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"Product Proliferation as Price Obfuscation? Evidence from the Mortgage Market"

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Presenter: Lu Liu, PhD student at Imperial College London

Product Proliferation as Price Obfuscation? Evidence from the Mortgage Market *

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Abstract

This paper provides a supply-driven explanation behind price dispersion and product proliferation in the mortgage market: given the salient cost dimension, interest rates, firms can issue new products and adjust prices via a secondary cost dimension, fees, to appear cheap to consumers who fail to minimize total cost. Hence non-salient fees may allow lenders to obfuscate prices and make the true cost ranking more difficult to read for consumers. I provide a framework in which I can test for this supply-side mechanism empirically, by studying lenders' price adjustment and product strategies in response to firm-specific shocks to funding cost. Using novel data on the universe of mortgage products on offer in the UK, I show that lenders maintain competitive interest rates, but raise fees and the number of product alternatives with different fees when their funding costs increase relative to other lenders. In loan-level data, I indeed find lower excess cost dispersion, as a measure of search outcomes, for products without fees compared to products with fees, suggesting that supply-driven motives may help explain suboptimal search in the mortgage market, by exacerbating existing demand-side search frictions.

JEL classification: G1, D12, D18

Keywords: mortgages, price dispersion, product proliferation

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1. Introduction

Picking a mortgage is one of the biggest and most complex financial decisions in a consumer's lifetime. As part of a broader recovery in mortgage markets since 2009, the number of different mortgage products on offer in the UK has more than tripled to date, outpacing mortgage issuance volumes. While this could reflect an improved choice environment,[1] more than half of all products on offer within a narrow product class appear strongly cost-dominated, i.e. more than £1000 more expensive than the cheapest alternative, pointing instead to market frictions.[2] In particular, many product alternatives are variations of the same product by the same lender in price terms, e.g. a high interest rate and low fee, or low interest rate and high fee variant.

What can explain this price dispersion and product proliferation in the mortgage market? While previous work has emphasized the role of demand-side factors,[3] this paper studies a supply-driven mechanism: in a market with one salient cost dimension, interest rates, lenders can issue new products and adjust prices via a less salient cost dimension, fees, to appear cheap to consumers who neglect fees and overemphasize interest rates. Lenders can hence use fees to obfuscate prices, i.e. to make the true cost ranking more difficult to read for consumers, consistent with existing models of price obfuscation (Gabaix and Laibson, 2006, Carlin, 2009).

The challenge to test this channel empirically consists of clearly measuring obfuscation and showing that it is driven by supply. I propose a framework in which this is possible, by studying lenders' price adjustment and product strategies in response to firm-specific time-varying shocks to wholesale funding cost. I show that lenders respond to these firm-specific cost shocks by maintaining competitive interest rates, but increasing fees and expanding the pricing space via product alternatives that differ in fees. The increase in fees is economically large: given a one standard deviation increase in the funding cost shock, lenders raise average fees by £60 and their highest fees by about £120, which is about 10 to 20 per cent of the average level of fees and corresponds to a 0.3 to 0.6 standard deviation change in fees.

[1] Similar to the observation made by Carlin and Manso (2010) who note that "[w]hile such proliferation may add value in completing markets, it may also adversely affect investor sophistication."

[2] For a given mortgage choice (Campbell and Cocco, 2003) of loan-to-value (LTV) ratio and fixation period, a residential mortgage can be thought of as a homogeneous financial product. Under perfect competition, consumers search for the cost-minimizing product and prices converge to the "law of one price". In contrast, the interquartile range of 75% LTV, 2-year fixed rate products on offer based on a loan size of £150,000 remains around £1000 over time, which is about 10% of the total 2-year cost.

[3] Borrowers may have unobserved preferences for specific brands that increase their willingness to pay, or alternatively, search and cognitive frictions may prevent borrowers from finding the cost-minimizing product (see Hortaçsu and Syverson (2004), Choi et al. (2009) for the index mutual fund market). One recent exception is work by Agarwal et al. (2017c) who study the effects of demand-side search and supply-side approval on equilibrium price dispersion in the mortgage market.

The fact that firms' optimal pricing strategy uses fees as an active margin of price adjustment to maintain the relative pricing of interest rates reveals that firms may exploit that demand is less price-elastic with respect to fees than to interest rates. In particular, if some consumers neglect fees and fail to find the cheapest product if both interest rates and fees vary, firms can use fees as an additional, but less salient pricing dimension to "hide" that some products are more expensive in total cost terms, as they can be priced to be dominated in the fee dimension, but not in terms of interest rates. For instance, if the cheapest product in the market is priced at 2% interest and zero fees, a 2.23% interest and zero fee product, which is around £400 more expensive, can be repriced at 1.95% interest and £495 fees, in order to appear less expensive in the more salient interest rate dimension.[4]

I further look at borrowing outcomes and find lower excess cost dispersion (accounting for borrower, product and regional characteristics) for products without fees, compared to products with fees, i.e. borrowers seem to come closer to the cost-minimizing benchmark in the class of products without fees than those with fees.

To develop the intuition more formally, I adopt a simple search model with heterogeneous consumers and firms to show that product proliferation in price dimensions can be understood as a price obfuscation mechanism in the presence of suboptimal search and consumer mistakes.

The framework matches two important stylized facts in the data: price dispersion, i.e. the existence of a substantial portion of cost-dominated products in the market at any one point in time, and fee heterogeneity. Here, fee heterogeneity can be interpreted as differences in obfuscation intensity, and points to the idea that lenders choose differentially to what extent to obfuscate.[5] In the model, there are lenders and consumers that differ in marginal cost and search cost, simplified respectively as high and low-cost lenders, and informed and uninformed consumers.[6] In this environment, *some* lenders have an incentive to price-obfuscate if *some* consumers search imperfectly or fail to fully cost-minimize. The mechanism is related to models by Salop and Stiglitz (1977), Carlin (2009) and Gabaix and Laibson (2006) on price dispersion, price complexity and add-on

[4]Assuming that the mortgage is repaid over an initial 2-year fixed rate period with a £150,000 loan value and 25 year amortization period, and is subsequently refinanced.

[5]For instance if there is a trade-off between the level and the attention paid to the fee by different borrowers (i.e. the higher the fee, the more likely it could be detected, so the more salient it becomes). This is a novel element compared to previous work that focuses on the choice between obfuscating and not obfuscating (Gabaix and Laibson, 2006), or that fixes the level of non-salient fees at an exogenously determined maximum level (Agarwal et al., 2017b) that holds across all firms, and could be micro-founded by theories of consumer inattention (De Clippel et al., 2014).

[6]"Uninformed" is a generalizing term that refers to the idea that this type of borrower is not fully total-cost minimizing and has a lower total cost sensitivity - these borrowers could also be interpreted as having high attention or search cost (Ellison and Wolitzky, 2012), being naïve (Carlin, 2009) or myopic (Gabaix and Laibson, 2006).

price obfuscation, respectively. The key idea is that high-cost lenders cannot attract informed consumers, but can lure uninformed consumers by "pretending" to have a low price (interest rate) while charging a hidden additional cost (fee). This is in contrast to low-cost lenders who, provided the share of informed consumers is large enough, will prefer to attract informed consumers with a low price product with no hidden cost. Given a fixed interest rate price frame (e.g. low or high interest rates), this prevents low-cost lenders from obfuscating as they cannot directly offer dominated products within their menus (e.g. a low interest rate product with, and without fees), which is in line with the data. In addition, if the probability of a borrower accepting a high price (i.e. a high interest rate product) is non-zero, the high-cost lender also prefers to use the full range of price and hidden cost combinations. The intuition is that lenders can exploit different types of consumer mistakes once there is an additional price dimension involved, which gives a theoretical motivation for product proliferation along price dimensions.

The presence of informed and uninformed consumers can thus motivate a separating equilibrium in which high-cost lenders obfuscate and use the full price space, and low-cost lenders do not obfuscate. Hence product proliferation along price dimensions can be understood as a price obfuscation strategy when fees are not fully salient and illustrates a potential novel supply-driven amplification mechanism behind price dispersion and suboptimal search in the mortgage market.

The obfuscation mechanism implies that firms actively exploit consumer mistakes such as fee neglect and relates to the literature on price dispersion across a range of homogeneous goods markets (Ellison and Ellison, 2009, Choi et al., 2009). A common empirical step to disentangle to what extent price dispersion is driven by genuine preferences compared to demand-side mistakes is to rule out the preference channel. I address this identification challenge from the supply side, using time-varying lender-specific shocks to wholesale funding cost that I construct using lenders' cross-sectional exposures to the shock (loan-to-deposit ratios) and an aggregate funding cost shock (LIBOR swap rates plus CDS spreads). In order to directly track lenders' pricing strategies over time, I employ a novel product-level dataset on the universe of all mortgages offered in the UK since 2009, allowing me to compute lenders' changes to interest rates and fees across products while observing detailed other product characteristics. This is important as loan-level mortgage origination data alone may not capture the full menu and prices offered by a given lender over time. I further complement my findings with borrowing outcomes recorded in the FCA Product Sales Data (PSD) which contains administrative data on all regulated mortgage originations in the UK. In order to rule out that the pricing strategy is driven by unobserved preference shocks, the identifying assumption is that demand shocks for a specific lender are uncorrelated to lender-specific cost shocks over

time.[7] My approach hence reveals a profit-maximizing strategy that can be rationalized with demand-side frictions, in particular fee neglect, and lenders' exploiting this as a source of market power.

Next, I try to rule out that this pricing strategy is driven by other supply-side mechanisms, most notably the use of fees to screen and reveal borrower types, where screening motives could be correlated with cost shocks. I find little evidence that fees are used to reveal borrower risk types. In contrast to the US, early repayment penalties exist in the UK, which are a more direct measure to screen for prepayment risk than fees.[8] For almost 90% of products in the sample, prepayment penalties do not vary across products by a given lender, i.e. they are uncorrelated with fees within a lender. This extends to a regression setup, where prepayment penalties do not significantly affect the interest rate-fee trade-off within and across lenders. This seeming lack of screening for heterogeneous prepayment risk could be explained by the relatively short initial fixation periods prevalent in the UK, with most borrowers refinancing at the end of a 2 to 5 year fixation period (Best et al., 2015). As another screening mechanism, lenders may use high fees to screen for liquidity risk, as highly liquidity-constrained borrowers may be less able to pay an upfront fee, or any other unobservable characteristics that may be correlated with default probabilities. The institutional framework in the market makes this less likely as borrowers are allowed to add the fee to the loan balance and repay it over the duration of the mortgage, at no additional cost.[9] I also find that cost pass-through via fees and product proliferation appears stronger for low LTV products, indicating that the mechanism is more relevant when default risk is low and selection on unobservables plays less of a role.[10]

The pricing model by lenders implies, however, a consistent link between fees and loan size, as the benefit of a lower interest rate, the interest cost reduction, is greater for larger loan balances.[11] For a given lender's product offering of high interest rate and low fee, vs. low interest rate and high fee product, there exists a unique loan value at which a borrower should be indifferent between choosing the low or high fee product. So

[7] One could perhaps imagine a link between cost shocks which have an effect on other services that existing customers receive who take out a mortgage, but it seems less likely that these type of services are adjusted at the frequency of quarterly cost shocks.

[8] In the US mortgage market, borrowers typically have the option to pay "points" (fees) upfront to obtain a lower interest rate, which decreases the refinancing incentive and signals lower prepayment risk (Stanton and Wallace, 1998).

[9] This can be seen in the loan-level data, and is also documented in Best et al. (2015) and confirmed in conversations with industry participants.

[10] In addition, loan-to-income ratios (LTI) seem positively correlated with fees at high LTI levels, indicating that high fees do not seem to screen out liquidity-constrained borrowers with high LTIs. This may instead be driven by high LTI borrowers also borrowing relatively larger loan values and hence have a bigger incentive to pay the fee. But in general, there is substantial fee variation across borrowers within LTI bins, suggesting that most of the variation in fees is independent of liquidity-related motives.

[11] In that sense, fees can be thought of as very coarsely screening for loan size.

from the perspective of a given borrower with a fixed loan size, she should actually only consider a single product by a given lender, such that price dispersion purely arises from choice across lenders. This does not seem to be the case in realized borrowing outcomes: I find substantial realized fee dispersion across the loan size distribution,[12] suggesting that consumers make mistakes in the fee dimension, in line with the intuition that lenders can exploit different types of consumer mistakes once there is an additional price dimension involved.

These findings are important for two reasons. First, I provide empirical evidence that lenders respond strategically to demand-side frictions and document a supply-driven mechanism behind product proliferation in price dimensions. The framework provides testable predictions of how firms obfuscate in the presence of non-salient fees. My work is the first to empirically identify this supply-side obfuscation channel using cost shocks, to the best of my knowledge. And second, I provide evidence that is consistent with fees making price comparisons more difficult for consumers, pointing to a potential amplification of existing demand-side frictions. This has macroeconomic consequences, for instance on the pass-through of monetary stimulus, and could redistribute gains across the borrower population, e.g. if less financially literate households are more likely to neglect total costs including fees and hence less able to benefit from lower interest rates.

The findings further contribute to the existing literature. Recent empirical work provides evidence of firms exploiting consumer mistakes across a range of retail financial markets (Ru and Schoar, 2016, Agarwal et al., 2017a, Andersen et al., 2015, Célérier and Vallée, 2017). My findings on firms adjusting non-salient fees in the mortgage market are consistent with evidence from the credit card market (Agarwal et al., 2014), mutual fund (Anagol and Kim, 2012) and social security markets Duarte and Hastings (2012), as well as consumers underreacting to non-salient taxes (Chetty et al., 2009), while I further document that the non-salient price component is set jointly in order for firms to compete in the salient price dimension.

The identification strategy also allows me to highlight the active role of the supply side for household finance problems (Foà et al., 2015), as firms dynamically respond to cost shocks to adjust their fees and product offering optimally, in response to a change in their competitive position. I further show that supply-side incentives play a role in understanding the drivers behind price dispersion (Hortaçsu and Syverson, 2004, Ellison and Ellison, 2009, Bhutta et al., 2018)[13] in markets for homogeneous goods, which could amplify existing search frictions. The identification based on cost shocks reveals a pricing strategy in line with search and cognitive frictions on the demand side, while making a

[12] With fee dispersion being lower for very small loan sizes where it almost never optimal to choose the low rate high fee product, see Figure A.6.

[13] See Baye et al. 2006 for a review.

preference-driven mechanism less likely, hence adding to the previous literature that has used experimental (Choi et al., 2009) and model-based approaches (Woodward and Hall, 2012) to distinguish between these two channels.

Lastly, I provide a framework that links the evidence in the UK mortgage market to theoretical predictions of price obfuscation with non-salient fees, in the spirit of models by Gabaix and Laibson (2006), Carlin (2009) and Piccione and Spiegler (2012). I show that high-cost lenders have an incentive to obfuscate and use the full range of prices and hidden fees if there are consumers who neglect fees and fail to cost-minimize, while low-cost lenders do not in order to attract fully cost-minimizing consumers, building on seminal work by Salop and Stiglitz (1977) and Varian (1980).[14] The idea that firms adjust the degree of obfuscation optimally is closely related to the model by Carlin (2009), where oligopolistic firms adjust price complexity strategically, and by Piccione and Spiegler (2012) where firms limit price comparability optimally via shifting price frames. In addition, how firms obfuscate in a market with non-salient fees is related to shrouding additional price components (fees) in a market with base goods (interest rates) (Gabaix and Laibson, 2006). In my setup, fees are an *obligatory* hidden price, from which informed consumers cannot subsitute away from once they choose the product. Hence informed consumers should choose between, rather than within firms, making a non-symmetric equilibrium in which firms specialize more likely.[15] I hence draw on both types of frameworks in order to describe lenders' pricing behavior with non-salient fees, while matching the observed fee and interest rate dispersion, in a stylized way, in a simple search model with heterogeneous consumers and firms. I emphasize the conditions under which a separating equilibrium ensues in which high-cost lenders obfuscate, while low-cost lenders do not.

The remainder of this paper is organized as follows. Section 2 provides some background on the UK mortgage market and the data used. Section 3 presents the mortgage pricing structure and stylized facts. Section 4 describes the identification strategy and empirical results, and Section 5 discusses the mechanism. Section 6 concludes.

[14] They show that if information costs or search frictions are heterogeneous across consumer groups, low price firms are able to sell a larger quantity to both informed and uninformed consumers, while high price firms sell a lower quantity to uninformed consumers.

[15] Other related models of strategic price obfuscation are Ellison and Ellison (2009), Chioveanu and Zhou (2013), Ellison and Wolitzky (2012), Spiegler (2006), Heidhues et al. (2017), see Grubb (2015) for a review.

