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, using novel data on the universe of products on offer in the UK. I find that the majority of mortgage products is significantly cost-dominated, with similar interest rates, but different fees. In order to understand how lenders adjust price components and product offerings, I construct firm-specific shocks to funding cost. 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. This can be interpreted as a price obfuscation mechanism: in a market with one salient cost dimension, interest rates, firms can issue new products and adjust prices via a secondary cost dimension, such as fees, to appear cheap to consumers who neglect fees and fail to minimize total cost. 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.

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1. Introduction

Picking a mortgage is one of the biggest financial decisions in a consumer's lifetime, where mistakes can be very costly. 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, I also document persistent price dispersion[1] and product proliferation along price dimensions that instead highlight frictions to optimal choice.[2] For instance, a consumer who has already optimized her mortgage choice, e.g. a 2-year fixed rate, 75% LTV product,[3] in recent years still had almost 200 of such products to choose from. Most notably, many of these are variations of the same product by the same lender in price terms, e.g. a high interest rate/low fee or low interest rate/high fee variant. This product proliferation along price dimensions seems difficult to explain through borrower preferences alone.[4] In particular, I show that there exist cost-dominated products in the market that have similar interest rates, but higher fees. More than 60% of products on offer are strongly cost-dominated, i.e. more than £1000 more expensive than the cheapest alternative, pointing to market frictions.

What can explain price dispersion and product proliferation in the mortgage market? Previous work has emphasized the role of demand-side factors: 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.[5] Building on this work, this paper looks at the role of the supply side and studies 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

[1] Within a narrow product class, e.g. for a given loan-to-value (LTV) ratio and fixation period, a residential mortgage is a homogeneous retail financial product. Hence consumers should search for the cost-minimizing product and prices converge to the "law of one price" with competition. However, the interquartile range of 75% LTV, 2-year fixed rate products on offer based on a loan size of £150,000 has remained around £1000 over time, which is about 10% of the total cost over two years (Figure 1).

[2] A similar observation is 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."

[3] For instance following Campbell and Cocco (2003).

[4] It is unlikely that products with different fees primarily satisfy demand for different intertemporal payment streams, e.g. if borrowers are liquidity constrained, as they can always choose to pay fees immediately or add them to the loan balance, at no additional cost.

[5] See e.g. Hortaçsu and Syverson (2004), Choi et al. (2009) for the index mutual fund market.

standard deviation change in fees. 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.

The fact that firms' optimal pricing strategy uses fees as an active margin of price adjustment instead of interest rates reveals that demand may be less price elastic with respect to fees than to interest rates. 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. 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.[6]

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, by modelling lenders and consumers that differ in marginal cost and search cost, simplified respectively as high and low-cost lenders, and informed and uninformed consumers.[7] 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 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). 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

[6] 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 subsequently refinanced.

[7] "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 being brand-loyal (Varian, 1980), having high attention or search cost (Ellison and Wolitzky, 2012), being naïve (Carlin, 2009) or myopic (Gabaix and Laibson, 2006).

proliferation along price dimensions. 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. This prevents them from obfuscating as lenders cannot offer (weakly) dominated products within their menus, which is in line with the data. 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 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 do, however, complement my findings on 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.[8] My approach hence reveals a profit-maximizing strategy that can be rationalized with suboptimal search and consumer 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-driven mechanisms, most notably screening motives. The idea is that lenders may provide a menu of interest rates and fees from which borrowers pick and thereby reveal their type,

[8] One potential source of correlation could be existing bank relationships and the impact of these cost shocks on other services that existing customers receive who also take out a mortgage, but it seems unlikely that customer services are adjusted that quickly, while the cost shocks are observed at quarterly frequency.

and these screening motives could be correlated with time-varying cost shocks. However, I find little evidence of screening. In contrast to the US, early repayment penalties exist in the UK, which is a more direct way to screen for prepayment risk than by using fees.[9] For more than 80% of products in the sample, repayment penalties do not vary across products by a given lender, i.e. they are uncorrelated with fees within a lender. This seeming lack of screening for heterogeneous early repayment risk could be explained by the relatively short initial fixation periods prevalent in the UK, with most borrowers refinancing at the end of the 2 to 5 year fixation period (Best et al., 2015). As another screening mechanism, lenders may use high fees or high-cost products to screen for liquidity risk or any other unobservable characteristics that may be correlated with default probabilities. I find that cost pass-through via fees and product proliferation appears stronger for low LTV products, indicating that the mechanism may play more of a role when default risk is low and selection on unobservables plays less of a role.[10]

These results are important for two reasons. First, they provide empirical evidence that lenders respond strategically to demand-side frictions and document a supply-driven mechanism behind product proliferation in price dimensions that makes price comparisons more difficult for consumers. This might lead to more suboptimal choices and market power. My work is the first to empirically identify the role of the supply side on price dispersion and product proliferation using cost shocks, to the best of my knowledge. And second, the pricing strategy via different price components may affect the pass-through of monetary stimulus and 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 contribute to existing strands of literature. First, recent empirical work provides evidence of firms exploiting consumer mistakes across a range of retail financial markets, including screening for less financially sophisticated borrowers (Ru and Schoar, 2016, Agarwal et al., 2017a) who for instance exhibit inefficient refinancing behavior (Andersen et al., 2015), or firms catering to retail investor biases (Célérier and Vallée, 2017). My findings on the role of fees as less salient but active margin of price adjustment is related to work by Agarwal et al. (2014), who find that a regulatory cap on hidden fees in the US credit card market is only partially offset by an increase in interest rates, in

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

[10] In addition, the loan-to-income ratio (LTI), which is one measure of liquidity constraints, seems to be positively correlated with fees at high LTI levels, indicating that high fees do not seem to screen out liquidity-constrained borrowers. This could also be a sign that high LTI borrowers tend to borrow greater loan values and have a greater incentive to pay the fee. But in general, there is substantial fee variation across borrowers within the same LTI bucket, suggesting that most of the variation in fees is independent of liquidity-related motives.

line with less than perfect competition and fees not being fully salient. Anagol and Kim (2012) and Duarte and Hastings (2012) find evidence that firms shroud fees and adapt to disclosure policies by changing the price format in order to limit price comparability in the Indian mutual fund and privatized Mexican social security market, respectively. I add to this literature by using an identification strategy based on cost shocks, in order to show lenders' optimal response to a deterioration in their competitive position.

Second, the identification strategy also allows me to highlight the active role of the supply side, as firms dynamically respond to cost shocks to adjust their fees and product offering optimally. In that sense I also contribute to the "supply side of housing finance" suggested by Foà et al. (2015) who show that variation in banks' incentives such as variation in the fixed rate bond spread has a direct effect on households' choice between fixed and variable rate mortgages over and above relative pricing effects, likely reflecting distorted advice on the banks' side. I further show that supply-side incentives play a role in understanding the drivers behind price dispersion[11] 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 preference-driven mechanism less likely, hence adding to the previous literature that has used experimental and model-based approaches to distinguish between these two channels. For instance, Choi et al. (2009) study demand for high-fee index funds in an experimental setup and find that search cost and fees matter in contrast to bundled customer services. But they find some persistence in higher fee product demand even when search cost are eliminated, pointing to some behavioral decision rules that prevent cost minimization. Woodward and Hall (2012) use a model-based approach to gain estimates of the marginal benefit of search in the mortgage market and find that the foregone benefits seem unlikely to be explained by search cost alone, but could be due to consumer confusion. Overall, the evidence that lenders have an incentive to price-obfuscate if consumers make mistakes provides support for both frictions to cost minimization on the demand side, as well as a possible amplification channel from the supply side.

Third, I link the empirical findings to theoretical models of price obfuscation. The observed product proliferation along price dimensions can be understood as a price obfuscation mechanism, in the spirit of 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, using a framework that builds on seminal work by Salop and Stiglitz (1977)

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

and Varian (1980).[12] A closely related mechanism is described by Carlin (2009) where oligopolistic firms adjust price complexity strategically, in turn affecting the share of informed borrowers and hence determining optimal price complexity in equilibrium. The obfuscation behavior could also be interpreted as shifting the price frame as in Piccione and Spiegler (2012), to exploit borrowers that are not able to fully discern the total cost ranking when both interest rates and fees vary.[13] A related intuition is to interpret interest rates as "base goods" and fees as obligatory, but more shrouded additional cost (Gabaix and Laibson, 2006). Other related models are Ellison and Ellison (2009), Chioveanu and Zhou (2013) and Ellison and Wolitzky (2012).[14] The intuition across these models is similar: the obfuscation mechanism results in higher search cost, lower consumer price sensitivity and is a source of market power.[15] Building on these results, I emphasize the separating equilibrium properties that when there are sufficient uninformed consumers, high-cost lenders have an incentive to obfuscate, while low-cost lenders do not, if there are sufficient informed consumers.

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 mortgage pricing facts and a pricing framework. Section 4 describes the identification strategy and empirical results, and section 5 discusses the mechanism. Section 6 concludes.

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]

[12] 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.

[13] Piccione and Spiegler (2012) provide a framework in which firms optimally adjust the price format to limit comparability across products and earn positive profits. The model collapses to Bertrand competition if one firm can always make prices fully comparable.

[14] My findings also inform other structural models of obfuscation as equilibrium outcome such as Spiegler (2006), Bachi and Spiegler (2015) and Heidhues et al. (2017).

[15] See also Grubb (2015) for a review.

[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).

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 interaction play more of a role for final prices, such that advertised prices are a less reliable measure of the realized price. For a given lender, prices are hence fully described as a function of observable product 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 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.

[18] In an earlier step, lenders will accept and reject loan applications based on credit history and other variables, 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.

