Strictly dominated mortgage choices:
Evidence from the UK[*]

Zanna Iscenko[†]

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Abstract

This paper develop a nonparametric methodology for assessing the quality of households' product search in the UK mortgage market without any assumptions about preferences over the horizontally differentiated product characteristics. Using a uniquely detailed combination of lending transaction reports, product information and credit bureau data for 700,000 UK households who took out a mortgage between January 2015 and July 2016, I conduct pairwise multidimensional comparisons between all products for which each borrower was eligible. This allows me identify choices where the chosen mortgage was strictly dominated on all elements of borrowing cost (interest rates, fees) by another available alternative with the same non-price characteristics. I find that 30% of UK households in the sample chose dominated mortgages, paying £550 ($750) more per year on average as a result.

Even after accounting for eligibility, borrowers with characteristics typically associated with lower financial capability (lower income and credit score, old age) and greater time constraints tend to make dominated mortgage choices more often. Going to a lender with whom a borrower has an existing relationship, such as a checking account or a credit card, is also associated with increased probability of making a dominated mortgage choice.

Keywords: mortgage, household finance, consumer behaviour, price dispersion

JEL Codes: G21, D14, D12

[†]Department of Economics, University College London, and UK Financial Conduct Authority. Email: zanna.iscenko@gmail.com . Any views expressed in this paper are my own and do not necessarily reflect the position of the Financial Conduct Authority.

1 Introduction

Mortgage debt is the largest single liability for households in many developed countries.[1] Choosing a mortgage is therefore one of the most important financial decisions households need to make. It is hardly a surprise that policy makers around the world are interested in how effectively households shop around for their mortgages and what borrowing costs they incur as a result.[2] Academic research on price dispersion for comparable mortgage products and its drivers is relatively scarce, however, and the existing papers are often constrained by data limitations about borrower preferences, product characteristics and the alternatives realistically available to borrowers of different credit risk (Woodward and Hall 2012; Allen, Clark, and Houde 2014a; Allen, Clark, and Houde 2014b; Alexandrov and Koulayev 2018; Bhutta, Fuster, and Hizmo 2019).

In this paper I contribute new detailed evidence on households' ability to search for good deals in the high-stakes setting of the mortgage market. To do this, exploiting uniquely granular combination of lending transaction reports, detailed product listings with lenders' eligibility criteria and credit files for nearly 700,000 UK households that took out a mortgage between January 2015 and July 2016. I also develop and implement a new methodology for measuring the effectiveness of households' product choices in the mortgage market or other circumstances with multidimensional product prices and heterogeneous household preferences. The proposed methodology — dominance analysis — identifies choices of unambiguously 'dominated' products by assessing, for each observed borrower, whether they were eligible for another product with the same features as their chosen mortgage but at a strictly lower price (i.e. having rates or fees that are lower with none that are higher).

This approach makes it possible to detect consumers who are likely to not be searching the market effectively without making any trade-offs between different price components or needing additional assumptions about household preferences (for instance, their degree of risk aversion or discount rate). First, using extensive data about individual borrowers and eligibility criteria for different mortgages enables me to directly identify the alternatives for which the borrower satisfied observable lending requirements (on factors including loan amount, loan-to-value ratio, property type and value, borrower income, employment status, age, history of credit impairments and credit score.) Second, only comparing products with identical substantive non-cost features ensures that households are not just paying extra to get a particular type of mortgage they prefer (e.g. a longer fixed rate). Finally, by requiring that the superior 'dominating' alternative be at least as good on all price dimensions separately, I can ensure that it is not unsuitable due to the borrower's circumstances, such as inability to pay higher up-front fees or desire to keep early redemption charges low due to a high relocation risk.

I find that nearly one in three UK consumers (29.9%) in 2015/16 chose mortgage products

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[1] For instance, mortgage debt accounts for over 80% of household liabilities in the UK and around 70% in the USA and Canada. Data from the Bank of England *Money and Credit Statistics January 2018*, UK Student Loans Company *Student Loans Balance FY16/17*, Federal Reserve Bank of New York *Household Debt and Credit Report Q1 2018* and Bank of Canada *Credit Conditions June 2018*.

[2] Examples of recent regulatory activity in the mortgages sector include FCA's Mortgages Market Study (FCA 2018), CFPB's Know Before You Owe initiative and the Residential mortgage products price inquiry by the Australian Competition and Consumer Commission.

that were dominated by apparently available alternatives. The average cost savings forgone as a result of a dominated choice ('excess cost') are £550 ($750) per year, equivalent to 12.7% of borrowers' annual mortgage costs, over the course of their initial teaser period alone. For over 17% of all borrowers (around 60% of those with dominated products), choices were strongly dominated, that is they involved excess costs above both £250 ($340) per year and 5% of the borrower's total annual mortgage costs. The frequency of dominated choices are similar among borrowers who use mortgage brokers and those who apply directly to the lender.

Even among the very prime borrowers—those with relatively high incomes, low loan-to-value ratios, and no factors that could typically complicate a mortgage application (self-employment, unusual property, etc)—the rate of dominated choices is 26%. Those borrowers would be less likely to be investigated closely by the lenders and are much less likely to have their options restricted by idiosyncratic lending criteria (if any) not recorded in the standardised data used in the dominance analysis. The high rate of dominated choices even among this very prime set of borrowers suggests that any additional unobservable lending criteria are unlikely to be a major driver of the overall results.

I do, however, find substantial heterogeneity in the frequency of dominated choices more generally. Consumers are more likely to choose dominated mortgages when they have characteristics associated with lower financial capability, such as low income, old age or poor credit history (reflecting the ability to manage finances in general). For example, strongly dominated (costly) choices are about a third less likely among consumers in the top 25% by credit rating compared to those in the bottom 25%. I also find that factors related to alternative demands on borrowers' time (such as the number of children or the complexity of the housing transaction) are also associated with more frequent dominated choices.

Although some behavioural models suggest that borrowers might make poor choices because they focus on headline prices and overlook other fees and charges (Bar-Gill 2012; Bordalo, Gennaioli, and Shleifer 2016), this is not a major driving force for dominated mortgage choices. For 92% of dominated choices, a superior alternative had a lower initial (headline) rate than the chosen dominated product. Nor did consumers appear to focus on comparing any other single price feature in their product choice.

I find that decision-makers tend to gravitate towards familiar alternatives. Brokers appear to prefer dealing with small sets of familiar lenders: an average intermediary observed in the data used just 5 mortgage lenders for 75% of their business.[3] In a half of dominated choices made through intermediaries, none of the strictly cheaper alternatives were offered by the intermediary's regular lenders, so it is plausible that they may not have been found or considered due to lack of familiarity.

The apparent tendency to choose familiar options is even more pronounced in non-intermediated transactions. Around 60% of consumers who did not use a broker took out a mortgage with one of the lenders with whom they already had financial product (current account, loan or credit card). This was despite those lenders accounting, on average, for less than 20% of products for which the relevant consumer was eligible. Even after controlling for a variety of demographic and situational factors, choosing a lender with whom the consumer already had a financial

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[3]It is not the case that all brokers used the same 5 lenders, however.

product increased the probability of getting a strongly dominated mortgage by 3 percentage points (to 21% from the sample average of 17.5%).

Related literature   This paper contributes to several strands of literature in household finance. It most directly fits with behavioural finance research that investigates dominated choices in other household finance contexts, such as Sinaiko and Hirth (2011) and Bhargava, Loewenstein, and Sydnor (2017) for insurance, and Elton, Gruber, and Busse (2004) and Egan (2019) for investment products. To the best of my knowledge, there has been no comparable work on the mortgage market prior to this paper. This is an important extension as ex ante one might expect households to search more and make better decisions in the high-stakes setting of managing the cost of their largest financial liability. Other novel contributions of my research to this literature include being able to identify dominated choices in the UK mortgage market as a whole rather than the more narrow contexts that involve choices between pairs of products. The dominance approach I develop also provides a flexible way to handle heterogeneity in product features, lenders' acceptance criteria and borrower characteristics, which are important features of many other household finance settings.

My uniquely granular dataset allows me to explore borrower and product characteristics that are associated with dominated choices in greater detail than has been possible previously. These findings on factors linked to lower-quality decisions also contribute to the broader research in behavioural finance and economics, by providing additional insights on the roles of salience (Bar-Gill 2012; Bordalo, Gennaioli, and Shleifer 2016; Gabaix and Laibson 2006; Gurun, Matvos, and Seru 2016) , familiarity bias (Coval and Moskowitz 1999; Huberman 2001; Pool, Stoffman, and Yonker 2012) and financial literacy (Agarwal et al. 2009; Lusardi and Mitchell 2014). I find several potential important influences on households' attention and search costs that can be investigated in future research.

More broadly, borrowers' mortgage decisions are an important topic in household finance. There is already extensive research on some aspects of the mortgage market, such as the timing of refinancing (Andersen et al. 2018; Agarwal, Driscoll, and Laibson 2013; Agarwal, Rosen, and Yao 2015; Campbell 2006; Keys, Pope, and Pope 2016, ,and many others) and the choice between fixed and variable rate contracts (e.g. Campbell and Cocco 2003; Coulibaly and Li 2009; Van Hemert 2010). It has been much less common for papers to examine how borrowers make choices between different lenders or contracts of different costs, to a large extent due to the challenges posed by adverse selection and limited availability of data on mortgage offer prices. There are already some papers that consider these questions, such as Woodward and Hall (2012), Allen, Clark, and Houde (2014a), Allen, Clark, and Houde (2014b), Alexandrov and Koulayev (2018), and Bhutta, Fuster, and Hizmo (2019). However, I extend the existing work in a number of ways. First, I construct a unique dataset that has not been used for mortgage research to date, and makes it possible to investigate the UK market with a different set of institutional features. Second, I document significant price dispersion and ineffective borrower search in both intermediated and non-intermediated transactions, whereas the existing literature largely focuses just on intermediated mortgages and the role of broker price discrimination as a driver of price dispersion. Third, I am able to construct individual choice sets that take account

of borrowers' risk and mortgage product availability at the time of their choice, reducing any likely distortions from adverse selection or unavailable products. Finally, by applying the high standard of strictly dominated choices to detect ineffective search by households, I produce a non-parametric measure of market frictions that is robust to different assumptions about household preferences.

The rest of the paper is structured as follows. Section 2 provides institutional background on the UK mortgage market. Section 3 describes the datasets and their representativeness. Section 4 sets out the methodology for identifying dominated choices and outlines the headline results. Section 5 investigates how the probability of making a dominated choice and the associated excess costs vary with borrower circumstances and demographic characteristics. Section 6 presents the initial findings on the role of lender familiarity in dominated choices of households and their brokers. Section 7 describes the characteristics of dominated mortgage products and of their suppliers. Section 8 summarises the main robustness checks and, finally, section 9 concludes. Additional robustness checks and more detailed tables and figures can be found in the Appendix.

2 Background on the UK mortgage market

Institutions in the UK mortgage market are rather different from those in other countries more commonly covered in the mortgage literature. To help interpret the methodology and findings, I first outline some of the relevant key institutional features of the UK market below.

2.1 Product design

The first distinctive feature of the UK market is that mortgages with interest rates that are fixed for terms longer than 5 years, let alone until maturity, are not typically offered by lenders. The predominant mortgage types involve interest rates that are fixed for a relatively short period by other countries' standards (2-5 years) and then reset to standard variable rate (reversion rate) - an interest rate which can be varied by the lender at their discretion, but in practice tends to move in line with the Bank of England monetary policy rate. Two-year fixed-rate contracts are by far the most common mortgage type, accounting for almost two-thirds of all new mortgage lending.

The small remaining minority of transactions (around 10%[4]) involve fully variable rate mortgages that typically track the Bank of England base rate for the contractual term. Variable contracts also offer attractive terms in the first 2-5 years of the contract, for example in the form of a lower spread over the underlying rate. The initial years of the mortgage during which the borrower benefits from special terms, such a fixed rate or a discount on the variable rate are commonly referred to as the 'deal period'.

Once their deal period expires, UK households do not appear to display systematic inertia in responding to refinancing incentives to quite the same extent that has been recently reported

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[4]Here and henceforth, the descriptive statistics are based on the dataset used for research, which covers all borrowers buying a new property and those refinancing an existing property with a new lender, but does not cover borrowers refinancing an existing mortgage with the same lender. For this reason, market statistics may be slightly different from those presented in other sources.

in household finance literature in the USA (e.g. Agarwal, Rosen, and Yao 2015; Keys, Pope, and Pope 2016) and Denmark (Andersen et al. 2019). In fact, according to the FCA (2018), a significant majority of borrowers on initial fixed rate deals — around 77% — tend to refinance their mortgages within 6 months of their deal period ending. Borrowers are often approached by their own lender or a previously used intermediary with offers to take out a new deal around that time. The 'exit costs' after the deal period expiry are typically low, just covering administrative charges of closing an account. Refinancing before the deal period expires involves high penalty charges — of around 1-4% of the outstanding loan amount. Hence, refinancing before deal period expiry is highly uncommon in the UK, although it can occur in cases of unexpected location or lifestyle changes.

There is also a lot of product heterogeneity on additional product features: for instance, whether the mortgage contracts allows the borrower to repay the loan faster than implied by their standard monthly instalments or to pay less for a short period of time.

2.2 Price posting and search

Another feature of the UK mortgage market that is different from settings covered in the mortgage literature is the absence of bilateral negotiation between individual borrowers and the lender (or the lender's agent).

Instead, at any given point in time, a UK lender posts a 'menu' of contracts they offer, each associated with specific eligibility criteria (e.g. borrower loan-to-value ratio (LTV)), features (e.g. length of the fixed-rate period and the degree of flexibility in repayments) and the corresponding set of prices, which normally include an up-front fee, the interest rate that applies during the deal period, the rate after the deal period ends, exit fees and any early refinancing penalty charges.

For most segments of the market, lenders offer many permutations of deal period term, product type and price structure to choose from. Combined with a relatively large number of lenders operating in the market, this leads to very large choice sets. For instance, in 2015/16 an average borrower was eligible for nearly 500 mortgage products.[5]

For each borrower, their required loan amount, the property they intend to purchase and their demographic and financial characteristics determine which subset of the menu they are eligible for. Each borrower selects a product from this subset, and applies for that particular mortgage with no scope for varying price terms or fees, which for example is described as the main driver of price dispersion in the Canadian market (Allen, Clark, and Houde 2014a).

Following the application, the lender evaluates whether this particular borrower fits their posted (and internal) risk criteria for the chosen mortgage and accepts or rejects the application. The lender does not normally suggest alternative products when rejecting an applicant. In verifying borrower eligibility, lenders normally rely on extensive information collected from the borrower, as well as access to detailed credit files that pool information about the borrower's creditworthiness across creditors and industries.

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[5]The sample mean for the size of the 'available product set' as defined in definition 1 in section 4.1.

2.3 Tools and policy context

During the recent time period covered by this research, the predominant majority (over 97%) of UK mortgage borrowers received mortgage advice before they applied for a mortgage loan. The primary function of advice is to help the consumer identify a suitable product in terms of its features — for instance, the length of the fixed-rate period. Advice does not need to be independent or to compare options across the whole of the mortgage market. In fact, many lenders have their own advisers who help the consumer decide which product from the lender's range is best for them or how long the term of their mortgage should be. Borrowers need to take additional steps to opt out of getting advice. As a result, consumers who take out mortgages without advice are likely to have higher incomes and a lot of confidence in their financial capability.

When searching for a mortgage, most consumers (over 70%) use an independent intermediary rather than going to a lender directly. Intermediaries provide advice as described above, but they are also able to search for mortgage deals across multiple lenders and help the borrower complete their application. Some intermediaries charge the borrower a fixed up-front fee, but commission from lenders for a successful referred applicant is typically a larger source of revenue.