2. Background and data

2.1. Background on the UK mortgage market

Mortgage borrowing accounts for around half of the median household's liabilities in the UK, which is similar to the US and one of the highest levels across developed economies (Badarinza et al., 2015).[16] Most UK mortgage contracts are relatively short duration fixed-rate mortgages, with 2 or 5-year fixed rate mortgages being most common, in contrast to 25 to 30-year fixed rate mortgages in the US. Mortgages are also "full recourse",[17] and default risk pricing takes place through a discrete interest rate schedule with jumps at maximum LTV bands in 5 to 10% steps (Best et al., 2015). Mortgage prices are to the largest extent determined by product characteristics such as LTV band, fixation duration, type (first-time/second-time buyer or refinancer), and not borrower-specific characteristics. The adjusted R^2 of a regression of interest rates and fees for originated loans (i.e. realized prices) on product class and time fixed effects is around 80-90%, as shown by Benetton (2017). This is in contrast to markets such as the US and Canada, where credit scores and borrower-lender bargaining play more of a role for final prices, such that advertised prices are a biased measure of realized prices. For a given UK lender, in contrast, prices are fully described as a function of observable product and borrower characteristics. This makes the UK mortgage market an ideal laboratory to study lenders' pricing strategies. The products that I observe are equivalent to the full universe of mortgages that a borrower can shop from and the prices reflect the final interest rates and fees that can be obtained.[18]

The largest six UK lenders together account for around 75% of the stock of mortgage lending.[19] They also account for a similar share of new lending flows, while the largest 27 borrowers together account for approximately 95% of new mortgage lending. Seven of these lenders join the sample in 2010, and two in 2012. The lenders include specialized and mutualized mortgage lenders known as building societies. According to the Building Societies Association, they account for around 20% of the stock of outstanding mortgages available in the UK. The presence of building societies introduces considerable variation in

[16] Based on a sample of 13 countries: Australia, Canada, Germany, Greece, Spain, France, Italy, Netherlands, Slovenia, Slovakia, Finland, UK and USA. Only the Netherlands have a higher mortgage borrowing share, at around 60% of median household liabilities.

[17] Meaning lenders can recover losses from defaulted borrowers though their assets and incomes for up to seven years, until the debt is paid (Aron and Muellbauer, 2016).

[18] In an earlier step, lenders will accept and reject loan applications based on a borrower's credit history, such that prices are implicitly conditional on approval. The approval mechanism depends on lender-specific internal credit models, but these do not differentiate between a borrower who takes out a high fee product, compared to a low fee product, and so should not confound my analysis.

[19] Between 2010 and 2015, see former quarterly "Trends in Lending" reports from the Bank of England: http://www.bankofengland .co.uk/publications/Pages/other/monetary/trendsinlending.aspx.

wholesale funding patterns, as they are required to raise at least 25% of funding through shares held by members of the building society.[20]

2.2. Data

I combine three datasets. First, my main data source is Moneyfacts which is one of the most commonly used financial price comparison websites in the UK,[21] and is accessed through the Bank of England. It comprises the universe of mortgage products on offer, with detailed product characteristics, since June 2008, by lender and at monthly frequency. The data used covers the time period from January 2009 to December 2016.

My analysis focuses on fixed-rate mortgages as the most common type of mortgage, available to first-time borrowers, accounting for on average 80% and 70% of the mortgages on offer, respectively. These are also estimated to cover respectively around 80% and 30% of the actual mortgages issued in the UK. Table 1 illustrates the product characteristics and a representative menu structure based on four products by Halifax, one of the largest UK mortgage lenders, as observed in April 2013. It shows that a borrower with a maximum 75% LTV ratio can choose between an annual interest rate of 3.39% and a total arrangement fee of £295, or "trade down" the interest rate to 2.69% by paying a higher fee, £1290. Some key variables, in particular fees and prepayment penalties, are extracted via a keyword search of raw text variables in the Moneyfacts data, with the extracted values marked in blue. "Arrangement Fee Notes" is a text variable that records different arrangement fee components and all fee components are added up for composite arrangement fees as the main fee variable. "Incentive" captures additional incentives and rebates.[22] "Prepayment penalty" specifies the terms of the early repayment penalty. Prepayment penalties vary very little within a given lender at any given point in time and are identical for most lenders across products. They do not seem to significantly affect the interest rate-fee trade-off in a regression analysis (see Section 5.4). Further descriptive statistics are provided in Table 2, Panel 1.

Second, I augment the Moneyfacts dataset with data on lender characteristics and funding cost. Data on lender characteristics for the 27 largest lenders in the UK is obtained from SNL Financial. These contain lender characteristics from balance sheet and income statement data (Table 2, Panel 2). Note that there is substantial variation in

[20] By 2007 amendment to the 1986 Building Society Act, see Building Societies Association: https://www.bsa.org.uk/information/consumer-factsheets/general/the-building-societies-act-1986-a-bsa-summary-fift.

[21] Recommended by the formerly government-led Money Advice Service on its "Mortgage comparison checklist", see https://www.moneyadviceservice.org.uk/en/articles/your-mortgage-comparison- checklist

[22] An example for an additional incentives is a cash rebate, but the incentive does not seem to affect the interest rate-fee trade-off, i.e. does not seem to be *priced* in terms of differential fees or interest rates and so should not affect the analysis within a given lender, which I confirm more formally in a regression setup.

the loan-to-deposit ratio across lenders, consistent with the regulatory differences between banks and building societies described above, but including variation within banks and building societies, which is important for the identification strategy described in Section 4. Data on wholesale funding cost are based on daily 2-year LIBOR swap rates and CDS premia averaged by month and quarter for the largest six lenders, and are obtained from Bloomberg and the Bank of England.

Lastly, I use the Financial Conduct Authority's Product Sales Database (PSD) which collects data on all regulated mortgage originations in the UK since 2005, and is accessed through the Bank of England via a data sharing agreement. Each loan contains detailed loan and borrower characteristics such as the product type, interest rate, fee (since 2015), LTI, age, income and postcode of the borrower.

2.2.1. Main dataset

The analysis focuses on the largest 27 lenders in the UK for which sufficient bank characteristics are available. Together, these account for around 95% of the average market share over the 2009-2016 sample period, making them highly representative of mortgage supply in the UK market. The main dataset is a lender panel with lender characteristics and pricing statistics, including changes in the level and distribution of interest rates and fees and fee-product alternatives on offer, collapsed at the lender-level, and a lender-specific funding shock, at quarterly frequency between 2009Q1 to 2016Q4.

The lender-level panel is built as follows. Starting from the universe of mortgage offers at monthly frequency, the initial Moneyfacts dataset from 2009 to 2016 contains 364,750 observations. Mortgages with non-standard eligibility criteria such as shared ownership or buy to let mortgages and duplicates are dropped, in order to focus on price changes within homogeneous product classes such as 2-year, 75% LTV mortgages, and to avoid additional product characteristics that affect a very small share of products. I further restrict my sample to fixed-rate mortgages (approximatey 70% of the sample), available to first time buyers, with a 2-year fixation period (70% and 40% of the remaining sample, respectively). I only keep the mortgage offers by the 27 largest lenders which make up about half of the observations. The resulting main Moneyfacts sample contains 28,852 unique mortgage offers, with approximately 300 observations on average each month. Lastly, the information on lender products and prices is collapsed at quarterly frequency and merged with the data on lender characteristics and funding cost (see Table 2, Panel 3).

3. Stylized facts for mortgage pricing

This section describes the mortgage pricing structure and cost-minimization problem that a borrower faces which guides the interpretation of the empirical results, and illustrates why fees could be interpreted as a non-salient cost component. It then sets out two stylized facts: first that there is evidence for substantial cost dispersion in the mortgage market, and second that this is accompanied by large heterogeneity across fees.

3.1. Mortgage cost-minimization problem and non-salient fees

Lenders offer product variants that provide an interest rate-fee trade-off, e.g. a high interest rate and low fee vs. a low interest rate and high fee product. A lender offers on average 2 to 3 of these products, meaning that borrowers get to choose between a low, medium and sometimes high fee product.[23] For a given borrower with a fixed loan size, the pricing scheme hence implicitly defines loan value cut-offs at which a borrower should be indifferent between paying the higher fee to obtain the interest cost reduction, which is greater for larger loan balances, or not paying the higher fee. This can be seen when computing the total cost C of a mortgage over two years (with monthly interest r and arrangement fee f), loan value L (amortized over 25 years, i.e. $T = 300$ in months), assuming a 2-year fixed rate product ($d = 24$) that is subsequently refinanced:

$$C = \frac{r}{1 - \frac{1}{(1+r)^T}} \cdot L \cdot d + f.$$

Hence for a given lender's product offering, there exists a unique L^* at which a borrower should be indifferent between the high interest rate (r_h) and low fee (f_l), and the low interest rate (r_l) and high fee (f_h) product,[24] namely

$$L^* = \frac{-(f_h - f_l)}{d \cdot \left(\frac{r_l}{1 - \frac{1}{1-(1+r_l)^T}} - \frac{r_h}{1 - \frac{1}{1-(1+r_h)^T}} \right)}.$$

This suggests that a given borrower with a fixed loan size should only consider one product per lender, and that the products available for a given borrower should be segmented according to loan size. However, this does not seem to be reflected in the way the product market is structured in practice. The implied loan value cut-offs vary strongly across lender and over time, and products appear marketed with an overall interest rate

[23] The 10th percentile of lender-quarter observations has only one product on offer, while the 90th percentile has about 5 products, see Table 2.

[24] Obtained from setting $C^{(r_h, f_l)} = C^{(r_l, f_h)}$ and solving for L.

ranking in mind.[25] That is, prices in the UK mortgage market tend to be prominently framed in terms of the cheapest interest rates available in the market, e.g. via "Best buy" tables, and many price comparison websites sort products by interest rate cost by default, as seen in Figure A.9. So while interest rates are made visible as the most salient price dimension, fees are often relegated to the footnotes or separate price categories.[26] The emphasis on the overall interest rate ranking leads to products with higher fees being more visible in the market overall, as illustrated in the following. Figure 1a shows the set of available products in a particular month, first as a pure interest rate ranking, and then in interest rate and fee-space (Figure 1b). The top 10 products with the lowest interest rates are clustered very tightly together when considering just the interest rate dimension, but all belong to the group of products with "higher fees", with some having fees up to £2000.

Hence the pricing structure may allow cost-dominated products (with fees) to compete with cost-minimizing products in the salient price dimension, interest rates, even though these products would not be intended to compete if borrowers correctly ruled out dominated products by applying the cut-off rule based on their loan size.[27]

In the following, the analysis takes the lender pricing structure as given and focuses on the choice of an average borrower, for a 2-year fixed rate mortgages for first-time buyers, with a maximum LTV of 70-75%, and a fixed loan size calibrated as the average of the realised loan size distribution, denoted $\bar{L}$. Given these product characteristics and loan size, the borrower faces a cost minimization problem. Figure 1b also illustrates the interest rate-fee combinations that yield the same total cost for the borrower (with loan value $\bar{L}$) as isocost curves $\bar{C}^{\bar{L}}$. It shows that for an average borrower, focusing narrowly on the interest rate ranking tends to be misleading as the cost-minimizing choice tends to be a product without fees (marked in green). The excess total cost paid for a given product compared to the cost-minimizing product can be read as the distance from the cost-minimizing isocost curve, which is at least £500 and up to £2000 for most of the interest-rate minimizing products in this example from the data. Figure A.5 illustrates that this tends to hold more generally, the loan value cut-off from which it is worthwhile to pay a medium fee (up to £1000) is at around the 75th percentile of the actual loan

[25] Industry contacts confirm that lenders do take the loan value cut-off into account when pricing their products, but that the lender's relative position in the overall interest rate ranking is an important concern when setting fees.

[26] Composite cost measures are not necessarily readily available. The APR, for instance, is measured over the full amortization period (usually 25 to 30 years), which is often not representative of a mortgage that is refinanced after the end of the initial fixation period. One explanation could be that some price comparison websites themselves may have an incentive to maintain a less transparent cost ranking, as this would allow them to better steer consumers, for instance to earn commissions.

[27] The loan size cut-offs implied by the interest rate-fee trade-off could be interpreted as an *outcome* of a pricing strategy in which (some) lenders use non-salient fees to improve their position in the overall interest rate ranking.

value distribution, while a loan value needs to be at around the 90th percentile for it to be worthwhile to pay a high fee (greater than £1000). Hence a relatively small sample of borrowers should consider products with fees, in particular high fees, in the first place, if they minimize total cost rather than interest rate cost. The prevalence of cost-dominated products that are differentiated in the fee dimension is further discussed in the following.

3.2. Facts on mortgage pricing

From the perspective of a borrower with an approximately average loan demand of £150,000, the majority of products on offer at any one point in time is strongly cost-dominated (defined as a cost difference of more than £1000). Table 3 shows the share of cost-dominated products by fee categories. Overall, only 14.5% of products are within £500 of the cheapest product in a given month. While about half of all products with a low to medium (up to £1000) fee are strongly cost-dominated, this is true for more than 90% of all products with higher fees. Some of this can be explained by the pricing structure outlined before: even within the cost-minimizing lender, the high fee or low fee alternative may be dominated for a given loan size. However, Figure 3 demonstrates that the majority of products appear always dominated, across the loan size distribution, i.e. they lie on a higher isocost curve for any given loan size. Table A.2 shows that a large share of products with fees remains cost-dominated even for borrowers with a high loan value of £250,000 (around the 90th percentile of the loan size distribution).[28]

Next, I examine the pricing patterns that generate the cost dispersion. Figure 2a shows the share of products on offer, by double-sorting all products by interest and fee quintile in a given month. It gives a sense of the most common type of products on offer. Similar to the illustrative example above, there are two product clusters in general: one with very low interest rates (lowest interest quintile, bottom row), but with medium to high fees (third to fifth fee quintile), and another with relatively low fees (lowest two fee quintiles), and medium-level interest rates. The prices show a pattern of horizontal differentiation along the fee dimension, reflecting products with similar interest rates, but higher fees. Figure 2b gives a sense of how expensive these products are compared to the cheapest product in a given month. The cost differential is naturally lowest close to the left lower corner where both interest rates and fees are low, and increases most visibly along the fee dimension. High fee products command a £3000 to £4000 premium on overage, compared to the cheapest product.

Figure 4 illustrates the heterogeneity across fees based on a histogram of fees for 2-year fixed rate, 75% LTV products, with clusters at £0 and £1000 and substantial variation in between and beyond £1000, with the largest fees at around £3000 to £4000.

[28] One notable difference is that the share of low fee cost-dominated products also increases for high loan values, as the interest rate differential gets magnified at higher loan values.

Hence overall, there seem to be many products in the market that have similar interest rates, but that are differentiated along the fee dimension.

4. Empirical analysis and results

This section develops the identification strategy using lender-specific time-varying funding cost shocks to understand lenders' price setting behavior, and shows the main results. I provide evidence that a lender-specific cost shock, i.e. a relative deterioration in the competitive position of the lender, is associated with significantly higher fees, while interest rates remain unchanged, and an increase in the number of product alternatives that differ in fees.

4.1. Identification strategy

The key idea is to build a supply-side cost shock that is orthogonal to any unobserved time-varying heterogeneity such as preference shocks. Work by Button et al. (2010) illustrates that the main determinant of UK lenders' mortgage pricing is funding cost.[29] The marginal source of funding is typically considered to be long-term wholesale debt due to its more elastic supply compared to retail deposits (Button et al., 2010).

I construct a *lender-specific* funding shock using a lender's pre-determined past loan-to-deposit ratio as a measure of its dependence on wholesale funding, interacted with aggregate changes in wholesale funding costs. This is akin to a Bartik (1991) shock[30] commonly used in the trade and labor literatures: if lender-specific *exposures* to wholesale funding are relatively sticky and as-good as randomly assigned after controlling for observables, interacting these with aggregate time-series variation in wholesale funding costs generates a funding shock that varies across lenders and time.[31][32]

Identifying variation then comes from cross-sectional variation in wholesale funding shares, cross-sectional variation in wholesale funding cost for the largest six lenders, and variation in aggregate wholesale funding cost over time. Long-term wholesale funding

[29] Which in their reduced-form decomposition also accounts for most of the aggregate variation in mortgage prices since 2008. The other two main components are credit charges, which account for expected losses and capital charges for unexpected losses, and a residual which captures other factors such as operating cost and mark-up (see Figure A.3).

[30] Originally using local industry employment shares × national industry employment growth rates as an instrument for labour demand (Goldsmith-Pinkham et al., 2017).

[31] As a related application, Jensen and Johannesen (2017) use pre-crisis variation across lenders in the loan-to-deposit ratio in a difference-in-differences setup to compare banks which are relatively more exposed to the wholesale funding shock of the 2007-2008 financial crisis to those that are relatively less dependent on wholesale funding.