[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

My analysis focuses on fixed-rate mortgages as the most common type of mortgage, and which are available to first-time borrowers, accounting for on average 80% and 70% of the mortgages on offer, respectively. They 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 rebates. "Prepayment penalty" specifies the terms of the early repayment cost. While incentives such as cash rebates can differ across products, these differences do not appear to be *priced* in terms of differential fees or interest rates. And prepayment penalties vary very little within a given lender at any given point in time and are identical for most lenders across products. Further descriptive statistics are provided in Table 2, Panel 1.

Second, I augment the Moneyfacts dataset with additional 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 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 2-year LIBOR swap rates and CDS premia averaged by month 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. 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 Moneyfacts data is merged with data on lender characteristics and funding cost and aggregated to quarterly frequency using cumulative funding cost shocks and average changes in prices and fee-product alternatives on offer (see Table 2, Panel 3).

3. Facts and framework for mortgage pricing

This section sets out two stylized facts, first that there is evidence for substantial and persistent total cost dispersion in the mortgage market, and second that lenders seem to differentiate their prices along the fee dimension. It then presents a framework for mortgage pricing to interpret the empirical results. The analysis focuses on 2-year fixed rate mortgages for first-time buyers, who borrow at 70-75% LTV. Conditional on these product characteristics and for a given loan size, the borrower faces a cost minimization problem when choosing a given mortgage based on interest rate and fees.[22]

3.1. Facts on mortgage pricing

Price dispersion in total cost terms has remained relatively persistent. Figure 1 shows densities of cost differentials over the 2009 to 2012 and 2013 to 2016 sample period,

[22]The intertemporal trade-off between paying a lower fee now and facing higher interest rate payments is assumed to be small given the small fixation window, and borrowers always have the option to add the fee to the loan balance at no additional cost, making this unlikely to be a main consideration.

computed for 2-year fixed rate mortgage at 75% LTV with a £150,000 loan value, amortized over 25 years, with year-month fixed effects partialled out. They hence capture the variation in prices *across* lenders and products in a given month. While the density has narrowed in the second half of the sample period, the dispersion in the right-hand tail has decreased by less than the left-hand tail, meaning that the presence of expensive products in the market has remained relatively unchanged. The interquartile range of total cost has remained around £1000 over time, which is about 10% of the cost of the mortgage over the 2-year window and hence economically sizeable. The difference between the 90th and 10th percentile product is around £2000 on average. Hence the degree of cost dispersion across products on offer for a homogeneous retail financial good seems substantial.

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. There seem to be two product clusters: 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 also 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. Table 3 shows the share of cost-dominated products by fee categories. The majority of products on offer appear strongly cost-dominated and 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 (cost difference of more than £1000), more than 90% of all products with higher fees are strongly cost-dominated.[23] So there seems to be a substantial share of cost-dominated products with similar interest rates but higher fees in the market, and substantial product proliferation of cost-dominated products along the fee dimension. Figure 3 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

[23]Figure A.5 and Table A.2 show that these patterns persist for a loan value of £250,000, so they are not just driven by the fact that it is more beneficial to pay a lower interest rate and higher fee for a larger loan size, since the interest rate cost savings apply to a larger loan value. High fee products remain cost-dominated even for borrowers with high loan values. 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.

£1000, with the largest fees at around £3000 to £4000.

3.2. Framework for mortgage pricing

I start from a simple framework to understand lenders' objectives. Lenders' revenue per mortgage for a 2-year fixed rate product that is refinanced at the end of the fixation period consists of interest paid and fees. Suppose a given lender prices a 2yr fixed rate, 75% LTV mortgage at 2% interest and zero fees. Total revenue ρ for this product over 2 years is £5820.35, computed as:

$$\rho = \underbrace{(L \times r - c \times L) \times \frac{((1+r)^d - 1)}{r} + c \times L \times d}_{\text{cumulative interest paid}} + fees$$

where L is the loan value (£150,000), $c = \frac{r}{1-(1+r)^{-N}}$ (factor to determine monthly payments), d is the fixation period (24 months) and r is the monthly interest rate. I can then solve for $\bar{\rho}$ for different fees, which yields an iso-revenue curve, shown in Figure 4a.[24] The lender should then be indifferent between all the points *along* the baseline curve, as each fee-interest combination yields the same revenue. With a perfect competition benchmark and marginal cost pricing, all products in the market should line up on this unique iso-revenue curve, which as discussed, seems unlikely given the substantial presence of cost-dominated product in the market. With cost heterogeneity across lenders and constant mark-up, differential pricing (revenue levels) reflect differences in marginal cost, as shown in Figure 4b.

In my empirical analysis, I assess the competitive response of a lender to a *relative* cost shock at a given point in time, compared to itself over time and across different lenders. I am interested in if and how lenders pass through lender-specific cost shocks, by looking at how lenders adjust product pricing and product offering. While aggregate financial conditions such as changes in monetary policy captured in the time series are expected to be passed through to borrowers, it is unclear if lender-specific funding conditions can be passed through. A fully competitive benchmark predicts that this is not possible given the law of one price for a homogeneous financial product. A cost shock while holding profits constant can be understood as shifting the iso-revenue curve up, i.e. a given level of profit can only be reached by increasing fees and/or interest rates. The lender needs to decide on its new product offering on the new iso-revenue line, and could either shift towards higher fees (movement to the right), higher interest rates (movement upwards), or both. Assuming a constant mark-up, the different iso-revenue curves can also be interpreted as belonging to different lenders, some of which have low marginal

[24] Assuming that the lender is indifferent between income from fees and interest payments, which is a simplifying assumption that could be relaxed.

cost and can hence afford to offer cheaper interest-fee combinations at the same profit (grey squares line), while others lie strictly above and have higher marginal costs (blue diamonds line).

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,[25] which in their reduced-form decomposition also accounts for most of the aggregate variation in mortgage prices since 2008. The marginal funding cost 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[26] 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.[27][28]

[25] 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).

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

[27] 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.

[28] My setup is a *modified* Bartik shock in the sense that I have additional exogenous 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.

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 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 L 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:

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

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.[29][30]

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.[31] 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.[32]

The identifying assumption for the overall identification strategy is

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

This seems plausible: any time-varying unobservables such as lender-time-specific demand shocks or lender-time-specific changes in risk strategy 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.

[29] It seems unlikely that CDS spreads are endogenous to contemporaneous mortgage pricing strategies. In order to alleviate that concern further, I use LIBOR swap rates only and a leave-one-out mean to include all CDS spreads but a given lender's own - the main results remain qualitatively similar, but are less significant, likely due to the increase in noise and less precise measurement of the shock.

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

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

[32] 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.

For instance, even if lender-time-specific changes in risk strategy were correlated with the funding shock, it should be interpreted as an outcome of the funding shock, that is allowed to be correlated with changes in the outcome variable of interest.[33]

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, median, minimum, maximum interest rates and fees at the lender level to track changes in a lender's pricing strategy over time.[34] To capture product proliferation along the fee dimension, I measure the number of fee-product alternatives as distinct fee notches such as £0, £1000, £1500 in a given quarter.[35] As a robustness check on different product classes, 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.

4.2. Main results

The first set of main results show how on average lenders' pricing strategies for 2yr 70-75% LTV products respond to funding cost shocks, reported 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. Table 5 provides further results on lenders' pricing strategies across the distribution of products. The results are similar and slightly larger for median fees and median total cost (Panel 1), which significantly increase by £78 and £69, respectively, while interest rates remain unchanged. Both the lowest (Panel 2, column 1) and highest (Panel 3,

[33] This would be an indirect effect of the funding shock affecting the optimal risk strategy, which in turn affects lenders pricing decisions. The coefficient estimate on the funding shock captures both direct and indirect effects, so this would not be an identification problem.

[34] All changes are measured as percentage changes, except for changes in fees, which are measured in absolute changes to avoid missing observations for zero fee products.

[35] Fee notches reflect the pricing frame, while there can be small interest rate adjustments at a higher frequency, reflecting aggregate time-series variation (e.g. as shown in Fuster et al. (2017)).

column 1) interest rate remain unchanged, while the effect seems particularly large for the highest fee product (Panel 3, column 2) which increases by around £120, and the highest total cost products become around £80 more expensive. Note that the funding cost shock can be interpreted as a lender-time-specific shock to marginal cost, such that these pricing changes reflect the optimal response of the lender when it becomes relatively less competitive. So lenders appear to maintain competitive 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 products is also intuitively consistent with the idea that competing for the lowest interest rate in the market is important and often saliently framed using best buy tables that show the cheapest interest rates in the market - 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 non-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 6, 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 and pricing strategy to pass through relative cost shocks and could be consistent with a greater pressure to maintain profit margins and quarterly earnings results.[36]

In contrast, the fee pass-through does not seem to hold for high LTV mortgages (90-95% LTV, Table 7), i.e. more risky products. Average total costs across products increase substantially in 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.[37] 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.

In order to test for product proliferation more specifically and to get a sense to what extent lenders expand their product range in price terms, Table 8 shows results of changes

[36]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.

[37]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.

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, indicating 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 suboptimal product choice, plays more of a role at higher LTV levels and hence makes the obfuscation strategy less viable due to adverse selection.[38]

Overall, I find evidence that lenders maintain competitive 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, consumers pay a percentage of the loan value in administration fees that depends only on loan characteristics,[39] meaning that a given borrower does not have to compare fees for her cost minimization problem.

In contrast, the evidence for the UK 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 now 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

[38] 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.

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

borrowed, and would require loan-amount-specific best-buy tables. This separation of pricing components (Grubb, 2015) and complicating of comparability across products (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 bank profits and optimal consumer search for policy makers.