Use of intermediaries is not a major focus of this paper, although they are relevant for understanding the different ways in which borrowers search for and compare mortgage products. Iscenko and Nieboer (2018) focus specifically on the effects of intermediation and advice, and provide more institutional context about these services.

3 Data

3.1 Datasets

Most of the research in this paper relies on the combination of the following datasets.

FCA Product Sales Data   The main source of data for this paper is the Product Sales Data (PSD), a confidential administrative dataset of new residential mortgage transactions reported by all UK lenders to the Financial Conduct Authority (FCA). Each transaction report is anonymised but contains detailed information about the characteristics of the loan (e.g. date, identity of the lender, loan amount, interest rate type), of the property used as collateral (postcode, purchase price) and of the borrower (e.g. age, date of birth, gross income, adverse credit events in the past).[6]

Moneyfacts   I supplement the PSD data with a more granular commercial dataset on product characteristics available from one of the leading UK product data aggregators, Moneyfacts, to obtain detailed product information needed to understand total borrowing costs and constructing choice sets, such as lenders' eligibility criteria. These product data provide daily snapshots of all mortgage products available on the market from 2011 to mid-2016 and contain detailed information on each product's complete price structure, extra features and lending standards.

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[6]   For more detail about the PSD and variables it covers, see: www.fca.org.uk/firms/systems-reporting/gabriel/system-information/data-reference-guides/psd/psd001 , version 1.3.

Credit reference data I also have access to selected variables from borrowers' credit files at the time of their mortgage application. This confidential information has been provided to the FCA by one of the UK's big 3 credit reference agencies (credit bureaus in the US) and covers over 90% of all mortgage transactions recorded in regulatory data. In addition to showing credit scores for the mortgage application, the available credit file variables also provide a rich picture of the borrower's creditworthiness and financial behaviour. The credit bureau has provided credit scores and other credit metrics for each borrower as they were around the time of mortgage application, so this information is the best approximation to the lender's information set after the credit check on the applicant borrower. Credit files are also a source of information about the existing relationships (e.g. through personal current accounts) the borrower has with the different lenders at the time of the application.

Other sources of data Some of the postcode level information about the demographic profile of the borrower's primary residence comes from other public and quasi-public sources. First, I rely on HM Land Registry's Price Paid Data to identify whether a mortgaged property is newly built, in cases when this information is not available in the PSD. This dataset contains addresses of all properties sold in England and Wales since 1995. If a mortgage is taken out on a property in a new postcode that starts appearing in Land Registry data only around the time of the transaction, this is a strong indication that the mortgaged property is a new-build. Second, I use UK 2011 Census data on average employment rates, educational attainment and socio-demographic status in the borrower's postcode as a proxy for demographic information that is not available on an individual basis, most importantly the borrower's education. Finally, I use the quarterly bank branch location data from Experian GOAD and the borrower's historical postcode data from their credit files to calculate the distance between borrower's homes at the time of the application and each lender's closest branch.[7]

3.2 Sample construction and representativeness

The construction of my sample starts with 1.3 million PSD mortgage transactions recorded for England and Wales between 1 January 2015 and 30 June 2016. Given the mandatory nature of regulatory reporting, these PSD data cover the universe of regional mortgage lending over those 18 months for the main three borrower groups: first-time buyers, home movers (existing mortgagors who are taking out mortgage to purchase a new property) and many remortgagors (borrowers refinancing loans on their existing property with a new lender).[8]

I restrict the sample to mortgages with LTV≥20%, loan value≥£20,000 and maturity of 5 or more years to avoid transactions that are likely to have low stakes and be unrepresentative of normal mortgage borrower behaviour. I also exclude mortgages that are part of government initiatives to support home ownership, and interest-only mortgages, where no principal repayment is required until the loan maturity date. Those types of loans cannot be included as they

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[7]This calculation is discussed in more detail in Iscenko (2020), where location data are more central to the analysis.

[8]Due to the limitations of the mortgage transaction reporting data and of Moneyfacts data on products for existing mortgage clients, internal remortgagors, who refinance their mortgage with their current lender, are not included in this research.

typically involve nuanced conditions that are not well captured in the data. Loans that satisfy these additional requirements represent the majority of all UK lending (87.5% of all transactions reported in England and Wales during the observation period).

I am able to match 64% of observations that satisfy the sample selection rules above to all three main additional datasets. I primarily use Moneyfacts, to obtain additional characteristics of the borrower's own mortgage and other mortgages that were available at the time the choice was made, credit bureau data for borrower creditworthiness and local area statistics, and Land Registry data to identify whether the property being purchased is a newly constructed building (new-build).

The comparison of summary statistics for the original population and the matched sample in Table 6 suggests that distributions of most demographic and financial variables of interest are very similar. Any material sampling bias from the imperfect merges to the additional data appears highly unlikely. However, as there are some groups that are somewhat over-represented in the sample, for instance remortgagers (40.6% compared to 36% in the population) or those with fixed-rate loans (92.1% compared to 89.9% in the population). I also explore the robustness of my findings to reweighting the sample to correct for these divergences in Section A.2.

The final sample used for all results in this paper unless otherwise stated contains 695,000 mortgage transactions. This is a uniquely granular dataset that provides detailed information about the individuals and market circumstances under which they made mortgage decisions. A combination of PSD and Moneyfacts alone has only recently started being used for research (Best et al. 2015; Cloyne et al. 2019; Benetton 2019; Robles-Garcia 2019; Liu 2019), but this paper is the first to supplement those data with further extensive credit file information that offers a much better understanding of the individual risk of the borrowers.

3.3 Descriptive statistics

3.3.1 Demographic overview

Panel A in Table 1 provides summary statistics on borrowers' demographic and financial characteristics.

The sample is roughly evenly split between the three main mortgage borrower groups — first-time buyers, home movers and remortgagors. These groups have interesting differences in the complexity of their housing transaction that may be simultaneous with the mortgage choice. In order of increasing complexity:

- remortgagors typically do not have an accompanying housing transaction to worry about and can focus on the loan

- first-time buyers are choosing the mortgage alongside trying to secure a house and navigate the legal process for its purchase for the first time, and, finally,

- home movers would usually be trying to sell their existing property, as well as going through the new house purchase (with the associated legal processes)

As the whole sample, by definition, consists of households that qualified for a mortgage loan,

Table 1: Sample descriptive statistics: Demographic

	Mean	σ	$Q_{0.25}$	$Q_{0.5}$	$Q_{0.75}$
PANEL A: Demographics					
Income[a] (£1000)	43.99	31.83	27.38	37.66	52.20
Property value (£1000)	290.26	221.82	156.00	230.00	350.00
Loan value (£1000)	179.97	130.07	99.95	146.87	221.00
Main borrower age (years)	38.18	9.12	31.00	37.00	45.00
Loan-to-value (LTV, %)	66.14	20.50	52.90	70.73	84.16
Credit score[b]	63.19	8.49	59.74	64.97	68.89
Balance on unsecured debt[c] (% income)	19.31	29.55	0.169	4.87	28.30
Postcode: % in low-skill occupations	29.03	12.78	19.58	27.20	36.74
Mortgage term (years)	23.33	7.50	18.00	25.00	30.00
=1 if impaired credit history	0.00298				
=1 if first-time buyer	0.26				
=1 if home mover	0.334				
=1 if remortgager	0.406				
=1 if self-employed	0.104				
PANEL B: Borrowing costs					
APR over deal period (%)	2.57	0.759	2.02	2.44	2.99
APR over 5 years (%)					
if stay on reversion rate	3.25	0.575	2.89	3.21	3.59
if switch to same loan after deal period	2.59	0.797	2.01	2.50	3.06
Initial interest rate (%)	2.70	0.761	2.14	2.54	3.14
Initial payment[d] (£per month)	889.22	632.57	515.59	726.76	1070.85
Initial payment (% income)	24.71	7.98	19.61	24.09	28.91
Up-front fee (£)	580.24	530.64	0.00	760.00	999.00
Early repayment penalty (% of loan)	2.63	0.97	1.50	2.60	3.00
Deal period length[e] (years)	3.15	1.68	2.00	2.00	5.00
=1 if fixed rate mortgage	0.921				
Observations			695,849		

Note: (a) Income is post-tax household earnings added across all borrowers named on the loan. (b) Overall borrower credit score as reported to mortgage lenders by one of the three major credit bureaus in the UK, normalised to range from 0 to 100. (c) Unsecured debt is all borrowing on the household credit file excluding mortgages, car loans and leasing agreements. (d) Initial mortgage payment is the minimum monthly interest and principal repayment the borrower has to pay during their introductory deal period. (e) Length of the fixed rate or the introductory discounted variable rate discount.

borrowers' credit scores are high relative to the population overall, with the mean of 63.[9] Many borrowers are also similar in their creditworthiness: credit scores are within just 5 points from the mean in 50% of transactions. Lenders' transaction reports indicate mortgage borrowers that have a material credit impairment within the past 5 years, such as County Court Judgments (a type of court order that is registered in case of failure to repay a specific debt). This sub-group has a significantly lower mean credit score of 50, but its credit score distribution nonetheless has a large overlap with the rest of the population. This highlights the importance of factors beyond material past impairments in assessing their desirability as a mortgage borrower.

There is no information about borrowers' educational attainment in regulatory transaction reports or credit bureau data. I therefore use census data about the proportion of individuals in low skill occupations in the postcode of borrowers' residence to provide a rough proxy for borrower's level of education. The average proportion of low-skilled workers is 29%, but it ranges from 0 to 93% depending on location.

3.3.2 Product choice and borrowing costs

In line with the UK market as a whole, a predominant majority of borrowers in my sample, 92%, take out a fixed-rate mortgage. Nearly all of fixed rate mortgages have either 2-year (58%) or 5-year (32%) deal periods, after which the mortgage reverts to a form of variable rate. Only 2% of observed mortgage transactions involve loans with fixed rate periods of over 5 years. Around 15% of the variable rate mortgages also have a discounted rate deal period (typically for 2 years).

Panel B in Table 1 summarises the distribution of main components of borrowing cost for the borrowers in the sample. Over a third of borrowers do not pay up-front fees (consistently with frequent remortgaging in the UK), but fees are material when they are charged, averaging £930. There is also considerable variation in the interest rates. For instance, even though the interquartile range for the initial interest rate is around one percentage point, this is equivalent to almost £2k difference in annual payments for the mean loan size in the sample (£180k). The difference between the bottom 25% and the top 25% by initial annual mortgage cost is over £6,500 per annum. An average household in the sample faces annual mortgage costs of nearly £12k a year during their deal period. Mortgage costs are thus a big part of household budget even in the current low interest rate environment, accounting for a quarter of post-tax household income.

Instead of comparing initial interest rates, it is more useful to aggregate the different components of the price into a standard metric for summarising multidimensional borrowing costs — the Annual Percentage Rate (APR).[10]

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[9]To avoid disclosing the identity of the credit bureau or any of their propitiatory information, I normalise credit scores to fall between 0 and 100.

[10] In line with standard practice and Financial Conduct Authority rules, the APR for borrower i with mortgage j over a period of T months is a rate that sets the present value of all mortgage cash flows to zero, i.e. the solution to:

$$L_i = P_{ij0} + \sum_{t=1}^{T} \frac{P_{ijt}}{(1 + APR_{ijT})^{\frac{t}{12}}} + \frac{B_{ijT}}{(1 + APR_{ijT})^{\frac{T}{12}}}$$

where P_{ijt} is the total payment contractually required by mortgage j in month t, comprising any fees, interest on the outstanding balance and the required proportion of capital repayment, P_{ij0} is the total up-front fee, L_i is

Figure 1: Variation in borrowing costs by product type

(a) APR by fixed length period   (b) APR by loan-to-value ratio quartiles
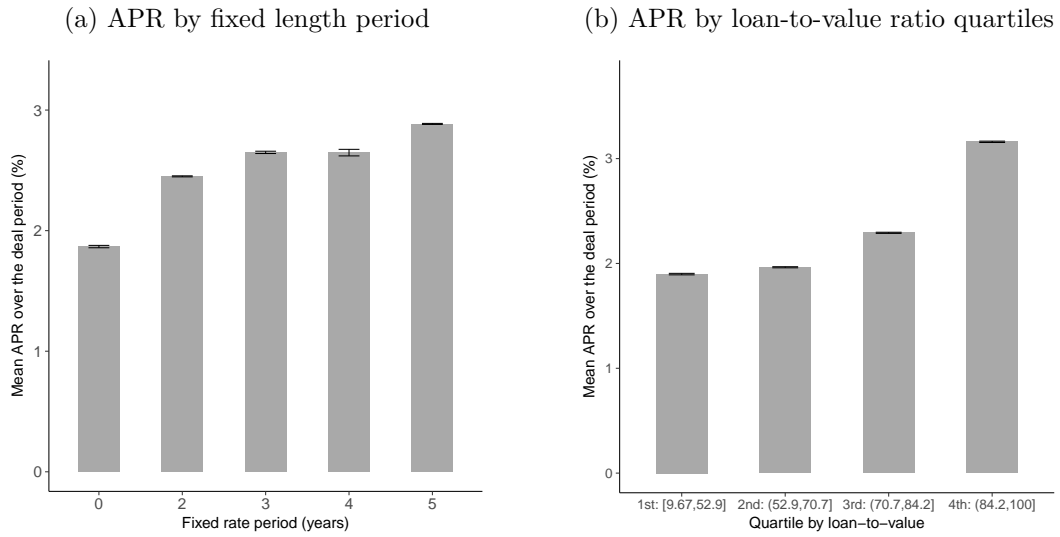
Note: Black error bars show the 99.9% confidence interval for conditional mean estimates based on unclustered standard errors.

I calculate APRs on two bases in this paper. The first is the deal period APR, which is a rate that covers only the fixed (or discounted) period, implicitly assuming that the borrower will remortgage once this period expires. This is a plausible assumption in the UK market as according to FCA (2018) calculations, only around 20% of borrowers stay on their reversion rate for more than one year after the period expires. However, deal periods vary, and APRs calculated over different time periods are not strictly comparable. I therefore also use 5-year APR as an alternative cost summary with a consistent time period for all borrowers. For borrowers whose deal periods are shorter than 5 years, I assume that they stay on their reversion rate for the remaining years. While it is a less plausible baseline description for the market, the 5-year approach also has an added benefit of reflecting some of the potential effect of reversion rates after the introduction period expires for borrowers who do not remortgage immediately.

Under both of these methods, the variation in APR within the sample is high. For instance, the difference between being at the 75th percentile and the 25th percentile of APRs is 0.97 percentage points (c.£1,750 per year for an average loan) on the deal period basis and 0.6 percentage points (c.£1,080 per year) on a 5-year basis. This interquartile difference is also highly economically significant, representing 2.5-4% of post-tax household income on average.

Not all of this price dispersion is due to search frictions, however. At least some is likely to be attributable to product differentiation and borrower risk. First, average APRs vary considerably depending on the features the product has. For instance, Figure 1a shows that the cost of a mortgage, at least in terms of deal period APR, increases with the length of time over which the interest rate is fixed. This is not surprising, as bearing the risk from potential monetary policy variation has additional costs for lenders, but nonetheless a risk averse borrower way be willing to pay lenders an additional premium to insure against rate variation. Similarly, borrowers may be willing to pay extra for flexible features of the mortgage or, for instance, reducing up-front fees if they are already close to their liquidity constraint due to expenses associated with a house purchase and move.

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i's loan amount and B_{ijT} is the balance outstanding on i's mortgage at after T months if product j is chosen.

