l)m}$ is lender l's branch network in the location of household i; ζ_i captures household unobserved characteristics (e.g., wealth, risk-aversion, housing preferences); ξ_{jm} captures unobservable product characteristics (e.g., advertising, screening) affecting the utility of all borrowers for product j in market m; ε_{ijm} is an idiosyncratic taste shock; and θ_i collects the demand parameters.

Following Benetton (2018), we construct the choice set of each borrower by comparing other borrowers with similar observable characteristics and imposing two additional restrictions based on affordability and liquidity constraints. First, households may not be able to borrow up to the desired leverage, due to supply side restrictions (such as loan-to-value or loan-to-income limits). Second, liquidity constraints may limit the ability of the household to increase the down-payment and consider products with lower maximum leverage. Both types of constraints restrict borrowers' choice sets in terms of maximum loan-to-value accessible among the full set available in the market. We assume household i solve the following problem:

$$\max_{j \in J_i} V_{ijm} = \bar{V}_{ijm} + \varepsilon_{ijm},$$

$$\textit{with } J_i \subseteq J_m \quad \textit{Affordability constraint}$$

$$j \in J_i \; if \; j \in \{max\ LTV_i - 1, max\ LTV_i, max\ LTV_i + 1\},$$

where J_m is the total number of products available in a given market m. In the standard case, the borrower has access to all products, thus $J_i \equiv J_m$.

We adopt two standard assumptions in the literature. Borrower i choose product j that gives her the highest utility, among the products available, that is i chooses product j if $V_{ijm} \geq V_{ij'm}$, $\forall j' \in J_i$. We assume that ε_{ijm} in equation (2) is identically and independently distributed across households and mortgage products with a type-I extreme value distribution.

Hence, the demand by borrower i in market m for product j is:

$$s_{ijm} = \frac{\exp(\bar{V}_{ijm}(Y_i, D_i, X_j, r_{jm}, f_{jm}, A_{ij(l)m}, \zeta_i, \xi_{jm}; \theta_i))}{\sum_{j'=0}^{J_i} \exp(\bar{V}_{ij'm}(Y_i, D_i, X_{j'}, r_{j'm}, f_{j'm}, A_{ij'(l)m}, \zeta_i, \xi_{j'm}; \theta_i))}. \tag{3}$$

At the chosen product, the borrower decides the optimal loan amount (q_{ijm}), which follows from Roy's identity:

$$q_{ijm} = -\frac{\frac{\partial V_{ijm}}{\partial r_{jm}}}{\frac{\partial V_{ijm}}{\partial Y_i}} = q_{ijm}(Y_i, D_i, X_j, r_{jm}, \zeta_i, \xi_{jm}; \theta_i). \tag{4}$$

Equations (3) and (4) uniquely define borrowers' product and loan demand, given their preferences and mortgage characteristics. In practice, our assumptions incorporate one exclusion restriction: the quantity choice does not depend on lenders' network of branches. We assume that this characteristic affect the probability of choosing a specific mortgage products (equation (3)), but not the optimal loan amount (equation (4)).

4.2 Lender Pricing with Rates and Fees

In each market m, L_m lenders maximize (expected) profits by pricing each product they offer. We assume the main source of revenue for lenders is the net interest income from the monthly payments and the initial origination fee.

The present value of net interest income from a risk-free mortgage to borrower i with fixed rate r_{jm} and maturity T_i is:

$$PV(q_{ijm}, r_{jm}, c_{jm}, T_i) = q_{ijm} \sum_{k=1}^{T_i} \left[\frac{r_{jm}(1+r_{jm})^{T_i}}{(1+r_{jm})^{T_i} - 1} - \frac{c_{jm}(1+c_{jm})^{T_i}}{(1+c_{jm})^{T_i} - 1} \right], \tag{5}$$

where q_{ijm} is the mortgage loan amount and c_{jm} is the marginal cost of providing mortgage j in market m. The vast majority of UK mortgages have a discounted variable or fixed rate, which revert to a higher standard variable rate at the end of the fixation period. Hence, borrowers have strong incentives to refinance the mortgage with a new loan when the fixation

period terminates (Cloyne et al., 2018). We focus on origination pricing, and leave to future research the analysis of retention pricing. For long maturity, the following approximation to equation (5) holds:

$$PV(q_{ijm}, r_{jm}, c_{jm}, t_j) \approx q_{ijm} t_j (r_{jm} - c_{jm}), \tag{6}$$

where t_j is the initial period with a discounted rate. We also assume lenders incur a fixed application cost a_{jm} to issue each mortgage. Lenders decide in each market m the initial rate and fees for each product j they offer, taking as given the rates and fees set by their competitors.

Given the demand system and the approximation of the present value of the net revenue from interest payment (6), we can write the problem of the lender as:

$$\begin{aligned}
\max_{r,f} \Pi_{lm}(r_{jm}, f_{jm}) &= \sum_{j \in J_{lm}} \Pi_{jm}(r_{jm}, f_{jm}) = \\
&= \sum_{j \in J_{lm}} \sum_{i \in I_m} s_{ijm}(r_{jm}, f_{jm}, r_{-jm}, f_{-jm}) \times [f_{jm} - a_{jm} + PV(r_{jm})] = \\
&= \sum_{j \in J_{lm}} \sum_{i \in I_m} s_{ijm}(r_{jm}, f_{jm}, r_{-jm}, f_{-jm}) \left[f_{jm} - a_{jm} + q_{ijm} t_j (r_{jm} - c_{jm}) \right].
\end{aligned} \tag{7}$$

Expected total profits of lender l are the sum of profits of all products it offers in market m ($\sum_{j \in J_{lm}}$) to borrowers in market m ($\sum_{i \in I_m}$). Note that rates of other products and fees enter the product demand (s_{ijm}), but not the present-value, which only depends on the conditional loan demand (q_{ijm}).

Lenders choose the rate r_j to satisfy the optimality condition:

$$\frac{\partial \Pi_l}{\partial r_j} = \sum_i s_{ij} q_{ij} t_j + \sum_i s_{ij} \frac{\partial q_{ij}}{\partial r_j} t_j (r_j - c_j) + \sum_{k \in J_l} \sum_i \frac{\partial s_{ik}}{\partial r_j} \left[f_k - a_k + q_{ik} t_k (r_k - c_k) \right] = 0, \tag{8}$$

where we remove the market subscript m for simplicity. The first term gives the additional profits from the higher rate on the quantity sold; the second term captures the changes in loan demand from a higher rate; the third term collects the impact of a higher rate on the

choice probability for all products J_l offered by lender l. Solving for the optimal interest rate yields:

$$r_j^* = \overbrace{c_j}^{\text{Marginal cost}} + \overbrace{\frac{\sum_i \frac{\partial s_{ij}}{\partial r_j}}{\sum_i \frac{\partial s_{ij}}{\partial r_j} q_{ij} + \sum_i \frac{\partial q_{ij}}{\partial r_j} s_{ij}} \frac{a_j}{t_j}}^{\text{Application cost}} - \overbrace{\frac{\sum_i s_{ij} q_{ij}}{\sum_i q_{ij} \frac{\partial s_{ij}}{\partial r_j} + \sum_i s_{ij} \frac{\partial q_{ij}}{\partial r_j}}}^{\text{Full mark-up}}$$
$$\underbrace{- \frac{\sum_i \frac{\partial s_{ij}}{\partial r_j}}{\sum_i \frac{\partial s_j}{\partial r_j} q_{ij} + \sum_i \frac{\partial q_{ij}}{\partial r_j} s_{ij}} \frac{f_j^*}{t_j}}_{\text{Other price}} - \underbrace{\sum_{k \neq j \in J_l} \frac{\sum_i \frac{\partial s_{ik}}{\partial r_j} [f_k^* - a_k + q_{ik} t_k (r_k^* - c_k)]}{t_j \left(\sum_i \frac{\partial s_{ij}}{\partial r_j} q_{ij} + \sum_i s_{ij} \frac{\partial q_{ij}}{\partial r_j} \right)}}_{\text{Other products}}. \tag{9}$$

Note that if there are no fees and no application costs, all lenders offer only one product, borrowers make only the discrete product choice, then equation (9) collapses to the standard mark-up pricing formula with one price: $r_j^* = c_j - \frac{\sum_i s_{ij}}{\sum_i \frac{\partial s_{ij}}{\partial r_j}}$.