In addition, fees appear less saliently advertised than interest rates, and best buy tables and price comparison websites in the UK tend to sort products by interest rates by default, while relegating specific fees to the footnotes. This is consistent with the empirical result that lenders pass through relative funding cost shocks via fees rather than interest rates, suggesting that borrowers may be less price-sensitive with respect to fees than to interest rates. Fees could be interpreted as a shrouded but obligatory additional cost (Gabaix and Laibson, 2006) that less sophisticated borrowers fall prey to if they only emphasize low interest rates, and more sophisticated borrowers can substitute away from by choosing the total cost-minimizing product in the market, regardless of fees or interest rates in isolation.[40]

[40]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.

5.2. Price obfuscation

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 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). 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 p (interest rate cost) and a hidden additional cost k (fees):

$$M = \Big\{ \{p, k\} : p \in \{\underline{p}, \bar{p}\}, k \in [0, \bar{k}] \Big\},$$

where headline prices are simplified and lenders either choose low ($\underline{p}$) or high interest rates ($\bar{p}$). 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 k (fee).[41] 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 $\{\underline{p}, 0\}$. 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 $\{\bar{p}, 0\}$ or $\{\underline{p}, k\}$ where $k > 0$, and has to forego the opportunity to extract higher profits using additional cost k from the uninformed demand share. High-cost lenders, on the other hand, cannot break even with contract $\{\underline{p}, 0\}$, so they need to obfuscate and charge $\{\underline{p}, k\}$ in order to be "cheap" in the eyes of uninformed consumers. In addition, if the probability of a borrower accepting a high price (i.e. a high interest rate product)

[41] The fee is bounded by a decrease in the match probability 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).

is non-zero, the high-cost lender will also prefer to use the full range of price and hidden cost combinations and offer both $\{\underline{p}, \tilde{k}\}$ and $\{\bar{p}, \hat{k}\}$ (where $\hat{k} < \tilde{k}$). 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.[42] 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. There is hence also a relative shift from informed to uninformed demand that should accompany that pricing change for a given lender. Appendix section 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. 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 provide complementary evidence that is consistent with the 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:

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

[42] 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.

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.

5.4. Alternative explanations and robustness

A possible concern could be alternative mechanisms that are based on supply-side strategies unrelated to price obfuscation, most notably screening motives. Lenders, by designing a menu of interest rates and fees, allow borrowers to pick their preferred mortgage which reveals information about their hidden type. A lender's preference for a particular borrower type may be correlated with the time-varying cost shocks a given lender faces. I conduct robustness checks to rule out the most common screening motives. First, it does not seem likely that lenders in the UK screen for prepayment risk using fees. In contrast to the US, early repayment penalties are allowed in the UK, which allows for 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 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 132 out of 1568 product-lender-time observations differ from each other within a given lender-time pair in terms of prepayment penalty terms. This seeming lack of screening for 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 should 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. In addition, fees could serve as a way to attain the optimal interest rate given asymmetric information problems that are linked to the level of the interest rate, i.e. adverse selection and moral hazard (Jaffee and Stiglitz, 1990), while upfront fees may have less incentive effects. But as seen in the main results, the increase in fee-product alternatives is only significant for relatively low

LTV products, indicating that the mechanism may play more of a role when default risk is low and selection on unobservables or moral hazard may play less of a role.

Lastly, lenders may use high fee products to screen for liquidity risk, as very liquidity-constrained borrowers may be unable to pay a high initial fee. However, the loan-to-income ratio (LTI), as one measure of liquidity constraints, seems to be positively correlated with fees at high LTI levels, indicating that high fees do not seem to screen out liquidity-constrained borrowers. It may point to a positive correlation between high LTI ratios and high loan values in general, based on which it is more beneficial to pay the fee and trade down to a lower interest rate. More generally, the benefit of paying the fee and receiving a lower interest rate should increase with greater loan values. However, there is substantial fee variation across borrowers within the same LTI and loan value bucket (except for very low and very high loan values), suggesting that most of the variation in fees is independent of liquidity-related motives or pure differences in loan size. Figure 6 provides an example of the variation in cost across a range of loan sizes. None of the high-fee mortgages (in orange) become cheaper to the group of best lower fee products, indicating that the underlying fee-rate trade-off of the high-fee products may be on a higher iso-revenue curve and that they are hence generally more expensive, regardless of the loan size.

Yet another idea is that lenders could use fees to manage the time profile of the cash flows they receive, for instance if they themselves are very financially constraint. They could also become more constraint following a cost shock, and prefer fee income that is relatively more immediate. However, these cash flow timing-based mechanisms are at odds with the fact that lenders offer the option to add fees to the loan balance at the borrower's discretion, and at no additional cost. In addition, the mechanism appears to persist when splitting the sample between 2009 to 2012 and 2013 to 2016, where the latter includes a period of substantial unconventional monetary policy and hence a market-wide liquidity shock where lenders had de facto near unconstrained access to long-term liquidity, contradicting a mechanism motivated by external finance constraints on the lender side.

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 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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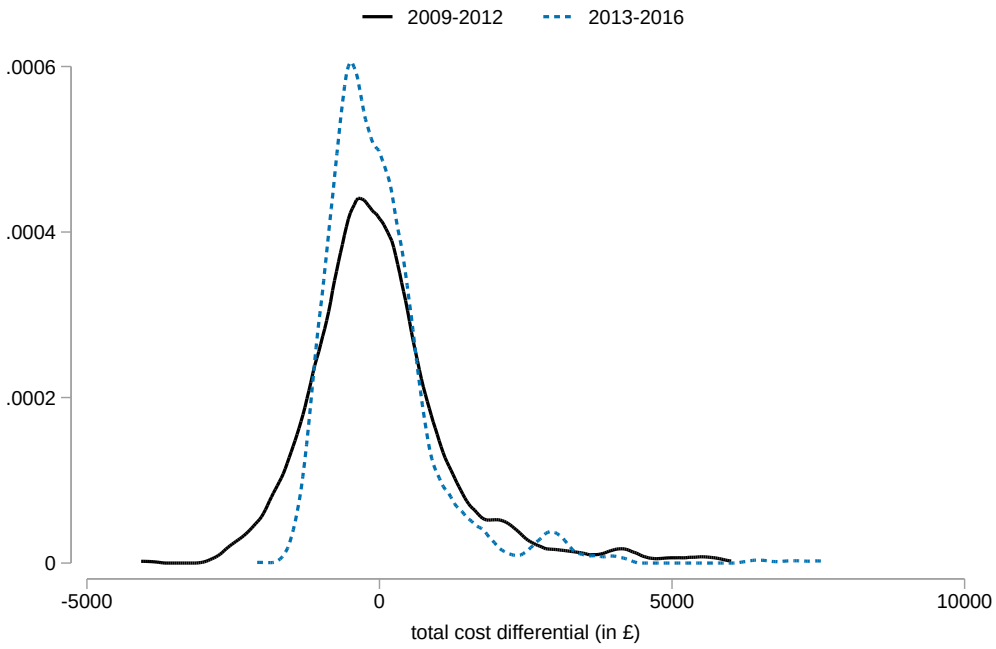
Main figures and tables

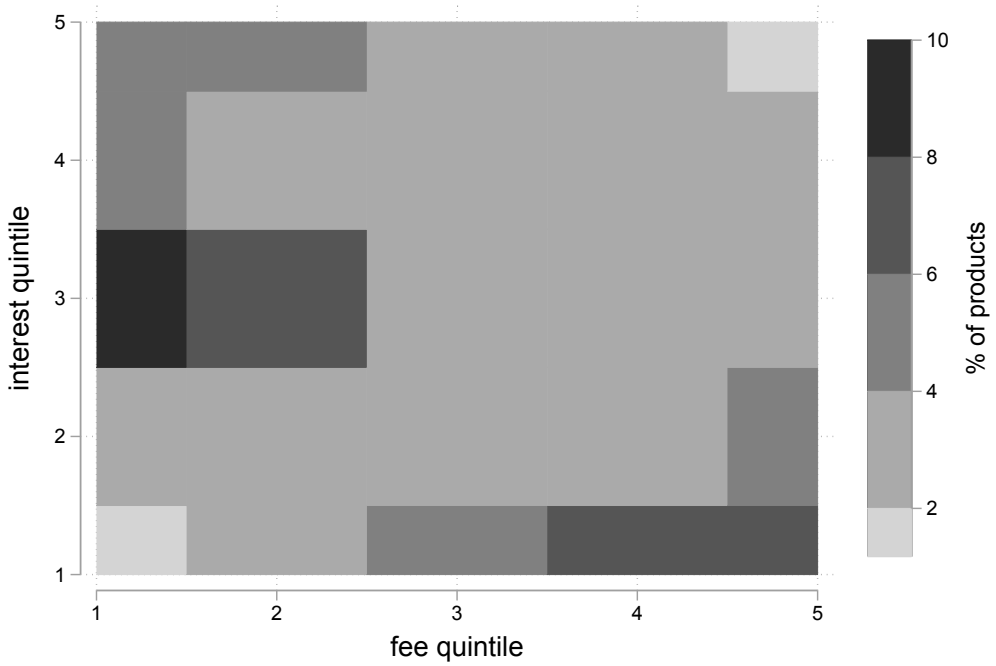
Figure 1: Total cost dispersion (interest rate cost and fees)