Differences in borrowers' credit risk are another reason why borrowing costs might vary even without any frictions in the market. Loan-to-value ratio (LTV), for instance, is a big determinant of lender's expected costs arising from credit risk. Most obviously, the LTV determines how shielded the lender is from loss in case the borrower defaults by the property they can repossess as collateral. With an LTV of 50% (and in the absence of transaction costs), for example, property prices need to halve for the lender to be unable to cover their loan advance with the repossessed collateral, whereas with LTV of 100% any fall in property prices could expose the lender to a loss. Furthermore, in line with literature on screening (Bester 1985; Freixas and Rochet 2008), loans with lower LTV are likely to attract borrowers with a lower probability of defaulting in the first place. Figure 1b shows the borrowing cost variation across the quartiles of LTV distribution for the same product type (2-year fixed rate). As predicted by theory, the average borrowing costs are significantly higher at higher LTV ratios.

4 Introduction to dominance analysis

To summarise, borrowing costs vary a lot between households in the sample. But at least a part of this variation may be due to heterogeneous preferences for mortgage types, features, and the timing of payments. Borrowers qualifying only for a subset of observed loans is also a contributing factor. Understanding whether variation in costs arises from these two legitimate confounders rather than market frictions is of considerable policy interest. It is also of academic interest as mortgage choices are a high-stakes environment with large implications for household budgets. Therefore, there are very strong incentives for households to invest effort in this decision.

Because of the heterogeneity of the borrowers and the products, APR does not provide a sufficient metric for ranking products as it implicitly assumes a constant discount rate or no constraints on intertemporal budget transfers. Neither do APRs, by construction, take into account situation-contingent charges such as the early repayment penalty.

Instead of this, I develop a new 'dominance-based' approach to identify cases where households incur avoidable extra borrowing costs that cannot be fully explained by either the individual's limited eligibility or preferences for product features or timing of mortgage expenses. This allows me to explore the extent to which the observed variation in borrowing costs arises from market frictions such as search costs and begin to investigate what market or borrower characteristics might be at play. The methodology developed in this paper builds on existing research that consider dominated choices in other household finance contexts, such as Sinaiko and Hirth (2011) and Bhargava, Loewenstein, and Sydnor (2017) for insurance and Elton, Gruber, and Busse (2004) and Egan (2019) for investment. One of the main novel contributions of this paper is that combination of granular data on both borrowers and products and the detailed individual-specific product ranking algorithm allows me to identify strictly dominated choices for all of conventional retail UK mortgage lending rather than in specific contexts. This approach to identifying dominated transactions is also flexible enough to handle heterogeneity in product characteristics, lenders' eligibility requirements, as well as borrower characteristics and preferences, which are all important features of the UK mortgage market and other household

finance settings. Because this approach does not require evaluating trade-offs between product features or price components, it is particularly well-suited to cases with multidimensional pricing and complex product design.

4.1 Identification of dominated choices

Since the approach used in this paper is not standard, I first define the key concepts:

Definition 1 (Available product set) *Let C_i be the set of products available to a borrower i who applies for a mortgage at time t_i. Then for any mortgage product j, $j \in C_i \iff$*

1. *j was offered by the lender at t_i and was available for at least a month in total; and*

2. *i satisfies all of j's eligibility criteria.*

The eligibility criteria come from two sources: the explicitly stated criteria in Moneyfacts (relating to borrower status —e.g. a first-time buyer or not self-employed — or minimum and maximum values of characteristics such as age, household income, property value, loan amount, or loan-to-value ratio) and additional rules derived from lender behaviour in the data (minimum credit score, and maximum loan-to-income and LTV ratios accepted for each product).

The minimum time on the market requirement is added to avoid potential distortions from lenders' flash deals: heavily discounted mortgage offers that are offered only briefly or in limited numbers but allow the lender to advertise very attractive rates in a concurrent marketing campaign. Given the imperfections in the data, it would be possible (or even likely) that such a product is not available to the consumer making a choice at exactly the 'right time' even if they meet the eligibility criteria on paper.

Definition 2 (Strict comparability) *Let, $\vec{f_j}$ be the vector of non-price features of product j. Then, without any assumptions about borrower preferences beyond non-satiation, two mortgage products j and k are* strictly comparable *if and only if they have the same non-price product features, $\vec{f_j} = \vec{f_k}$,*

Definition 3 (Comparable set of available products) *Let $\tilde{C}_{ij}$ be the comparable set of alternatives to product j for borrower i. For any mortgage k, $k \in \tilde{C}_{ij} \iff$*

1. *k is available to borrower i, $k \in C_i$, and*

2. *k is strictly comparable to j, $\vec{f_j} = \vec{f_k}$.*

I restrict effective choice sets to only comparable product to ensure that mortgage products can be ranked for each borrower without any assumptions about the form of their utility function. Otherwise, the borrower's risk or time preferences, or the degree of uncertainty they face, could mean that they might be willing to forgo the lowest cost in present value terms to get (or avoid) certain product features. Taking borrowers' revealed preferences over features as given and restricting comparisons to mortgages that are substantively the same on main dimensions avoids this problem, albeit at the cost of also making it impossible to assess whether borrowers select product features that are suitable for their preferences.

The available data allow me to hold the following non-price product features constant: mortgage rate type (fixed or variable, and duration of the deal period), whether the mortgage allows repaying the principal faster than the contractual monthly payments even if with some restrictions (early repayments), whether the mortgage allows underpayments or payment holidays (typically subject to earlier overpayments). This list covers all product features that are explicitly listed in regulatory rules as affecting whether or not a particular mortgage product is appropriate to the borrower's needs and circumstances.[11] This level of detail also goes beyond what is normally observed by researchers in mortgage household finance literature, which — often for the reasons of data availability — tends to focus on borrower choice between fixed and variable contracts (e.g. Campbell and Cocco 2003; Coulibaly and Li 2009; Van Hemert 2010).

Definition 4 (Dominance) *Mortgage $j \in C_i$ with a vector of price elements $\vec{p}_j \in \mathbb{R}^D$, is dominated by mortgage k for borrower i $\iff$*

1. *k is a comparable alternative to j, $k \in \tilde{C}_{ij}$, and*

2. *all elements of cost of j are, individually, at least as high as for k, and strictly higher for at least one price element, $\vec{p}_j \geq \vec{p}_k$ and $p_{jd} \neq p_{kd} \, \exists d = 1, ..., D$.*

I control for the price elements individually: initial interest rate, interest rate after teaser expiry (reversion rate), up-front fee (adjusted for cashback and other promotional discounts), fee at normal termination of the mortgage, and penalty charge for early repayment.

The dominance ranking between two products is defined only with reference to the specific borrower i for two reasons. First, for any comparison to be meaningful, it needs to be feasible for the borrower to take out either of the loans. This requires checking the specific combination of borrower characteristics against eligibility criteria for the two products. Second, some mortgages involve fixed fees and in others fees are expressed as a percentage on loan amount, so it is possible for the product ranking on fees to flip depending on the size of the mortgage. Calculating and ranking fees for each borrower for their observed loan amount solves this problem.

Definition 5 (Dominated choice) *Let $\mathcal{D}_i$ be the set of all mortgages that dominate the mortgage chosen by borrower i. Then, i's choice is* dominated *if and only if $\mathcal{D}_i \neq \varnothing$.*

I apply these concepts to assess the quality of borrowers' choices in this paper by going through the following steps for each borrower i in the sample. First, I identify the set of all products i is eligible for and which have the same features as i's chosen mortgage. Second, I calculate costs of each mortgage in C_i for i. Finally, I compare the costs of i's chosen product with every product on each price dimension separately to identify products that satisfy the conditions for dominance.

4.2 Cost of dominated choices

Measuring the cost of dominated product choices requires assumptions that go beyond the non-parametric method of purely detecting dominance. In particular, to calculate the cost of a

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[11]The rule in question is MCOB 4.7A.6. of the FCA Handbook. The list provided in this section of the Handbook also contains several considerations regarding borrower's eligibility for the mortgage, which are covered by Definition 1, which identifies the set of available contracts.

mortgage one needs to, at the very least, decide on a time period for comparison, decide weights assigned to costs incurred in different time periods and, finally, make some assumptions about borrower behaviour over time (e.g. time of refinancing and whether any penalties are triggered). Comparisons of outcomes for different borrower types further require a consistent approach to be used for borrowers.

I calculate and compare total mortgage costs and the excess costs as a result of dominated choices by building on the standard cost metric for loans which were discussed in the preceding section, Annual Percentage Rates (APRs). As before, I calculate excess costs over two time horizons: the duration of the mortgage deal period (which abstracts from any additional costs borrowers might incur if they do not refinance their loans at the end of their incentive rate period) and a '5-year basis', which keeps the time horizon fixed across all borrowers at 5 years — the longest widespread deal period length. I revisit the sensitivity of the results to the selected comparison periods in the Robustness section.

For either of these cost measures, the annual mortgage cost over a period of T months for borrower i with mortgage j is simply $M_{ijT} = L_i \times (APR_{ijT})$, where L_i is i's loan amount and APR_{ijT} is the annual percentage rate calculated on the basis of i's loan size and the price structure of product j over T months using the standard formula in footnote 10.

Calculating the excess cost from a dominated product choice requires accounting for two additional complications: slower repayment of the underlying loan due to increased costs (which is not captured by the APR) and the possibility of multiple products with costs that are strictly superior to one's chosen mortgage.

Definition 6 (Excess mortgage cost) *Let $\mathcal{D}_i$ be the set of all mortgages that dominate the mortgage j taken out by borrower i. Also let B_{ijT} be the outstanding loan balance i still needs to repay after T months on a mortgage product j. Then, the excess cost i incurs per year as a result of making a dominated mortgage choice is the average of the differences in annual mortgage costs between the dominated product and all of the dominating alternatives in D_i:*

$$\Delta M_{iT} = \frac{1}{|D_i|} \sum_{k \in D_i} L_i(APR_{ijT} - APR_{ikT}) + \frac{12}{T}(B_{ijT} - B_{ikT})$$

This cost can also be expressed as a percentage reduction in actual mortgage costs the borrower forgoes due to their dominated product choice:

$$\%\Delta M_{iT} = \frac{\Delta M_{iT}}{M_{ijT}} * 100$$

The first term of the cost differential between two products is the higher interest payments captured by the APR difference. The second term is the adjustment for the difference in the remaining loan balance outstanding at the end of the comparison term. This difference arises because standard mortgage payments on the cheaper loan will include more principal repayment and thus yield a lower balance at the end of any given time horizon (other than the end of contract). This difference in balances needs to be compensated; otherwise the borrower would continue to incur 'excess cost' from the dominated choice relative to a superior alternative even after remortgaging as they would be paying interest of a larger loan than they would have had

if they took out a superior mortgage.[12]

I calculate the excess cost of a dominated choice as an average across all dominating alternatives to ensure additional robustness. Analysis based purely on the 'best available mortgage' benchmark would make the estimated costs very sensitive to changes in the 'frontier' products over time and across groups, and might be less representative of the overall expected cost of not searching efficiently. Furthermore, comparing choices to the best possible alternative is less useful from the policy perspective, as even under well-functioning search it will often be unrealistic to expect that all borrowers choose the best possible mortgage product.[13]

The definition of the excess cost from dominated choices is a financial measure, and it does not take account of borrowers' time preferences. Remaining agnostic about individual borrowers' (potentially heterogeneous) time and risk preferences is, after all, one of the main reasons for measuring search effectiveness using strict dominance between products rather than ranking them on a single aggregated price metric. However, the qualitative findings on the scale of the excess costs would not be materially affected by alternative time preference assumptions because of the short time periods for comparison. For instance, with the annual discount factor of 0.98 commonly used in the literature (see, for instance, Blundell et al. (2016)) would produce a 5-year cost only 5% less than the original approach. Most importantly, because dominance checks for product superiority (or at least equivalence) on all price dimensions individually and for each borrower, there is no set of time preference assumptions, even heterogeneous and time-varying, that would make the cost of holding a dominated product negative.

Finally, I combine the definitions of dominance and excess cost to specify a sub-group of consumers whose dominated choices clearly result in non-trivial costs to filter out marginally dominated choices that could be partly driven by measurement error and explore factors that might affect consumers experiencing material losses.

Definition 7 (Strongly dominated choice) *Let $\mathcal{D}_i$ be the set of all mortgages that dominate the mortgage j which borrower i takes out in the data. Then, i's mortgage choice is* strongly dominated $\iff$ *:*

1. *i's mortgage product is dominated by available alternatives, $\mathcal{D}_i \neq \varnothing$; and*

2. *as a result, over their deal period i incurs annual excess costs of at least:*

   - *£250 in absolute terms ($\Delta M_{iT} \geq 250$) and*

   - *5% of their annual mortgage payment under product j ($\%\Delta M_{iT} \geq 5$).*

As shown in Section 8 on robustness checks, the qualitative results in the rest of this paper are robust to using alternative excess cost cut-offs to define 'strong' dominance.

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[12]To simplify the computational burden of calculating annual excess costs, I divide the total additional balance repayment needed equally between years in the comparison period.

[13]A potential conceptual downside of using the average rather than the best possible product is the risk of niche cases where making a better choice increases the excess cost. Consider, for instance, a borrower choosing the worst product out of a set with prices {11,9,1} (average excess cost of 6) compared to choosing the second-worst product (average excess cost of 8). However, this does not occur much in practice: the excess cost obtained with the proposed method are very highly correlated those obtained with the frontier method (correlation coefficient 0.968).

Table 2: Dominated choices: headline results

	Mean	$Q_{0.25}$	$Q_{0.5}$	$Q_{0.75}$
Households with dominated products (%)	29.9			
Households with strongly dominated products (%) [a]	17.5			
Excess cost from dominated choices (deal period)[b]				
£ per year	549.70	184.63	330.15	583.73
% of annual mortgage payment	12.73	5.94	10.19	15.88
% of household income	1.47	0.531	0.955	1.64
Excess cost from dominated choices (5-year)[c]				
£ per year	565.56	170.67	327.71	659.31
% of annual mortgage payment	10.13	4.35	7.77	13.97

Notes: (a) strong dominance is defined as a choice which results in annual excess cost greater than or equal to £250 per annum and 5% of borrower's annual mortgage cost. (b) All distributions of excess costs are for the subset of borrowers with dominated products. Excess cost (as per definition 6 in section 4.2) is the mean difference between household's borrowing costs with the chosen (dominated) mortgage product and borrowing costs (for the same loan amount, etc.) under each of the strictly superior mortgage products that dominate the observed choice. (c) Five-year excess cost assumes that the borrower remains on their contractual reversion rate until the end of the five-year period if their fixed rate or discounted rate deal expires earlier.

## 4.3 Results on the frequency and costs of dominated mortgage choices

Applying the definitions of dominance above to the data reveals that 30% of mortgage borrowers chose products that were dominated by another available alternative. These choices have material economic consequences: buying a dominated product led borrowers to forgo mean savings of approximately £550 per year over the deal period (just over 3 years on average), equivalent to reducing mortgage costs by 12.7% or to losing 1.5% of their household income. The excess cost of dominated choices is only slightly lower at 10% of annual mortgage costs if calculated on a standardised 5-year basis, as shown in Table 2. The lower annual cost is likely at least in part driven by the additional up-front fees paid on the dominated product being spread over a larger number of years.

Dominated choices have significant economic consequences for a large proportion of households. Mortgage products selected by 17.5% of the observed borrowers meet the criteria for strongly dominated choice given above and thus lead to considerably higher mortgage costs than were possible under available superior alternatives.

Figures 2a and 2b elaborate on the distribution of annual excess costs per year incurred as a result of dominated choices. Households that forgo relatively small amounts when they choose a dominated mortgage are quite common. Dominated choices 'cost' about a half of the borrowers £350 or less per year, and for 13% of the sample annual costs are as low as £100. The distribution also has a thick right tail, however, and large losses are also quite frequent. Around a third of borrowers with dominated products are foregoing the opportunity to reduce their mortgage costs by 10% or more, and a non-trivial minority of 15% face avoidable excess cost of over £1,000 per year over a period of 2 to 5 years.