Similarly, the optimal fee of product j equals:

$$\frac{\partial \Pi_l}{\partial f_j} = \sum_i s_{ij} + \sum_i s_{ij} \frac{\partial q_{ij}}{\partial f_j} t_j (r_j - c_j) + \sum_{k \in J_l} \sum_i \frac{\partial s_{ik}}{\partial f_j} [f_k - a_k + q_{ik} t_k (r_k - c_k)] = 0. \tag{10}$$

The first term of equation (10) gives the change in lender profits due to higher fees on the current market share of product j; the second term gives the change in lender profits due the changes in loan amount; the third term collects the effect of a higher fee on the choice probability of all products offered by the lender. Solving for the optimal fee yields:

$$f_j^* = \overbrace{a_j}^{\text{Application cost}} + \overbrace{\frac{\sum_i s_{ij} \frac{\partial q_{ij}}{\partial f_j} + \sum_i q_{ij} \frac{\partial s_{ij}}{\partial f_j}}{\sum_i \frac{\partial s_{ij}}{\partial f_j}} t_j c_j}^{\text{Marginal cost}} - \overbrace{\frac{\sum_i s_{ij}}{\sum_i \frac{\partial s_{ij}}{\partial f_j}}}^{\text{Mark-up}}$$
$$\underbrace{- \frac{\sum_i s_{ij} \frac{\partial q_{ij}}{\partial f_j} + \sum_i q_{ij} \frac{\partial s_{ij}}{\partial f_j}}{\sum_i \frac{\partial s_{ij}}{\partial f_j}} t_j r_j^*}_{\text{Other price}} - \underbrace{\sum_{k \neq j \in J_l} \frac{\sum_i \frac{\partial s_{ik}}{\partial f_j} [f_k^* - a_k + q_{ik} t_k (r_k^* - c_k)]}{\sum_i \frac{\partial s_{ij}}{\partial f_j}}}_{\text{Other products}}. \tag{11}$$

Equations (9) and (11) yield a negative relation between the rate and the fee of each product j, consistent with the empirical evidence of Section 2.1. Rates and fees are substitute tools for

lenders to increase profits; their optimal setting depends on funding costs and on application costs, as well as on the relative elasticities of households demand with respect to each of them.

Lenders' optimal rates and fees, as well as borrowers' optimal choice of mortgage product and of loan amount, characterize the equilibrium in the mortgage market.

5 Estimation and Identification

In this section we describe the parametric assumptions that we make in order to estimate the model. Moreover, we discuss the key variations in the data that we exploit to identify the model parameters, as well as how we address endogeneity concerns arising from unobservable product characteristics.

5.1 Estimation

Demand. The demand model in Section 4.1 predicts household choice of mortgage product and of loan amount as a function of observable and unobservable products attributes, observable and unobservable household characteristics/preferences, and a vector of parameters that we estimate.

We follow the literature on discrete-choice demand models and assume that ε_{ijm} in equation (2) is identically and independently distributed across households and mortgage products with a type-I extreme value distribution. Hence, the conditional probability that borrower i in market m chooses product j is:

$$Pr(i \ chooses \ j) = p_{ijm}(\zeta_i) = \frac{\exp(\bar{V}_{ijm})}{\sum_{j'=0}^{J_i} \exp(\bar{V}_{ij'm})}. \tag{12}$$

The unconditional probability obtains by integrating out borrowers unobservable heterogeneity

ζ_i, which we assume follows a normal distribution with variance σ ($\zeta_i \sim N(0, \sigma)$):

$$s_{ijm} = \int_{\zeta} p_{ijm}(\zeta_i) dF(\zeta_i). \tag{13}$$

We build on Train (1986) and assume that the indirect utility $\bar{V}_{ijm}$ equals:

$$\bar{V}_{ijm} = \frac{\gamma}{1-\psi}(Y_i - f_{jm})^{1-\psi} + \mu \exp(\delta_{jm} + \eta D_i + \zeta_i) + \lambda A_{ij(l)}, \tag{14}$$

where $\delta_{jm} = -\alpha_r r_{jm} + \beta X_j + \xi_{jm}$ capture all observed and unobserved product attributes. Hence, Roy's identity yields the following loan demand function q_{ijm} for borrower i in market m, conditional on choosing product j:

$$\ln(q_{ijm}) = \ln\left(-\frac{\frac{\partial \bar{V}_{ijm}}{\partial r_{jm}}}{\frac{\partial \bar{V}_{ijm}}{\partial Y_i}}\right) = \ln\left(\frac{\mu\alpha}{\gamma}\right) + \psi \ln(Y_i - f_{jm}) + \delta_{jm} + \eta D_i + \zeta_i. \tag{15}$$

From equation (15) and the assumption that ζ_i follows a normal distribution, the probability of the conditional loan demand is:

$$f(\ln(q_{ijm})|j \neq 0) = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-\frac{\left(\ln(q_{ijm}) - \ln\left(\frac{\mu\alpha}{\gamma}\right) - \psi \ln(Y_i - f_{jm}) - \delta_{jm} - \eta D_i\right)^2}{2\sigma^2}\right). \tag{16}$$

Therefore, the joint log-likelihood that individual i chooses product j in market m and loan amount q_{ijm} is:

$$\ln(L_i) = \sum_{j=0}^{J_i} \mathbb{I}_{ijm} \left[\ln(s_{ijm}) + \ln(f(\ln(q_{ijm})|j \neq 0))\right], \tag{17}$$

where $\mathbb{I}_{ijm}$ is an indicator variable equal to one if borrower i chooses product j, and zero otherwise.

We proceed in two step to estimate the demand parameters. In the first step, we include a full set of product-market fixed effects δ_{jm} in the log-likelihood to account for the possible

correlation between the interest rate r_{jm} and the fees f_{jm} with unobservable product type characteristics ξ_{jm}. Then, we maximize the log-likelihood function (17) separately for each of 24 markets, constructed as a combination of income (above or below the median income), age (above or below the median age), and geographic region (London, South, Mid, North, Wales, Scotland). Thus, for each market, we obtain the utility parameters γ, ψ, η, and λ, the scaling factors σ and μ, and the product-market fixed effects δ_{jm}.

In the second step, we estimate, separately for each market m, the coefficients α and β of the interest rate r_{jm} and of the other product characteristics X_j through an IV regression whose dependent variable is the product-market fixed effect $\hat{\delta}_{jm}$ estimated in the first step:

$$\hat{\delta}_{jm} = -\alpha r_{jm} + \beta X_j + \xi_{jm}. \tag{18}$$

We describe in Section 5.2 the supply-side instruments that we employ to obtain consistent estimates of the parameters of (18).

Supply. The estimation of the supply side parameters relies on lenders' optimal pricing. Specifically, we back out the unobserved funding cost and application cost of each product by inverting equations (9) and (11), respectively, and solving for these costs as functions of observed interest rates, observed fees, and estimated mark-ups. We then analyze how these costs depend on different covariates through the following regressions:

$$c_{jm} = \psi^c FLS_{j(l)m} + \tau^c X_j + \gamma^c_m + \gamma^c_{j(l)} + \kappa^c_{jm}, \tag{19}$$

$$a_{jm} = \psi^a FLS_{j(l)m} + \tau^a X_j + \gamma^a_m + \gamma^a_{j(l)} + \kappa^a_{jm}, \tag{20}$$

where the dependent variables c_{jm} and a_{jm} are the estimated funding costs and application costs, respectively; $FLS_{j(l)m}$ is a variable that measures the participation to the FLS of lender l offering product $j(l)m$, which we describe precisely below; X_j are the product attributes that affect borrower demand; γ_m and $\gamma_{j(l)}$ are market and lender fixed effects, respectively; and κ_{jm} is a structural error term capturing unobservable cost determinants

(e.g., advertising, screening). The participation in the FLS is a choice of each lender and, thus, the variable $FLS_{j(l)m}$ is endogenous; hence, we estimate equations (19) and (19) using instrumental variables that exploit variation arising from the FLS design, which we describe in Section 5.2.