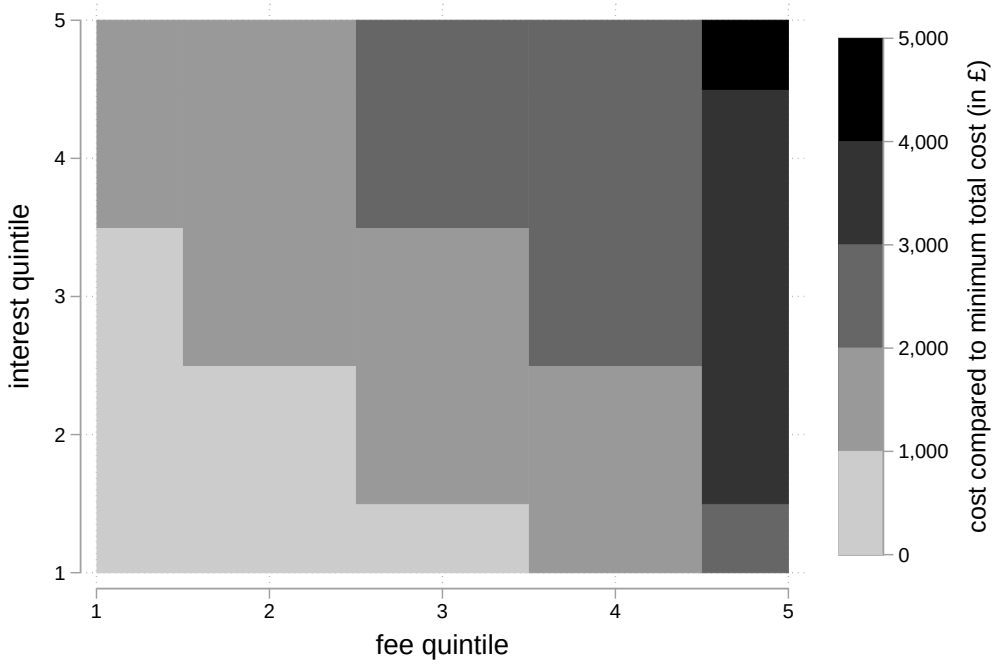
Notes: This figure shows densities of total cost differentials for the years 2009 to 2012 and 2013 to 2016, computed for a £150,000 loan value amortized over 25 years, based on 2-year fixed rate 75% LTV products for first-time buyers. The cost differential is measured as the residual from a regression of total cost (including fees) on year-month fixed effects to partial out aggregate variation in cost levels, in particular interest rate cost.

Figure 2: Products by interest and fee quintile

(a) Share of products by interest and fee quintile

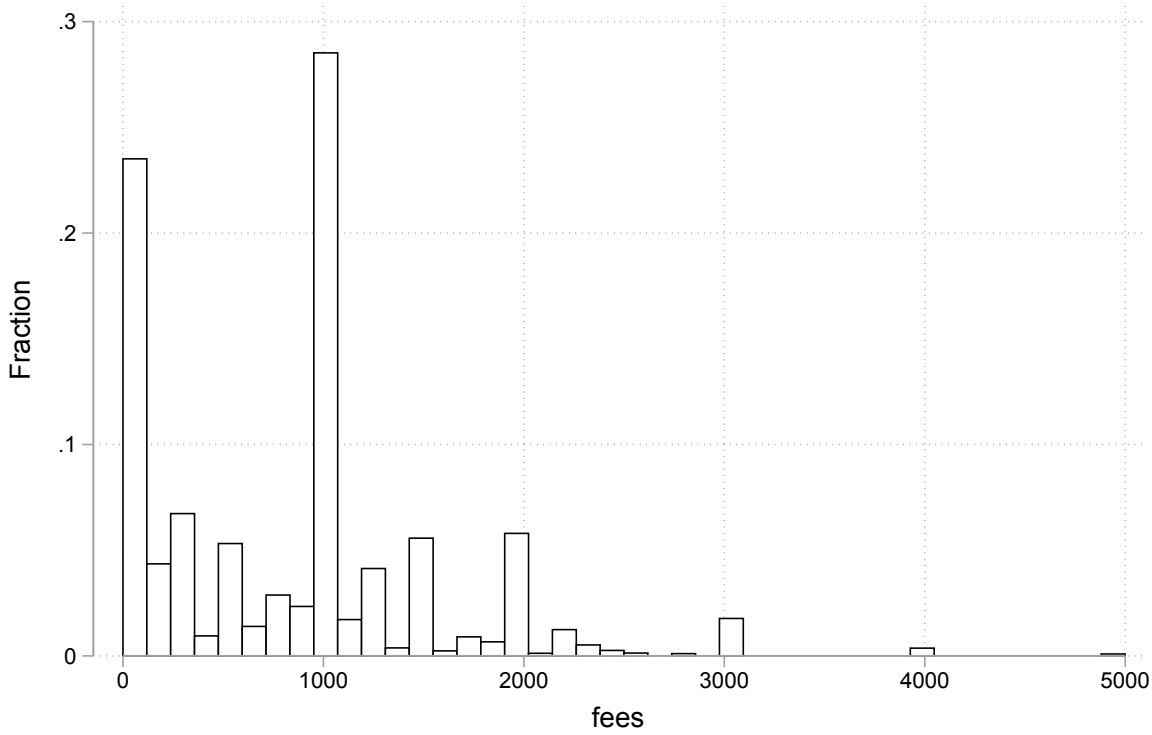


(b) Cost differential for average product in interest and fee quintile



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.

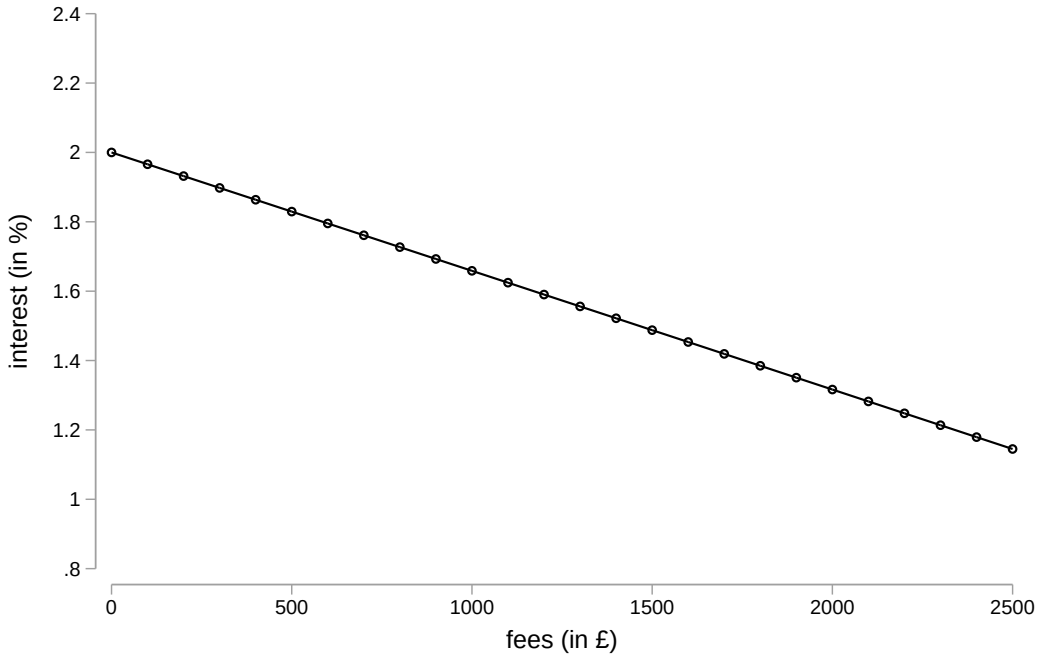
Figure 3: Histogram of fees (2yr fix, 75% LTV)



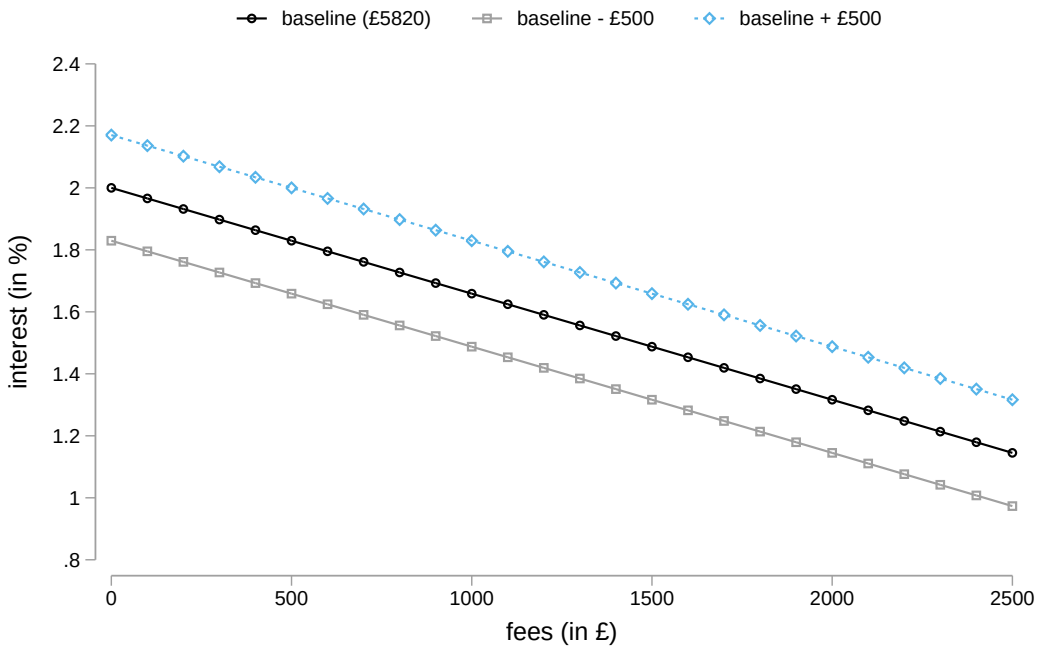
Notes: This figure shows a histogram of fees, based on all products available for 2yr fixed rate, 75% LTV products over the sample period.