[32] My setup is a *modified* Bartik shock in the sense that I use additional variation based on *lender-specific* wholesale funding cost for the largest six lenders. In the standard Bartik example, this corresponds to regional industry employment growth rates, which are normally unobserved.

cost are constructed as the 2-year LIBOR swap rate (r_t^{libor}) plus senior CDS spreads (s_{jt}) following Harimohan et al. (2016). Denote B the set of large lenders for which I observe lender-specific CDS spreads. Then the shock is constructed as the lender-specific loan-to-deposit ratio in 2008 (one year prior to the start of my analysis), $ltd_{j,2008}$, based on annual balance sheet data, interacted with long-term wholesale funding cost:

$$\phi_{jt} = \begin{cases} ltd_{j,2008} \times \left(r_t^{libor} + s_{jt}\right), & \forall j \in \{B\} \\ ltd_{j,2008} \times \left(r_t^{libor} + \bar{s}_t\right), & \forall j \notin \{B\}. \end{cases} \tag{1}$$

I use lender-specific CDS spreads for the largest six lenders, and for all other lenders, I use the average CDS spread ($\bar{s}_t$) over all six lenders to capture any industry-wide variation in wholesale funding costs.[33] One possible concern is that CDS spreads may not be fully exogenous to contemporaneous mortgage pricing strategies. As explained in Button et al. (2010), bank's operations may actually alleviate links between funding and mortgage markets within a given bank. Banks usually centralize their funding operations within a treasury department across the bank, which then makes funding available to other business units, who further decide on business-specific lending margins (known as "transfer pricing"). That makes it more likely that for instance the risk strategy chosen for the mortgage market is at the most an outcome of shocks to funding cost, but not the other way round.[34] In addition, in most of the sample period from 2010, bank CDS spreads appear to be driven by banks' exposure to systemic factors such as the Euro Area sovereign debt crisis, that have limited links to the domestic mortgage market, as shown in Figure A.4. This is in line with the idea that banks can be considered as "price takers" in wholesale funding markets, in particular from the perspective of the mortgage business unit over the main sample period.[35]

In addition, the exogeneity of the wholesale funding share conditional on observables is the key identifying assumption for the validity of the standard Bartik shock (Goldsmith-Pinkham et al., 2017), i.e. loan-to-deposit ratios need to be uncorrelated with lender-specific characteristics conditional on controls. One way to do a balance test is to regress the Bartik funding shock on lagged levels and changes of lender characteristics, as suggested by Goldsmith-Pinkham et al. (2017) and reported in the appendix.[36]

[33] The cross-sectional and time-series variation in the overall funding shock is illustrated in Figures A.2 and A.1.

[34] In addition, my analysis focuses on analysis within homogeneous mortgage product categories, such as 70-75% LTV, where default risk is low. Within LTV band variation in default risk is explicitly not priced (as per the discrete pricing scheme commonly used), making the risk adjustment channel within LTV band in response to changes in CDS spreads likely to be small in the first place.

[35] Future work aims to complement this strategy with evidence from events that are plausibly exogenous shocks to funding cost.

[36] Table A.1 shows results for this exercise, based on individual years.

None of the lender characteristics (including size, return on assets, net interest margin and leverage) seem systematically correlated with the funding shock, especially not when measured in changes.[37]

The identifying assumption for the overall identification strategy is

$$E\left[\epsilon_{jt} \mid \phi_{jt}, \gamma_t, \theta_j\right] = 0, \tag{2}$$

i.e. time-varying unobservables such as lender-time-specific demand shocks should not be correlated with the funding shock. By construction, the lender-specific loan-to-deposit share is predetermined, and the aggregate funding shock is not driven by firm-specific decisions or should be exogenous to mortgage pricing decisions by large lenders for which there are CDS spreads available.

I now turn to the construction of the dependent variables. A lender offers on average about 2.7 products in the 2-year fixed rate, 70-75% LTV, first-time borrower product class, per quarter. Average interest rates and fees are about 3% and £700, respectively (see Table 2). I collapse these product characteristics including average, minimum, maximum interest rates and fees at the lender level to track changes in a lender's pricing strategy over time. To capture the number of interest rate-fee product alternatives on offer, I measure the number of distinct fee notches such as £0, £1000, £1500 in a given quarter. As a robustness check for higher risk mortgages, I repeat the analysis for 2-year fixed rate 90-95% LTV products.

The analysis is based on a quarterly lender panel from 2009Q1 to 2016Q4. The main specification is

$$\Delta outcome_{jt} = \alpha + \beta \cdot \Delta\phi_{jt} + \gamma_t + \theta_j + \epsilon_{jt}, \tag{3}$$

which regresses changes in the outcome variables on changes in the funding cost shock ϕ, and γ_t and δ_j are time and lender fixed effects, respectively. This captures the idea that I am interested in how lenders respond to *relative* shocks to their competitive position, as aggregate shocks and lender-specific levels are absorbed in the fixed effects. While aggregate shocks such as changes in aggregate financial conditions are expected to be passed through, the idea behind pricing with non-salient fees refers to how lenders respond to shocks that change their relative competitive position, such as trying to match the lowest interest rates available in the market by increasing fees when their funding costs increase.[38]

[37] Note, however, that the sample for each regression is very small, since the cross-section of lenders with a full set of lender characteristics is between 16 and 27.

[38] This probably requires some degree of market power as modelled in Agarwal et al. (2014) and which I intend to incorporate in my theoretical framework.

4.2. Main results

The first set of main results show how lenders adjust pricing strategies in terms of interest rates and fees on average in response to relative funding cost shocks, reported in Panel 1 in Table 4. The average interest rate remains unchanged (-1 basis point) and is not significantly different from zero, while average fees increase significantly by £63 in response to a one standard deviation funding cost shock, which is an increase of around 10% of the average level of fees. Overall, products become more expensive: total costs over a one year period increase significantly by around £60, which is similar for the two year period but not statistically significant. Panel 2 and 3 look at lenders' pricing strategies across two types of products, the high rate, lowest fee product (r_h, f_l) and the lowest rate, high fee product (r_l, f_h), respectively. While interest rates do not change significantly for either product, the increase in fees seems driven by the highest fee product, which increases by around £120, and the highest total cost products become around £80 more expensive. Since the analysis focuses on the within-lender response to a shock to marginal cost (controlling for lender and time fixed effects), these price changes should reflect the optimal response of the lender when it becomes relatively less competitive. So lenders appear to maintain their relative pricing of interest rates, but increase fees in response to a deterioration in their competitive position. The fact that the overall increase in fees is driven by the highest fee product is also intuitively consistent with the idea that competing for the lowest interest rate in the market is important - which can be partly achieved by increasing fees.

Next I split the sample according to four different lender categories to get a sense of what type of lender seems to be driving this strategy: the largest six lenders that make up around 3/4 of market share, building societies, challenger banks (defined as a bank that does not belong to the top six lenders or building societies), and publicly traded lenders that comprise lenders from all three of the former categories. The numbers need to be interpreted with the caveat that the samples become relatively small (around 200 to 300 lender-quarter observations). The results are reported in Table 5, which shows that the increase in fees in response to a funding cost shock is most prominent for the sample of big six banks and publicly traded lenders, where the latter contains four of the big six banks and three more banking groups. This could be tentatively interpreted as a stronger preference to pass through relative cost shocks and could be consistent with a greater pressure to maintain profit margins and quarterly earnings results.[39]

In contrast, the pass-through via fees does not seem to hold for riskier mortgages (90-95% LTV, Table 6). Average total costs across products increase substantially in

[39]Provided the pass through via fees is profitable and not offset by a decrease in market share, which depends on the price sensitivity of borrowers, further discussed in section 5.

response to a funding cost shock, by between £80 to £200, but this is almost entirely driven by increases in interest rates. This suggests that pricing strategies differ across less risky and riskier LTV markets and may depend on the competitive structure and borrower population of a given LTV market.[40] If fees are interpreted as a relatively fixed price frame that reflect fixed cost of originating a mortgage which may adjust less frequently, then the pass-through of funding cost shocks via interest rates seems a more intuitive dimension to adjust changes in variable costs, which is further discussed in the next section.

In order to test for product proliferation in interest-rate fee variants more specifically and to get a sense to what extent lenders expand their product range in price terms, Table 7 shows results of changes in the number of fee-product alternatives as dependent variable, regressed on the funding cost shock. The first column shows that the overall number of products increases by 22% in response to a one standard deviation change in the cost shock. The second and third column show results for changes in fee-product alternatives within different narrow product classes. The coefficients is significantly positive for 2-year 70-75% LTV products but not for 90-95% LTV products, suggesting that expanding the product range in price terms may be more relevant at lower LTV levels. An intuitive explanation could be that unobserved default risk, which could be correlated with sub-optimal product choice, plays more of a role at higher LTV levels and hence makes the obfuscation strategy less viable due to adverse selection.[41]

Overall, I find evidence that lenders maintain their relative pricing of interest rates following a cost shock, but that they increase fees and the pricing space as reflected by the number of product alternatives that differ in fees.

5. Mechanism and discussion

5.1. The role of fees

There are at least two conventional functions of mortgage origination fees. On the one hand, they could be seen as compensating for a fixed cost component of originating a mortgage such as paper work and processing cost. Hence they should not be related to higher frequency changes in marginal cost such as funding cost. Alternatively, fees could reflect a variable cost of originating larger mortgages. For instance in Denmark,

[40] For instance, if the adverse selection problem is much worse for high LTV loans, lenders may not want to attract borrowers based on a low interest rate with high fees. This differential pass-through is also documented by Agarwal et al. (2017b) for the US credit card market.

[41] There is existing evidence that firms choose rent-extraction strategies differentially across borrower groups, for instance Nelson (2017) finds that US lenders target existing clients who have high credit scores but seem less likely to switch banks to increase credit card rates, while this strategy is not employed for low credit score borrowers where default risk is the main pricing factor.

consumers pay a percentage of the loan value in administration fees that depends only on loan characteristics,[42] meaning that a given borrower does not have to compare fees for her cost minimization problem.

In the UK, while the interest rate-fee trade-offs imply optimal cut-offs for different loan values, the market is not clearly segmented or standardized by loan size and all product variants appear marketed as pooled, with an emphasis on the overall interest rate ranking. The evidence further suggests that fees serve as an active margin and additional degree of freedom when setting mortgage prices. This affects the direct comparability of total cost across mortgages: instead of comparing mortgage prices using a scalar, where the interest rate is a sufficient statistic for the total interest rate cost and can be compared using a general best-buy table, consumers face a price vector of interest rates and fees. In order to compare total cost across products, borrowers need to add fees to the loan-specific interest rate cost, which depends on the loan amount borrowed, and would require loan-amount-specific best-buy tables. This separation of pricing components (Grubb, 2015) and limiting of comparability across products (Carlin, 2009, Piccione and Spiegler, 2012) may decrease borrowers' total price sensitivity and make search more difficult.

This interpretation is also consistent with the evidence that lenders appear to increase the number of fee-product alternatives in response to cost shocks, which could be interpreted as expanding the pricing space in both fee and interest rate dimensions. Borrowers may be less able to find the cheapest product if both fees and interest rates vary, compared to if they were confronted with a composite (scalar) price measure. This is similar to findings by Ellison and Ellison (2009) in an online shopping environment for a homogeneous consumer electronic good, who document a range of case study practices to make search more difficult, including shrouding shipping cost and competing on additional quality dimensions. One interesting implication of their findings could be that without fees, the market would be extremely price-sensitive given the ease of price search if there is a unique price ranking by interest rates. While this counterfactual is unobserved, I provide supportive evidence by looking at the sample of borrowers who choose a zero fee product, who indeed exhibit less price dispersion (Figure 5), which may point to trade-offs between the volatility of bank profits and optimal consumer search for policy makers.

5.2. Price obfuscation with non-salient fees

The channels above point to a price obfuscation mechanism in which adjusting interest rates and fees separately may allow lenders to extract rents from consumers who neglect

[42] E.g. collateral and period of interest rate fixation, see Danmarks Nationalbank, Statistics on Banking and Mortgage Lending, Interests, April 2018.

fees or get confused by the many product variations in price terms and who hence choose suboptimally, leading to a decrease in total price elasticity. Moreover, there exist products in the market that are cost-dominated, i.e. that are on higher iso-revenue curves, and products that are cost-minimizing and often by more than £1000 cheaper, leading to substantial price dispersion in the products on offer at any one point in time.

I can motivate these findings by reinterpreting a standard framework with price dispersion, consumers with heterogeneous price sensitivity ("informed/uninformed") and firms with heterogeneous marginal cost ("low/high cost") (Salop and Stiglitz, 1977, Varian, 1980, Galenianos and Gavazza, 2017).[43] Uninformed consumers prefer low price (interest rate) products and choose randomly from the set of products with low headline prices, while informed consumers only purchase the cost-minimizing product. I assume that borrowers demand one homogeneous mortgage, i.e. LTV, fixation period and loan value are given and equal across borrowers, such that interest rates set by lenders are equivalent to setting the interest rate cost and both terms are used interchangeably.

Lenders offer contracts M which specify the headline price r (interest rate cost) and a hidden additional cost f (fees):

$$M = \Big\{\{r, f\} : r \in \{r_l, r_h\}, f \in [0, +\infty)\Big\},$$

where headline prices are simplified and lenders either choose low (r_l) or high interest rates (r_h). The key intuition is that high-cost lenders cannot attract informed consumers, but can lure uninformed consumers by "pretending" to have a low price (interest rate cost) while charging a hidden additional cost f (fee).[44]

As long as the proportion of informed consumers is high enough, low cost lenders have an incentive to gain the informed demand share and charge low prices with no add-on costs, i.e. they offer contract $\{r_l, 0\}$. They further receive a proportion of "lucky" uninformed consumers who randomly choose them. If firms cannot offer weakly dominated contracts, then the low cost lender cannot offer the contract $\{r_h, 0\}$ or $\{r_l, f\}$ where $f > 0$, and has to forego the opportunity to extract higher profits using additional cost

[43] Relatedly, Agarwal et al. (2014) derive a model in which the degree of competition and non-salience of fees affects the way banks offset regulations that impose caps on hidden fees by increasing interest rates. They find that in response to the 2009 CARD Act in the US, banks had to reduce hidden fees on credit cards substantially, but left interest rates almost unchanged in order to preserve the optimal quantity of demand which seems largely driven by interest rates, with borrowers neglecting fees. In contrast to this setup, however, I observe substantial fee heterogeneity and price dispersion based on cost-dominated products in the fee dimension, hinting at heterogeneity across lenders who, in my setup, trade-off the magnitude of fees with the ability of borrowers to detect hidden fees as an active margin of adjustment.

[44] The fee is further bounded by a decrease in the match probability that a given borrower chooses the product when f increases, which captures the idea that the probability of obfuscation going undetected decreases with the size of the additional cost. This mechanism could be micro-founded based on e.g. partially attentive consumer search (De Clippel et al., 2014).

f from the uninformed demand share.

High-cost lenders, on the other hand, cannot break even with contract $\{r_l, 0\}$, so they need to obfuscate and charge $\{r_l, f\}$ in order to be "cheap" in the eyes of uninformed consumers. In addition, if the probability of a borrower accepting a a high interest rate product is non-zero, the high-cost lender will also prefer to use the full range of price and hidden cost combinations and offer both $\{r_l, f_h\}$ and $\{r_h, f_l\}$ (where $f_l < f_h$). In other words, if consumers make different types of mistakes and more mistakes if both prices and hidden costs vary, a high-cost lender has more to gain from the additional degree of freedom, providing a theoretical motivation for product proliferation along price dimensions.

The framework hence motivates a separating equilibrium in which high-cost lenders obfuscate and use the full price space and low-cost lenders do not obfuscate, given informed and uninformed consumers consumers. It can also explain the presence of cheap and expensive products in the market, as firms trade off margins and quantities, such that high-cost lenders offer more expensive products than low-cost lenders for the uninformed demand share, while low-cost lenders offer the cost-minimizing product and choose not to obfuscate because they capture the informed demand share, which is a common intuition from many search models.[45]

In this framework, firms who are hit by a cost shock increase fees but not interest rates and may also expand their pricing space as reflected in the number of fee-product alternatives. While their total prices become unambiguously more expensive as they move to a higher iso-revenue curve, they can still capture the uninformed demand share by maintaining competitive interest rates, and increasing fees and product variations.[46] Appendix B develops the setup and conditions under which low-cost firms do not obfuscate and high cost firms do obfuscate in equilibrium in more detail.

5.3. Additional results

This subsection provides supportive evidence for additional predictions following from the price obfuscation mechanism with non-salient fees.

5.3.1. Excess cost dispersion in borrowing outcomes

Fee-based product proliferation is a profitable obfuscation strategy if there is suboptimal search and fee-neglect on the demand side. I show further evidence consistent with the

[45] This intuition is embedded in Salop and Stiglitz (1977) using a static Nash equilibrium solution with monopolistic competition, Varian (1980) using a static mixed strategy equilibrium solution, and Galenianos and Gavazza (2017) using a dynamic search model with heterogeneous costs and quality.

[46] There is hence also a relative shift from informed to uninformed demand that should accompany that pricing change for a given lender, which is another testable prediction.

idea that consumers neglect fees and exhibit a lower price sensitivity with respect to fees than to interest rate cost. As a proxy of the degree of consumer mistakes, I borrow an idea from Gurun et al. (2016): I compute *excess* cost as the residual from a regression of total cost based on actual mortgage originations in the 2015-2016 PSD data on relevant product, cohort and borrower characteristics for 2-year fixed rate products, as follows:

$$totalcost_{ijt} = \alpha + \delta_t + \theta_j + \beta_1 loanval_i + \beta_2 LTV_i + \gamma' \mathbf{X}_i + \epsilon_{ijt}$$

where δ_t and θ_j are month and region fixed effects. The regression includes the loan value and LTV as a baseline, and can include further controls in $\mathbf{X}$ such as LTI, age and income. Figure 5 plots the baseline residuals ϵ_{ijt} which measure how much the cost varies across borrowers who took out very similar products at the same time and in the same region, and can hence be interpreted as "excess" cost, by fee categories. It shows that borrowers with zero fee products indeed seem to have a narrower distribution and hence lower price dispersion, while the distributions for products with fees are more dispersed, and in particular high fees seem to come with a larger right tail of excess cost. This is suggestive and supportive evidence that borrowers neglect fees and appear better at cost minimization if there is no fee involved.