5.2 Identification

Demand. The estimation of the demand parameters faces two main endogeneity concerns. First, the discrete-continuous choice generates selection bias if we do not account for the discrete product choice when we estimate the continuous quantity choice. To address this concern, we estimates the discrete and continuous choice jointly, maximizing the log-likelihood (17). As we recounted above, the local branch network enters in the discrete choice only; specifically, we exploit variation in the branch network along with variation on the location of borrowers' houses at the postcode level to identify the effect of lenders' local branch networks on borrowers' choice among lenders.

Second, lenders simultaneously set interest rates and origination fees, which could be correlated with unobserved product characteristics. For example, a lender could raise the interest rate and the origination fee on its mortgage products, while lowering its underwriting standards. We would not observe the latter, but we could observe borrowers (risky ones, in particular) choosing the products of this lender despite their higher rates and fees; hence, we would mistakenly infer that these borrowers do not respond to prices, whereas their choice depend on the lender's unobserved underwriting standards.

Our two-step estimation procedure deals with the possible correlation between the fees f_{jm} and the unobservable characteristic ξ_{jm} by including product-market fixed effects δ_{jm} that capture all the variation at the product-market level. However, we can still identify the parameters γ and ψ that determine how origination fees affect demand because: 1) Origination fees are lump-sum. This implies that borrowers should be indifferent between a decrease in their income Y_i and a corresponding increase in fees f_{jm} by the same amount—i.e., only $Y_i - f_{jm}$ matters to them, which varies across borrowers and across products. 2)

Roy's identity restricts all parameters—most notably, the product-market fixed effects—that enter the discrete product demand and the continuous loan demand to be the same (up to a scaling factor). Hence, any residual variation in the loan demand that the fixed effects δ_{jm} do not capture and that is correlated with $Y_i - f_{jm}$ identifies the parameter ψ in the continuous-choice equation; similarly, any residual variation in the product demand that the fixed effects δ_{jm} do not capture and that is correlated with $Y_i - f_{jm}$ identifies the parameter γ in the discrete-choice equation.

Moreover, our estimation deals with the possible correlation between the interest rate r_{jm} and the unobservable characteristic ξ_{jm} in regression (18) by exploiting risk-weighted capital requirements as supply-side instruments that shift the interest rate r_{jm}. Benetton (2018) and Robles-Garcia (2019) document that capital requirements affect lenders' cost of supplying a specific product, and they vary across products and across lenders, depending on whether they use an internal model or a standardized approach to measure credit risk. Thus, our exclusion restriction is that risk-weighted capital requirements do not affect borrowers' choice directly, but they do indirectly through their effects on mortgages rates only.

The other parameters in equation (18) are identified them from the co-variation between the exogenous product characteristics X_j and borrowers' choices.

Supply. The main parameters of interest in the cost equations are the coefficients of the variable $FLS_{j(l)m}$, which measures the participation of lender l to the FLS. In our main specifications, we use lender l's cost of borrowing from the FLS facilities, and in Appendix D we perform several robustness checks using alternative variables related to lenders' participation in the FLS. More precisely, as we recount in Section 3, the cost of borrowing from the FLS facilities depends on banks' lending in the period after the introduction of the scheme relative to the period before its introduction, ranging from a minimum of 25 basis points for banks that increased net lending relative to the baseline period, to a maximum of 150 basis points for banks that decreased net lending by five percent relative to the baseline period. Thus, $FLS_{j(l)m}$ varies over time, before and after the implementation of the policy, and in the cross-section across because, depending on their net

lending growth. Hence, we can control for lender and market fixed effects and exploit the joint variation across lenders and over time to identify the effects of FLS on lenders' costs.

Nevertheless, participation to the FLS, as well as the amount borrowed under the scheme, are lenders' endogenous choices, which can be correlated with potentially unobservable, time-varying bank characteristics that we may not be able to fully control for with our set of fixed effects. Hence, we implement an instrumental variable approach, using as instrument the average share of assets outside the UK before the FLS announcement interacted with a dummy equal to one in the post FLS period. The idea of this instrument is that Bank of England's monetary policy interventions may be less relevant for lenders for which the UK domestic market constitutes a smaller share of their overall activity.

The identification of the effect of exogenous product characteristics X_j in equations (19) and (20) relies on how these characteristics—such as length of the initial period, which captures lenders' interest rate risk, and the maximum loan-to-values, which captures default risk—covary with costs c_{jm} and a_{jm}, respectively.

5.3 Results

Demand. Table 4 collects the main demand parameters. We report the average of each parameter across groups. Figures A2 and A3 in Appendix D illustrate the heterogeneity of these estimates across different groups. Borrowers prefer mortgage with a higher maximum loan-to-value limit and fixed-rate mortgages with a longer fixation period, all else equal. A higher number of branches in a location has a positive effect on borrowers' product demand, though this coefficient is not precisely estimated.

Figure 8 displays different plots that illustrate how the model fits the data (see also Table A1 in Appendix D). Overall, the fit is quite good, although the model underpredicts that many mortgage products have low market shares (panel (a)), and that borrowers choose low-LTV products (panel (c)).

Given that borrowers' sensitivity to rates and fees play a central role for our counterfactual analyses, in Table 5 we report the demand elasticities to the interest rate and the origination

Table 4: Demand Parameters

	α_r	$\beta_{highLTV}$	β_{Fix5}	λ	ψ	γ	μ	σ
Mean coefficient	0.058	0.033	0.014	0.039	0.617	0.822	11.685	0.256
Mean standard error	(0.008)	(0.011)	(0.007)	(0.353)	(0.002)	(0.340)	(0.029)	(0.014)

Note: Mean coefficients is the average of the estimated demand parameters across different groups. Mean standard error is the average of the estimated standard errors across different groups. All estimates include lender and market fixed effects. The standard error for the parameters in the first stage are computed by the inverse of the information matrix; the standard errors for the mortgage attributes estimated in the second stage are clustered at the product level.

fee for the average product, as well as for different lenders and leverage levels. Panel A reports the elasticity of loan demand with respect to the interest rate. We find that a unit increase (i.e., 100 basis points) in the interest rate leads to a decrease in loan demand by approximately six percent. The resulting elasticity of loan demand is on average -0.24, varying from -0.34 at the tenth percentile to -0.14 at the ninetieth. The elasticity of loan demand is slightly higher for the largest four banks at -0.24 than for the other banks at -0.22. The heterogeneity of the elasticity across mortgages with different LTVs is larger than that across lenders. The average loan demand elasticity is -0.21 for products with a leverage below 85 and it reaches -0.30 for products with a leverage above 85.