Figure 4: Iso-revenue curves

(a) Unique iso-revenue curve

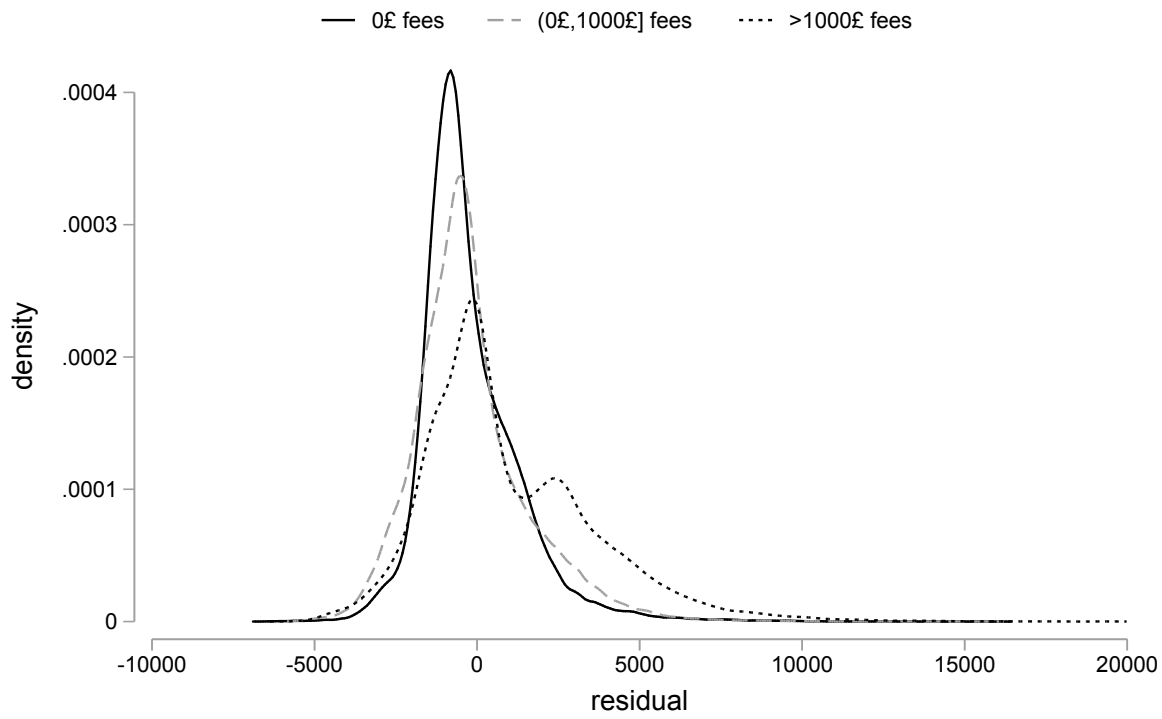


(b) Iso-revenue curves and lender heterogeneity



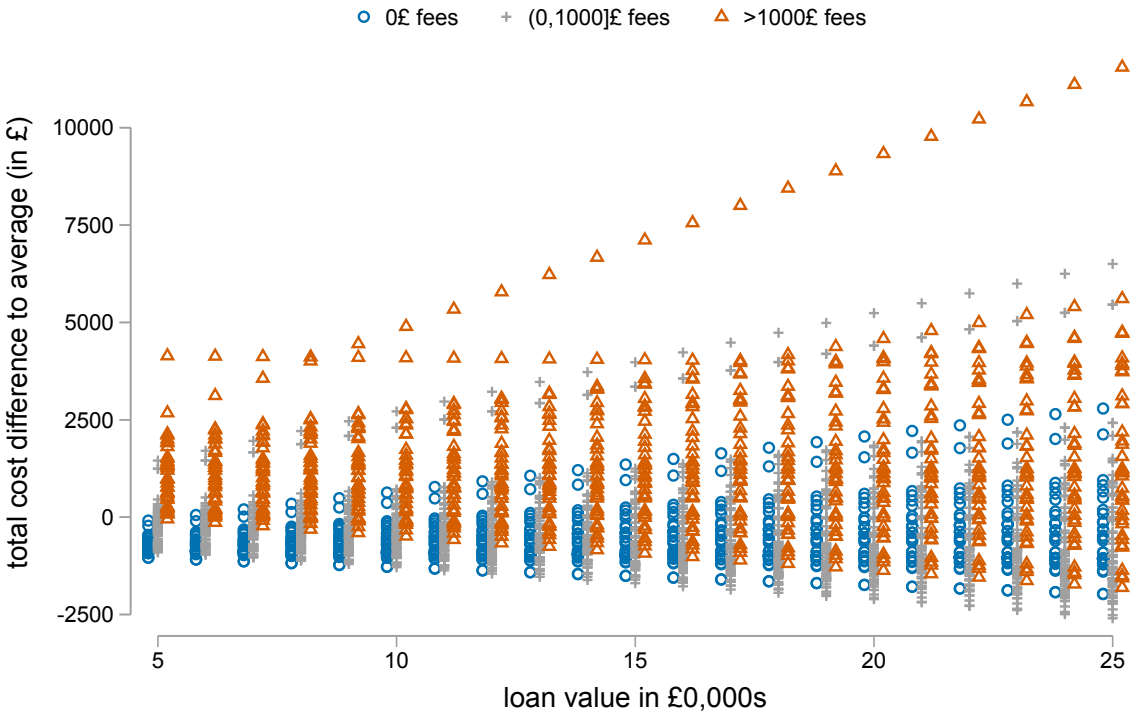
Notes: This figure shows iso-revenue curves based on a baseline revenue of £5820.35.

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: 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 range of 2yr, 70-80% LTV products in February 2015.

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
initial (teaser) rate (in %)	28852	3.37	1.24	1.89	3.24	5.09
initial rate 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
Total 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

	Δ in average			
	interest	fees	total cost	
			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

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 4 different regressions of changes in average interest rates, 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.

Table 5: Changes in price components and total cost

Panel 1: Δ in median				
	interest	fees	total cost	
			1 year	2 years
$\Delta\phi$ (std.)	-0.01	77.93*	68.94**	71.88
	(0.03)	(39.79)	(30.65)	(48.71)
N	671	671	671	671
R^2	0.472	0.103	0.420	0.484
Panel 2: Δ in minimum				
$\Delta\phi$ (std.)	-0.03	4.69	37.12	33.65
	(0.04)	(12.76)	(35.38)	(62.23)
N	671	671	671	671
R^2	0.480	0.066	0.404	0.475
Panel 3: Δ in maximum				
$\Delta\phi$ (std.)	0.02	124.86*	81.90**	76.95
	(0.02)	(65.20)	(37.81)	(46.16)
N	671	671	671	671
R^2	0.370	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 interest rates, 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 1-3 report results for changes in the median, minimum and maximum interest rate, fee and total cost (over one and two years), respectively.

Table 6: Changes in price components and total cost, by lender type

	Δ in average				Δ in max			
	interest	fees	total cost 1 year	total cost 2 years	interest	fees	total cost 1 year	total cost 2 years
Panel 1: Big Six banks only								
$\Delta\phi$ (std.)	-0.01	122.85***	113.04**	102.70	0.04	106.59*	81.08*	103.03
	(0.05)	(39.07)	(43.58)	(83.77)	(0.04)	(48.90)	(42.41)	(68.47)
N	285	285	285	285	244	244	244	244
R^2	0.519	0.127	0.548	0.559	0.595	0.259	0.650	0.673
Panel 2: Building societies only								
$\Delta\phi$ (std.)	0.03	11.17	36.80	62.10	0.02	49.38*	17.62	8.91
	(0.03)	(31.21)	(35.30)	(60.13)	(0.04)	(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	0.366	0.120	0.334	0.380
Panel 3: Challenger banks only								
$\Delta\phi$ (std.)	-0.03	46.61	15.64	-15.33	0.01	106.16	61.17	41.80
	(0.03)	(47.94)	(32.81)	(41.55)	(0.03)	(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	0.445	0.233	0.344	0.441
Panel 4: Publicly traded only								
$\Delta\phi$ (std.)	0.01	102.13	121.20*	140.50	0.05	187.94**	177.18**	216.72*
	(0.06)	(66.06)	(61.27)	(99.43)	(0.06)	(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	0.642	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 maximum interest rates, 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 7: Changes in price components and total cost (90-95% LTV)

Panel 1: Δ in average				
	interest	fees	total cost	
			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: Δ in median				
$\Delta\phi$ (std.)	0.08***	-16.10	84.05***	166.03***
	(0.02)	(11.48)	(22.52)	(40.41)
N	515	515	515	515
R^2	0.257	0.090	0.245	0.249
Panel 3: Δ in minimum				
$\Delta\phi$ (std.)	0.08***	11.82	82.17***	166.89***
	(0.02)	(28.07)	(26.74)	(42.98)
N	515	515	515	515
R^2	0.247	0.100	0.233	0.258
Panel 4: Δ in maximum				
$\Delta\phi$ (std.)	0.10***	-25.09*	85.86***	202.16***
	(0.02)	(12.81)	(18.66)	(38.85)
N	515	515	515	515
R^2	0.246	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 16 different regressions of changes in interest rates, 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 90-95% LTV product offers only. Panel 1-4 report results for changes in the average, median, minimum and maximum product, respectively.