5.3.2. Dependence on zero-fee and high-fee products

The true cost ranking across lenders should be fully and uniquely revealed (i.e. valid across the loan size distribution) when looking at the interest rate ranking across products without fees. So low cost lenders should have a relatively higher market share in products without fees, while high-cost lenders may try to avoid products without fees, as they cannot improve their interest cost ranking by increasing fees. Hence high-cost lenders should also be relatively reliant on products with fees, in particular high fees. This seems to hold up in the data where I measure the within-lender market share as the share of products for a given lender in a given quarter that has zero or high fees, out of all products issued by that lender in that quarter (based on mortgage origination data from PSD). As a proxy of a lender's cost-level, I compute the average total cost distance to the cost-minimizing product across all the products offered by a given lender in a given quarter, based on the Moneyfacts product data and a loan value of £150,000, which should approximately capture the endogenous choice of a lenders' offered interest rate-fee trade-offs together with their position in the cost distribution, which I refer to as lender-time-specific excess cost.[47] Figure 6a shows that there is indeed a negative

[47] This measure could be refined to account for different points of the loan-size distribution for different fee types.

relationship between the within-lender market share of zero fee products and lender-time-specific excess cost, while Figure 6b shows that there is a positive relationship for high-fee products.[48] This could be interpreted as suggestive evidence that low-cost lenders are relatively more competitive in the zero-fee product as would be expected, and that high-cost lenders are relatively more reliant on high-fee products. Note that the proxy for high and low-cost lender is measured as time-varying, reflecting the idea that lenders' position in the total cost ranking fluctuates over time.

5.4. Discussion of alternative channels and robustness

I consider and try to rule out alternative channels, most notably screening motives using fees which could be correlated with lender-specific cost shocks. I find limited evidence for lenders' use of fees to screen for risk types.

First, the market setting makes it unlikely that lenders in the UK screen for prepayment risk using fees. In contrast to the US, lenders are allowed to set early repayment penalties, providing them with a more direct way to screen for prepayment risk than by using fees, (known as points (Stanton and Wallace, 1998) in the US). However, there is also limited variation in prepayment penalty terms for products within a given lender. Only 7 out of 27 lenders have any variation across products, and only around 10% of product observations offer different prepayment penalty terms within a given lender at the same point in time. I further confirm that prepayment penalty terms do not significantly alter the interest rate-fee trade-off pricing of a given lender in a regression framework, outlined below. This seeming lack of screening and pricing of heterogeneous repayment risk could be explained by the relatively short initial fixation periods of 2 to 5 years prevalent in the UK, at the end of which most borrowers refinance, as documented by Best et al. (2015).

Second, lenders could price in potential borrower selection on unobservable characteristics that affect default probabilities, for those who choose a relatively more expensive fee-interest rate alternative. For instance, Choi et al. (2009) show that demand for high-fee index funds seems to be primarily driven by mistakes due to financial illiteracy, which could be correlated with unobservable default risk. Lenders may also use products with fees to screen for liquidity risk which may be correlated with default, as highly liquidity-constrained borrowers may be unable to pay an upfront fee. But as seen in the main results, the cost pass-through via fees and increase in fee-product alternatives is only significant for low LTV products, indicating that the mechanism may play more of a role when default risk is low and selection on unobservables may play less of a role.

[48] This relationship is not mechanical, as there is an omitted category with medium fee products (0,1000].

Yet another concern is that lenders may have a time-varying preference for fee income, for instance if they become financially constrained. Fees did appear relatively more elevated during the immediate aftermath of the financial crisis in 2008/2009. However, this (together with some of the other alternative channels) are at odds with the general institutional setting that lenders offer the option to add fees to the loan balance at the borrower's discretion, and at no additional cost. The cost pass-through via fees also appears to persist when splitting the sample between 2009 to 2012 and 2013 to 2016, where the latter includes a period of substantial central bank liquidity support, suggesting that financial constraints should not be a main concern in general.

Lastly, a given lenders' interest-rate fee pricing does imply that borrowers with different loan sizes should choose different products, i.e. it should serve as a coarse way of screening for loan sizes. But as established before and shown in Figure A.5, only a relatively small sample of borrowers should consider products with fees at all, in particular high fees, compared to picking a product alternative with no or low fees. For the average borrower (borrowing at the average of the loan size distribution at a given point in time), the isocost curve with cost-minimizing fee-rate combinations tends to be steeper than the price terms that are on offer (as seen in Figure 1b), meaning that the cost-minimizing choice tends to be a product without fees or low fees. I can show that the interest rate cost reduction for the average borrower tends to be lower than the fee required to get the lower interest rate more formally in a product-level regression of interest rate cost on fees shown in Table 8. If a borrower should be indifferent between the lower fee, higher interest rate and the higher fee, lower interest rate product, the slope coefficient β on fees would be -1, i.e. a £1 paid in fees would yield a £1 interest rate reduction. The baseline correlation in column (1) with time and product (LTV) fixed effects is negative, but not significant. Column (2) and (3) saturate the regression further with lender and lender-time fixed effects, in order to measure the interest cost-fee trade-off within a given lender that is on offer at a given point in time. The coefficient is strongly negatively significant, but is only around -0.4. Columns (4) to (6) add additional product-level control variables including the early prepayment penalty, a cashback indicator as an example of measurable additional incentives and the length of the incentive description text. Only the incentive length shows up as positively significant within lender, tentatively suggesting that lenders provide a worse trade-off when the description of incentives is more extensive, consistent with obfuscation motives that make the product more complex (Célérier and Vallée, 2017). Lastly, column (8) introduces a square term for fees which is strongly positively significant, capturing the fact that the trade-off becomes worse for product with high fees, as expected.

6. Conclusion

What can explain product proliferation along price dimensions and price dispersion in the mortgage market? This paper provides novel empirical evidence from the supply side: I show that lenders increase fees and expand the pricing space as reflected by the number of fee-product alternatives in response to a cost shock, while interest rates remain relatively unchanged. This is consistent with a price obfuscation mechanism given suboptimal search and consumer fee neglect, where lenders exploit borrowers' lower price sensitivity with respect to fees and "pretend" to be cheap in the more salient interest rate dimension. Fees can be interpreted as hidden additional cost but active margin of price adjustment, resulting in fee heterogeneity and substantially cost-dominated products that differ in fees in the data. Product proliferation in price dimensions hence reflects a potential supply-side amplification mechanism behind suboptimal search in the mortgage market.

The paper provides a direct empirical test of lenders' optimal price adjustment strategy given within-lender variation in cost shocks for identification, and rationalizes the empirical results as a price obfuscation mechanism. Marginal cost shocks may be more difficult to observe in other non-financial product markets, making this a novel application in arguably the largest and most important retail financial market, the mortgage market. This complements field and experimental evidence that explain retail financial product price dispersion (Choi et al., 2009, Anagol and Kim, 2012, Duarte and Hastings, 2012).

These findings are important for policy and pose new questions relating to competition and the pass-through of monetary policy (Scharfstein and Sunderam, 2015, Agarwal et al., 2017b) in the presence of behavioral biases. I propose a supply-driven pricing and product offering strategy that makes price comparisons more difficult for consumers, likely leading to more suboptimal choices and market power, and relating to the pass-through of monetary policy by redistributing its effects across the borrower population, which could be the subject of future work.

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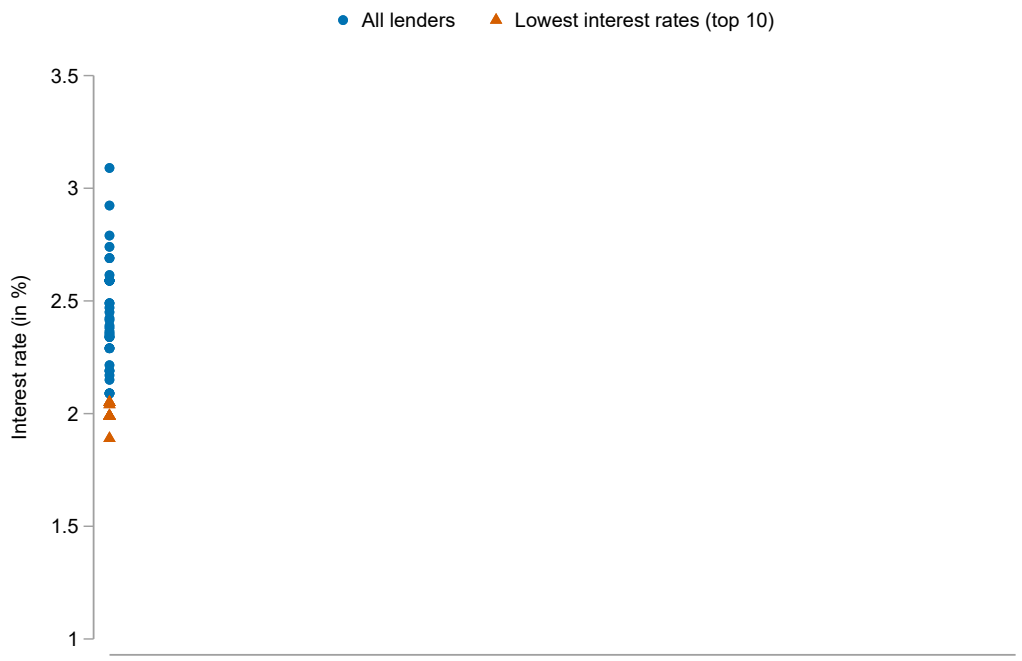
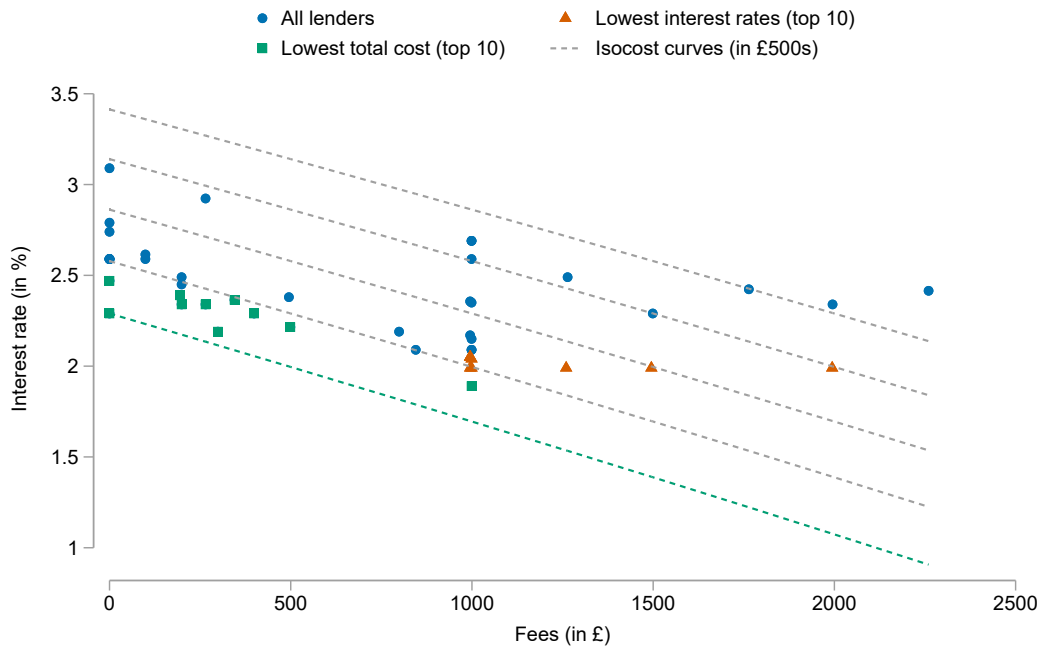
Main figures and tables

Figure 1: Example of products on offer

(a) Interest rate ranking ignoring fees



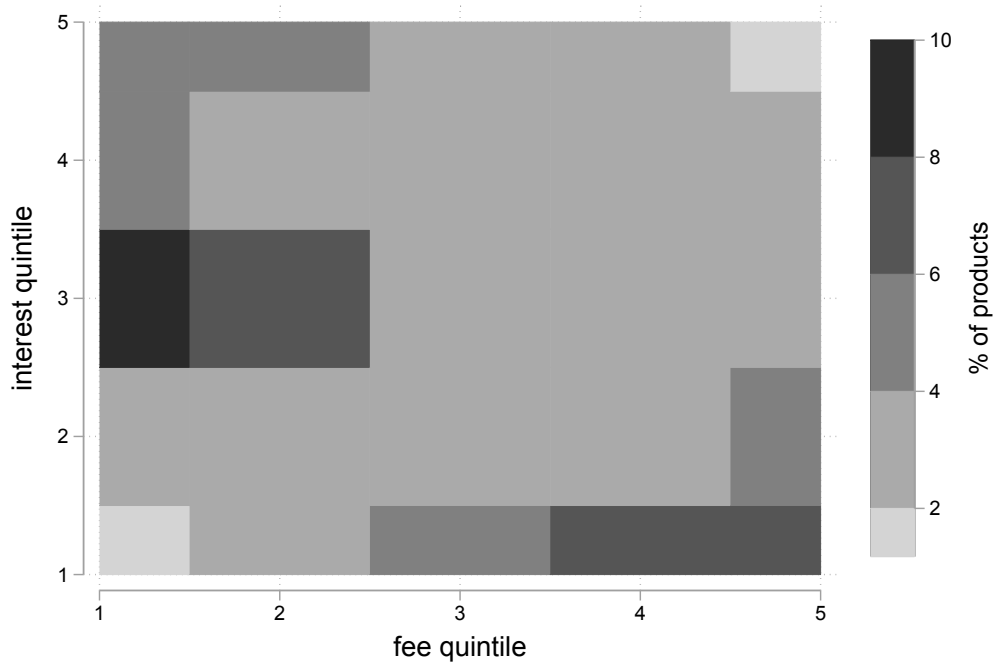
(b) Interest rates, fees and isocost curves



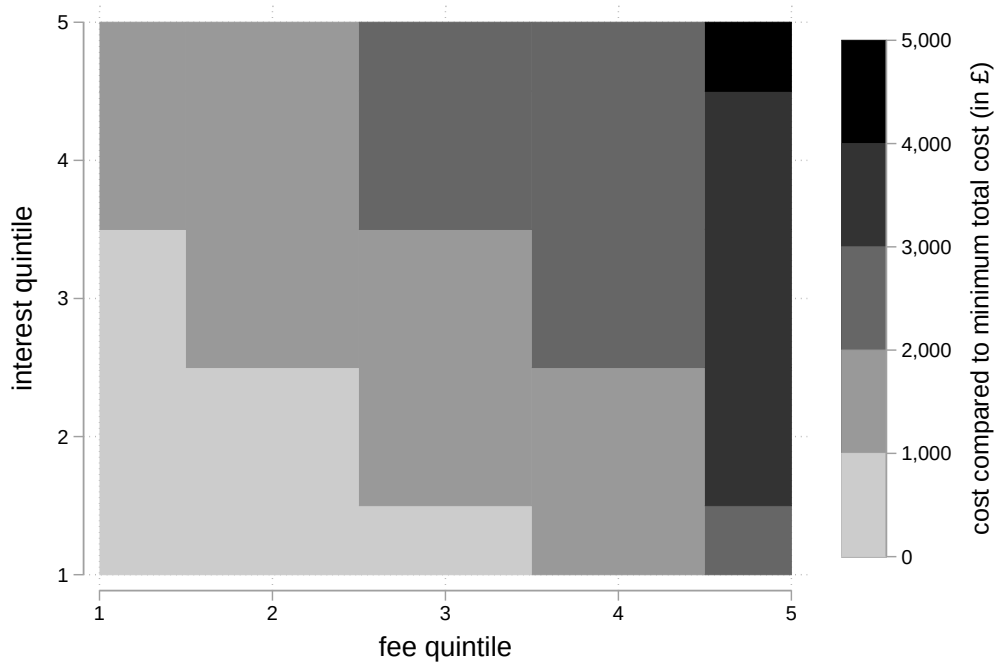
Notes: Figure 1a shows the set of 2yr 70-75% LTV products on offer in February 2014 when ignoring fees. Figure 1b shows the same set of products in interest rate-fee space, together with isocost-curves based on the total cost of a given product over two years and the average loan size in that month, amortized over 25 years.