Given that the total amounts 'left on the table' are in the hundreds of pounds even for households with relatively small excess costs, it appears unlikely that the dominated choices are fully rationalised by preferences over intangible product attributes such as the lender's brand. Some form of market friction appears to be needed to rationalise the large amounts of money

Figure 2: Distribution of excess costs from dominated choices

(a) Absolute

(b) Relative
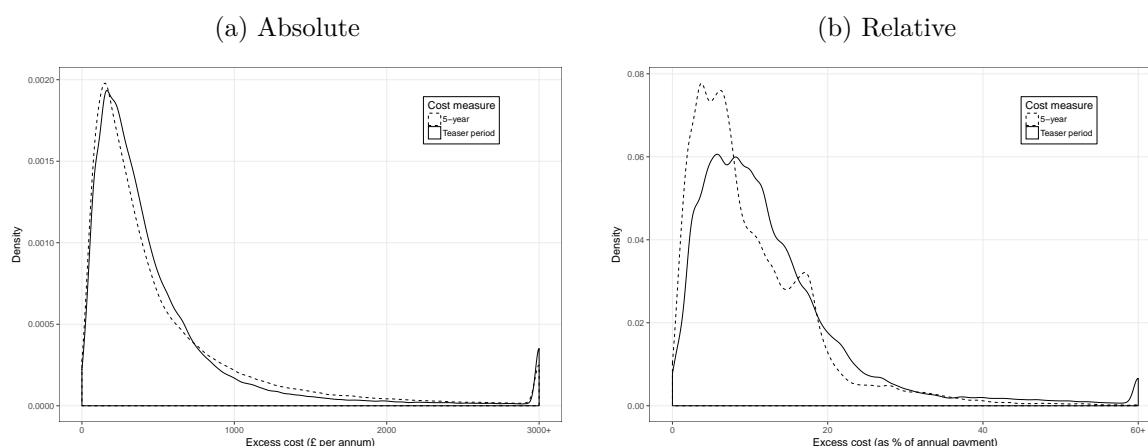
Note: All distributions of excess costs are for the subset of borrowers with dominated products. Where excess costs are calculated on the basis of remortgaging after five years, the borrower remains on the reversion rate until the end of the five-year period if their fixed rate or discounted rate deal expires earlier.

so systematically forgone. For instance, the complexity of researching and assessing costs of different mortgage options, combined with low financial sophistication of some of the borrowers could result in prohibitively high search costs that result in narrow sets of products that are considered.

While there is clear and potentially interesting demographic variation, it appears likely that it occurs on many demographic and behavioural dimensions at once and therefore requires a more systematic regression approach before influences of individual factors can be meaningfully discussed.

5 Demographic variation

5.1 Univariate trends

The likelihood of a household choosing a dominated mortgage product, and the costs of doing so, vary with many standard demographic characteristics. While dominated choices are present to some degree across all types of borrowers, demographics appear to play a role in shaping propensity towards such choices.

Figure 3 illustrates high-level univariate trends in dominance rates and costs with the three core borrower characteristics: credit score, income and age. The dominance approach already controls for these three variables in assessing each borrower against product eligibility criteria and identifying whether their chosen mortgage is dominated by any other available options. Yet, there is clear residual variation in both the likelihood of making a dominated choice and its cost across all three of these factors. For instance, borrowers in the lowest score band (35-45) are nearly 10 percentage points more likely to make a dominated choice than those with the highest credit scores (75-85), and their excess cost as a proportion of the overall mortgage payment is nearly twice as large.[14] The borrower's age and income are also associated with varying

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[14]Individuals with the worst credit ratings (30 and below) have somewhat lower dominated choice probabilities. This is likely because individuals with such poor credit typically have much fewer mortgage options available to

Figure 3: Dominance rate and excess cost split by demographics
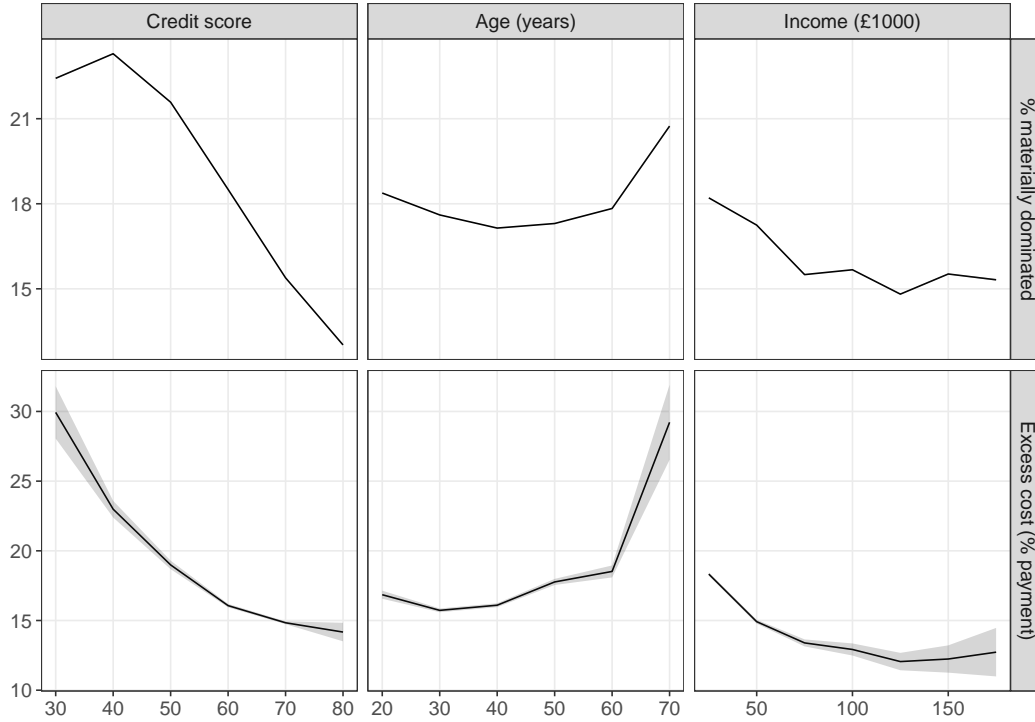
Note: Average rates and costs calculated in 10-point groups for credit score and age, and in £25k buckets for income. Borrowers in top and bottom 0.5% on each of the demographics are classified as outliers and omitted from the graphs. Grey bands show the 99.9% confidence interval for the conditional means.

rates: for both, the difference in average dominance rates between the top and the bottom band is around 3 percentage points. Also notably, the variation in probability of dominated choice and costs follows a relatively common hump-shaped pattern in the quality of financial decision-making (see, e.g. Finke, Howe, and Huston (2017) for an overview), with middle-aged individuals performing best of all.

Overall, however, while there is clear and potentially interesting demographic variation, it appears likely that it occurs on many demographic and behavioural dimensions at once and therefore requires a more systematic regression approach before influences of individual factors can be meaningfully discussed.

5.2   Regression specification

I investigate how the dominated choice probabilities and costs vary with borrower demographic characteristics and financial circumstances using the following general model:

$$Y_i = X_i\beta + N_i\xi + Z_i\delta$$

where $Y_i = \log \frac{\pi_i}{1-\pi_i}$, is a transformation of π_i, is the probability that borrower i's chosen product is *strongly* dominated, or $Y_i = \%\Delta M_{i,Deal}$, the excess cost from a strongly dominated

them, and so the likelihood of there being another strictly superior alternative to any given product is lower.

choice over the deal period expressed as a percentage of the borrower's total mortgage cost.[15]

On the right-hand side, X_i is a vector of i's demographic and credit risk characteristics, including to household income, loan amount, credit score, borrower type, employment status, number of children, unsecured debt volume, etc, as well as some quadratic forms of continuous demographic variables (see the full list of demographic covariates in Table 7), N_i is a quadratic polynomial of the total number of products in the choice set C_i, Z_i is a vector of indicator variables for search channel (and, in some specifications, region of house purchase). β, ξ and δ are vectors of parameters, which are estimated with MLE for specifications that focus on the probability of dominated choice and OLS for the excess cost specifications. I calculate cluster-adjusted standard errors using the approach in Cameron, Gelbach, and Miller (2011) to account for possible geographical and temporal correlation between behaviour of households (e.g. due to regional advertising campaign by a specific lender). Clusters are based on a combination of year and quarter of transaction with postcode area of the mortgage property, producing 624 groups in total.

Fixed effects in Z_i include indicators for whether the transaction was advised and also for the borrower searching lenders directly or through an intermediary. These factors are important to control for since borrowers are highly likely to select into search channels depending on characteristics related to other variables in the model, such as complexity of their credit situation, their financial capability or income. The potential for selection bias also means that the estimates of advice or intermediation fixed effects in this model are very unlikely to have a meaningful interpretation. Because of this, I restrict my attention to demographic covariates in this section, and Iscenko and Nieboer (2018), a companion paper, focuses on identifying meaningful causal effects of mortgage advice and intermediation on dominance rates (as well as other borrower outcomes) by applying difference-in-differences matching estimation to a recent UK policy change. The results reported later in the paper are robust to using more detailed fixed effects, e.g. additional fixed effects for the size and type of the intermediary firm (if any) used by the borrower.

5.3 Marginal demographic effects

To simplify interpretation of quadratic terms and logistic regression coefficients, Table 3 presents average marginal effects obtained from regressions above, for the probability and excess cost. The table also report marginal effects which are scaled by one standard deviation of the explanatory variable to illustrate relative economic significance.[16]

Overall, the estimated demographic marginal effects are consistent with the idea of heterogeneous search costs changing the likelihood that a borrower discovers (or selects) better alternatives during their search. There are broadly two channels through which the variables in the model can affect search costs: the borrower's ability to search (e.g. financial capability and available time) and the complexity of choice they are facing (e.g. number of options and

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[15]Regressions focus on strongly dominated choices to minimise effects of small measurement errors on classification of transactions as dominated, and also to explore demographic effects on cases with large costs and greater economic significance. Qualitative findings are robust to alternative specifications of strong dominance. See section 8.2

[16]Regression results before transformations are provided in Table 7.

Table 3: Estimated marginal effects

	Marginal effect[a]	Effect of 1σ change
PANEL A: Effects on P(Strongly dominated choice) (in pp)		
Income (in £1000)	−0.19	−5.17
Loan value (£1000)	0.05	6.32
=1 if joint mortgage	−0.15	
Number of dependent children	1.23	1.18
Borrower age	0.14	1.30
=1 if home mover	3.63	
=1 if remortgager	−3.25	
Postcode: % in low-skill occupations	0.03	0.40
Number of available products[b]	0.01	3.45
=1 if new-build property	3.61	
=1 if self-employed	4.78	
=1 if non-standard property[c]	2.38	
Credit score	−0.28	−2.36
Balance on unsecured debt (% income)[d]	0.08	2.28
Loan-to-value ratio (LTV, %)	0.24	4.84
Observations	647,758	
PANEL B: Effects on excess cost (in pp of annual mortgage cost)		
Income (in £1000)	0.0910	2.45
Loan value (£1000))[b]	−0.0831	−10.69
=1 if joint mortgage	−0.2540	
Number of dependent children	0.2150	0.21
Borrower age	0.0135	0.12
Number of available products[b]	−0.0002	−0.06
=1 if self-employed	1.9019	
Credit score	−0.1744	−1.48
Balance on unsecured debt (% income)[d]	0.0138	0.41
Loan-to-value ratio (LTV, %)	−0.0776	−1.59
Postcode: % unemployed	−0.1356	−0.27
Observations	112,363	

Notes: (a) Marginal effects calculated using regression specifications (2) and (4) in Table 7, respectively. All reported effects are statistically significant at 1% level. Standard errors are computed using the delta method and clustered on year and postcode area. (b) Number of products in borrower's comparable set of available products as defined in Definition 3. (c) Proxy for the mortgaged property having non-standard characteristics takes the value of 1 if the purchased property is in the bottom price decile among properties with the same number of rooms mortgaged in the same postcode and in the quarter of transaction. This reflects that properties with any lending restrictions are typically sold at a considerable discount. (d) Total amount of borrowers' non-mortgage and non-car debt (i.e. credit card balances, personal loans, used overdrafts and other forms of short-term credit) at the point of mortgage application, as percent of post-tax income. (e) Since the outcome variable is measured in percent of the overall mortgage payment, loan value has a strong mechanical effect on the measure by increasing the denominator and the estimated marginal effect does not have a meaningful interpretation.

application complications).

5.3.1 Ability to search effectively

Credit history   The process of identifying dominated choices explicitly ensures that the borrower exceeds the minimum credit scores that have been accepted for a potentially dominating alternative in a similar LTV band. Yet, regression results show that after controlling for a range of demographics, borrowers with high credit scores are still better at avoiding dominated choices and pay less if they make one. One possible mechanism behind this effect could be financial capability: it is likely that borrowers who are good at managing their money will both have better credit histories and make better high-stakes financial decisions. A borrower with lower capability is likely to have more difficulty identifying relevant products and comparing their costs, which in effect could be thought of as higher (perhaps sometimes prohibitive) search costs. Figure 4 provides additional detail on the variation in the estimated average marginal effect of credit score on the probability of making a strongly dominated at different credit score levels. The estimated marginal effect is most beneficial for borrowers with the worst credit histories, and grows smaller as credit score improves. This pattern is consistent with borrowers who are worst at managing their finances in general having most to gain from slightly better financial sophistication and ability to search for products. The ratio of unsecured debt to income — another potential proxy for ability to manage one's finances – has very similar effects to credit scores, with higher levels of debt being associated with higher likelihood of dominated choices and larger excess cost.

Credit history could also influence the effectiveness of borrowers' search through the second channel mentioned above — complexity of the mortgage choice (conditional on any level of sophistication). Lenders' minimum acceptable credit scores and tolerance for minor credit history 'blemishes' are often not public or can be searched in standardised way, unlike many other eligibility criteria. This can mean that (despite satisfying the criteria in the data), households with less-than-perfect credit scores may be more uncertain about being accepted for the best mortgages or at the very least may need to spend more time and effort investigating their eligibility for any given mortgages.

Income   Household income continues to have a strong negative association with the likelihood of a strongly dominated choice after controlling for other demographic factors. The average marginal effect of income is, in fact, considerably larger than univariate trends might suggest, with a £1,000 increase in household income being associated with 0.2pp reduction in dominance rate on average. As Figure 4 shows, however, the size of this effect varies a lot with the level of household income. Among the poorest households in the sample with post-tax incomes around £25k, an additional thousand in household income reduces the likelihood of a dominated choice by 0.4 percentage points or more. In fact the marginal effect of increasing household income from £30k to £40k alone lowers the risk of making a strongly dominated choice by around 15%. However, the beneficial marginal effect of income on the quality of product choices declines sharply as income increases and disappears entirely when household income reaches £100k or more.