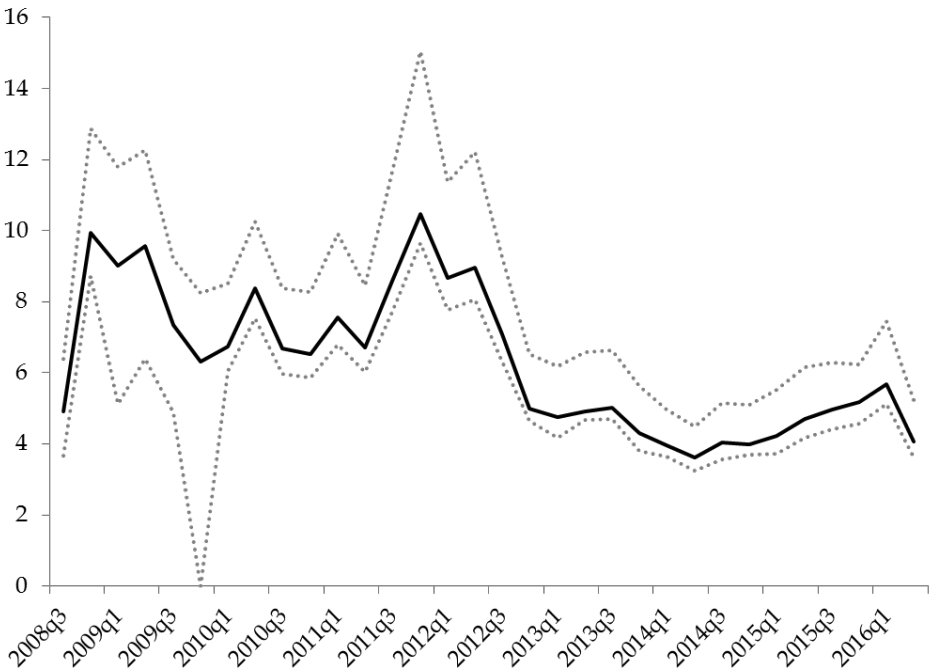
Table 8: Change in fee-product alternatives

	all products	2yr	
		70-75% LTV	90-95% LTV
$\Delta\phi$ (std.)	0.22***	0.05*	0.02
	(0.07)	(0.03)	(0.04)
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.

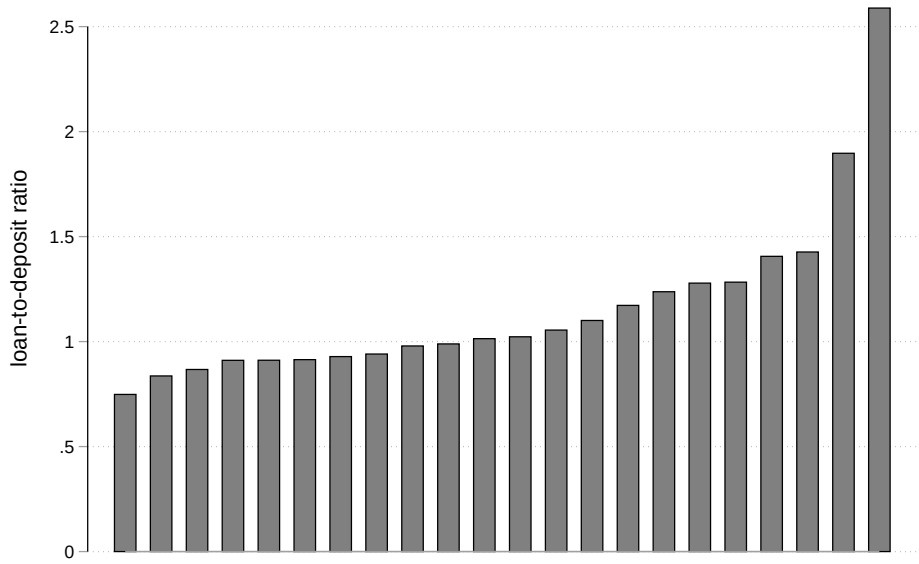
A. Additional figures and tables

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



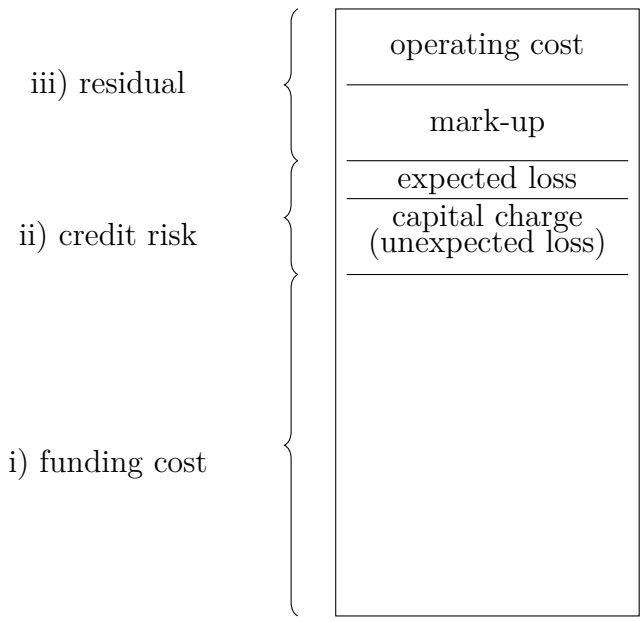
Notes: This figure shows the distribution of the funding shock ϕ_{jt} over time, with the median in black and 25th and 75th percentiles in dashed lines. The funding shock is constructed as $\phi_{jt} = ltd_{j,2008} \times \left(r_t^{libor} + s_{jt}\right)$ for the top six lenders for which lender-specific 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

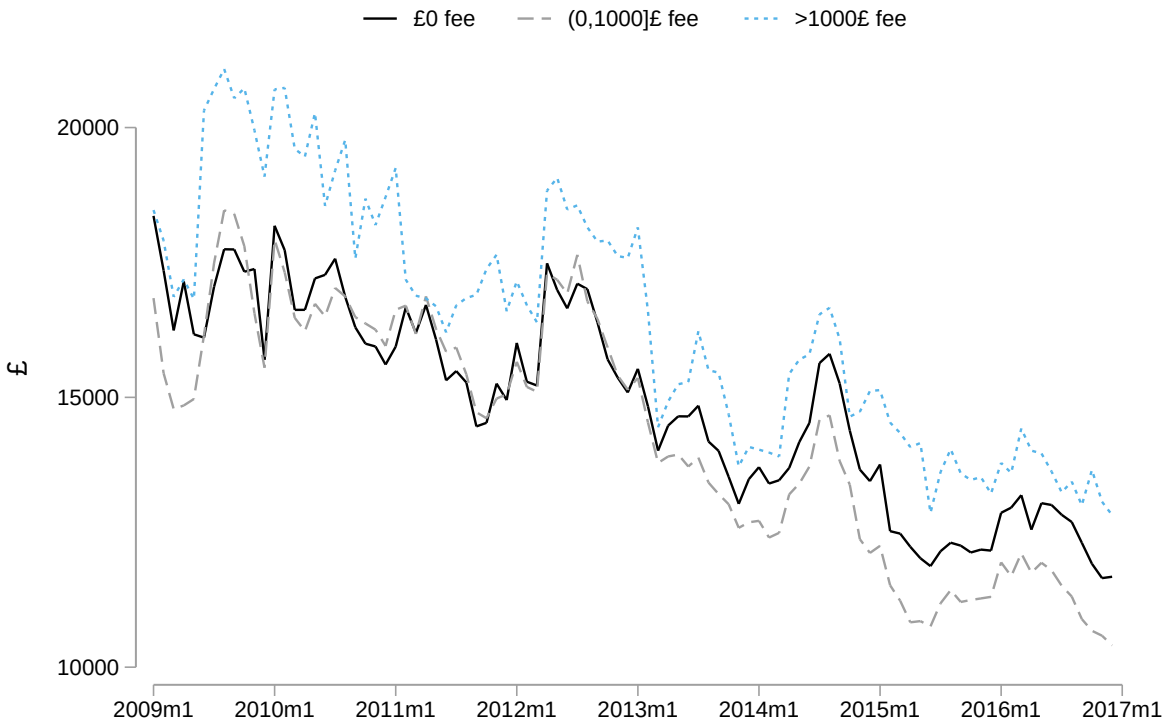


Notes: Adapted from Button et al. (2010). The proportions are stylized, but similar to what they estimate for the period between 2010 and 2012.