Figure 2: Products by interest and fee quintile

(a) Share of products by interest and fee quintile

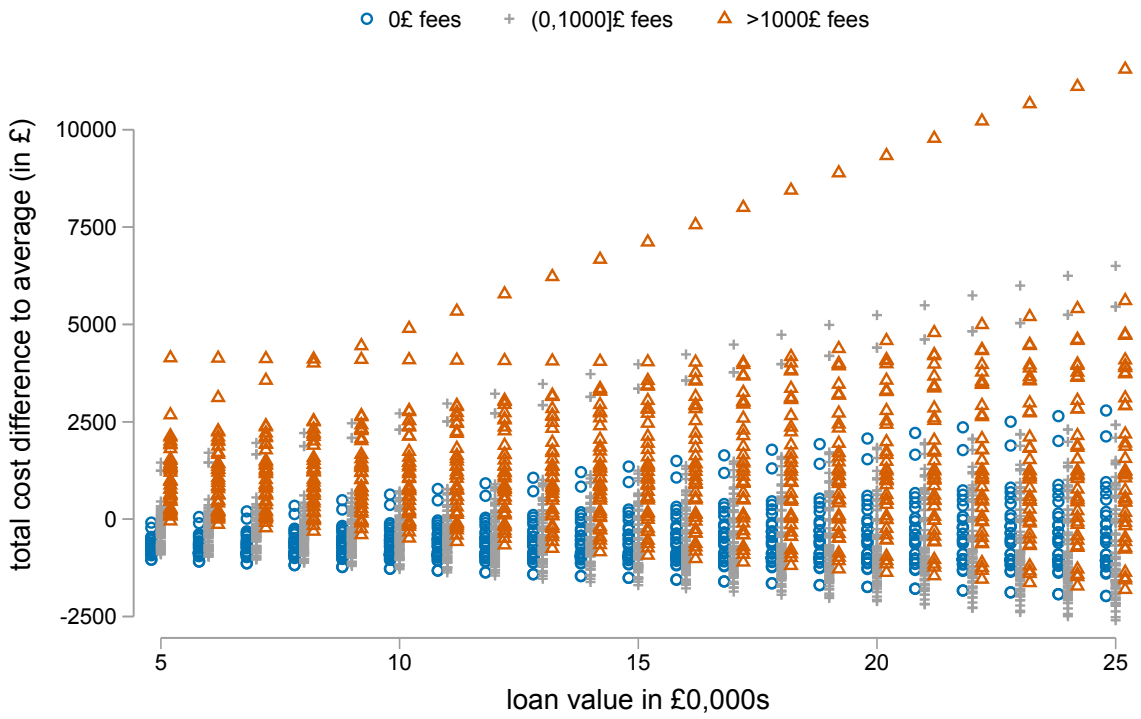


(b) Cost differential for average product in interest and fee quintile



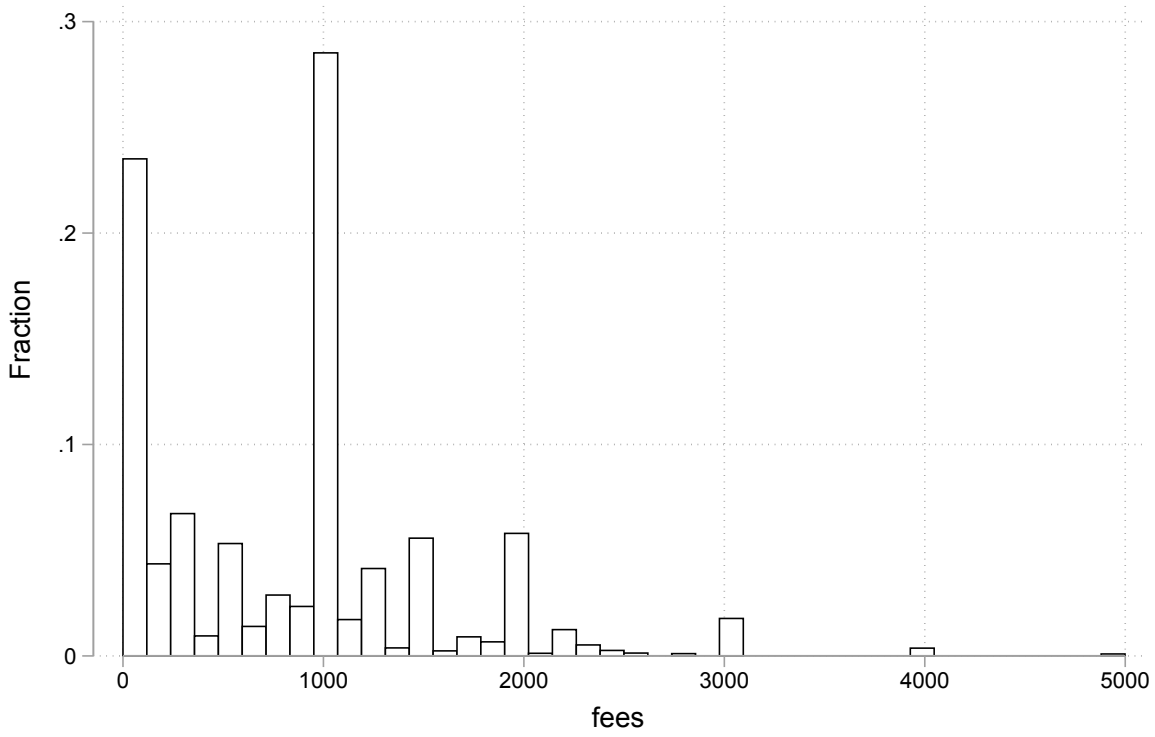
Notes: Figure 2a shows the frequency of products by its position in the rate and fee distribution in a given month, based on 75% LTV 2-year fixed rate products from January 2009 to December 2016. For instance, the lower left corner represents products in the lowest interest and fee quintile and make up around 2% of total products. Figure 2b shows the average (across products in a given interest and fee quintile) cost differential in £, measured as the difference between total cost and the minimum total cost product in a given month, based on a 75% LTV 2-year fixed rate product over two years, for a loan size of £150,000 amortized over 25 years.

FIGURE 3: TOTAL COST DISPERSION BY FEE CATEGORY



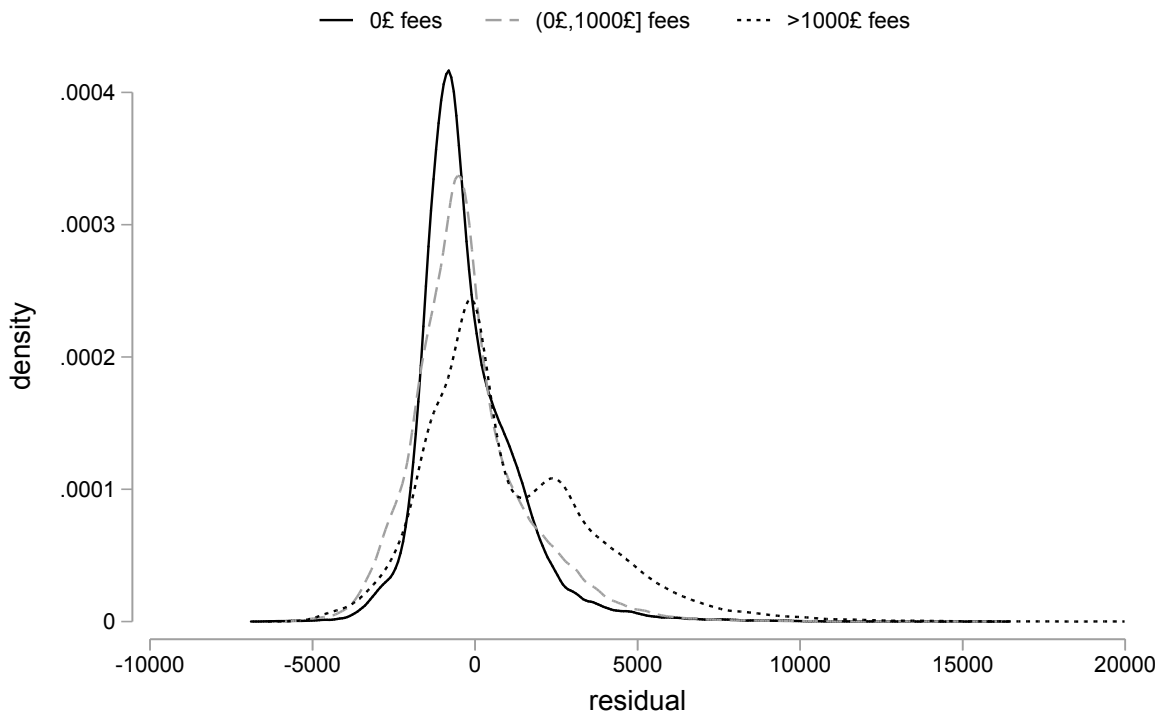
Notes: This figure shows the total cost dispersion relative to the average product, by loan value and fee category, for the set of 2yr, 70-75% LTV products on offer in an example month.

FIGURE 4: HISTOGRAM OF FEES (2YR FIX, 75% LTV)



Notes: This figure shows a histogram of fees, based on all products available for 2yr fixed rate, 75% LTV products over the sample period.

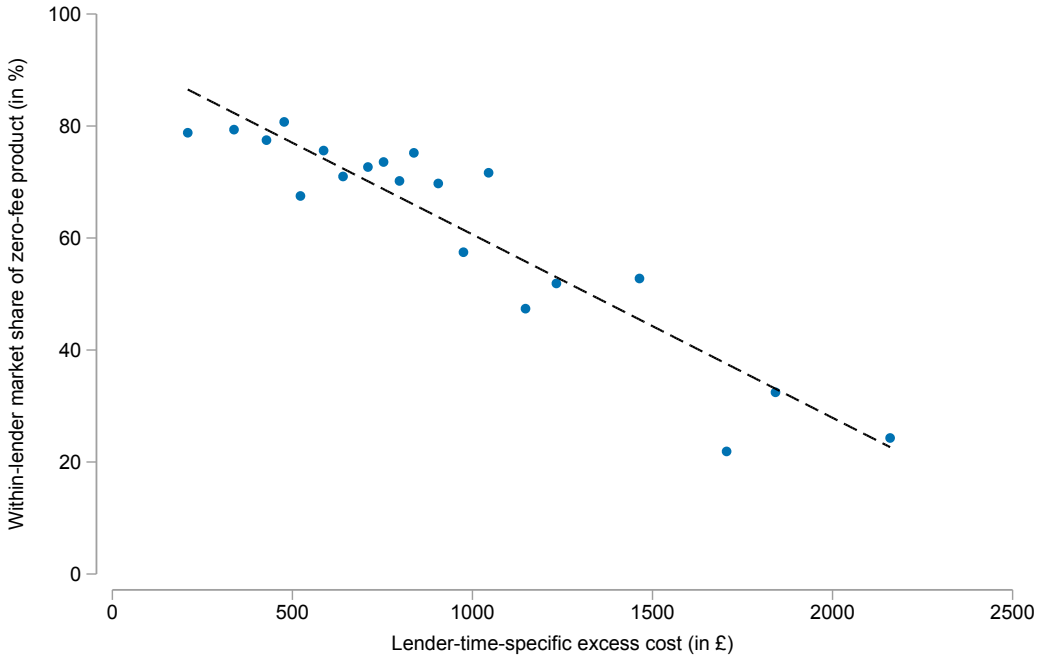
Figure 5: Excess cost dispersion by fee category



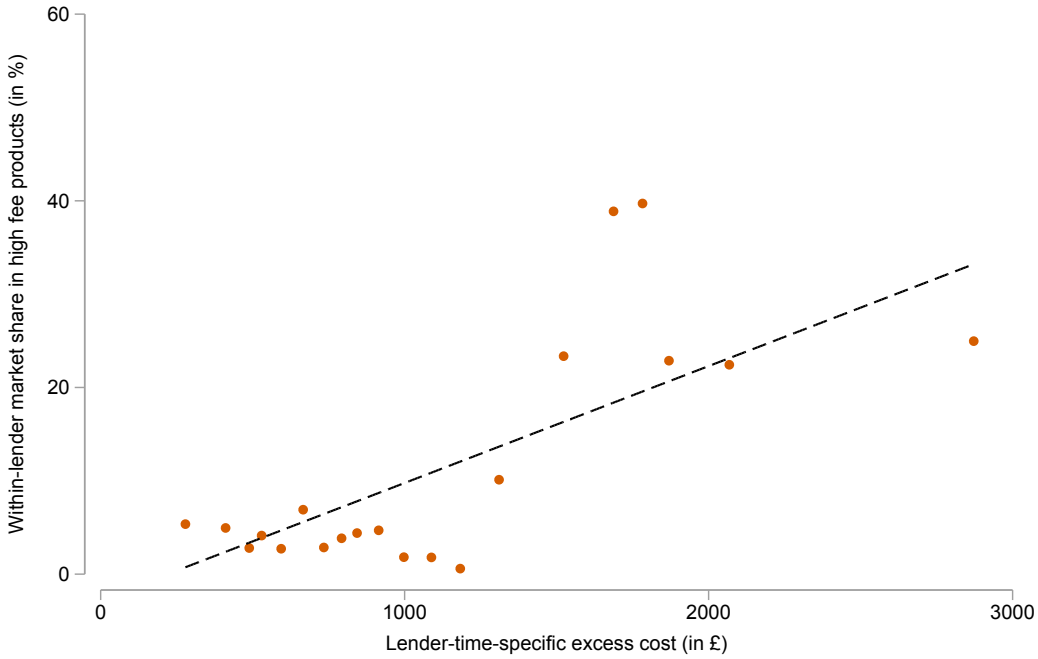
Notes: This figure shows the densities of excess cost by fee categories. Excess cost is measured as the residual from a regression of loan-level borrowing outcomes on year-month and region fixed effects and LTV (based on 2015-2016 PSD data).

FIGURE 6: RELATIVE MARKET SHARES BY LENDER EXCESS COST LEVEL

(A) RELATIVE MARKET SHARE IN ZERO-FEE PRODUCT



(B) RELATIVE MARKET SHARE IN HIGH-FEE PRODUCT



Notes: Figure 6a shows a binscatter of within-lender market share (share of products in that fee category out of all products issued in a given quarter) in the zero-fee product by lender-time-specific excess cost, measured as the difference between a given lenders' average total cost of mortgages on offer and the cost-minimizing product in a given quarter. Figure 6a shows the equivalent binscatter for high-fee products where high fees are defined as fees > £1000.

Table 1: Example of Moneyfacts data structure

Variable	75% LTV, low fee	75%, high fee
Collected date	30/04/2013	30/04/2013
Lender	Halifax	Halifax
Initial Period (in months)	27	27
Max LTV % FTB	75	75
Initial Rate	3.39	2.69
Arrangement Fee Notes	Completion GBP295	Arrangement GBP995, Completion GBP295
Incentive	GBP150 rebate. No Higher Lending Charge (HLC).	GBP150 rebate. No Higher Lending Charge (HLC).
Prepayment penalty	to 31/8/15: 3/2% Mortgage Advance	to 31/8/15: 3/2% Mortgage Advance
	90% LTV, low fee	90% LTV, high fee
Collected date	30/04/2013	30/04/2013
Lender	Halifax	Halifax
Initial Period (in months)	28	28
Max LTV % FTB	90	90
Initial Rate	5.59	4.99
Arrangement Fee Notes	Completion GBP295	Arrangement GBP995, Completion GBP295
Incentive	No Higher Lending Charge (HLC).	No Higher Lending Charge (HLC).
Prepayment penalty	to 31/8/15: 3/2% Mortgage Advance	to 31/8/15: 3/2% Mortgage Advance

Notes: This table shows three different mortgage offers by three different lenders in April 2016. It illustrates the data structure and provides examples of the text variables "Initial Text", "Arrangement Fee Notes", "Incentives", and "Redemption Penalty" (not yet used in analysis). The main variables extracted via keyword search are interest rates, fee components and total fee amount (in blue).