Figure 4: Variation in marginal effects of income, age and credit score on dominated choices

Marginal effect of income

Marginal effect of main borrower age

Marginal effect of credit score
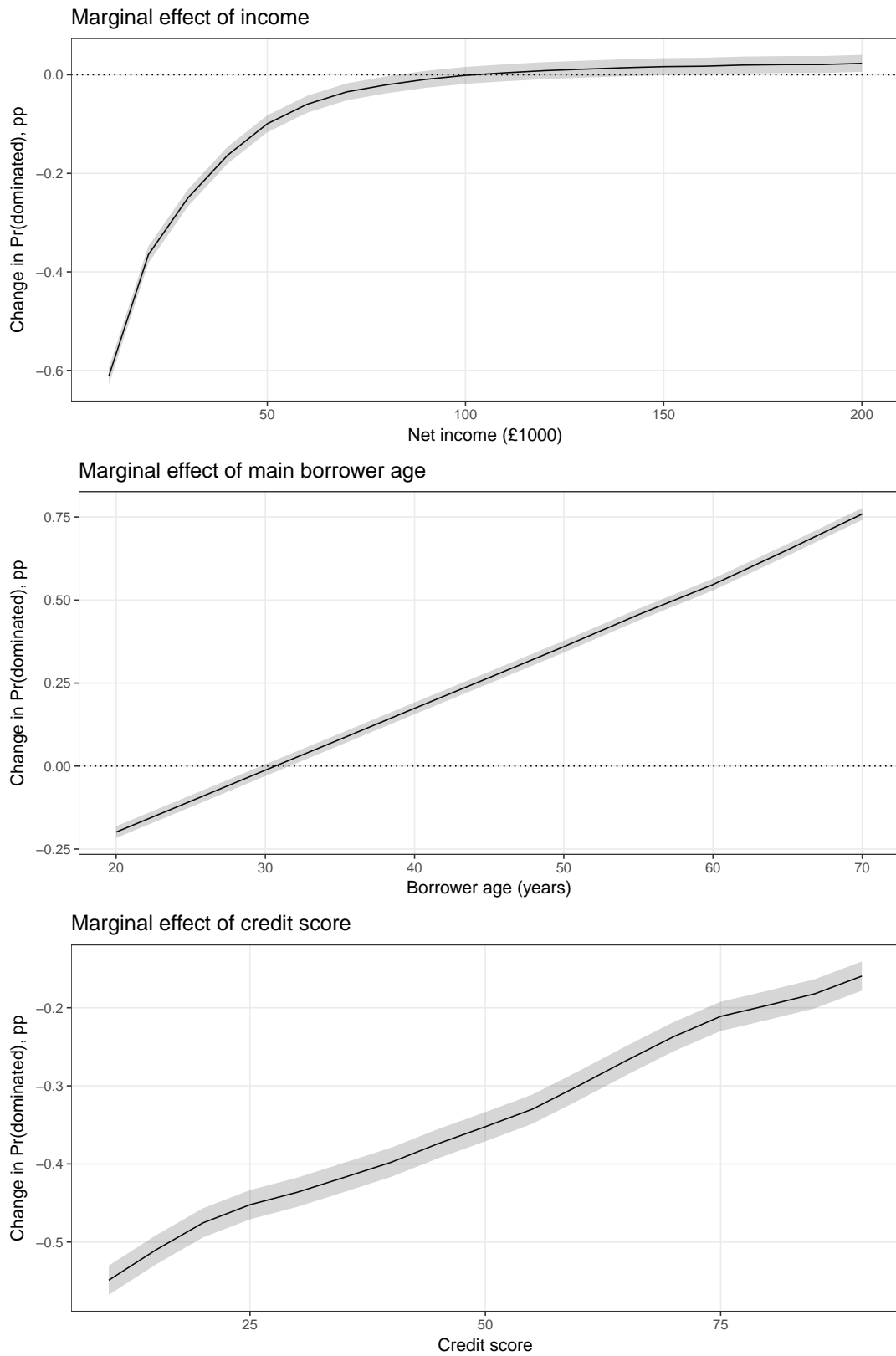
Note: Individual marginal effects calculated using regression specification (2) in Table 7 and aggregated into bins of £10 for income and of 5 for age and credit score to obtain conditional averages. Standard errors obtained using delta method. Grey bands show the 99.9% confidence interval for the conditional marginal effect estimate.

Income should not have a direct effect on probability of dominated choices as it is explicitly considered when identifying sets of products for which the borrower is eligible. There is, however, extensive evidence that household income and wealth are closely correlated with education and financial capability (summarised, for example, in Lusardi and Mitchell 2014; Calvet, Campbell, and Sodini 2009). More affluent households are thus more likely to have the numerical skills and experience to compare mortgage products effectively, resulting in lower search costs other things equal. This explanation is also consistent with the pattern of change in the estimated effects with the level of income. For low income households, additional earnings are likely to be associated with more years of education or a more technical occupation. High-earning households, however, are already likely to have graduate-level education and be employed in a quantitative industry. In this case, a small additional increase in income is unlikely to proxy for a change in factors that are relevant for better financial decisions.

There may also be a countervailing effect of income on search costs, as the opportunity cost of time is often linked to earnings in the context of consumer search (Marmorstein, Grewal, and Fishe 1992) and the broader literature starting with, for example, Becker (1965). The higher cost of time for high-earners could be a contributing factor to the declining beneficial effects of income on the likelihood of a strongly dominated choice and also slight detrimental effects of income on the size of the excess cost from dominated mortgages (see Table 3).

Age Age is another factor that is commonly linked to financial sophistication, and found to have an effect on the quality of financial decisions more generally (Agarwal et al. 2009; Lusardi and Mitchell 2014). The original research by Finke, Howe, and Huston (2017), as well as their overview of the other literature on the topic, suggest that both financial capability test scores and observed quality of financial decisions tend to peak between the age of 45 and 55, and then decline sharply into old age. Broadly in line with earlier findings, age has a small positive average marginal effect of increasing age on the probability of a strongly dominated choice and the size of the resulting loss. The variation in the marginal effect with main borrower age in 4 reveals that the relationship between average quality of decisions and age follows the standard inverse U-shape. Increasing age having a positive effect for younger borrowers, but turning progressively detrimental later in life. One distinction prior studies is that, other things equal, ability to avoid inferior mortgage products peaks around age 30, earlier than estimates in the existing literature. This could be because the model already includes some controls for the quality of financial decisions such as credit scores, which would also capture some of the age-related changes in financial ability to the extent that it affects credit use.

Borrower type The estimated differences in dominated choice probability between borrower types are large and have directions that are consistent with the theory. Remortgagors have the lowest probability of making dominated choices, followed by first-time buyers whose probability is more than 3 percentage points higher, and then borrowers moving house who, with another 3.5 percentage point increase in dominance rates, are nearly 50% more likely to choose an inferior product than remortgagors.

One potential explanation for this pattern is the difference between the three groups in the extent to which their time is likely to be occupied by a concurrent housing transaction instead.

Home movers are very likely to be both buying and selling a property at the same time on top of needing to make a mortgage choice. Involvement in these demanding and high-stakes housing transactions is likely to significantly increase the opportunity cost of shopping around for a mortgage instead, and thus reduce search. First-time buyers are only dealing with one housing transaction while choosing a mortgage, and so are likely to have more time to think about the mortgage relative to movers, which could account for better dominance rates. Finally, remortgagors typically have no 'distractions' from housing, and are therefore likely to have the most time to dedicate to mortgage search.

It may be initially surprising that first-time buyers — households who by definition have the least experience with mortgage products — do not perform worse than movers. It is likely that selection effects also contribute to this finding. The UK housing market in the past years has been extremely challenging for first-time buyers, as the house price growth and stagnation in real incomes make it very difficult for those not already on the housing ladder to save enough for a deposit. It seems plausible that households who have managed to purchase their first property in these difficult conditions are considerably better than average in terms of their financial sophistication, and also may only be able to make the purchase if they keep costs down as much as possible. The only first-time buyers in my 2015/16 sample are households who satisfy these requirements. Moving and remortgaging, in contrast, are easier and open to a wider range of households regardless of financial competence since they can rely on the realised equity in their existing property.

Other   Additional factors that can contribute to ability to search are education and demands other than the concurrent housing transaction that affect the borrower's free time. Regression coefficients on relevant variables also appear plausible. First, the detrimental marginal effects of the number of children on both probability of strongly dominated choice and the resulting excess cost may be another example of alternative demands on the borrowers' time increasing the opportunity cost of mortgage search. Second, the borrower being located in an area with higher proportion of residents in low-skill occupations according to the UK Census — an indirect proxy for borrower's own education and thus financial capability to shop around effectively — is also associated with slightly higher dominance rates.

5.3.2   Complexity of the mortgage choice

The regression results also suggest that factors that increase the complexity of the choice (for a borrower of any given capability) have expected effects.

The number of available products has a small estimated marginal effect for one extra product in the choice set. However, increasing the number of products by one standard deviation has a more material effect. This is, in part, a reflection of the large variation of 'complete' choice sets. Regression estimates suggest that the effects decline very rapidly after choice set size reaches 10-15. Once there are dozens of products to wade through, an extra 10 does not matter much as the borrower is unlikely to consider all of them.

There are also large estimated effects for some of the standard factors that can increase the complexity of application and uncertainty about acceptance (even if on paper the loan satisfies

the requirements). Those characteristics include being self-employed, buying a newly built home or a property that is otherwise unusual (as reflected by it being sold at a discount relative to house prices in the area). While the dominance calculation ensures that borrowers satisfy the standardised posted criteria, there can be additional uncertainty about banks' idiosyncratic treatment of unusual cases, which could make search and comparing lenders more complicated.[17]

6 Familiarity

Having outlined the borrower and product characteristics that are associated with dominated choices, I also consider whether the search process may be contributing to the observed outcomes. In particular, I focus on whether the strength of a pre-existing relationship with a lender plays a role in product choice, given that there is extensive evidence that household and professional choices are biased towards the familiar options in other contexts such as equity investments (Coval and Moskowitz 1999; Huberman 2001; Pool, Stoffman, and Yonker 2012, and many others).

6.1 Intermediary search

A natural hypothesis for why dominated choices arise is that the set of mortgage products the borrower considers (consideration set) is smaller than the available choice set. Given the structure of the UK market, there are some ex ante reasons to think that consideration sets may be constrained by the way in which the borrower searches the market. A borrower can either search by themselves and apply directly to lenders, or use the services of an intermediary. There are many different firms of intermediaries, which vary greatly in their size and the nature of their commercial agreements with lenders. Some of the mortgage products may, for example, be available exclusively to a subset of intermediaries in the market. Some intermediaries may only cover products from a subset of existing lenders ('a panel'). Alternatively, a lender may only make their most attractive offers available to direct (non-intermediated) applicants to reduce commission costs.

Purchases made through intermediaries offer particularly useful grounds for exploring the possible links between dominated choices and the options actively considered as UK market structure offers a sequence of identifiable restrictions on intermediary's consideration set. In Table 4, I show how the frequency of choices that are dominated by *alternatives within the restricted consideration set* changes with these restrictions.[18]

The first feature of the UK market that can restrict products intermediaries consider in practice is that some products are only available to borrowers who go to the lender directly. Often, this is a product-specific restriction, for example a lender may accept business from intermediaries in general, but have a promotional product that is available only to direct applicants. An intermediary can, in principle, know about these direct-only deals and suggest

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[17]As discussed in section 8.1, the general findings on dominance and excess cost are robust to excluding borrowers in these unusual circumstances.

[18]The difference between the baseline dominance rate in the set that includes all available products the borrower qualifies for and the rate in a more restricted consideration set gives the extent to which intermediaries' dominated choices are rationalised by limitations on consideration sets in practice.

Table 4: Effects of changing consideration sets on in dominance rates of intermediated transactions

	Assumed consideration set	% transactions dominated within consideration set	
		All intermediaries	Intermediaries with known panels
	All available products	30.8	30.1
A	No direct-only products	21.3	20.2
B	Products from panel lenders		23.5
	Products from familiar lenders:		
C	jointly accounting for 90% business	18.4	19.4
D	jointly accounting for 75% business	15.4	15.7
	All restrictions (A+B+D)	12.8	12.9
	Observations	133,818	432,291

Notes: The percentages of business are calculated on the basis of the number of borrowers directed by the intermediary to a given lender in 2014 as a proportion of the total number of borrowers who took mortgages through this intermediary in the same year.

that the borrower contact the lender directly. The intermediary cannot, however, help their client in arranging this application or earn any commission for the resulting sale, so it is highly likely that the direct-only deals are not considered by them closely or at all. Eliminating these products from the consideration set reduces the rate proportion of dominated intermediated transactions by around a third, from 30.8% to 21.3%.

The source of the second institutional restriction is that some large intermediaries have panels of preferred (or 'tried and tested') lenders, whom employees are recommended to use. While it is possible for an employee to send a customer to an off-panel lender, this often requires additional paperwork and is likely to be avoided other than in very unusual circumstances. Data on panels are not public, but I have privately supplied panel data from 5 large intermediary 'networks', which jointly account for approximately a third of intermediated transactions. The proportion of transactions that are dominated by products from in-panel lenders is 23.5%, down from the 30.1% unrestricted dominance rate for the same 5 intermediaries. Part of the reason for only a moderate reduction is that intermediaries' official panels are usually very broad to cover a range of borrower circumstances, and may not necessarily reflect lenders that are used a lot in practice.

A natural extension of the idea of panels is to investigate whether in most normal circumstances intermediaries tend to consider a smaller subset of lenders with whom they are most familiar. Repeated interactions with a lender allow intermediaries to learn about their eligibility requirements. The intermediary may also believe that their existing relationship with a lender may ensure a smoother application process for the customers. It is plausible that search costs and uncertainty are lower when using familiar lenders, and that intermediaries consider those in the first instance.

To proxy for familiarity, I calculate each lenders' share in business of any given intermediary. I then identify the most frequently used lenders which jointly account for 75 or 90% of each intermediary's mortgage transactions and restrict that intermediary's consideration set only to products from these preferred lenders. For most intermediaries, the subgroups of familiar lenders are small: the median number of lenders that make up 75% of intermediary mortgage transactions is 5, rising to 8 for 90% of transactions. Larger intermediary firms have more diverse sets of regular suppliers, but even those still remain around 10 on average and smaller

than a typical panel.

As can be seen in Table 4, restricting intermediary's consideration set only to lenders that supply 75% of their business has by far the largest effect on its own, nearly halving the rate of choices that are dominated within the consideration set to under 16%. When familiarity is combined with all other restrictions in this section, only 13% of intermediary transactions continue to be dominated by a product in the resulting consideration set compared to over 30% when using the whole available choice set. Almost 60% of dominated transactions through intermediaries can therefore be explained by plausible (and perhaps practically justified) restrictions on consideration sets that lead borrowers' agents to overlook the strictly superior alternatives.

6.2 Direct search

Next, I consider whether individual borrowers are drawn to lenders they already know, and the extent to which it might contribute to dominated choices. Mortgages are infrequent transactions for most households, but most mortgage lenders in the UK also offer other financial products which are more common, for instance, current accounts, personal loans and credit cards. Using the information in the credit files, it is possible to identify lenders with whom borrowing household already had one of these financial products at the time of their mortgage search. On average, around 13% of all mortgage products in a household's choice set came from lenders with an existing banking relationship.

Figure 5 shows that the proportion of products from familiar lenders varies between whether the the borrower used an intermediary and whether they made a dominated choice. For each of the four sub-groups it also compares this figure to the proportion of borrowers who chose a familiar lender for their mortgage. The differences between direct and intermediated transactions are striking. Among households who were assisted by an intermediary, just over 20% ended up borrowing from a lender with whom they already had a financial product. While their probability of choosing a familiar lender is above the proportion of mortgage products from these lenders in their choice sets (10%), this could be because firms with good deals on other financial services might also offer more attractive mortgages and are therefore more likely to be both familiar to the borrower and to be selected out of a set of other mortgage products.

It seems highly unlikely that the same mechanism can explain the patterns for the borrowers who made their own choices, however. Both the dominated and non-dominated sub-groups of these borrowers had somewhat higher proportion of familiar lenders' products in their choice sets (14% and 19%, respectively) than in intermediated transactions, but they were overwhelmingly more likely to take out one of these familiar mortgages as a result. Over 55% of direct borrowers whose mortgages were not dominated selected a lender they knew, as did two thirds of borrowers with dominated products. Both groups were 3 times more likely to go to one of their existing banks for a mortgage than their intermediated counterparts. The underlying drivers that make borrowers so likely to choose their own banks are important to investigate in further work, but outside the scope of this paper. Overall, however, whoever is making decisions — the intermediary or the borrower themselves — seems to be particularly drawn to offers where there is some degree of familiarity from past experiences.