Figure A.4: Average total revenue per loan, by fee categories

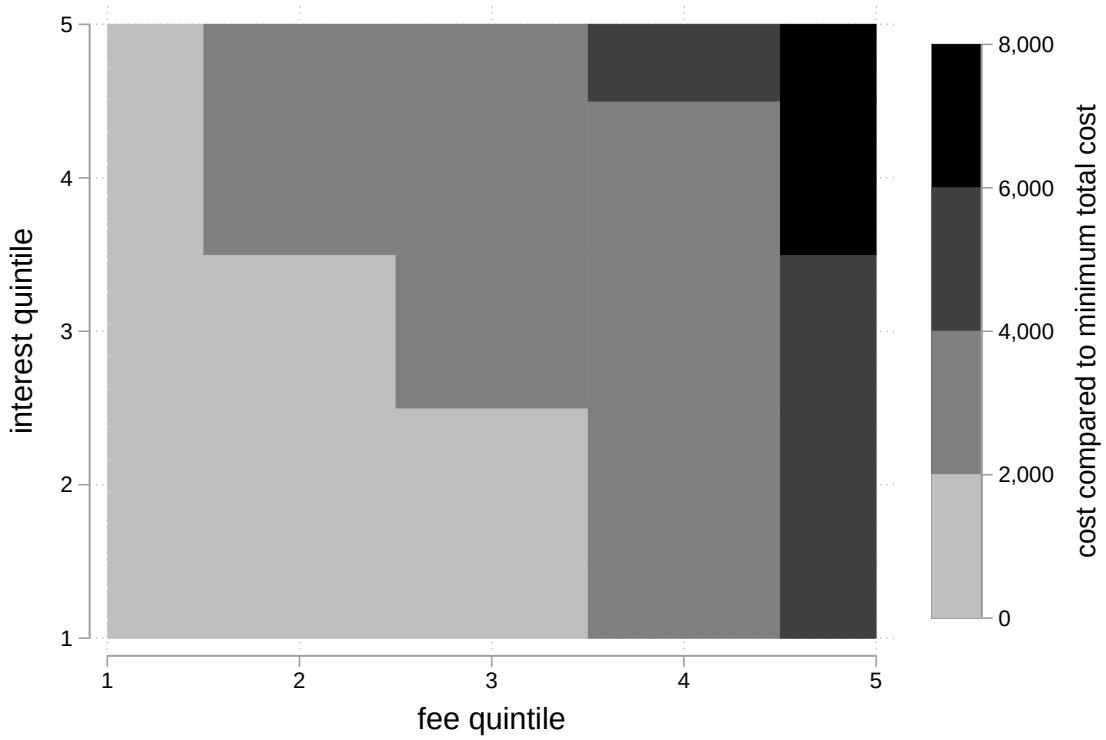
(a) Average loan size

(b) 90th percentile loan size



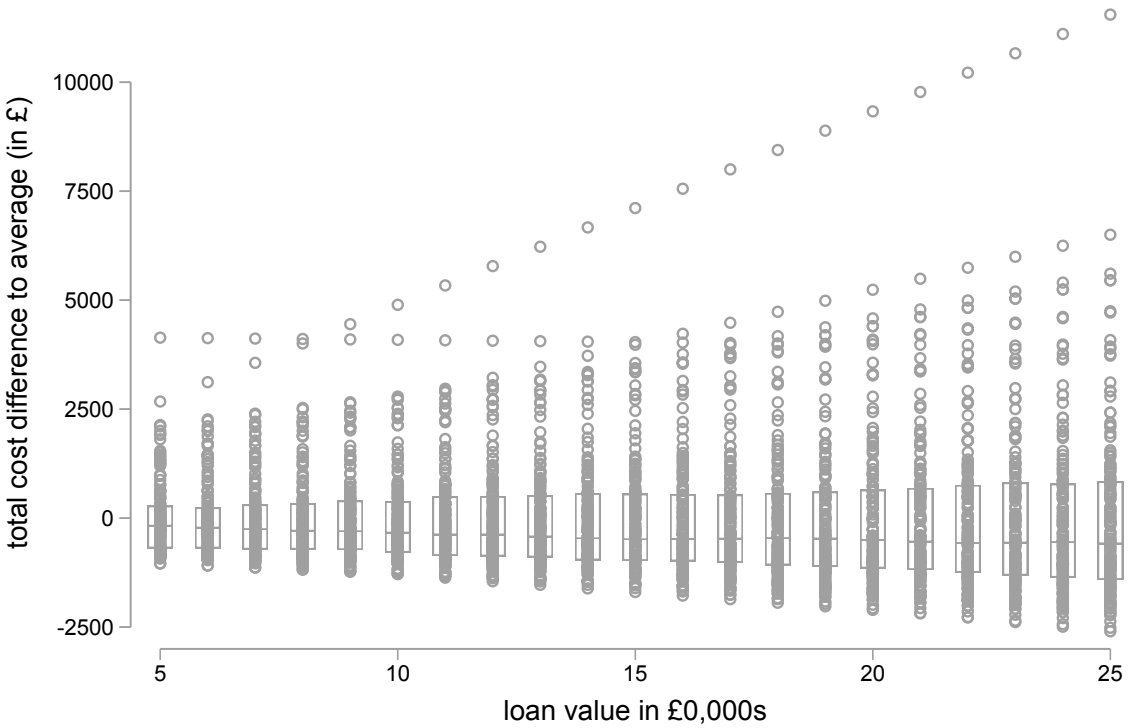
Notes: This figure shows the average total revenue per loan in a given month, computed as the interest paid over 2 years plus fees, using the mean (90th percentile) loan value in a given year and a 25 year amortization period; by fee categories.

Figure A.5: Cost differential for average product in interest and fee quintile (high loan value)



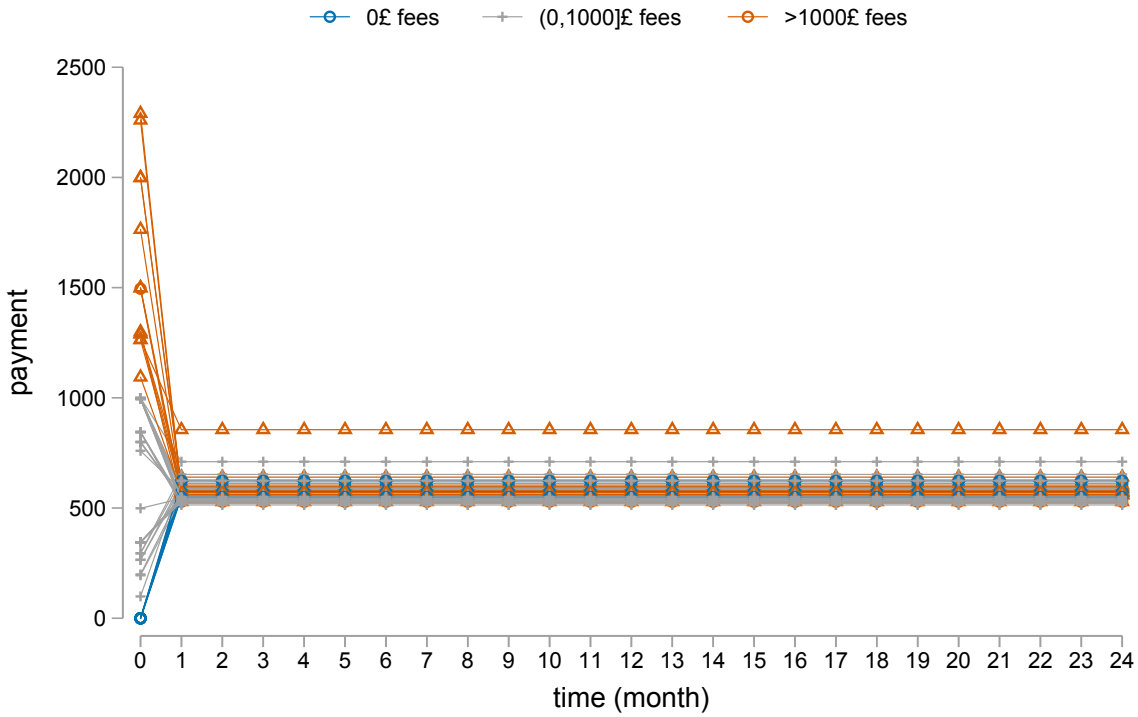
Notes: This figure shows the average (across products in a given interest and fee quintile) cost differential in £, measured as the difference between total cost and the minimum total cost product in a given month, based on a 75% LTV 2-year fixed rate product over two years, for a loan size of £250,000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

Figure A.6: Total cost dispersion by loan size



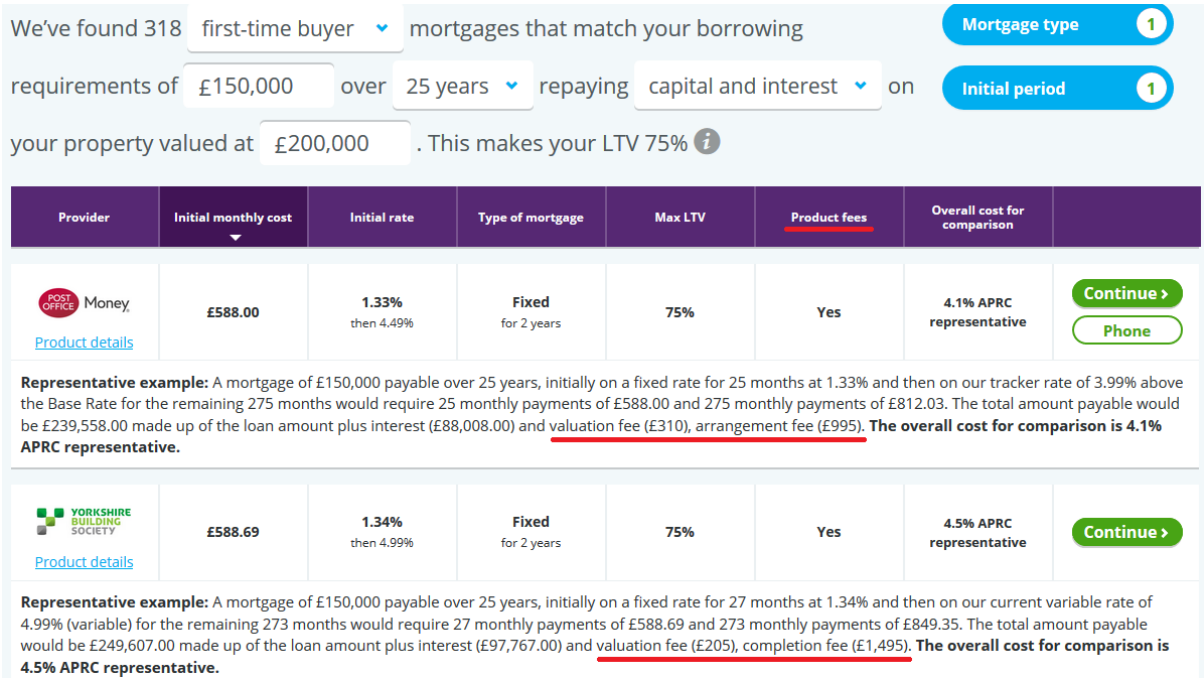
Notes: This figure shows the total cost dispersion relative to the average product, by loan value, for the range of 2yr, 70-80% LTV products in February 2015.