Table 2: Descriptive statistics

Panel 1: Summary of Moneyfacts variables (monthly)

Variable	count	mean	sd	p10	p50	p90
Interest rate (in %)	28852	3.37	1.24	1.89	3.24	5.09
Initial fixation period (in months)	28852	25.89	1.33	24	26	28
Max LTV, first-time buyer	28852	77.48	10.26	60	80	90
No additional product fees (indicator)	28852	0.2	0.4	0	0	1
Arrangement fees (in £)	9718	1001.66	449.76	495	995	1499
Booking fees (in £)	11799	484.74	525.33	99	199	999
Completion fees (in £)	8672	544.19	382.51	245	295	999
Reservation fees (in £)	739	564.43	298.76	195	400	999
Fees (sum of fee components)	28852	713.64	605.13	0	845	1495
Number of obs.	28852					

Panel 2: Lender characteristics (annual)

Variable name	count	mean	sd	p10	p50	p90
log(total assets)	178	17.77	2.02	15.55	17.35	20.92
return on assets	172	0.05	1.25	-0.62	0.23	0.69
return on equity	172	1.40	14.73	-12.39	5.28	11.89
total debt to total equity	178	19.28	8.85	9.32	17.88	29.27
net interest margin	172	1.38	0.70	0.63	1.32	2.10
net customer loan to deposit ratio	176	104.84	25.32	76.07	101.93	128.01
problem loans to gross customer loans	170	6.85	7.80	1.01	4.74	13.31
Number of obs.	179					

Panel 3: Lender panel variables (quarterly)

Variable name	count	mean	sd	p10	p50	p90
levels						
funding shock	801	6.70	3.91	3.43	5.86	11.29
avg. interest	803	2.93	0.98	1.75	2.77	4.29
avg. fees	803	689.49	388.63	299.50	595.00	1090.00
avg. total cost (1 year)	803	8243	1045	6985	8112	9672
avg. total cost (2 years)	803	15797	1974	13488	15582	18443
no. of all products	876	10.31	5.46	4.00	10.00	17.00
no. of 2yr, 70-75% LTV products	803	2.77	1.48	1.00	2.33	4.67
no. of 2yr, 90-95% LTV products	783	2.36	1.30	1.00	2.00	4.00
changes						
funding shock (std.)	765	-0.00	1.00	-1.00	-0.06	0.90
avg. interest	778	-0.10	0.31	-0.43	-0.06	0.18
avg. fees	778	3.44	195.60	-166.67	0.00	166.50
avg. total cost (1 year)	778	-92.91	355.10	-416.89	-58.62	216.98
avg. total cost (2 years)	778	-189.26	645.35	-801.01	-117.93	359.09
no. of all products (%)	866	0.06	0.28	-0.17	0.00	0.32
no. of 2yr, 70-75% LTV products (%)	778	0.06	0.29	-0.21	0.00	0.33
no. of 2yr, 90-95% LTV products (%)	753	0.05	0.27	-0.17	0.00	0.33

Notes: Panel 1 reflects the main dataset that contains offers for first-time buyers and 2-year fixed rate contracts only. Data on lender characteristics and funding data (Panel 2 and 3) are obtained from SNL Financial and Bloomberg. Variables in Panel 3 are built from Moneyfacts, lender characteristics and funding data.

Table 3: Proportion of cost-dominated products by fee category (in %)

excess cost	fees					total
	zero fees	(0,500]	(500,1000]	(1000,1500]	>1500	
<=500	4.6	5.4	4.3	0.1	0.0	14.5
(500,1000]	4.4	5.4	10.0	1.3	0.0	21.1
(1000,2000]	6.6	6.3	13.4	5.5	2.7	34.5
(2000,4000]	2.8	5.1	8.0	4.1	2.8	22.9
>4000	0.7	1.8	2.7	1.2	0.6	7.1
total	19.1	23.9	38.5	12.3	6.2	

Notes: This table shows the proportion of all products (in %) between January 2009 and December 2016 split by excess cost compared to the lowest cost product available in a given month, and fee categories. The cost are computed for a 2-year fixed rate mortgage over two years, at 75% LTV for first-time buyers, for a loan size of £150,000, amortized over 25 years.

Table 4: Changes in price components and total cost

Panel 1				
	Δr_{avg}	Δf_{avg}	ΔC_{avg}	
			1 year	2 years
$\Delta\phi$ (std.)	-0.01	63.47*	59.24**	54.81
	(0.03)	(33.10)	(27.63)	(44.86)
N	671	671	671	671
R^2	0.479	0.105	0.436	0.496
Panel 2				
	Δr_h	Δf_l	$\Delta C_{(r_h,f_l)}$	
			1 year	2 years
$\Delta\phi$ (std.)	0.02	4.69	37.12	33.65
	(0.02)	(12.76)	(35.38)	(62.23)
N	671	671	671	671
R^2	0.370	0.066	0.404	0.475
Panel 3				
	Δr_l	Δf_h	$\Delta C_{(r_l,f_h)}$	
			1 year	2 years
$\Delta\phi$ (std.)	-0.03	124.86*	81.90**	76.95
	(0.04)	(65.20)	(37.81)	(46.16)
N	671	671	671	671
R^2	0.480	0.113	0.341	0.404

Notes: */**/*** denote p<0.1, p<0.05 and p<0.01, respectively. Includes lender and time (year-quarter) fixed effects. Standard errors are clustered at the lender level. This table reports results from 12 different regressions of changes in average interest rates, fees and total cost (over one and two years) on changes in funding shock ϕ, and the equivalent for highest interest rates-lowest fees, and lowest interest rates-highest fees products, based on lender-level panel data between 2009 Q1 and 2016 Q4, at quarterly frequency. All pricing characteristics are based on 2-year fixed rates and 70-75% LTV product offers only.

Table 5: Changes in price components and total cost, by lender type

	Δr_{avg}	Δf_{avg}	ΔC_{avg}		Δr_l	Δf_h	$\Delta C_{(r_l, f_h)}$	
			1 year	2 years			1 year	2 years
Panel 1: Big Six banks only								
$\Delta\phi$ (std.)	0.01	46.67	63.93	80.81	0.00	106.59*	81.08*	103.03
	(0.04)	(28.05)	(33.77)	(65.72)	(0.03)	(48.90)	(42.41)	(68.47)
N	244	244	244	244	244	244	244	244
R^2	0.697	0.263	0.704	0.723	0.658	0.259	0.650	0.673
Panel 2: Building societies only								
$\Delta\phi$ (std.)	0.03	11.17	36.80	62.10	0.03	49.38*	17.62	8.91
	(0.03)	(31.21)	(35.30)	(60.13)	(0.03)	(24.54)	(51.63)	(76.09)
N	238	238	238	238	238	238	238	238
R^2	0.467	0.100	0.434	0.477	0.478	0.120	0.334	0.380
Panel 3: Challenger banks only								
$\Delta\phi$ (std.)	-0.03	46.61	15.64	-15.33	-0.07	106.16	61.17	41.80
	(0.03)	(47.94)	(32.81)	(41.55)	(0.06)	(106.80)	(54.51)	(46.63)
N	221	221	221	221	221	221	221	221
R^2	0.525	0.236	0.397	0.505	0.513	0.233	0.344	0.441
Panel 4: Publicly traded only								
$\Delta\phi$ (std.)	0.01	102.13	121.20*	140.50	-0.02	187.94**	177.18**	216.72*
	(0.06)	(66.06)	(61.27)	(99.43)	(0.05)	(78.68)	(69.69)	(107.68)
N	245	245	245	245	245	245	245	245
R^2	0.706	0.252	0.587	0.686	0.655	0.266	0.502	0.613

Notes: */**/*** denote p<0.1, p<0.05 and p<0.01, respectively. Includes lender and time (year-quarter) fixed effects. Standard errors are clustered at the lender level. This table reports results from 16 different regressions of changes in the average, and lowest interest rates-highest fees and total cost (over one and two years) on changes in funding shock ϕ, based on lender-level panel data between 2009 Q1 and 2016 Q4, at quarterly frequency. All pricing characteristics are based on 2-year fixed rates and 70-75% LTV product offers only. Panel 1-4 report results for sub-samples containing the largest six lenders, building societies, challenger banks and publicly traded lenders, respectively.

Table 6: Changes in price components and total cost (High LTV)

Panel 1				
	Δr_{avg}	Δf_{avg}	ΔC_{avg}	
			1 year	2 years
$\Delta\phi$ (std.)	0.09***	-10.41	84.13***	178.66***
	(0.02)	(11.54)	(20.73)	(38.33)
N	515	515	515	515
R^2	0.271	0.083	0.255	0.274
Panel 2				
	Δr_h	Δf_l	$\Delta C_{(r_h,f_l)}$	
			1 year	2 years
$\Delta\phi$ (std.)	0.10***	11.82	82.17***	166.89***
	(0.02)	(28.07)	(26.74)	(42.98)
N	515	515	515	515
R^2	0.246	0.100	0.233	0.258
Panel 3				
	Δr_l	Δf_h	$\Delta C_{(r_l,f_h)}$	
			1 year	2 years
$\Delta\phi$ (std.)	0.08***	-25.09*	85.86***	202.16***
	(0.02)	(12.81)	(18.66)	(38.85)
N	515	515	515	515
R^2	0.247	0.085	0.236	0.262

Notes: */**/*** denote p<0.1, p<0.05 and p<0.01, respectively. Includes lender and time (year-quarter) fixed effects. Standard errors are clustered at the lender level. This table reports results from 12 different regressions of changes in average interest rates, fees and total cost (over one and two years) on changes in funding shock ϕ, and the equivalent for highest interest rates-lowest fees, and lowest interest rates-highest fees products, based on lender-level panel data between 2009 Q1 and 2016 Q4, at quarterly frequency. All pricing characteristics are based on 2-year fixed rates and 90-95% LTV product offers only.

Table 7: Change in fee-product alternatives

	ΔN^f		
	All products	Low LTV	High LTV
$\Delta\phi$ (std.)	0.22***	0.05*	0.02
	(0.07)	(0.03)	(0.04)
Year-Quarter FE	Y	Y	Y
Lender FE	Y	Y	Y
N	750	671	515
R^2	0.181	0.072	0.104

Notes: */**/*** denote p<0.1, p<0.05 and p<0.01, respectively. This table reports results from 5 different regressions of percentage changes in number of fee-product alternatives on changes in funding shock ϕ, based on lender-level panel data between 2009 Q1 and 2016 Q4, at quarterly frequency. Standard errors are clustered at lender level. Column (1) reports results for changes in the number of fee-product alternatives offered across all products, while columns (2)-(5) report results for changes within 2-year fixed rate 70-75% LTV, 2-year 90-95% LTV, 5-year 70-75% LTV and 5 year 90-95% LTV product categories, respectively.

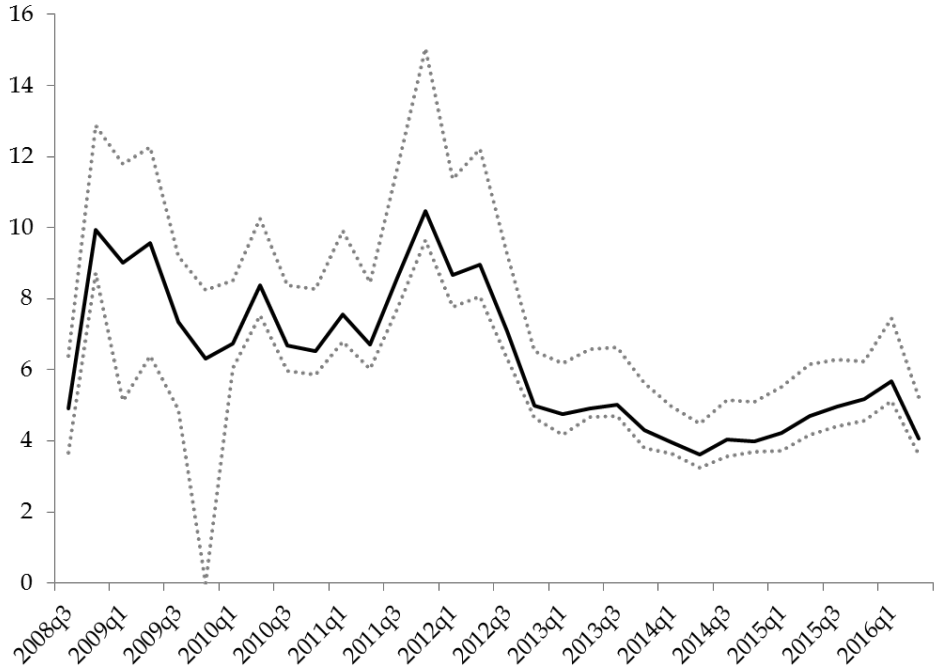
Table 8: Fee-rate trade-off

Dep. var: interest cost	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Fees	-0.1948	-0.4277***	-0.4022***	-0.2280**	-0.4080***	-0.3481***	-0.9646***
	(0.1237)	(0.1130)	(0.1224)	(0.1053)	(0.1061)	(0.1100)	(0.1475)
Early prepayment penalty				-0.0297	0.0463	0.1009	0.0774
				(0.0332)	(0.0653)	(0.2513)	(0.2556)
Cashback indicator				0.0213	-0.0553	-0.1554	-0.1274
				(0.2818)	(0.1312)	(0.1598)	(0.1337)
Incentive (length)				-1.1580	1.0516**	2.8123***	1.6274**
				(1.0172)	(0.5076)	(0.7435)	(0.6264)
Fees^2							0.0003***
							(0.0001)
Year-Month FE	Y	Y	Y	Y	Y	Y	Y
LTV FE	Y	Y	Y	Y	Y	Y	Y
LTV×Year-Month FE	Y	Y	Y	Y	Y	Y	Y
Lender FE	N	Y	Y	N	Y	Y	Y
Lender×Year-Month FE	N	N	Y	N	N	Y	Y
Observations	29718	29718	29650	29718	29718	29650	29650
Adj. R^2	0.695	0.812	0.841	0.698	0.813	0.844	0.858

Notes: */**/*** denote p<0.1, p<0.05 and p<0.01, respectively. This table reports results from 7 different regressions of interest cost, calibrated to the average loan size in a given month, on fees, based on product-level panel data for the full sample, at monthly frequency. Standard errors are clustered at lender level. The early prepayment penalty is computed for the average loan size.

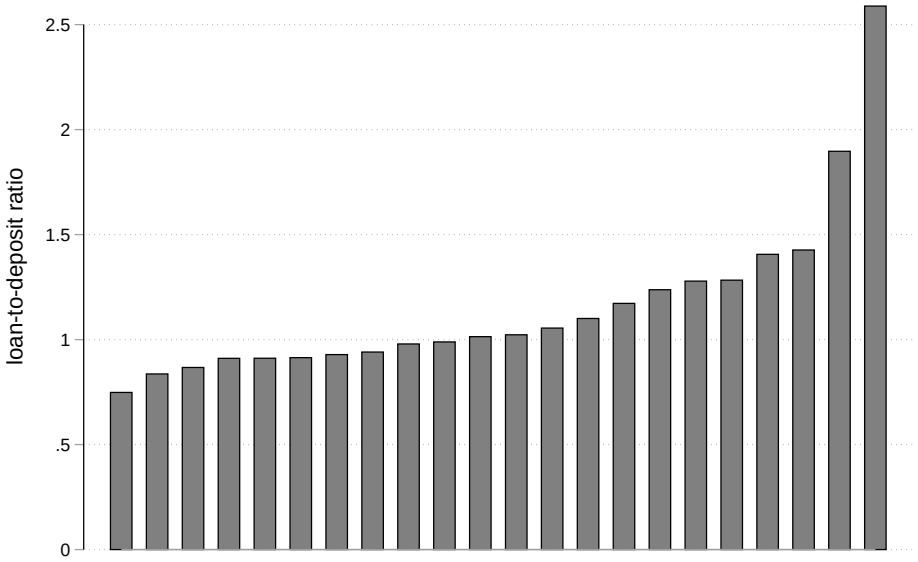
A. Additional figures and tables

Figure A.1: Distribution of funding shock ϕ_{jt}, 2008-2016



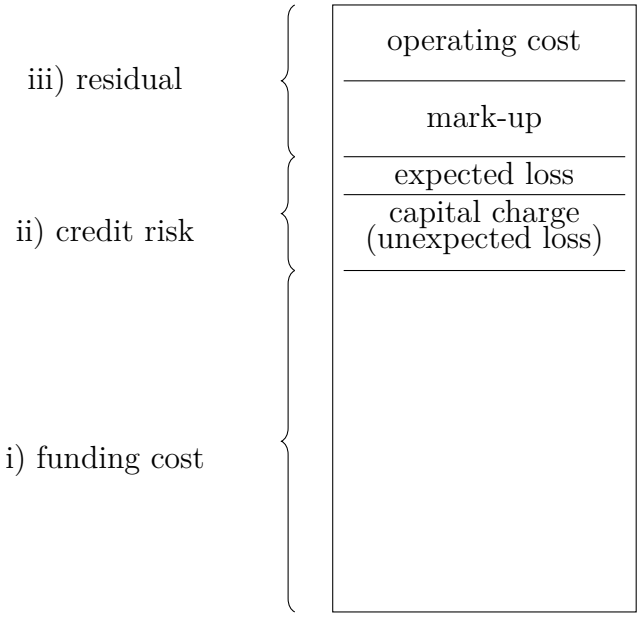
Notes: This figure shows the distribution of the funding shock ϕ_{jt} over time, with the median in black and 25th and 75th percentiles in dashed lines. The funding shock is constructed as $\phi_{jt} = ltd_{j,2008} \times \left(r_t^{libor} + s_{jt}\right)$ for the top six lenders for which lender-specific CDS spreads (s_{jt}) are available, and $\phi_{jt} = ltd_{j,2008} \times \left(r_t^{libor} + \bar{s}_t\right)$ for all other lenders. $ltd_{j,2008}$ is the lender-specific loan-to-deposit ratio in 2008, and r_t^{libor} refers to 2-year LIBOR swap rates.