To test whether selecting a familiar bank also increases the likelihood of making a dominated

Figure 5: Propensity to choose lenders with an existing relationship
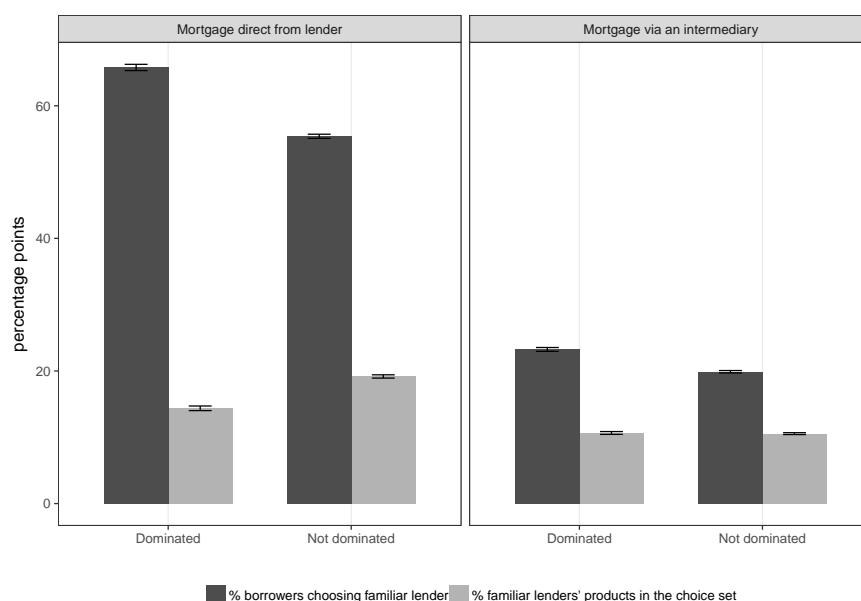
Note: A borrower is considered to have an existing relationship with the lender if they had at least one of the following products with this lender at or before the time of their mortgage application: a current account, an overdraft, a credit card or a personal loan (mortgages are excluded due to data limitations).

choice, I re-run the model described in section 5.2 with an additional indicator variable that takes the value of 1 if the borrower's mortgage is from a familiar financial institution. The coefficient on this variable is highly statistically significant (Table 10). Even after all the controls discussed above, selecting a familiar bank is associated with a 3.7 percentage point increase in the likelihood of making a strongly dominated choice, a large effect compared to the unconditional probability of 17.5%. Given the mean cost of a strongly dominated choice of £810 per year, this suggests that, other things equal, a borrower staying with the familiar lender faces a 'familiarity premium' of £30 per year in expected additional excess costs.[19]

7 Product and supplier characteristics

Finally, in this section I provide further descriptive evidence on dominated choices, focusing on the characteristics of products and suppliers that are associated with more frequent dominated choices by borrowers. First, I describe the patterns in lenders that supply more frequently dominated products, or products that frequently 'dominate' others. Second, I explore and fail to find evidence for the hypothesis that the relative salience of different price elements of mortgage product is a material driver of dominated choices. Finally, I investigate the extent to which the observed dominated choices can be explained by borrowers' strong preferences for characteristics of mortgage suppliers (e.g. an existing relationship through other products or

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[19]For borrowers with dominated products, the size of their excess cost does not materially differ between those who used a lender they knew or one without an existing relationship. This simple calculation also assumes that all borrowers without dominated products have excess costs of zero, and the only source of the 'familiarity premium' is the increase in the likelihood of dominated choices.

Figure 6: Proportion of dominated mortgage transactions, by lender size category
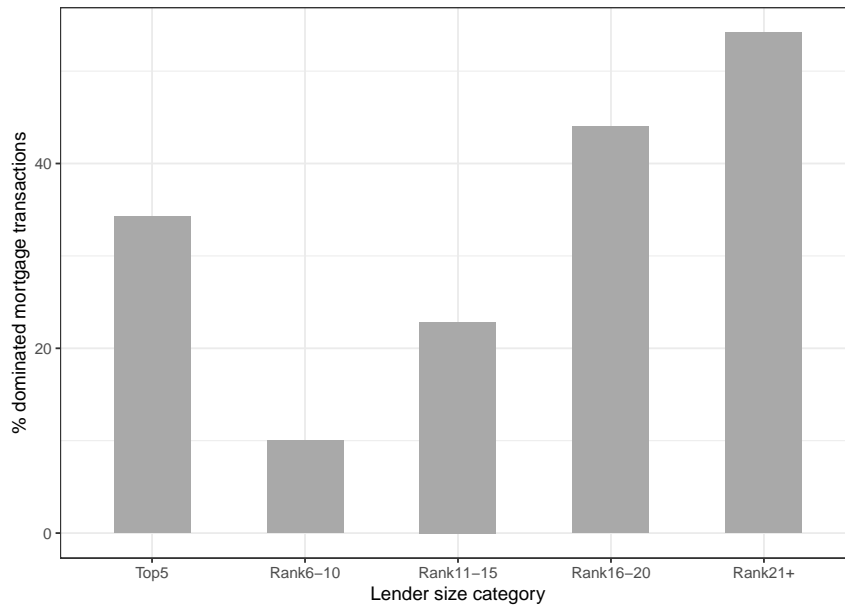
closer branches) rather than characteristics of individual products alone.

7.1 Supply of dominated products

The dominance measure used in Section 4 is based on individuals and alternatives they face. Hence, the same mortgage product may be dominated for some borrowers who choose it, but not others. For discussing the broader market dynamics of who supplies dominated products and where the strictly superior alternatives come from, we need to aggregate those borrower-based measures to firm level.

Suppliers of dominated products   For each lender (or a category of lenders) j, I define j's proportion of dominated mortgage transactions as the ratio of the number of instances where a borrower chooses j's mortgage product which is dominated by another alternative to the total number of times j's mortgage products are chosen.

This ratio varies considerably between suppliers. For one half of the lenders, the proportion of dominated mortgage transactions lies between 18% and 62%, and the average is 43%. Extremes are very uncommon. Every lender, big or small, had at least some mortgage transactions where their product was dominated by other alternatives available to the borrower. There are also only a couple of very small suppliers whose products were dominated for every borrower who chose them.

Figure 6 shows that there are systematic differences in the proportion of dominated mortgage transactions depending on lender size.[20] Perhaps predictably, suppliers whose mortgage loans are dominated most often tend to be small, potentially reflecting both aversion to more expensive products among at least some borrowers and also suppliers' higher costs due to lack of access to lending economies of scale.

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[20]Here and henceforth, lender size bands are based on lender's rank by total mortgage lending volume between January 2015 and June 2016.

The proportion of dominated mortgage transactions does not decline monotonically as lender size increases which is what one would expect if only those two factors were at play. The lowest proportion of dominated mortgages of below 10% is seen among the second-tier lenders ranked between 6 and 10 by size, with smaller banks ranked 10-15 not too far behind. The top 5 largest lenders buck the trend with over 30% of their mortgage transactions dominated by other alternatives. This might suggest that a getting a mortgage from a Top 5 bank offers additional benefits that borrowers value and trade-off against the product specific characteristics captured by the dominance measure. Alternatively, it is possible that the largest lenders are a natural focal point for borrowers who are less able or willing to search (and thus to identify the best priced deals).

Suppliers of dominating products   It is also useful to consider which supply the *dominating* products (i.e. the available alternatives that were strictly superior on price and product characteristics to the chosen dominated product). This is also not a straightforward question, as there were two or more dominating alternative mortgages for more than a half of the borrowers who made dominated choices.
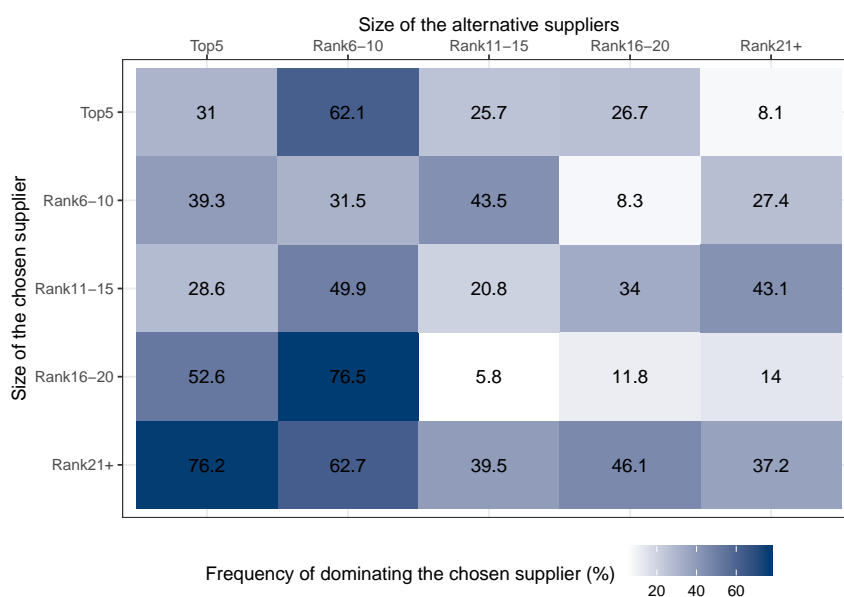
To compare lenders' relative importance as a source of dominating alternatives, I calculate two measures. First, lender k's 'frequency of dominating other products' is a simple ratio of the number of dominated mortgage choices in which lender k's mortgages are among the dominating alternatives to the number of all dominated choices in the sample. Second, k's frequency of dominating lender (or a category of lenders) j is the ratio of dominated choices where j's mortgage was chosen and it was strictly dominated by at least one product from k to the total number of dominated choices of j's mortgages.

If the majority of dominated choices were driven by dominating alternatives from the same one or two lenders, one would expect the frequencies of dominating other products to be very high (approaching 1) for those suppliers, and be near zero otherwise. What we see in practice is very different. On average, each supplier of a dominating alternative appears in fewer than 5% of dominating choices. Even for the 5 most frequent suppliers of dominating alternatives, the proportion of dominated choices in which they appear is below 24%. All this strongly suggests that suppliers of dominating products vary from one borrower's case to the next, and no single 'superior' lender is responsible for driving the majority of the dominated choices.

Figure 7 illustrates the complex nature of dominance relationships between lenders further. Out of all dominated mortgages originated by the largest 5 lenders, at least one dominating product came from another Top 5 firm in 31% of the cases, from lenders ranked between 6 and 10 in 63% of the cases, and from smaller lenders ranked 11 and below in around 40% of the cases.

For the choices where a mortgage from a lender in the 6-10 bank was dominated, one of the dominating alternatives also came from a Top 5 lender in more than a third of the cases even though those lenders have much higher proportion of dominated mortgage originations on average. In general, no single group of lenders is solely responsible for dominating the other lenders' mortgages. Instead, when a borrower's choice of a particular lender is dominated, it is due to a mix of better products being available from different lenders at the time of that

Figure 7: Frequency of dominating other lenders, by size category

Size of the alternative suppliers

	Top5	Rank6–10	Rank11–15	Rank16–20	Rank21+
Top5	31	62.1	25.7	26.7	8.1
Rank6–10	39.3	31.5	43.5	8.3	27.4
Rank11–15	28.6	49.9	20.8	34	43.1
Rank16–20	52.6	76.5	5.8	11.8	14
Rank21+	76.2	62.7	39.5	46.1	37.2

Frequency of dominating the chosen supplier (%)   20 40 60

particular choice. In fact, it is not uncommon for the same 2 lenders to dominate each other's products depending the borrower's circumstances (e.g. the LTV band).

These stylised facts strongly suggest that the supply of dominated products is more complicated than some 'bad' lenders that are consistently dominated by 'better' maverick ones. Dominated choices, instead, are a product of a complex match between the alternatives on offer by different suppliers and the individual borrower's circumstances and abilities to find them.

7.2 Salience of price features

A hypothesis often seen in behavioural literature is that consumers focus on a small subset of all relevant factors when making complex decisions. For instance, rather than calculating total costs that balance all elements, households could focus on most immediate or prominent elements of the price and choose products that are cheapest on that basis, even if this product also has large 'shrouded' costs (Bar-Gill 2012; Bordalo, Gennaioli, and Shleifer 2016; Gabaix and Laibson 2006). In principle, mortgage markets, including in the UK, are a candidate for such errors as well since advertising and consumers' own discussions often focus on the introductory interest rate (Gurun, Matvos, and Seru 2016) and borrowers appear to be more cost-sensitive to products with fees (Liu 2019). If true, this behaviour could result in a high observed dominance rate as households that focus on the introductory rate alone might be in effect indifferent between two mortgages that have the same introductory rate but might differ a lot on other dimensions, and might pick the more expensive one as long as the headline rate was the best they've seen. I test whether this holds in practice by calculating the proportion of dominated choices in which the household chose a mortgage with a strictly higher introductory interest rate rather than minimising that dimension as salience ideas might predict.

As I show in Figure 8, far from being the only dimension that borrowers minimise effectively, the introductory rate is in fact the price element where a strictly positive difference with the

Figure 8: Role of mortgage price components(PC) in excess costs

(a) Total contribution to excess cost

(b) Strictly positive cost contribution, by PC
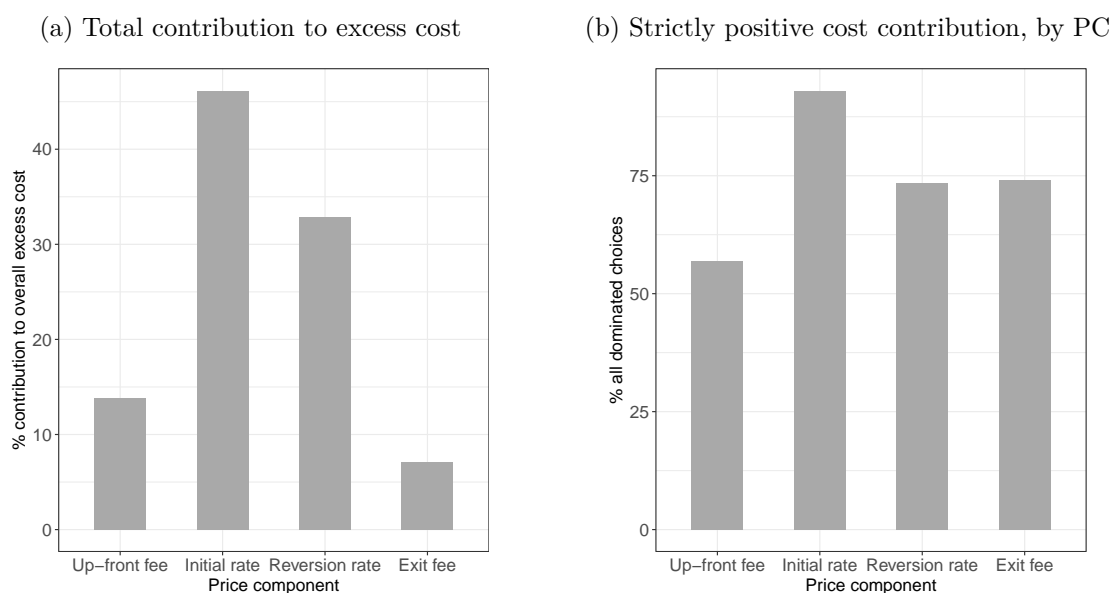
dominating product is most common. Around 92% of borrowers with dominated mortgages ended up with a strictly higher introductory rate relative to better available alternatives. In contrast, buyers of dominated mortgages pay strictly higher up-front fees in only 55% of the cases. Moreover, the differential between the initial rates on the dominated product and better alternatives on average accounts for over a half of the total excess cost that buyers of dominated products incur. (I use costs incurred over 5 years here to also see the potential impacts of reversion rates). If I use the deal period basis only and assume borrowers switch immediately after it expires, the contribution of initial rates to total cost is even higher. Buyers of dominated products do not therefore appear distracted by minimising introductory rate at the cost of overlooking differences in other cost elements.