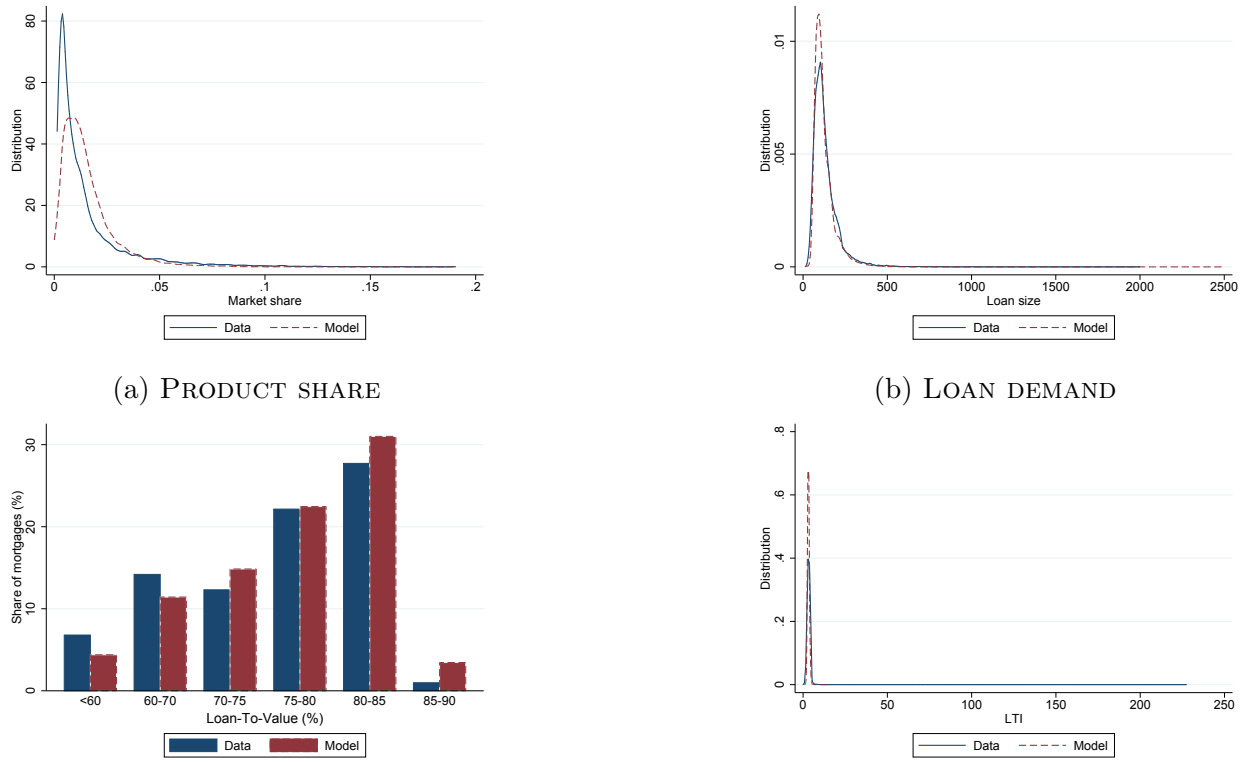
In Panel B of Table 5 we report the discrete elasticity of the product demand with respect to the interest rate. We find that, on average, a one-percent increase in the rate leads to a 5.8-percent decrease in the market share, which is slightly higher than previous studies of the UK and US mortgage market (Benetton, 2018; Buchak et al., 2018a). The elasticity is, perhaps surprisingly, slightly larger for the big four banks than for the other banks, and considerably larger for high-LTV products relative to low-LTV products.

In Panel C of Table 5 we report the elasticity of the continuous-choice loan demand to fees. We find that, on average, a one-percent increase in the fee leads to a decrease in loan demand by 0.01-percent. To give an idea of the magnitude, going from a zero-fee mortgage to a mortgage with a £1,000 fee will decrease loan demand by almost two percent. The percentiles of the elasticity of loan demand with respect to the origination fee document a considerable heterogeneity across markets: in some markets, borrowers have an elasticity to

Table 5: Demand Elasticities to Rates and Fees

	mean	**sd**	**p10**	**p50**	**p90**
Panel A: Elasticity rate - continuous					
Total	-0.236	0.081	-0.343	-0.226	-0.141
By lender					
Big 4	-0.244	0.084	-0.354	-0.231	-0.146
Others	-0.218	0.072	-0.311	-0.209	-0.132
By LTV					
LTV≤85	-0.214	0.067	-0.300	-0.208	-0.132
LTV>85	-0.298	0.086	-0.410	-0.290	-0.194
Panel B: Elasticity rate - discrete					
Total	-5.787	2.105	-8.436	-5.516	-3.438
By lender					
Big 4	-5.947	2.170	-8.698	-5.678	-3.506
Others	-5.432	1.904	-7.852	-5.172	-3.344
By LTV					
LTV≤85	-5.336	1.920	-7.717	-5.089	-3.221
LTV>85	-7.077	2.074	-9.625	-6.892	-4.690
Panel C: Elasticity fee - continuous					
Total	-0.013	0.012	-0.031	-0.010	0.000
By lender					
Big 4	-0.014	0.012	-0.033	-0.011	0.000
Others	-0.010	0.010	-0.023	-0.008	0.000
By LTV					
LTV≤85	-0.013	0.012	-0.031	-0.011	0.000
LTV>85	-0.011	0.011	-0.026	-0.008	0.000
Panel D: Elasticity fee - discrete					
Total	-0.052	0.054	-0.134	-0.037	0.000
By lender					
Big 4	-0.053	0.054	-0.134	-0.043	0.000
Others	-0.048	0.055	-0.134	-0.032	0.000
By LTV					
LTV≤85	-0.054	0.054	-0.136	-0.043	0.000
LTV>85	-0.044	0.054	-0.123	-0.024	0.000

Note: Panel A shows the elasticity of loan demand with respect to the rate. Panel B shows the elasticity of product demand with respect to the rate. Panel C shows the elasticity of loan demand with respect to the fee. Panel D shows the elasticity of product demand with respect to the fee. The different elasticities are computes using the formulas in Appendix C.



(a) Product share

(b) Loan demand

(c) LTV

(d) LTI

Figure 8: Model fit. The charts shows the estimates of the structural demand parameters in different cells given by income, age and region.

fees equal to -0.03, whereas in others they have an elasticity to fees almost equal to zero. However, the heterogeneity in the elasticity with respect to the origination fee between large and small lenders, and between low-LTV and high-LTV products, is small.

Finally, in Panel D of Table 5 we report the elasticity of the discrete-choice product demand to fees. On average, a one-percent increase in the fee leads to a 0.05-percent decrease in the market share, with a large heterogeneity across products and markets: some display an elasticity -0.13, whereas others do not seem to respond to fees at all. We do find minor differences in the elasticity with respect to the origination fee between large and small lenders, while low-LTV products have a slightly higher elasticity than high-LTV products—i.e., -0.05 versus -0.04, respectively.

To gain a better sense of the relative magnitudes of these different demand elasticities with respect to rates and fees, we calculate the decrease in fees that fully offsets a 10-basis-

Table 6: Cost Parameters

	OLS	First Stage	IV	Reduced Form	Placebo
	(1)	(2)	(3)	(4)	(5)
FLS	-0.283***		-0.415***		
	(0.057)		(0.126)		
Assets Abroad × Post		-0.015***		-0.005**	0.003
		(0.003)		(0.002)	(0.002)
Cost shifters and X_j					
Risk weights	8.055***	-0.124	8.076***	7.936***	10.641***
	(0.797)	(0.383)	(0.797)	(0.884)	(1.047)
Swap rates	0.335***	-0.040	0.316***	-0.908	0.333***
	(0.102)	(0.051)	(0.104)	(0.782)	(0.116)
High LTV	0.606***	0.030	0.608***	0.638***	0.497***
	(0.079)	(0.033)	(0.079)	(0.100)	(0.096)
Variable rate	-0.070	0.049	-0.067	-0.154*	-0.163*
	(0.079)	(0.034)	(0.079)	(0.086)	(0.089)
Fix 5 years	0.214***	0.007	0.220***	0.564**	0.308***
	(0.076)	(0.033)	(0.077)	(0.240)	(0.087)
Time, Region, Lender f.e.	Yes	Yes	Yes	Yes	Yes
Marginal cost (mean)	2.33		2.33	2.61	2.45
F statistic			22.40		
Adjusted R^2	0.81	0.51	0.71	0.82	0.83
Observations	12,489	12,489	12,489	4,419	3,701

Note: The dependent variable is the marginal cost of lending. FLS is the cost of FLS funding, which depends on lending growth since the start of FLS. Asset abroad is the share of assets abroad for each lender in the period before the FLS announcement. Standard errors are clustered at the product level.

point increase in the interest rate in borrowers' demand functions. A 10-basis-point-increase in the interest rate requires an average decrease of £368 to keep the continuous loan demand (15) constant. Thus, this magnitudes is very similar to that of the empirical "exchange-rate" between rates and fees that we reported in Table 2. Similarly, a 10-basis-point increase in the interest rate requires an average decrease of £XXX to keep the individual discrete-choice demand (12) constant.