FIGURE A.2: LOAN-TO-DEPOSIT RATIO (2008)



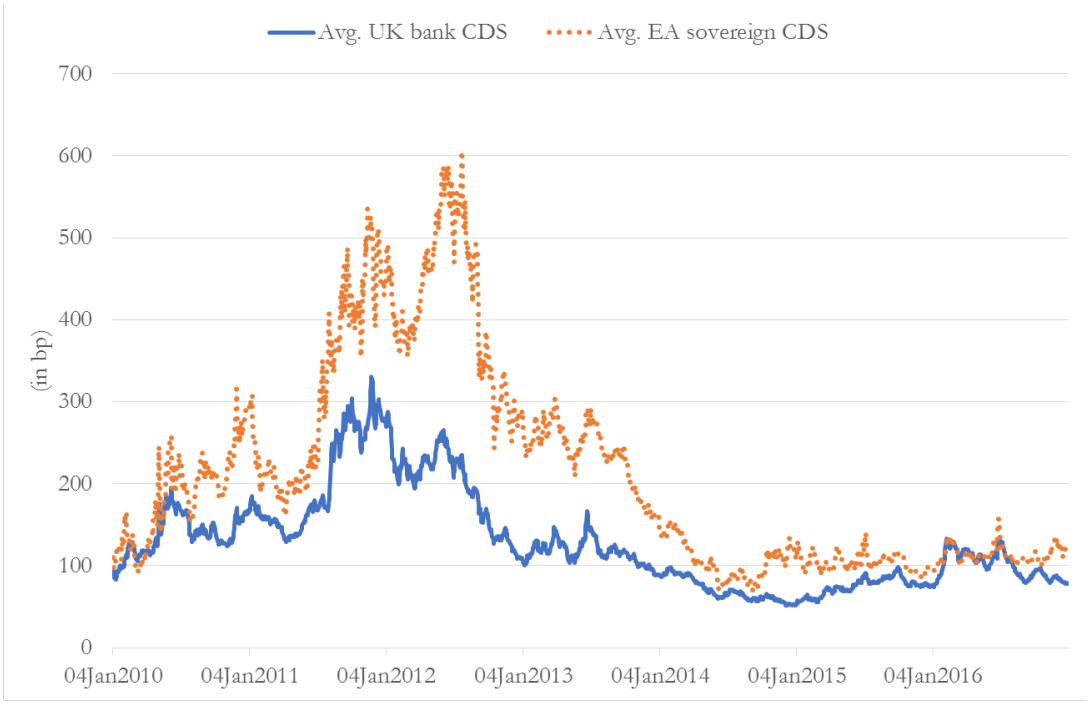
Notes: This figure shows loan-to-deposit ratios in 2008 across lenders.

FIGURE A.3: ILLUSTRATION OF MORTGAGE PRICE COMPONENTS



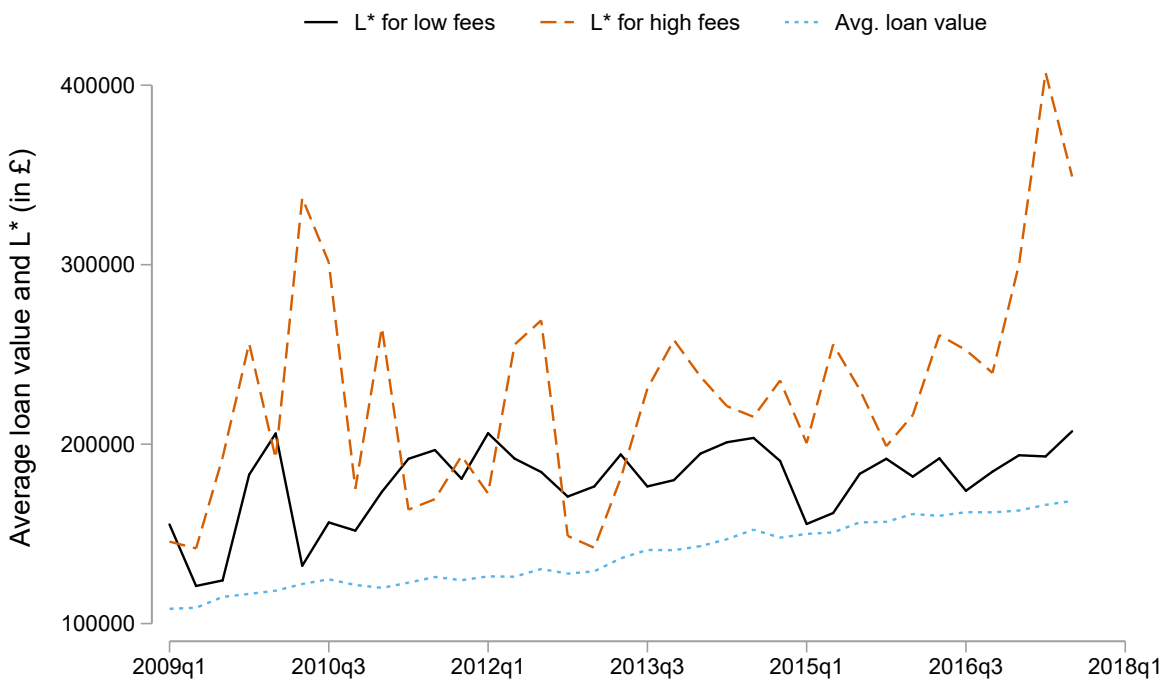
Notes: Adapted from Button et al. (2010). The proportions are stylized, but similar to what they estimate for the period between 2010 and 2012.

FIGURE A.4: UK BANK CDS SPREADS AND EA SOVEREIGN CDS SPREADS



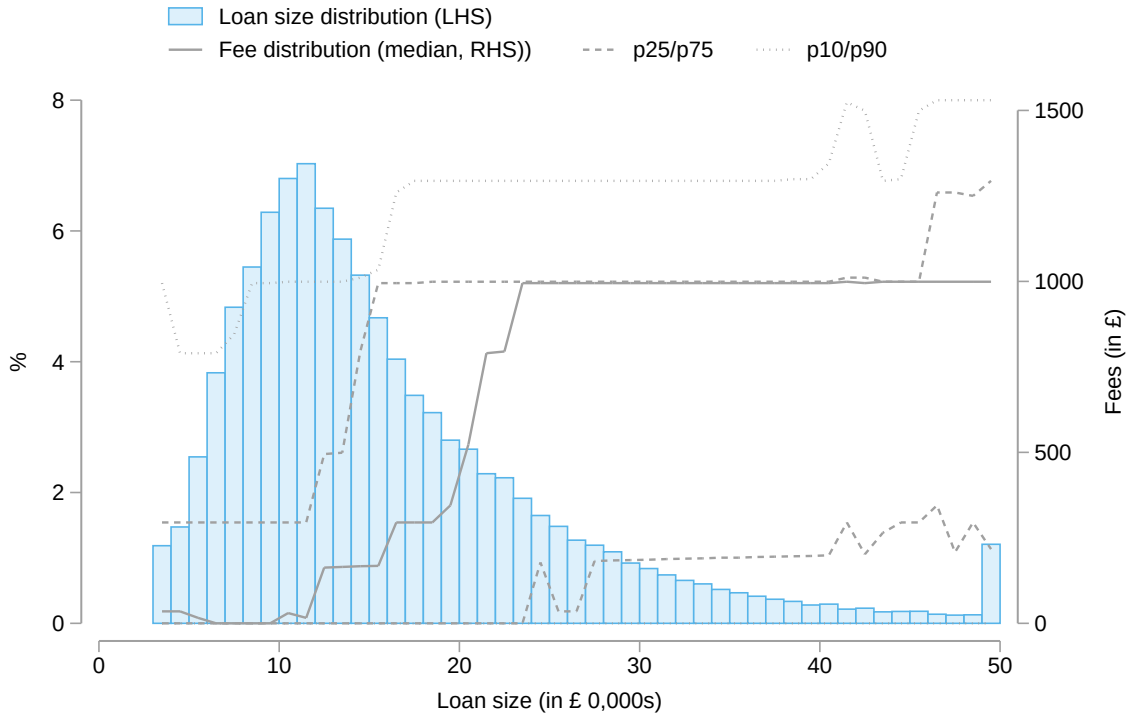
Notes: UK banks average over six largest banks. EA sovereign CDS spreads measured as average over Spanish and Italian 5yr sovereign CDS spreads.

FIGURE A.5: L^* COMPARED TO AVERAGE LOAN SIZE OVER TIME



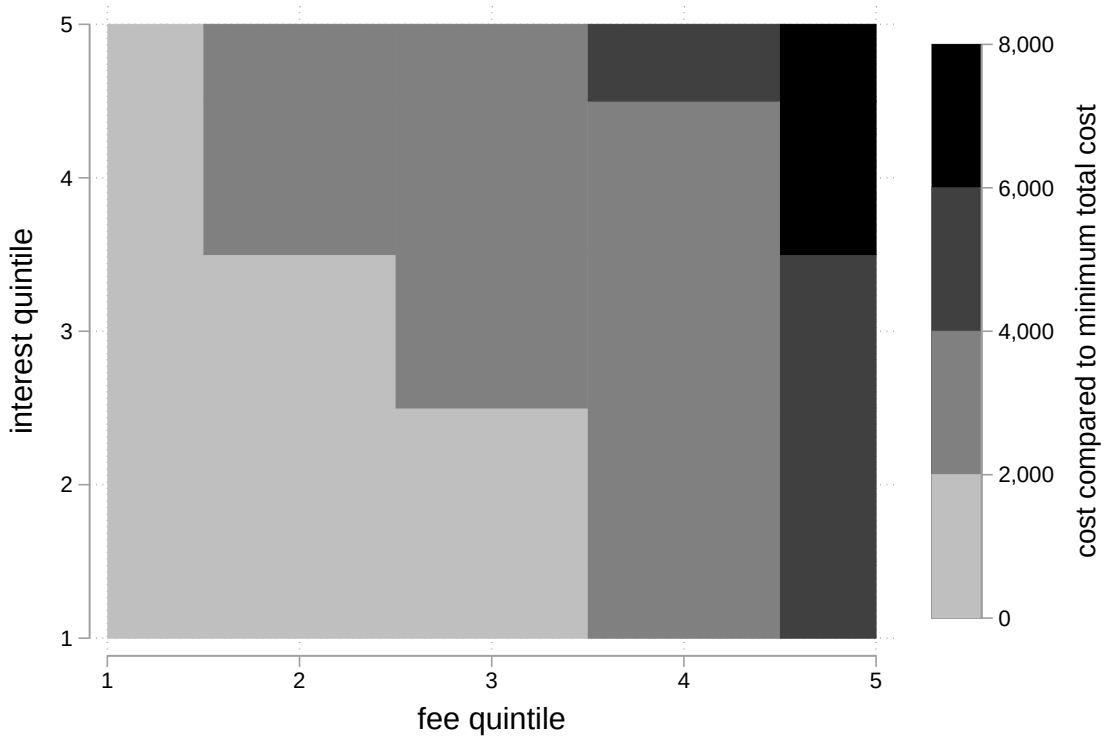
Notes: This figure shows the median loan value thresholds L^* at which a borrower should be indifferent between paying no fee and a higher interest rate, and paying a (low / high) fee and a lower interest rate, together with the average loan size over time.

FIGURE A.6: LOAN VALUE HISTOGRAM AND FEE DISTRIBUTION



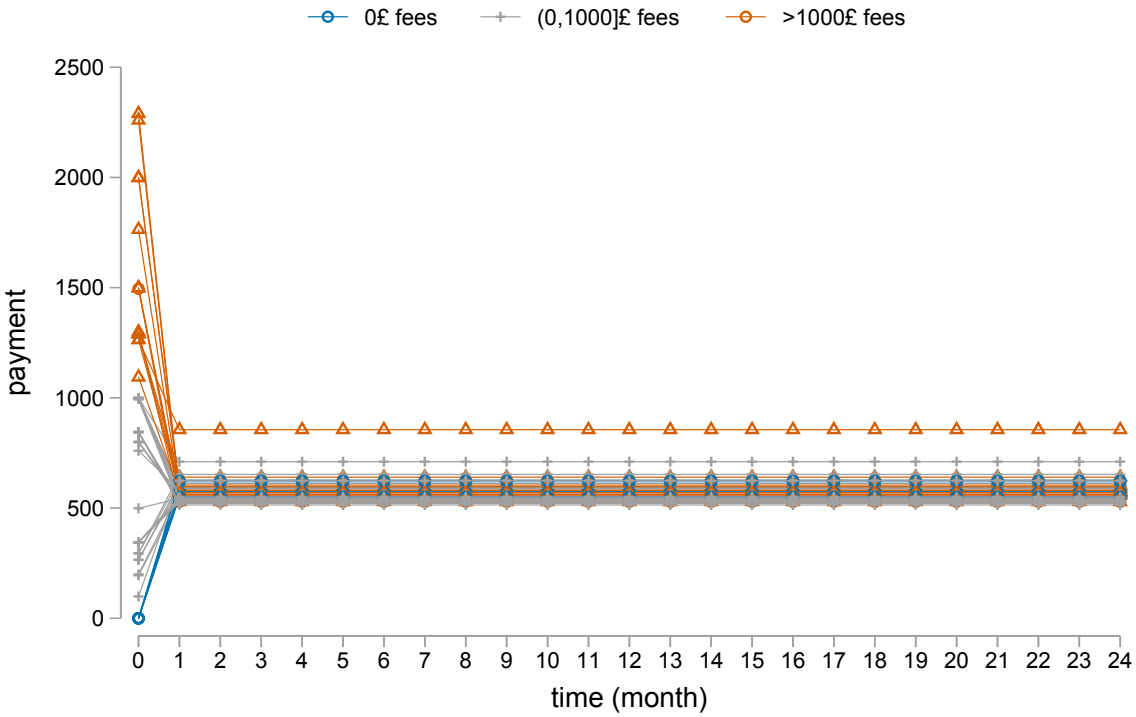
Notes: This figure shows the realised loan size and fee distribution (based on PSD data from 2015-2016).

FIGURE A.7: COST DIFFERENTIAL FOR AVERAGE PRODUCT IN INTEREST AND FEE QUINTILE (HIGH LOAN VALUE)



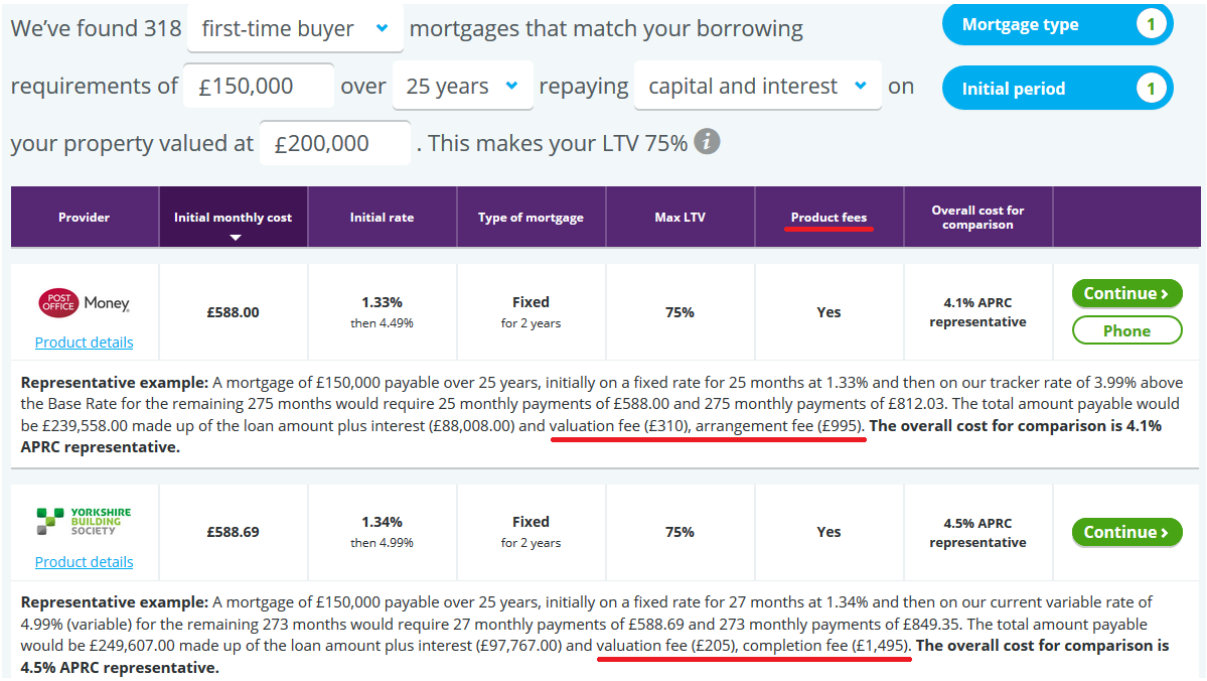
Notes: This figure shows the average (across products in a given interest and fee quintile) cost differential in £, measured as the difference between total cost and the minimum total cost product in a given month, based on a 75% LTV 2-year fixed rate product over two years, for a loan size of £250,000 amortized over 25 years.