Figure A.7: 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.8: Screenshot from MoneySupermarket.com



We've found 318 first-time buyer mortgages that match your borrowing requirements of £150,000 over 25 years repaying capital and interest on your property valued at £200,000. This makes your LTV 75%

Mortgage type 1

Initial period 1

Provider	Initial monthly cost	Initial rate	Type of mortgage	Max LTV	Product fees	Overall cost for comparison	
Post Office Money Product details	£588.00	1.33% then 4.49%	Fixed for 2 years	75%	Yes	4.1% APRC representative	Continue › Phone
Representative example: A mortgage of £150,000 payable over 25 years, initially on a fixed rate for 25 months at 1.33% and then on our tracker rate of 3.99% above the Base Rate for the remaining 275 months would require 25 monthly payments of £588.00 and 275 monthly payments of £812.03. The total amount payable would be £239,558.00 made up of the loan amount plus interest (£88,008.00) and valuation fee (£310), arrangement fee (£995). **The overall cost for comparison is 4.1% APRC representative.**							
Yorkshire Building Society Product details	£588.69	1.34% then 4.99%	Fixed for 2 years	75%	Yes	4.5% APRC representative	Continue ›
Representative example: A mortgage of £150,000 payable over 25 years, initially on a fixed rate for 27 months at 1.34% and then on our current variable rate of 4.99% (variable) for the remaining 273 months would require 27 monthly payments of £588.69 and 273 monthly payments of £849.35. The total amount payable would be £249,607.00 made up of the loan amount plus interest (£97,767.00) and valuation fee (£205), completion fee (£1,495). **The overall cost for comparison is 4.5% APRC representative.**							

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.

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 mechanism

The model[43] has two types of firms and two types of consumers: high ($\bar{c}$) and low cost ($\underline{c}$) 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 $\bar{c}$ or $\underline{c}$ such that consumers cannot learn which firm has low or high prices.[44] In the context of the mortgage market, consumers search anew each time they refinance.[45]

Firms: There are N firms in total, and $\underline{n}$ low-cost firms. Firms set headline prices $p \in \{\underline{p}, \bar{p}\}$, i.e. they either offer low or high interest rates. We have $\bar{c} > \underline{c}$, $\bar{p} > \underline{p}$ and $\underline{p} - \bar{c} < 0$, the latter meaning that high-cost firms cannot break even by charging low prices.[46] However, firms can choose to obfuscate prices and charge a hidden additional cost k. The amount of k determines the matching or acceptance probability of consumers m, given by

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

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

[43]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 $\underline{p}$) 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 ($\bar{p}$) only sell to unlucky uninformed consumers who randomly pick a high price firm, hence selling a lower quantity (uninformed demand share).

[44]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.

[45]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.

[46]This could be interpreted as firms being forced to exit the market if they can only charge $\underline{p}$, or, in repeated versions of the game, firms exiting temporarily while their cost draw is $\bar{c}$.

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, and α is an attention or salience factor where

$$\alpha = \begin{cases} 1 & \text{if } p = \underline{p}, \\ \epsilon & \text{if } p = \bar{p}, \end{cases}$$

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 $k = 0$.

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 k (fees):

$$M = \Big\{\{p, k\} : p \in \{\underline{p}, \bar{p}\}, k \in [0, \bar{k}]\Big\},$$

where $\underline{p} < \bar{p}$.

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 $\{\underline{p}, \underline{k}\}$ cannot offer $\{\bar{p}, \underline{k}\}$ or $\{\underline{p}, \bar{k}\}$ where $\underline{k} < \bar{k}$. On the other hand, a firm that offers $\{\bar{p}, \hat{k}\}$ could offer another contract $\{\underline{p}, \tilde{k}\}$ where $\hat{k} < \tilde{k}$. Hence the set of feasible product offerings is

$$\mathcal{M} = \{(\underline{p}, k); (\bar{p}, k); (\underline{p}, \tilde{k}), (\bar{p}, \hat{k})\}. \tag{5}$$

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. 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 $p = \underline{p}$ and pick a product at random, neglecting hidden cost k (fees) more the smaller the size of the additional cost, captured in the

matching function γ. [47] The process could be interpreted as uninformed consumers looking at a best buy table that emphasizes the cheapest interest rates available in the market, while not differentiating between fees. Prominent price search engines in the UK such as Moneysupermarket.com seem to reflect and perhaps exacerbate this bias by sorting by interest rates by default, and only providing a yes/no indicator for fees, which are only quantified in the footnotes (see Figure A.8). As noted above, with some small probability ϵ, uninformed consumers may also consider $p = \bar{p}$, but informed consumers never do as long as there exists a product with $p = \underline{p}$.

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

$$\Pi = (p - c + k) \cdot Q \tag{6}$$

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

The informed demand share is invariant to changes in the price format and will only be non-zero if $p = \underline{p}$, i.e. it would be zero if $p = \underline{p} + k$, as captured by the indicator function.[48]

Separating equilibrium: Firms choose their product offering from $\mathcal{M}$ and set p and k. The profit for a low cost lender ($\Pi_{\underline{c}}$) if it does not obfuscate (NO) is

$$\Pi_{\underline{c}}\Big[NO \mid (\underline{p}, 0)\Big] = (\underline{p} - \underline{c})\frac{\lambda}{N} + (\underline{p} - \underline{c})\frac{1-\lambda}{\underline{n}}. \tag{8}$$

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

$$\Pi_{\underline{c}}\Big[O \mid (\underline{p}, k)\Big] = (\underline{p} - \underline{c} + k)\frac{\lambda}{N}\gamma(k), \tag{9}$$

or even obfuscate with high prices:

$$\Pi_{\underline{c}}\Big[O \mid (\bar{p}, k)\Big] = (\bar{p} - \underline{c} + k)\frac{\lambda}{N}\epsilon\gamma(k). \tag{10}$$

For sufficiently small ϵ, we assume that $\Pi\Big[O, \mid (\underline{p}, k)\Big] \geq \Pi\Big[O, \mid (\bar{p}, k)\Big]$. As long as $\epsilon \geq 0$,

[47] This behavior could be further micro-founded, for instance based on heterogeneous search costs (Stahl, 1989, Ellison and Wolitzky, 2012), where some consumers have no search costs and learn all prices, and where some have to pay a cost to learn a price.

[48] This assumption could be relaxed, e.g. by assuming that if the lender chooses to obfuscate with hidden cost k, the match probability $m = \alpha\gamma(k)$ 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 lender can offer

$$\Pi_{\underline{c}}\Big[O \mid (\underline{p}, \tilde{k}), (\bar{p}, \hat{k})\Big] = (\underline{p} - \underline{c} + \tilde{k})\frac{\lambda}{N}\gamma(\tilde{k}) + (\bar{p} - \underline{c} + \hat{k})\frac{\lambda}{N}\epsilon\gamma(\hat{k}) \\ \geq \Pi_{\underline{c}}\Big[O \mid (\underline{p}, \tilde{k})\Big] \geq \Pi_{\underline{c}}\Big[O \mid (\bar{p}, \hat{k})\Big]. \tag{11}$$

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

$$\Pi_{\underline{c}}\Big[NO \mid (\underline{p}, 0)\Big] \geq \Pi_{\underline{c}}\Big[O \mid (\underline{p}, \tilde{k}), (\bar{p}, \hat{k})\Big] \\ \geq \Pi_{\underline{c}}\Big[O \mid (\underline{p}, \tilde{k})\Big] \geq \Pi_{\underline{c}}\Big[O \mid (\bar{p}, \hat{k})\Big], \tag{12}$$

for any small enough ϵ.

Next, we consider profits for high-cost lenders ($\Pi_{\bar{c}}$). Recall that $\Pi_{\bar{c}}\Big[NO \mid (\underline{p}, 0)\Big] < 0$, so the high-cost lender can only set high prices $\bar{p}$ if it does not obfuscate, which yields

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

The profit from obfuscating at a low price is

$$\Pi_{\bar{c}}\Big[O \mid (\underline{p}, k)\Big] = (\underline{p} - \bar{c} + k)\frac{\lambda}{N}\gamma(k), \tag{14}$$

and for a high price we get

$$\Pi_{\bar{c}}\Big[O \mid (\bar{p}, k)\Big] = (\bar{p} - \bar{c} + k)\frac{\lambda}{N}\epsilon\gamma(k). \tag{15}$$

Lastly, we have

$$\Pi_{\bar{c}}\Big[O \mid (\underline{p}, \tilde{k}), (\bar{p}, \hat{k})\Big] = (\underline{p} - \bar{c} + \tilde{k})\frac{\lambda}{N}\gamma(\tilde{k}) + (\bar{p} - \bar{c} + \hat{k})\frac{\lambda}{N}\epsilon\gamma(\hat{k}) \\ \geq \Pi_{\bar{c}}\Big[O \mid (\underline{p}, \tilde{k})\Big] \geq \Pi_{\bar{c}}\Big[O \mid (\bar{p}, \hat{k})\Big], \tag{16}$$

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 ($\bar{p}, k = 0$), 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

$$\Pi_{\bar{c}}\Big[O \mid (\underline{p}, \tilde{k}), (\bar{p}, \hat{k})\Big] \geq \Pi_{\bar{c}}\Big[NO \mid (\bar{p}, 0)\Big] \tag{17}$$
$$> \Pi_{\bar{c}}\Big[NO \mid (\underline{p}, 0)\Big].$$

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.[49] 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.

[49]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.