Supply. Table 6 collects the coefficient estimates of equation (19). The dependent variable is the estimated marginal cost, which we obtain by inverting equation (9). The main coefficient of interest is ψ^c, which captures the effect of the FLS on lenders' marginal costs. For the moment, we assume that application costs $a_j m = 0$.

The OLS estimates reported in column (1) of Table 6 imply that a 100-basis-point

reduction in lenders' marginal borrowing costs leads approximately to a 30-basis-point-reduction in the marginal cost of lending. Given an average marginal cost of about 230 basis points, the FLS decreases marginal costs by 12 percent for the average mortgage product.

As we explained in Section 5.2, participation to FLS is an endogenous choice by the banks, which can be correlated with unobservable determinants of lenders marginal costs. Hence, we use an instrumental-variable strategy, using as instrument lenders' share of assets outside the U.K. before the FLS announcement interacted with an indicator variable equal to one in the post FLS period and zero otherwise. Column (2) in Table 6 reports the first-stage estimates. Lenders with a larger share of assets abroad benefit less from the FLS. We should point out that the additional controls do not seem to play a significant role in the first-stage, which suggests that different lenders do not differ in their product mix and other observable characteristics affecting marginal costs. Column (3) in Table 6 shows the second-stage IV estimates. A 100-basis-point reduction in lenders' costs of borrowing from the FLS facilities leads approximately to a 42-basis-point-reduction in the marginal cost of mortgage lending. Given an average marginal cost of about 230 basis points, the FLS decreases marginal costs by 18 percent for the average mortgage product.

While our main focus is on the effects of FLS on lenders marginal costs, Table 6 also reports the estimates for other variables that affect the marginal cost of offering a mortgage. Higher risk-weights increase marginal costs, as they raise the capital that lenders need in order to increase mortgage lending. Higher swap rates also increase marginal costs, as they increase the spread lenders have to pay to exchange the fixed interest rate with the variable benchmark (e.g., Euribor). Product with higher default risk, measured by a higher the loan-to-value, and higher interest rate risk, measured by the longer fixed rate, have higher marginal costs, as expected. We do not find a statistically significant difference in the marginal costs between variable rate and short-term fixed rate mortgages.

Finally, in columns (4) and (5) of Table 6 we aim to perform a falsification test of our IV strategy by comparing the reduced-form regressions that combine the first-stage and the second-stage regressions displayed in columns (2) and (3) on data from different periods:

column (4) uses data for 2012, whereas column (5) uses data from 2011. More precisely, the IV estimates of columns (2) and (3) imply that, during the FLS period, banks with a higher share of assets abroad have higher marginal costs, and the reduced-form estimates in column (4) confirm this. The exclusion restriction of our IV strategy is that the only channel through which the share of asset abroad affect lenders' costs of originating mortgages in the UK is via their utilization of FLS. A threat to our identification strategy is that the share of assets abroad affects the costs of originating mortgages in the U.K. irrespective of the FLS. Thus, we use data from 2011—i.e., the year before the FLS the introduction of the FLS—to investigate the conditional correlation between lenders' share of assets abroad and their marginal costs. Column (5) of Table 6 shows that we do not find a significant effect of the share of assets abroad on lenders marginal costs in the period pre-FLS, thereby buttressing the validity of our IV-strategy.

In Appendix D, we report further analysis using three alternative ways to measure lender participation in the FLS. First, we construct an indicator variable equal to one for lenders with positive outstanding amount of FLS borrowing, and zero otherwise. The coefficient estimates show that lenders with a positive outstanding amount of FLS borrowing have 60-basis-point-lower marginal costs than lenders not borrowing from the scheme; given an average marginal cost of about 240 basis points, the FLS decreases marginal costs by 25 percent for the average mortgage product. Second, we use a continuous measure of FLS borrowing, thereby exploiting a finer variation across participating lenders as well relative to a binary participation variable. Specifically, we use the logarithm of the outstanding amount of FLS borrowing interacted with a dummy equal to one in the post FLS period. The estimates show that a 10-percent-increase in FLS borrowing is correlated with a 0.6-basis-point decline in the marginal cost. Third, we distinguish between lenders participating in the FLS and increasing lending thereafter versus lender not borrowing or borrowing but decreasing lending. We find that lenders borrowing from FLS and increasing lending have a 35-basis-point-lower marginal costs relative to other lenders, which is about a 15-percent-lower cost for the average mortgage product.

Table 7: Counterfactual policies

	Panel A: Pre - FLS							
	Cost (%)	Rate (%)	Fee (.000)	APR (%)	Quantity (.000)	Market Size	Profit (Million)	Consumer Surplus
Baseline	2.72	4.14	0.60	4.16	109	0.92	111	74.5
No Fee	2.72	4.28	0	4.28	110	0.91	90	74.55
	Panel B: Post - FLS							
	Cost (%)	Rate (%)	Fee (.000)	APR (%)	Quantity (.000)	Market Size	Profit (Million)	Consumer Surplus
Baseline	2.43	3.98	0.49	4.00	114	0.95	125	83.67
No FLS	2.94	4.03	0.49	4.05	113.8	0.94	88	83.62
No Fee	2.43	4	0	4.00	114.8	0.95	100	83.7
No FLS - No Fee	2.94	4.06	0	4.06	114.7	0.94	70	83.66

Note: Results from counterfactual analysis. No FLS is a counterfactual in which we shut down the effect of FLS on lenders marginal costs from column (1) in Table 6 and for now we assume no change in fees and that 80% of the increase in marginal cost is pass on to mortgage rates. No Fee is a counterfactual in which we force all products to have zero fees, thus for each product type k there is a unique product j with zero fee and a new equilibrium rate (for now we assume that the new mortgage rates is the highest for the same product type). No FLS - No fee is a combination of the previous two counterfactuals. Cost, rate and fees are the averages across all consumers and products in the market; Q is the total quantity given by the predicted shares multiplied by the predicted quantity in billions of pounds; Π is the average profits of the lender; CS is the average consumer surplus.

6 Counterfactual Policies

In this section, we use the estimated parameters to study the effect of the FLS, as well as the effects of two-part pricing with rates and fees, on the mortgage market. Specifically, Table 7 reports, for the baseline case (i.e., the estimated model) and for alternative counterfactual scenarios that we consider, these key outcomes of interest: lenders' marginal cost, mortgage rates and fees, volumes of mortgage originated, lenders' profits, and consumer surplus. Panel A focuses on the two and a half years before and Panel B on the two and a half years after the introduction of the FLS.

The first row of each Panel of Table 7 looks at the baseline case—i.e., the prediction of our model, which matched the data quite closely, as we showed in Section 5.3. The marginal cost of issuing a mortgage was 272 basis points before the FLS and 243 basis points after. Before the FLS, borrowers paid an average interest rate of 414 basis points and an average origination fee of about £600, while after the FLS the rate declined to approximately 400 basis points and the fee to £490. Following the decrease in both rates and fees, the Annual Percentage Rate (APR) decreases from 416 basis points before the FLS to 400 after. The column labeled 'Quantity' reports the predicted average loan amount, while the column labeled 'Market Size' reports the share of mortgage originations relative to the outside option. The loan size increases from £109 thousands before the FLS to £114 thousands after the FLS. The market size increase from 92 percent to 95 percent in the same period. Finally, we compute lenders' profits, using equation (7), and consumer surplus, using equation 25 in Appendix C. Both lenders' profits and consumer surplus increase in the period after the FLS, as lenders and borrowers share the cost decrease due to FLS.