7.3 Contributions of additional supplier characteristics

I also explore to what extent dominated choices could, at least in principle, be explained by extremely strong preferences for other choice dimensions other than price or product characteristics. I rank the borrower's chosen product and all of its dominating alternatives on four additional attributes of the choice situation and the lenders: (a) whether the borrower has an existing relationship (current account) with the lender, (b) the distance to the lender's closest branch from the borrower's old address, (c) the maximum loan-to-value ratio the lender accepts for the product, and the lender's customer satisfaction score.[21]

A borrower's dominated choice is considered 'potentially explainable' by one of four criteria if the chosen product is even slightly better on this criterion than all of the dominating alternatives. In this case, it is possible that strong preferences for the comparative advantage offered by chosen product (e.g. for dealing with the lender with which one already has an account) might have

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[21]Based on the results of a survey by Which? reported in *Advice Guides: Compare mortgage lenders* in May 2016.

Figure 9: Maximum proportion of dominated choices explainable by tastes for lender characteristics
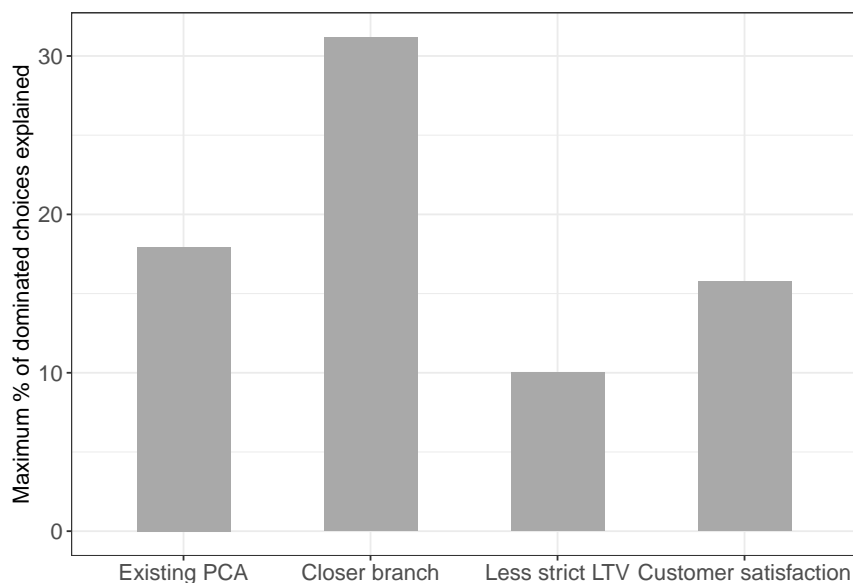
outweighed the strictly lower costs of the available dominating alternatives.[22]

For some borrowers, the 'explanations' offered by such advantages will not be very plausible – it is extremely unlikely, for instance, that someone would choose to pay hundreds of pounds for being with a lender whose branch is 0.1mi closer. This very generous definition of 'potential explainability', however, makes it possible to obtain an upper bound on the proportion of dominated choices that could be, at least in principle, attributed to the additional measurable lender characteristics.

Figure 9 shows the maximum proportion of the observed dominated choices attributable to each new measure. Potential preference for closer branches could explain at most a third of dominated choices. The other individual criteria fare even worse - only up to 18% of the dominated choices are attributable to preference for using one's current account provider for a mortgage, up to 16% to preference for higher customer satisfaction ratings and up to 10% to perceived lender strictness as proxied by the maximum LTV ratio they accept for the product. To put it differently, lenders who offer dominating alternatives are not systematically worse than providers of the chosen dominated products on other non-price dimensions borrowers might care about.

Overall, in just over 50% of the dominated mortgage choices the chosen lender is slightly better than all dominating alternatives on *any* of the four criteria. This is the maximum proportion of dominated choices that could be explained by preferences for these additional characteristics. Nearly a half of the observed dominated choices cannot be attributed to borrower preferences, however extreme, for lender familiarity, proximity, customer service and the (observable) lower lending standards.

Therefore, additional explanations, such as the difficulty some borrowers have in identifying

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[22]This can also be thought of as extending the definition of dominance in Definition 4 to include the four criteria above.

the available alternatives or comparing them, are needed to account for many of the observed dominated mortgage choices.

8 Robustness

The findings reported above are robust to a wide range of alternative assumptions. In this section I summarise two main robustness checks for the results in the paper: (a) calculating the dominated choice rates and excess costs for the subset of 'very prime' borrowers, who are least likely to face any eligibility restrictions, and (b) varying the definition of strong dominance for the demographic regressions in section 5. Additional robustness checks can also be found in section A in this paper's appendix.

8.1 Prime borrowers only

The regression results that show large economic and statistical significance of some of the factors that complicate the mortgage application can raise the concern that the proposed model does not adequately deal with eligibility in non-routine circumstances. If true, this would mean that filtering products based on standard eligibility criteria may overestimate the range of products a borrower would in reality qualify for and over-estimate dominance rates as a result.

I explore whether this concern is likely to be material by investigating a restricted sub-sample of very low risk borrowers in routine circumstances that are highly unlikely to involve lender discretion on top of assessing applicants against the posted criteria. This 'ultra-prime' sub-sample contains borrowers who satisfy all of the following criteria: LTV≤65%, loan-to-income ratio ≤2.5, mortgaged property that is not a new-build or sold at a discount that could indicate other irregularities, credit score in the top 25% of all borrowers, and the borrower is not self-employed or due to repay the loan after reaching retirement age.[23] This is a very conservative set of assumptions, which restricts the sample to approximately 63,000 observations.

Table 5 compares the average dominance rates and costs incurred in this restricted prime sample to the full-sample results reported earlier. In general, the improvement in most of the metrics in the ultra-prime sub-sample is very small. For instance, the proportion of borrowers who buy dominated products is still at 26.1%, only a marginal decrease from the original 29.9%. The absolute value of excess borrowing costs incurred due to dominated choices appears more affected as it falls to approximately £284 from £550 on a deal period basis. However, part of the effect is due to a much smaller size of the loans in the ultra-prime sample due to the selection rule that caps LTV at 65%. In fact, excess costs relative to the annual mortgage payment are higher among very prime borrowers, at 13.1% compared to 12.7% average for the whole sample. Overall, the fairly small effects of restricting the analysis to borrowers where lender discretion and heterogeneity in internal standards are extremely unlikely to play a role suggests that those factors are not a major underlying driver of the findings.

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[23]There are no official categories of prime borrowers. However, the criteria above have been discussed with the FCA specialists on firms' business models, who confirmed that this was a plausible way of capturing borrowers at the top of the range of prime lending.

Table 5: Comparison of mean results in the very prime and full samples

	Very prime	All
Households with dominated products (%)	26.1	29.9
Mean excess borrowing cost (deal period)		
£ per year	284.66	549.70
% of annual mortgage payment	13.12	12.73
Mean excess borrowing cost (5-year)		
£ per year	360.63	565.56
% of annual mortgage payment	11.45	10.13
Observations	62,979	695,831

Note: The 'very prime' sub-sample contains borrowers who satisfy all of the following criteria: LTV≤65%, loan-to-income ratio ≤2.5, mortgaged property that is not a new-build or sold at a discount that could indicate other irregularities, credit score in the top 25% of all borrowers, and the borrower is not self-employed or due to repay the loan after reaching retirement age.

8.2 Definition of strong dominance

Regression specified in section 5.2 uses the indicator for borrower's choice being strongly dominated (excess cost above £250 and 5% of annual mortgage cost) as an outcome variable. To demonstrate that the qualitative results of interest are robust to other definitions of strongly dominated choice, Table 10 shows regression results under several alternative cut-offs: any dominated choice, excess cost above £250 or 5%, excess cost above £250 or 10%, and excess cost above £500 or 10%. The signs, significance and scale of coefficients for the main variables of interest discussed in section 5.3 and 6 are largely unchanged across a range of alternative definitions. The model with any dominated choice as the dependent variable has the most deviations from baseline approach and lower significance of some of the covariates. This is unsurprising, however, as the primary motivation for using strong dominance is the concern about the possibility of noise introduced into some of the 'lightly' dominated choices by possible measurement error.

9 Discussion and conclusion

This paper proposes a dominance-based approach to identifying search frictions in markets with heterogeneous consumers, varying product features and complex pricing. Applying this methodology to choices of borrowers in the UK mortgage market reveals that around 30% of UK households between January 2015 and July 2016 choose mortgage products that are strictly dominated by apparently available alternatives and incur economically significant costs as a result. The likelihood of choosing a dominated mortgage and the size of the resulting loss vary with the demographics that are often associated with financial capability — income, age and credit score (ability to manage other finances) — and also the complexity of the choice the borrower faces. There is also a clear tendency for both intermediaries and borrowers to focus more on familiar lenders. The findings on the high rate of dominated choices are robust to a wide range of robustness checks, including, importantly looking at the very prime consumer sub-

group, whose options are least likely to be restricted by lenders' idiosyncratic lending criteria.

The dominance methodology developed in this paper offers a way of detecting poor consumer outcomes that does not require making trade-offs between different product features and cost elements. This makes it more robust to uncertainty about borrower preferences than traditional cost comparison metrics such as APR benchmarking. This methodology is particularly well-suited to measuring frictions in consumer search in markets with multidimensional pricing, large degree of product differentiation and heterogeneous consumers needs — circumstances that apply to many retail financial markets and beyond.

This robustness comes at the price of only being able to identify choices that *cannot* be explained on cost grounds under any assumptions about the consumer's future behaviour or preferences for product features. There may be cases where a borrower has alternatives that are not strictly superior on all price characteristics to their chosen product, but would still have been better for that individual consumer given their preferences.[24]

This research also provides initial evidence about the specific frictions in the search and product choices that consumers make in the mortgage market. Research in a more structural setting (see, e.g. Iscenko (2020)) should be able to shed further light on how different factors interact in driving choices of particular products over others, albeit at the cost of making more assumptions about borrowers' needs and preferences than are required in this paper.

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[24]For instance, the alternative might have slightly higher fixed fees but a lower interest rate than the chosen product, and the specific borrower has no strong need to minimise up-front costs and their loan is large enough for interest rate savings to offset the higher fees. The chosen product might have been a better option for another household, however, with a higher preference to minimise borrowing costs early on or a much smaller loan.

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A   Additional robustness checks

A.1   Cost specification

I undertake two checks to determine whether the choice of time horizons for calculations is causing me to overestimate the size and economic significance of excess costs from dominated choices (reported in Table 2).

I calculate average annual excess cost and cumulative excess cost separately under all time horizons from 1 to 25 years for each borrower with a dominated mortgage.[25] As before, the borrowers are assumed to incur no cost from their dominated mortgage in years after remortgaging. For each borrower, I obtain the minimised excess cost from the dominated choice under two approaches: (a) the average annual cost difference between the dominated and superior products over the time period that minimises the *cumulative* excess costs and (b) the smallest possible annual excess cost. In effect, the first measure is the cost of a dominated choice conditional on the household realising their error immediately and responding optimally to minimise its consequences. The second measure is simply a lower bound on the standard excess cost statistics reported in this paper.

Table 8 summarises the results of this comparison. The most surprising finding is that the annual excess cost over the time horizon that minimises total costs of a dominated choice is actually higher than under the baseline assumptions — with the median of £350 and a mean of £708 per year, compared to £330 and £550 per year, respectively, on a deal period basis. This is because for many households the cost-minimising response to making a dominated choice is to absorb the early redemption penalty and remortgage very quickly, incurring a higher additional cost but over a shorter period. In fact, 1 year is the cost-minimising time on the dominated mortgage for over 56% of the sample. While interesting as a sensitivity check, this behaviour is clearly out of line with empirical facts as practically no consumers remortgage before their deal period expires (FCA 2018), and the vast majority of borrowers have deal periods of 2 years and longer.

The sensitivity check using the time horizon that produces the smallest possible annual costs predictably reduces excess costs relative to the baseline assumptions. On that basis, the mean estimated annual cost falls to £229 and the median to £109 (see Figure 10 for the full distribution). However, this scenario again involves implausible borrower behaviour as it implies that nearly all borrowers stay on their mortgage products for years or even decades after their introductory rate expires. For nearly a third of the sample it means not remortgaging for 25 years or more, in contrast with the relatively prompt responses to expiry of the short UK deal periods actually observed in the market (see section 2.1). Furthermore, these low annual costs are produced by behaviour that is the opposite minimisation of total excess costs which are what matters for household overall utility.

The sensitivity checks with more conservative cost measures do not undermine the earlier findings that a large number of households incur additional borrowing costs of hundreds of pounds (over multiple years) as a result of choosing dominated mortgage products.

A.2   Sample representativeness

As discussed in section 3.2, the composition of this paper's primary sample deviates from the population on a small number of dimensions: for instance, the proportion of loans with a fixed introductory rate, or of borrowers buying their first property. Since the probability of dominated choices, and costs incurred as a result vary with borrower demographics, I explore whether the sample findings are likely to apply in the overall population by re-weighting the sample to be

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[25]In cases where remortgaging after the given number of years (e.g. 1 year) triggers any contingent penalties for early repayment, the calculation takes into account the difference in any such penalties between dominated mortgage and the average for all dominating products.

closer to population distribution by using multivariate probability weights based on indicators for a fixed-rate loan and borrower type (first-time buyer and remortgager) and for quintiles of income, borrower age, LTV and loan amount.

Table 9 presents the results of the re-weighting. The demographic means in the weighted sample are almost identical to those in the population, including in variables that previously diverged. The headline results on dominance and excess cost are very close in the un-weighted and weighted sample. The proportion of dominated choices declines slightly from 29.9% to 29.5% while the strong dominance rate increases by 0.2 percentage points to 17.5%. Excess costs are also very similar. For instance, the annual excess cost as a % of the borrower's mortgage payment is 12.4% before re-weighting and 12.7% after. Correcting for divergences in demographics results in only small changes but has non-trivial computational costs, so the baseline findings in the paper are presented without re-weighting.

A.3 Are choices better than random?

It could be easy to interpret the earlier sections as focusing too much on the flaws and not recognising the extent of search that is carried out effectively. I check this by investigating whether borrowers would do materially worse than their observed outcomes if they had just picked a mortgage at random out of products they qualified for.

I go through their comparable set of available products (as defined in subsection 4.1) for each borrower and identify all alternatives, whether chosen or not, that are dominated for that particular borrower. I then use the ratio of dominated products to the total number of alternatives in the individual's comparable choice set as the probability of this borrower making a dominated choice if their choices were random.[26] The mean probability of making a dominated choice at random in the sample is approximately 70%, a lot higher than the realised rate of dominated choices of 30%.

Figure 11 elaborates on this by comparing probabilities and realised rates of dominated choices in small consumer clusters defined by permutations of the range of demographic factors (represented by the individual grey dots). If borrowers were choosing as well as random, one would expect probabilities and realised dominance rates to be broadly equal in many cases. That is, the results for individual groups of borrower would be concentrated around the dotted 45 degree line. Instead, it is clear that the vast majority of the consumer 'clusters' have performed better than random chance. In fact, the cubic spline fitted to summarise the (univariate) relationship between the average proportion of dominated products in the borrower cluster and its realised dominance rates has the slope of 0.5. On average, for a 10 percentage point increase in the proportion of dominated products in the choice set, the frequency of dominated mortgage choices increases by at most 5 percentage points.

This exercise provides reassurance that households invest effort into search and make better decisions than chance would suggest, regardless of their demographic profile and use of specialist support (e.g. an independent intermediary).

B Additional figures and tables

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[26]Given the extreme computational demands of these pairwise comparisons, I cannot derive probabilities by simulating random behaviour.