FIGURE A.8: MORTGAGE PAYMENT PROFILE OVER TIME



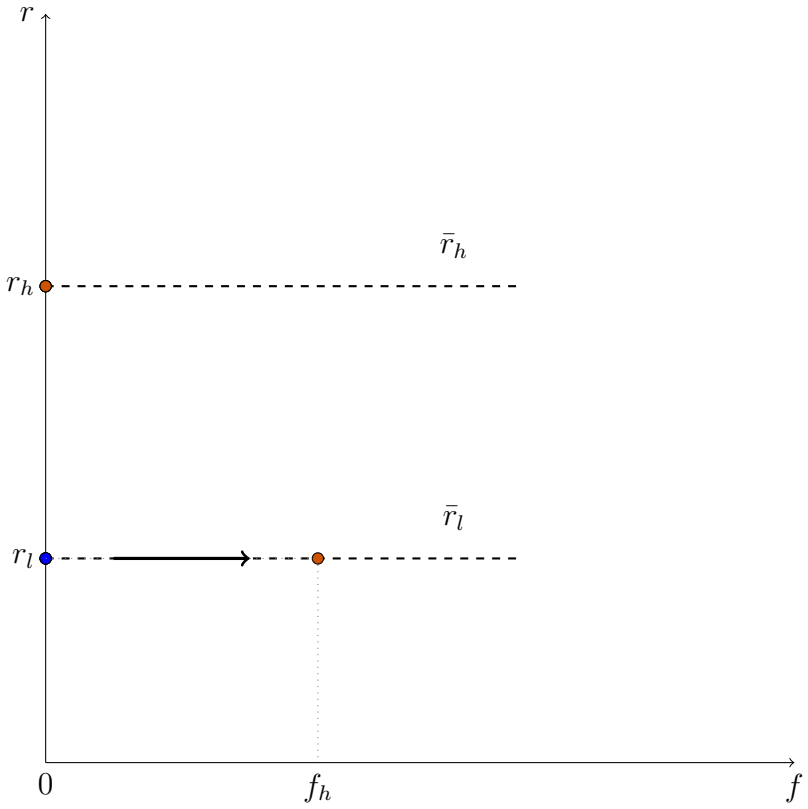
Notes: This figure shows the payment profile for a borrower who takes out a 2yr fixed rate mortgage at 75% LTV for an average loan size, for the range of 2yr 75% LTV products in February 2015.

FIGURE A.9: SCREENSHOT FROM MONEYSUPERMARKET.COM



Notes: This figure shows the search result for 2-year fixed rate mortgages, at 75% LTV for first-time buyers, for a loan size of £150,000, and the default ranking by interest rates, with fees in the footnotes.

FIGURE A.10: ILLUSTRATION OF PRICING WITH NON-SALIENT FEES



Notes: This figure shows how a cost-dominated product can be repriced from dominating in the interest rate to dominating in the (less salient) fee dimension, so that it lies on the same "iso-interest-cost"-curve $\bar{r}_l$ as the cost-minimizing product.

TABLE A.1: BALANCE TESTS FOR FUNDING SHOCK ϕ

	Lagged levels			Changes		
	2009	2012	2016	2009	2012	2016
log(assets)	6.03	0.36	0.55	-0.52	-0.03	-0.09
	(6.98)	(1.80)	(0.98)	(0.39)	(0.06)	(0.16)
return on assets	-10.85	-9.51***	1.96	-0.16	-0.01	0.01
	(10.06)	(1.55)	(1.77)	(0.14)	(0.02)	(0.02)
net interest margin	-2.04	1.71	-2.71*	-0.30	-0.01	0.08
	(7.77)	(3.93)	(1.42)	(0.47)	(0.12)	(0.09)
leverage	0.48	0.19	-0.17	-0.01	0.00	-0.00
	(0.50)	(0.19)	(0.10)	(0.01)	(0.00)	(0.00)
big 6 lenders (indicator)	-21.40	11.08	2.33	0.11	0.06	-0.01
	(29.06)	(8.21)	(3.58)	(0.32)	(0.05)	(0.03)
Observations	16	22	27	16	22	22
R^2	0.443	0.726	0.393	0.160	0.236	0.084

Notes: */**/*** denote p<0.1, p<0.05 and p<0.01, respectively. This table reports results from 6 different regressions, based on cross-sectional regressions of funding shock ϕ_j on lender characteristics for the years 2009, 2012 and 2016 separately, in lagged levels and changes. The table is based on Table 3 in Goldsmith-Pinkham et al. (2017). Standard errors are clustered at lender level.

Table A.2: Proportion of cost-dominated products by fee category (in %) (high loan value)

excess cost	fees					total
	zero fees	(0,500]	(500,1000]	(1000,1500]	>1500	
<=500	0.9	2.2	3.6	0.4	0.0	7.3
(500,1000]	2.6	3.5	6.1	0.8	0.2	13.2
(1000,2000]	5.8	6.0	11.9	3.4	2.0	29.0
(2000,4000]	7.2	7.1	10.5	4.9	2.6	32.3
>4000	2.7	5.1	6.4	2.7	1.3	18.2
total	19.1	23.9	38.5	12.3	6.2	

Notes: This table shows the proportion of all products (in %) between January 2009 and December 2016 split by excess cost compared to the lowest cost product available in a given month, and fee categories. The cost are computed for a 2-year fixed rate mortgage over two years, at 75% LTV for first-time buyers, for a loan size of £250,000, amortized over 25 years.

B. Theoretical motivation of price obfuscation with non-salient fees

The model[49] has two types of firms and two types of consumers: high (c_h) and low cost (c_l) firms, and a unit mass of consumers with λ representing the fraction of uninformed consumers, and $1-\lambda$ the fraction of informed consumers.

There is only one period. However, the model can be thought of as a repeated one-shot game with no dynamic dependence, i.e. at each period, an i.i.d cost shock realizes such that firm j has either c_h or c_l such that consumers cannot learn which firm has low or high prices.[50] In the context of the mortgage market, consumers search anew each time they refinance.[51]

Firms: There are N firms in total, and n_l low-cost firms. Firms set headline prices $r \in \{r_l, r_h\}$, i.e. they either offer low or high interest rates. We have $c_h > c_l$, $r_h > r_l$ and $r_l - c_h < 0$, the latter meaning that high-cost firms cannot break even by charging low prices.[52] However, firms can choose to obfuscate prices and charge a hidden additional cost f. The amount of f determines the matching or acceptance probability of consumers m, given by

$$m = \alpha\gamma(f) = \alpha e^{-sf}, \tag{4}$$

where γ is a decreasing function in f and is 0 for $f \to \infty$, capturing the trade-off that the more obvious the obfuscation, i.e. the higher f, the more likely it will be detected,

[49] Note that the framework adopts and reinterprets the model by Salop and Stiglitz (1977) and introduces price obfuscation. In Salop and Stiglitz (1977), consumers do not know which firms sell at low prices and can choose to gather that information, but differ in their search cost ex ante. Firms are identical and have U-shaped average cost curves, i.e. some fixed cost and increasing marginal cost. Firms engage in Nash price setting behavior and in equilibrium, profits are zero, i.e. prices equal average cost, yielding a monopolistic competition framework. Then a two-price equilibrium can occur: low price firms (selling at r_l) sell to consumers for whom it is less costly to search and who become informed, plus (lucky) uninformed consumers who randomly chose a low price firm, and they sell a combined greater quantity q of the product (informed plus uninformed demand share). High price firms (r_h) only sell to unlucky uninformed consumers who randomly pick a high price firm, hence selling a lower quantity (uninformed demand share).

[50] This is consistent with evidence that prices fluctuate at high-frequency and that the price ranking of lenders also varies over time. The intuition is similar to that of models with mixed strategy equilibria (Varian, 1980, Carlin, 2009) in which the mixing could be interpreted as temporal price dispersion.

[51] This is a simplification that ignores temporal dependence that could arise e.g. from borrower heterogeneity in refinancing inertia (Andersen et al., 2015). In the UK, around 70-80% of borrowers refinance after the initial fixation period of usually 2 or 5 years, making the assumption that they search for the cheapest product each time they need to refinance justifiable. There could be learning, however, in the sense that on average second-home buyers and refinancers may be more informed and price-sensitive than first-time buyers, which would be captured in the size of parameter λ and which I can test empirically, e.g. if results vary for the second-home and refinancing market.

[52] This could be interpreted as firms being forced to exit the market if they can only charge r_l, or, in repeated versions of the game, firms exiting temporarily while their cost draw is c_h.

affecting the match rate. s is a parameter that governs the speed of decay and can be calibrated to the data, e.g. for $s = 0.0015$, the match probability is 0.01 for a very high additional cost of £3000 and low price product. α is an attention or salience factor where

$$\alpha = \begin{cases} 1 & \text{if } r = r_l, \\ \epsilon & \text{if } r = r_h, \end{cases}$$

i.e. α governs consumers' emphasis on low prices (interest rates). For $\epsilon \geq 0$, there may still be a very small fraction of uninformed borrowers who consider high price products, for instance the match rate is 0.05 for $\epsilon = 0.05$ and $f = 0$.
I assume that borrowers demand one homogeneous mortgage, i.e. LTV, fixation period and loan value are given and equal across borrowers, such that interest rates set by lenders are equivalent to setting the interest rate cost and both terms are used interchangeably. Firms hence offer contracts M which specify the headline price p (interest rate cost) and a hidden additional cost f (fees):

$$M = \Big\{\{r, f\} : r \in \{r_l, r_h\}, f \in [0, +\infty]\Big\},$$

where $r_l < r_h$.
Firms may offer multiple contracts, but these cannot be weakly dominated within a firm, in line with the data and possibly regulatory concerns. That means that a firm that offers contract $\{r_l, 0\}$ cannot offer $\{r_h, 0\}$ or $\{r_l, f\}$ where $f > 0$. On the other hand, a firm that offers $\{r_h, f_l\}$ could offer another contract $\{r_l, f_h\}$ where $f_l < f_h$. Hence the set of feasible product offerings is

$$\mathcal{M} = \{(r_l, f); (r_h, f); (r_l, f_h), (r_h, f_l)\}. \tag{5}$$

Consumers: Consumers demand one homogeneous mortgage and have utility

$$U = \begin{cases} v - \text{total cost}, & \text{if purchasing the mortgage} \\ 0, & \text{otherwise}, \end{cases}$$

where v is the valuation that determines the upper threshold for total cost at which the borrower is indifferent between purchasing a mortgage or not. Prices are assumed to be set such that all consumers participate. Informed consumers are fully cost minimizing and pick any mortgage from the set of firms who offer the lowest total cost (interest rate and fees). Uninformed consumers prefer to look at the set of low price products (interest rates) with $r = r_l$ and pick a product at random, neglecting hidden cost f

(fees) more the smaller the size of the additional cost, captured in the matching function γ. The process could be interpreted as uninformed consumers looking at a best buy table or price search engine that emphasizes the cheapest interest rates available in the market, while not differentiating between fees. As noted above, with some small probability ϵ, uninformed consumers may also consider $r = r_h$, but informed consumers never do as long as there exists a product with $r = r_l$.

Demand and profits: Firms maximize profits, which are given by:

$$\Pi = (r - c + f) \cdot Q \tag{6}$$

$$\text{where} \quad Q = \underbrace{\frac{\lambda}{N}\alpha\gamma(f)}_{\text{uninformed demand share}} + \underbrace{\frac{1-\lambda}{n_l}\alpha\gamma(f) \cdot I_{[r=r_l]}}_{\text{informed demand share}}. \tag{7}$$

The informed demand share is invariant to changes in the price format and will only be non-zero if $r = r_l$, i.e. it would be zero if $r = r_l + f$, as captured by the indicator function.[53]

Separating equilibrium: Firms choose their product offering from $\mathcal{M}$ and set r and f. The profit for a low cost lender (Π_{c_l}) if it does not obfuscate (NO) is

$$\Pi_{c_l}\Big[NO \mid (r_l, 0)\Big] = (r_l - c_l)\frac{\lambda}{N} + (r_l - c_l)\frac{1-\lambda}{n_l}. \tag{8}$$

As an alternative, it could choose to obfuscate (O) with low prices:

$$\Pi_{c_l}\Big[O \mid (r_l, f)\Big] = (r_l - c_l + f)\frac{\lambda}{N}\gamma(f), \tag{9}$$

or even obfuscate with high prices:

$$\Pi_{c_l}\Big[O \mid (r_h, f)\Big] = (r_h - c_l + f)\frac{\lambda}{N}\epsilon\gamma(f). \tag{10}$$

For sufficiently small ϵ, we assume that $\Pi\Big[O, \mid (r_l, f)\Big] \geq \Pi\Big[O, \mid (r_h, f)\Big]$. As long as $\epsilon \geq 0$, the lender can offer

$$\begin{aligned}\Pi_{c_l}\Big[O \mid (r_l, f_h), (r_h, f_l)\Big] &= (r_l - c_l + f_h)\frac{\lambda}{N}\gamma(f_h) + (r_h - c_l + f_l)\frac{\lambda}{N}\epsilon\gamma(f_l) \\ &\geq \Pi_{c_l}\Big[O \mid (r_l, f_h)\Big] \geq \Pi_{c_l}\Big[O \mid (r_h, f_l)\Big].\end{aligned} \tag{11}$$

[53] This assumption could be relaxed, e.g. by assuming that if the lender chooses to obfuscate with hidden cost f, the match probability $m = \alpha\gamma(f)$ for the uninformed and informed demand share will be equally affected, or to some extent affected affected, as long as there is a sufficiently large spillover from obfuscation on the acceptance probability to the informed demand share.

The condition under which low-cost lenders do not obfuscate is given by combining equations 8 and 11:

$$\begin{aligned}\Pi_{c_l}\Big[NO \mid (r_l, 0)\Big] &\geq \Pi_{c_l}\Big[O \mid (r_l, f_h), (r_h, f_l)\Big] \\ &\geq \Pi_{c_l}\Big[O \mid (r_l, f_h)\Big] \geq \Pi_{c_l}\Big[O \mid (r_h, f_l)\Big],\end{aligned} \tag{12}$$

for any small enough ϵ.
Next, we consider profits for high-cost lenders (Π_{c_h}). Recall that $\Pi_{c_h}\Big[NO \mid (r_l, 0)\Big] < 0$, so the high-cost lender can only set high prices r_h if it does not obfuscate, which yields

$$\Pi_{c_h}\Big[NO \mid (r_h, 0)\Big] = (r_h - c_h)\frac{\lambda}{N}\epsilon. \tag{13}$$

The profit from obfuscating at a low price is

$$\Pi_{c_h}\Big[O \mid (r_l, f)\Big] = (r_l - c_h + f)\frac{\lambda}{N}\gamma(f), \tag{14}$$

and for a high price we get

$$\Pi_{c_h}\Big[O \mid (r_h, f)\Big] = (r_h - c_h + f)\frac{\lambda}{N}\epsilon\gamma(f). \tag{15}$$

Lastly, we have

$$\begin{aligned}\Pi_{c_h}\Big[O \mid (r_l, f_h), (r_h, f_l)\Big] &= (r_l - c_h + f_h)\frac{\lambda}{N}\gamma(f_h) + (r_h - c_h + f_l)\frac{\lambda}{N}\epsilon\gamma(f_l) \\ &\geq \Pi_{c_h}\Big[O \mid (r_l, f_h)\Big] \geq \Pi_{c_h}\Big[O \mid (r_h, f_l)\Big],\end{aligned} \tag{16}$$

which shows that obfuscating and using the full price space is the profit-maximizing strategy for a high-cost firm. The firm can always offer a high price product with no hidden cost ($r_h, f = 0$), but add a low-price product with high hidden cost. Hence combining equation 13 and 16 and the negative profit condition for low prices we get

$$\begin{aligned}\Pi_{c_h}\Big[O \mid (r_l, f_h), (r_h, f_l)\Big] &\geq \Pi_{c_h}\Big[NO \mid (r_h, 0)\Big] \\ &> \Pi_{c_h}\Big[NO \mid (r_l, 0)\Big].\end{aligned} \tag{17}$$

Equations 12 and 17 characterize the conditions for a separating equilibrium in which low-cost lenders do not obfuscate, and high cost-lenders obfuscate and use the full range of prices and hidden costs. Note that lenders trade off margins and quantities, such that high-cost lenders offer more expensive contracts than low-cost lenders for the

uninformed demand share, while low-cost lenders charge low total prices and choose not to obfuscate because they capture the informed demand share, which is a common intuition from many search models.[54] The model can hence explain the empirical results and would predict an increase in fees in response to a cost shock, but not in interest rates. It also provides intuition for why expanding the pricing space as reflected in the number of fee-product alternatives can increase profits for high-cost lenders, but is less desirable or infeasible for low-cost lenders. Future work aims to develop the framework further.

One obvious extension would be to allow low-cost lenders to offer cost-minimizing products that are interest rate loss leaders but with a fee to break even following Gabaix and Laibson (2006), which matches the data. The intuition would be that if even informed borrowers over-emphasize the interest rate price dimension, low-cost lenders may be forced to engage in some "obfuscation" in order to compete, setting a baseline fee such as £1000 that high cost lenders then deviate from.

[54]This intuition is embedded in Salop and Stiglitz (1977) using a static Nash equilibrium solution with monopolistic competition, Varian (1980) using a static mixed strategy equilibrium solution, and Galenianos and Gavazza (2017) using a dynamic search model with heterogeneous costs and quality.