No FLS. In the second row of Panel B of Table 7, we report the effects of FLS in the mortgage market. Specifically, we use the estimates from column (3) of Table 6 and shut down the effect of the scheme on lenders' marginal costs by assuming $\psi^c = 0$. Lenders' marginal costs increase from approximately 245 to 295 basis points. As a preliminary analysis, we assume that this increase in marginal costs is passed through to interest rates according to the pricing equation , whereas fees do not change. Thus, in the post FLS period, origination fees remain constant at £490, while interest rates (and APRs) increase by only 5 basis point, from 398 to 403. The loan amount and market size post FLS is larger than that pre FLS, but lower than in the baseline post FLS period. The loan amount declines by about £200 ; the market size declines by approximately one percent. Lenders profits decline by almost 30 percent, because of higher costs which are not pass-on to rates and lower volumes. Consumer surplus declines by approximately 0.1 percent.

No Fees. We further study the effects of two-part pricing with rates and fees by

imposing a ban on fees. This is of interest for at least two reasons. First, Greenwood and Scharfstein (2013) document the growth in fees associated with an expansion in household credit, particularly fees associated with residential mortgages. Hence, our model is well suited to understand the contribution of mortgage origination fees to lenders' profits. Second, the financial press recently reported that the Financial Conduct Authority (FCA) is currently considering the regulation of mortgage origination fees (*The Financial Times*, Mortgage lenders under FCA review for masking high fees, December 12, 2016).

We consider the effects of a ban on fees both before and after FLS. The second row of Panel A of Table 7 reports that, on average, interest rates increase by about 15 basis points and there is a small decrease in market size as a result of the higher rates, despite the zero fees. Lenders profits decrease by about 19 percent, while consumer surplus increases slightly. The third row of Panel B of Table 7 reports the effects of a ban on fees post FLS. On average, interest rates increase by only two basis points and almost no changes in loan amounts and market size. The largest effect is again on lenders' profits which decline by 20 percent relative to the baseline, while consumer surplus increases slightly.

No FLS and No Fees. In the last row of Panel B of Table 7 we report the case when we remove the FLS and we ban fees—i.e., the previous two scenarios simultaneously. The change in marginal cost is the same as that of the counterfactual in which we shut down the FLS, but the ban on fees further increases the rate by three basis points relative to the case when lenders can charge positive origination fees. Comparing the pass-through rate in the case with and without fees, we find that multi-dimensional pricing reduces the pass-through by about two percent.[5] The ban on fees has a arge negative effect on lenders' profits: in the case without FLS but no ban on fees, lender profits decrease by about 30 percent relative to the baseline case, whereas in the case without FLS and ban on fees, lender profits decrease by 44 percent relative to the baseline.

[5]The change in rates divided by the change in marginal costs ($\frac{\Delta Rate}{\Delta Cost}$) as a result of FLS is 10 basis points in the case with fees and 12 in the case without fees.

7 Conclusions

TO DO LIST:

1. Endogenize participation in the FLS in the model;

2. Try correlation between average ζ_i of each product and c_{jm}.

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Appendix

The appendix is structured as follows. Section B details how we construct our main dataset by merging the differences data sources on mortgage choices from the Financial Conduct Authority, products offered from Moneyfacts and lenders borrowing from the Bank of England. Section D provides additional details about the estimation approach and on the fit of the model.

A Mortgage pricing across LTV bands in the PSD

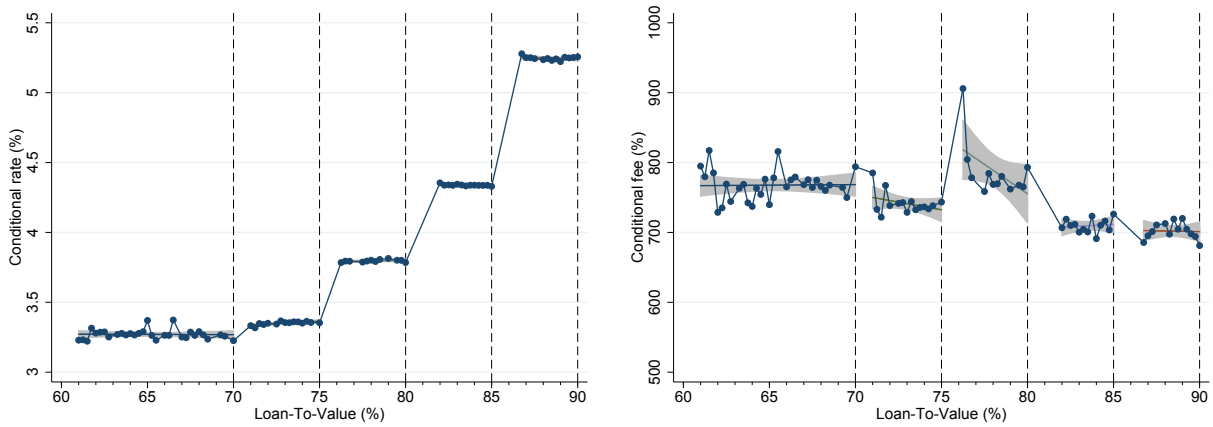


Figure A1: LTV PRICING

Note: Panel (a) shows how the average initial interest rates on mortgage originations vary within and across LTV bands. Panel (b) displays a similar picture for origination fees. Source: the Financial Conduct Authority Product Sales Database. Sample: for interest rates, 2010-2014; for fees, 2015, which is the first year since when origination fees are available in the PSD.

Figure A1 illustrates the main pricing structure of UK mortgages using the universe of mortgage originations from the PSD. Specifically, the left panel displays that the interest rate varies across LTV bands, with (almost) no variation within bands, consistent with the pattern reported in (Cloyne et al., 2018; Benetton, 2018). In other words, UK lenders seem to price default risk almost exclusively through LTV bands, and not through borrower-specific pricing, as it is instead the case in the US mortgage market. Moreover, this panel motivates

us to model borrowers' choice as a discrete-choice among these LTV bands, lenders, and other product characteristics. The right panel displays that fees –which we observe in the PSD only since 2015– exhibit very limited variation across and within bands, potentially suggesting that lenders use them mainly to extract consumer surplus.

B Data Construction

- Step 1: Matching mortgages with time-lender-LTV band-rate to moneyfacts to recover dealtype.
  - Moneyfacts missing 2013 month 6
  - Sometimes cannot find LTV band in moneyfacts corresponding to LTV band in PSD. Cases in which no jumps in PSD. E.g. Nationwide in November 2009 does not have 75-80 band, only max 70-75 and 80-85, but then introduce it later.
  - Sometimes more than one dealtype for the same interest rate-lender-LTV band-month. E.g. 2 and 3 years fixed with different fees.
  - We manage to keep 456,323 out of 517,546 (88%)
  - Nationwide specialized in 3 years fixed. Checked with moneyfacts.
- Step 2: Matching mortgages with time-lender-LTV band-dealtype-rate to recover product rate (as a check) and fees.
- Step 3: Predicting dealtype and fee level for mortgages when both rates and dealtype missing (42%, approx 350K obs). First
  - Rename lender to outside if dealtype is different from zero, two, three and five. Rename lender to outside if fix zero and floating five. Less than 1%.
  - Ordered logit model for dealtype. We run regression for each ratetype (FRM,ARM) and LTV band with dummy for age, income, region and time. We compute the predicted probabilities and compare it with the empirical frequencies. We take the highest predicted proability if larger than the empirical frequency. Otherwise we take the one with the largerst positive difference with the empirical frequency.
  - Ols model for interest rate. We predict the interest rate with dummies for product (excluding lender) and age-income-region

- We match the mortgages with imputed dealtype and rate with moneyfacts and take the interest with the smallest difference to recover interest and fees