Table 6: Selected summary statistics: Population-sample comparison

	Sample			Population[a]		
Variable	Mean	σ	Median	Mean	σ	Median
Income[b](£1000)	43.74	26.95	37.65	43.55	34.55	37.00
Loan value (£1000)	179.69	128.60	146.79	184.45	134.33	150.53
Main borrower age (years)	38.17	9.12	37.00	37.67	8.98	37.00
Loan-to-value (LTV, %)	66.14	20.50	70.73	67.73	19.03	72.63
Initial interest rate (%)	2.56	0.738	2.44	2.58	0.791	2.44
Mortgage term (years)	23.33	7.50	25.00	23.93	7.40	25.00
=1 if self-employed	0.104			0.104		
=1 if first-time buyer	0.26			0.275		
=1 if remortgager	0.406			0.36		
=1 if fixed rate mortgage	0.921			0.90		
Observations		695,849			1,087,766	

Notes: (a) Due to mandatory nature of regulatory reporting by mortgage lenders, full PSD data are the population of residential mortgage lending in the UK. To focus on the potential selection arising from imperfect merge with other data sources, PSD population data are filtered down to mortgages relevant for this research using the criteria in section 3.2, e.g. LTV≥20%. (b) Income is post-tax household earnings added across all borrowers named on the loan.

Figure 10: Distribution of excess costs incurred due to dominated mortgage choice
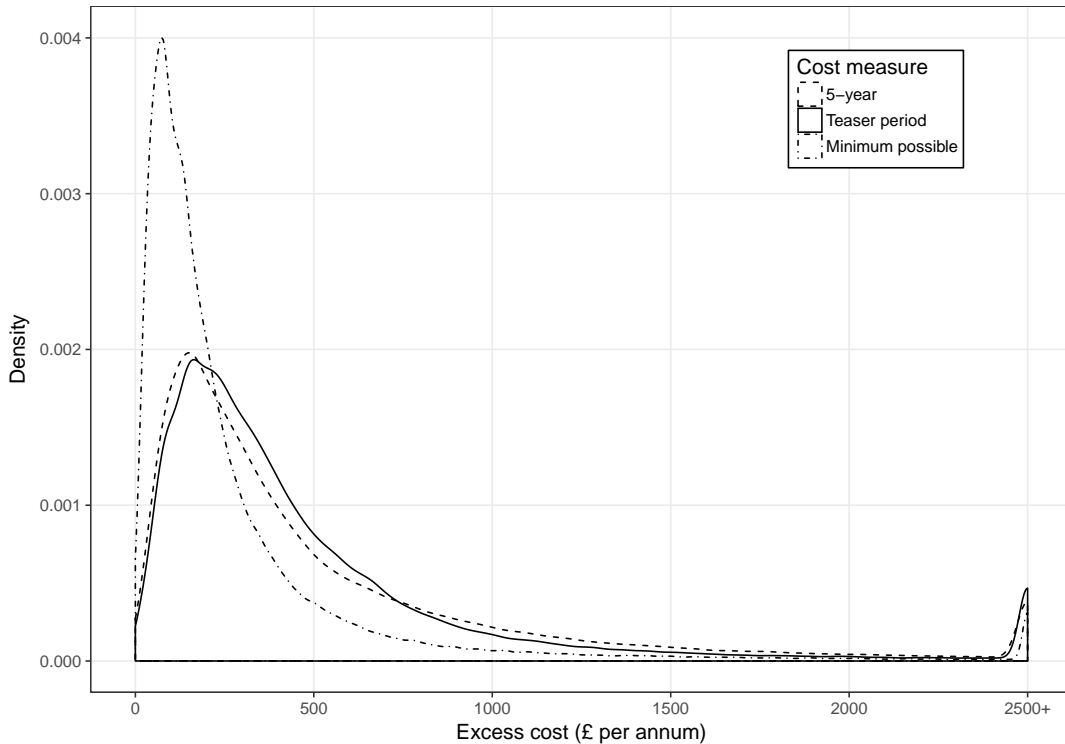
Table 7: Regression results for main borrower characteristics

	=1 if strongly dominated, logistic			Average excess cost [a], OLS	
	(1)	(2)	(3)	(4)	(5)
Borrower age (years)	0.013^{***b}	-0.042^{***}	-0.043^{***}	0.172^{***}	0.175^{***}
Borrower age (years) ^{2}		0.001^{***}	0.001^{***}	-0.002^{***}	-0.002^{***}
Loan-to-value ratio (LTV, %)	0.021^{***}	0.017^{***}	0.018^{***}	-0.078^{***}	-0.083^{***}
log(Loan value (£1000))	-0.106^{***}	6.150^{***}	6.324^{***}	-105.104^{***}	-108.041^{***}
log(Loan value (£1000))^2		-0.245^{***}	-0.254^{***}	4.050^{***}	4.180^{***}
log(Income (£1000))	0.034	-4.023^{***}	-4.206^{***}	34.366^{***}	35.555^{***}
log(Income (£1000))^2		0.181^{***}	0.190^{***}	-1.555^{***}	-1.608^{***}
=1 if joint mortgage	-0.019	12.043^{***}	12.002^{***}	-82.421^{***}	-76.184^{***}
=1 if joint$\times log$(Income (£1000))		-1.942^{***}	-1.934^{***}	14.160^{***}	12.991^{***}
=1 if joint$\times log$(Income (£1000))^2		0.076^{***}	0.075^{***}	-0.602^{***}	-0.548^{**}
Number of dependent children	0.076^{***}	0.089^{***}	0.092^{***}	0.215^{***}	0.189^{***}
=1 if remortgagers	-0.216^{***}	-0.252^{***}	-0.251^{***}	-0.199	-0.211
=1 if home movers	0.235^{***}	0.242^{***}	0.250^{***}	0.026	-0.036
Credit score	-0.022^{***}	-0.028^{***}	-0.029^{***}	-1.552^{***}	-1.543^{***}
Credit score^2		0.0001^{*}	0.0001^{*}	0.011^{***}	0.011^{***}
=1 if self-employed	0.342^{***}	0.320^{***}	0.322^{***}	1.902^{***}	1.857^{***}
=1 if non-standard property^b	0.142^{***}	0.165^{***}	0.156^{***}	-0.235	-0.201
=1 if new-build property	0.265^{***}	0.243^{***}	0.252^{***}	0.572^{*}	0.569^{*}
Postcode: % in low-skill occupations	0.002^{***}	0.002^{***}	0.002^{***}	-0.004	-0.005
Postcode: % unemployed	0.004	0.008^{**}	0.005^{*}	-0.136^{***}	-0.093^{***}
Balance on unsecured debt (% income) ^{c}	0.004^{***}	0.006^{***}	0.006^{***}	0.016^{***}	0.015^{***}
Balance on unsecured debt (% income)^2 ^{c}		-0.00002^{***}	-0.00002^{***}	-0.00005^{***}	-0.00004^{**}
Number of available products ^{d}	0.001^{***}	0.002^{***}	0.002^{***}	0.004^{***}	0.004^{***}
Number of available products^2 ^{d}		0.00000^{***}	0.00000^{***}	0.00000^{***}	0.00000^{***}
Channel FEs	Yes	Yes	Yes	Yes	Yes
Regional FEs	No	No	Yes	No	Yes
Observations	647,758	647,758	647,758	112,363	112,363
R^2				0.233	0.234

Notes: (a) Average annual excess cost expressed as percentage of the total annual mortgage payment calculated over the duration of the initial deal period. (b) Proxy for the mortgaged property having non-standard characteristics takes the value of 1 if the purchased property is in the bottom price decile among properties with the same number of rooms mortgaged in the same postcode and in the quarter of transaction. This reflects that properties with any lending restrictions are typically sold at a considerable discount. (c) Total amount of borrowers' non-mortgage and non-auto debt (i.e. credit card balances, personal loans, used overdrafts and other forms of short-term credit) at the point of mortgage application, as percent of post-tax income. (d) Number of products in borrower's comparable set of available products as defined in definition 3.
*p<0.1; **p<0.05; ***p<0.01. Standard errors are clustered on year and postcode area.

Table 8: Distributions of annual excess cost (£pa) under different time horizons

			Smallest possible	
	Deal period	5 years	Total cost	Annual cost
Mean	549.70	565.56	708.49	229.02
$Q_{0.25}$	184.63	170.67	156.34	47.50
$Q_{0.5}$	330.15	327.71	350.32	108.75
$Q_{0.75}$	583.73	659.31	745.92	256.47
Years (median)	2	5	1	17

Table 9: Effects of sample re-weighting on selected variables and results

| Variable | Mean values | | |
	Sample	Weighted sample	Population
Gross income (£1000)	63.16	63.32	63.42
Net income (£1000)	43.78	43.70	43.64
Loan value (£1000)	179.75	185.15	186.63
Borrower age (years)	38.17	37.66	37.63
Loan-to-value (LTV, %)	66.14	67.48	67.89
Initial interest rate (%)	2.56	2.56	2.57
Mortgage term (years)	23.33	23.91	24.01
=1 if self-employed	0.104	0.105	0.104
=1 if first-time buyer	0.26	0.275	0.275
=1 if home mover	0.334	0.365	0.365
=1 if remortgager	0.406	0.36	0.36
=1 if fixed rate mortgage	0.921	0.899	0.899
Results:			
=1 if dominated	0.299	0.295	
=1 if strongly dominated	0.175	0.177	
Excess cost (% annual payment)	12.73	12.43	
Observations	695,849	695,849	1,042,204

Figure 11: Observed dominated choice rates vs predicted under random mortgage choices
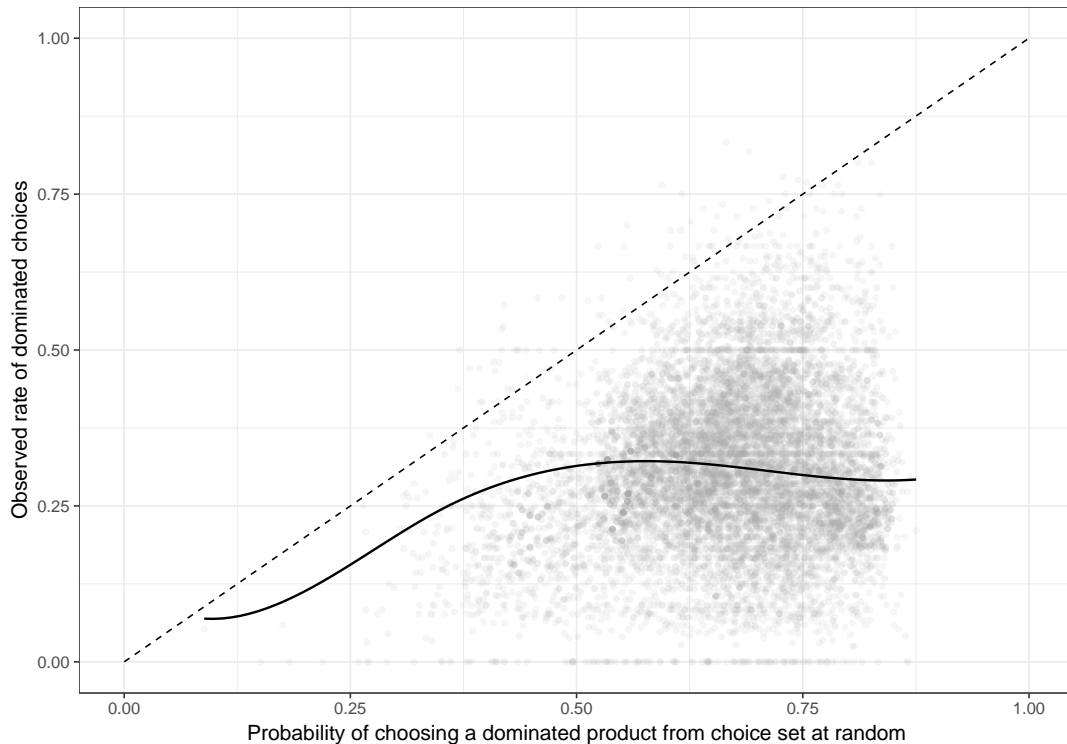
Note: Individual dots represent each of the 15,800 clusters of borrowers defined by permutation of quintiles of key demographic variables (LTV, credit score, age, etc) and additional discrete borrower categories (e.g. self-employed vs not). If households chose products from their full comparable set of available products (definition 3) at random, one would expect observations to lie along the dotted 45 degree line. The solid line summarises the actual relationship between probabilities of dominated choices and the realised dominated rates using a cubic spline with 4 degrees of freedom.

Table 10: Robustness of effects to alternative definitions of strong dominance

	=1 if dominated choice and excess cost $\geq$:				
	Baseline (£250 & 5%)	Any (£0 & 0%)	£250 or 5%	£250 & 10%	£500 & 10%
Borrower age (years)	-0.044^{***}	-0.053^{***}	-0.048^{***}	-0.031^{***}	-0.031^{***}
Borrower age (years)^2	0.001^{***}	0.001^{***}	0.001^{***}	0.001^{***}	0.001^{***}
Loan-to-value ratio (LTV, %)	0.018^{***}	0.014^{***}	0.016^{***}	0.016^{***}	0.019^{***}
log(Loan value (£1000))	6.168^{***}	-3.636^{***}	-6.756^{***}	8.045^{***}	10.559^{***}
log(Loan value (£1000))^2	-0.246^{***}	0.146^{***}	0.274^{***}	-0.345^{***}	-0.422^{***}
log(Income (£1000))	-4.078^{***}	-3.428^{***}	-2.689^{***}	-5.498^{***}	-3.327^{***}
log(Income (£1000))^2	0.185^{***}	0.153^{***}	0.115^{***}	0.252^{***}	0.158^{***}
=1 if joint mortgage	12.724^{***}	-0.085	-0.470	21.956^{***}	16.304^{***}
=1 if joint$\times log$(Income (£1000))	-2.058^{***}	0.207	0.292	-3.777^{***}	-2.670^{***}
=1 if joint$\times log$(Income (£1000))^2	0.080^{***}	-0.019	-0.024	0.160^{***}	0.106^{***}
Number of dependent children	0.089^{***}	0.075^{***}	0.084^{***}	0.090^{***}	0.083^{***}
=1 if home mover	0.251^{***}	0.271^{***}	0.269^{***}	0.274^{***}	0.255^{***}
=1 if remortgager	-0.244^{***}	-0.117^{***}	-0.156^{***}	-0.188^{***}	-0.357^{***}
Credit score	-0.013^{***}	0.003	0.005	-0.022^{***}	-0.043^{***}
Credit score^2	-0.0001	-0.0002^{***}	-0.0002^{***}	-0.00001	0.0002^{***}
=1 if self-employed	0.305^{***}	0.349^{***}	0.326^{***}	0.304^{***}	0.326^{***}
=1 if non-standard property	0.163^{***}	0.204^{***}	0.181^{***}	0.149^{***}	0.158^{***}
=1 if new-build property	0.249^{***}	0.188^{***}	0.242^{***}	0.308^{***}	0.206^{***}
Postcode: % in low-skill occupations	0.002^{***}	0.001^{***}	0.001^{***}	0.002^{***}	0.002^{***}
Postcode: % unemployed	0.009^{**}	0.005^{*}	0.004	0.010^{***}	0.003
Balance on unsecured debt (% income)	0.005^{***}	0.003^{***}	0.004^{***}	0.006^{***}	0.007^{***}
Balance on unsecured debt (% income)^2	-0.00001^{***}	-0.00001^{***}	-0.00001^{***}	-0.00002^{***}	-0.00002^{***}
Number of available products	0.002^{***}	0.002^{***}	0.002^{***}	0.002^{***}	0.001^{***}
Number of available products^2	0.000^{***}	0.000^{***}	0.000^{***}	0.000^{***}	0.000^{***}
=1 if chose familiar lender	0.270^{***}	0.261^{***}	0.270^{***}	0.213^{***}	0.143^{***}
Channel FEs	Yes	Yes	Yes	Yes	Yes
Observations	639,509	639,509	639,509	639,509	639,509

*p<0.1; **p<0.05; ***p<0.01. Standard errors are clustered on year and postcode area.