C Model: Additional Material

Demand elasticities. The discrete-continuous choice model loan demand elasticity ($\epsilon^{r,q}_{ijm}$) and product share demand elasticity ($\epsilon^{r,d}_{ijm}$) relative to the interest rate are respectively given by:

$$\epsilon^{r,q}_{ijm} = \frac{\partial q_{ijm}}{\partial r_{jm}} \frac{r_{jkm}}{q_{ijm}} = \frac{\partial \ln(q_{ijm})}{\partial r_{jm}} r_{jm} = -\alpha_r r_{jm} \tag{21}$$

$$\begin{aligned} \epsilon^{r,d}_{ijm} &= \frac{\partial s_{ijm}}{\partial r_{jm}} \frac{r_{jm}}{s_{ijm}} = -\alpha_r \mu \exp(-\alpha_r r_{jm} + \beta X_j + \xi_{jm} + \zeta_i) s_{ijm}(1 - s_{ijm}) \times \frac{r_{jm}}{s_{ijm}} = \\ &= -\alpha_r \mu \exp(-\alpha_r r_{jm} + \beta X_j + \xi_{jm} + \zeta_i)(1 - s_{ijm}) r_{jm} \end{aligned} \tag{22}$$

The loan demand and discrete elasticity relative to the fee are respectively given by:

$$\epsilon^{f,q}_{ijm} = \frac{\partial q_{ijm}}{\partial f_{jm}} \frac{f_{jm}}{s_{ijm}} = -\frac{\psi}{Y_i - f_{jm}} \tag{23}$$

$$\begin{aligned} \epsilon^{f,d}_{ijm} &= \frac{\partial s_{ijm}}{\partial f_{jm}} \frac{f_{jm}}{s_{ijm}} = -s_{ijm}(1 - s_{ijm}) \frac{\gamma}{(Y_i - f_{jm})^{\psi}} \times \frac{f_{jm}}{s_{ijm}} = \\ &= -(1 - s_{ijm}) \frac{\gamma f_{jm}}{(Y_i - f_{jm})^{\psi}} \end{aligned} \tag{24}$$

The elasticity at the product-market level are computed by averaging across consumers in each market.

Consumer surplus. The expected compensating variation $E[cv]$ for a change in interest rate, all else equal, equals:

$$E\left[\max_{j \in J^0} U(y, r^0_j, X_j, \epsilon_j)\right] = E\left[\max_{j \in J^0} U(y, r^1_j - cv, X_j, \epsilon_j)\right], \tag{25}$$

where r^0_j is the price of product j before the change and r^1_j is the price after the change.

Hence, the difference in expected consumer surplus equals:

$$\Delta E[CS] = \frac{1}{\gamma \left(Y_i - f_{jm}\right)^{-\psi}} \left[\ln \left(\sum_{j=1}^{J^1} \exp(V_j^1) \right) - \ln \left(\sum_{j=1}^{J^0} \exp(V_j^0) \right) \right], \tag{26}$$

where $\gamma \left(Y_i - f_{jm}\right)^{-\psi}$ is the marginal utility of income.

D Estimation: Additional Material

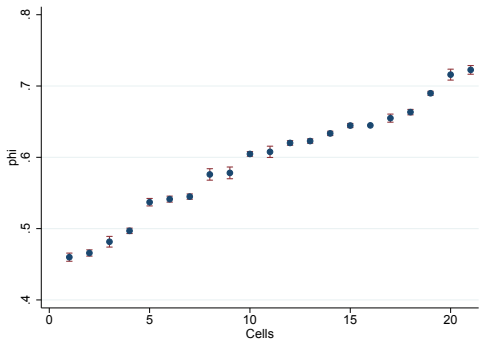
Table A1: Fit of the model

	mean	**sd**	**p10**	**p50**	**p90**
loan value					
Data	134.8	80.5	66.3	115.5	217.5
Model	124.5	66.5	69.0	107.1	201.3
LTI					
Data	3.4	2.0	2.2	3.4	4.6
Model	3.1	0.6	2.4	3.1	3.8
Product shares					
Data	1.8	3.0	0.2	0.8	4.4
Model	1.9	2.5	0.6	1.4	3.2
LTV					
Data	80.7	7.5	70.0	80.0	90.0
Model	78.5	5.3	71.4	79.0	85.1

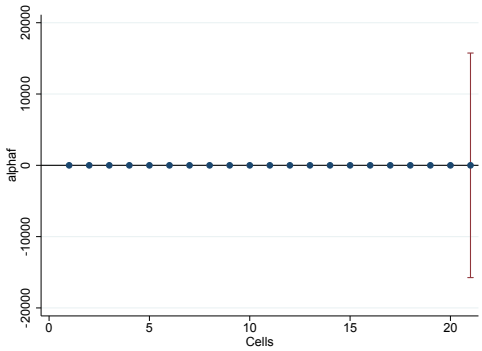
Note: write.

Figure A2: **Demand estimates: first stage**

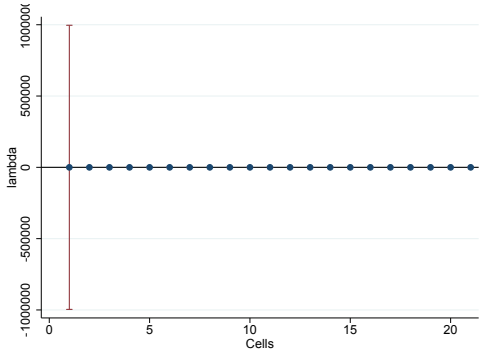
Notes: The charts shows the estimates of the structural demand parameters in different cells given by income, age and region.



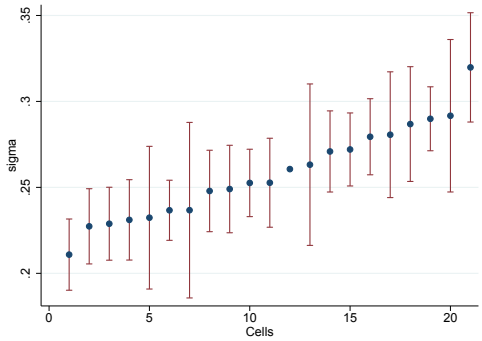
(a) Income (ϕ)



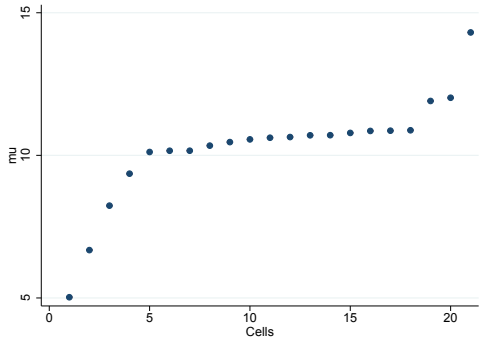
(b) Fee (α_f)



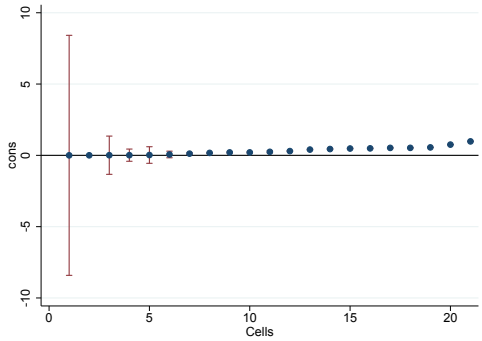
(c) Branches (λ)



(d) Variance (σ)



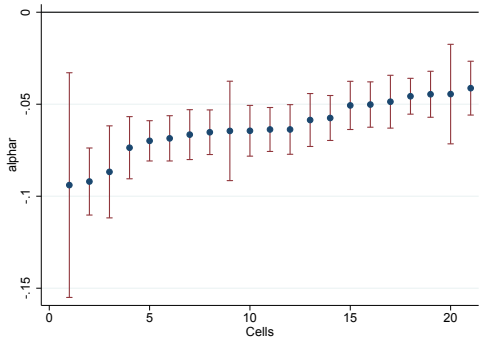
(e) Scaling (μ)



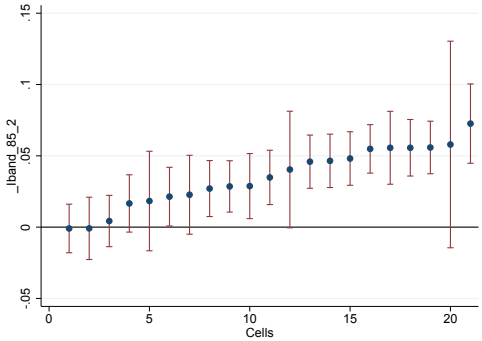
(f) Constant

Figure A3: **Demand estimates: second stage**

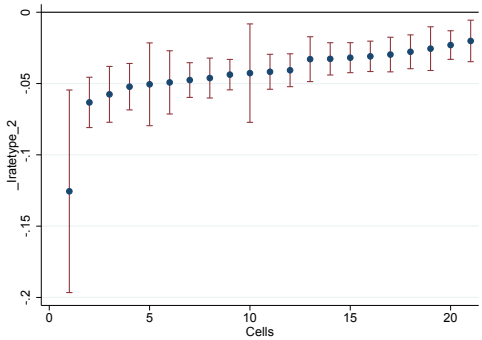
Notes: The charts shows the estimates of the structural demand parameters in different cells given by income, age and region.



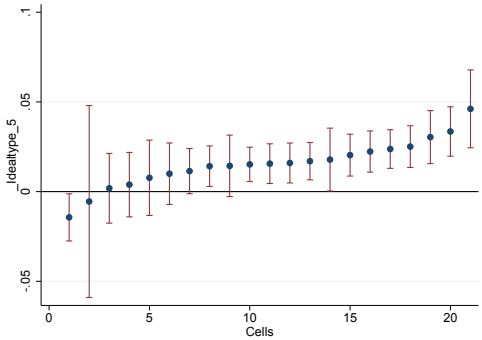
(a) Interest (α_r)



(b) High LTV



(c) Variable rate



(d) 5-years fixed

Table A2: Structural supply parameters: OLS

	Actual borrowing		Ex-post lending	
	(1)	(2)	(3)	(4)
FLS outstanding (dummy)	-0.576***			
	(0.063)			
FLS outstanding (log)		-0.061***		
		(0.007)		
Lending growth > 0 (dummy)			-0.350***	
			(0.067)	
Reduction in mc (%)				-0.283***
				(0.057)
Risk weights	8.818***	8.493***	8.121***	8.055***
	(0.794)	(0.787)	(0.796)	(0.797)
Swap rates	0.286***	0.311***	0.339***	0.335***
	(0.097)	(0.099)	(0.101)	(0.102)
High LTV	0.547***	0.573***	0.600***	0.606***
	(0.076)	(0.077)	(0.079)	(0.079)
Variable rate	-0.085	-0.068	-0.062	-0.070
	(0.072)	(0.074)	(0.078)	(0.079)
Fix 5 years	0.234***	0.225***	0.215***	0.214***
	(0.073)	(0.075)	(0.076)	(0.076)
Time f.e.	Yes	Yes	Yes	Yes
Region f.e.	Yes	Yes	Yes	Yes
Lender f.e.	Yes	Yes	Yes	Yes
Marginal cost (mean)	2.33	2.33	2.33	2.33
Adjusted R^2	0.82	0.82	0.81	0.81
Observations	12,489	12,489	12,489	12,489

Note: The dependent variable is the marginal cost of lending. FLS outstanding dummy is a variable equal to one in the post FLS period for lenders with a positive outstanding amount of FLS borrowing. FLS outstanding log is equal to the logarithm of the outstanding amount of FLS borrowing interacted with a dummy equal to one in the post period. Lending growth >0 is a dummy equal to one in the post FLS period for lenders with a positive lending growth since the start of FLS. Reduction in marginal costs is a the reduction of marginal costs as a result of different lending growth since the start of FLS: 1.25% (125 basis points) if lending growth is > 5%; 0 if lending growth < -5% and 0.75% (75 basis points) otherwise.

Table A3: Structural supply parameters: First Stage

	FLS outstanding (dummy)	Reduction in mc (%)	Lending growth > 0 (dummy)	Reduction in mc (%)
	(1)	(2)	(3)	(4)
Assets Abroad × Post	-0.014***	-0.084***	-0.008***	-0.015***
	(0.003)	(0.027)	(0.003)	(0.003)
Risk weights	1.149***	6.389**	0.162	-0.124
	(0.311)	(2.932)	(0.391)	(0.383)
Swap rates	-0.062	-0.489	-0.050	-0.040
	(0.057)	(0.500)	(0.055)	(0.051)
High LTV	-0.083***	-0.390*	0.005	0.030
	(0.025)	(0.236)	(0.033)	(0.033)
Variable rate	0.008	0.291	0.057*	0.049
	(0.020)	(0.199)	(0.032)	(0.034)
Fix 5 years	0.022	0.182	0.021	0.007
	(0.035)	(0.313)	(0.036)	(0.033)
Time f.e.	Yes	Yes	Yes	Yes
Region f.e.	Yes	Yes	Yes	Yes
Lender f.e.	Yes	Yes	Yes	Yes
F statistic	21.19	9.66	6.73	22.40
Observations	12,489	12,489	12,489	12,489

Note: The dependent variable are different measures that capture the FLS treatment. FLS outstanding dummy is a variable equal to one in the post FLS period for lenders with a positive outstanding amount of FLS borrowing. FLS outstanding log is equal to the logarithm of the outstanding amount of FLS borrowing interacted with a dummy equal to one in the post period. Lending growth >0 is a dummy equal to one in the post FLS period for lenders with a positive lending growth since the start of FLS. Reduction in marginal costs is a the reduction of marginal costs as a result of different lending growth since the start of FLS: 1.25% (125 basis points) if lending growth is > 5%; 0 if lending growth < -5% and 0.75% (75 basis points) otherwise. The excluded instrument is the fraction of asset abroad from the bank balance sheet before the FLS interacted with a dummy equal to one is the post FLS period.

Table A4: Structural supply parameters: IV

	Actual borrowing		Ex-post lending	
	(1)	(2)	(3)	(4)
FLS outstanding (dummy)	-0.457***			
	(0.123)			
FLS outstanding (log)		-0.074***		
		(0.019)		
Lending growth > 0 (dummy)			-0.759***	
			(0.234)	
Reduction in mc (%)				-0.415***
				(0.126)
Risk weights	8.652***	8.601***	8.250***	8.076***
	(0.799)	(0.807)	(0.819)	(0.797)
Swap rates	0.305***	0.297***	0.296***	0.316***
	(0.101)	(0.101)	(0.103)	(0.104)
High LTV	0.558***	0.567***	0.600***	0.608***
	(0.077)	(0.077)	(0.080)	(0.079)
Variable rate	-0.083	-0.065	-0.044	-0.067
	(0.073)	(0.072)	(0.078)	(0.079)
Fix 5 years	0.227***	0.231***	0.233***	0.220***
	(0.074)	(0.075)	(0.078)	(0.077)
Time f.e.	Yes	Yes	Yes	Yes
Region f.e.	Yes	Yes	Yes	Yes
Lender f.e.	Yes	Yes	Yes	Yes
Marginal cost (mean)	2.33	2.33	2.33	2.33
F statistic	21.19	9.66	6.73	22.40
Adjusted R^2	0.72	0.72	0.69	0.71
Observations	12,489	12,489	12,489	12,489

Note: The dependent variable is the marginal cost of lending. FLS outstanding dummy is a variable equal to one in the post FLS period for lenders with a positive outstanding amount of FLS borrowing. FLS outstanding log is equal to the logarithm of the outstanding amount of FLS borrowing interacted with a dummy equal to one in the post period. Lending growth >0 is a dummy equal to one in the post FLS period for lenders with a positive lending growth since the start of FLS. Reduction in marginal costs is a the reduction of marginal costs as a result of different lending growth since the start of FLS: 1.25% (125 basis points) if lending growth is > 5%; 0 if lending growth < -5% and 0.75% (75 basis points) otherwise. The excluded instrument is the fraction of asset abroad from the bank balance sheet before the FLS interacted with a dummy equal to one is the post FLS period.