The Demand for Long-Term Mortgage Contracts and the Role of Collateral *

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Abstract

Long-term fixed-rate mortgage contracts protect households against repricing when aggregate interest rates and credit risk change. Using UK administrative data, I show that the cost of a longer-term mortgage compared to rolling over a sequence of shorter-term contracts is increasing in the loan-to-value (LTV) ratio, a measure of credit risk. High-LTV borrowers incur a "collateral term premium", in addition to a standard bond term premium. At 95% LTV, collateral term premia raise the cost of a 5-year fixed-rate contract relative to a sequence of 2-year contracts by around 70 basis points per annum. To quantify the net benefit of longer-term contracts to households, I build a life-cycle model of optimal mortgage fixation choice. Collateral term premia lower the insurance benefit of 5-year (10-year) fixed-rate contracts to high-LTV borrowers by half (two thirds). Credit risk hence affects household insurance in the interest rate dimension, leading riskier borrowers to insure less against interest rate risk.

JEL classification: D15, E43, G21, G22, G5, G52

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1. Introduction

Long-term contracts offer households protection against repricing when fundamentals change (Harris and Holmstrom, 1982, 1987). The most important financial contract based on its weight in household balance sheets is the mortgage, with loan repayment over around 30 years. Yet the period over which households fix their mortgage rate varies widely across countries, from two to five years in countries such as the UK, Canada and Australia, to 30 years in the US. More frequent repricing exposes households to different sources of repricing risk, most prominently aggregate interest rate risk, and credit risk,[1] making fixation length an important contract feature. How do households choose mortgage contract fixation length and hence insurance against repricing, and how valuable is such insurance?

A basic insurance framework suggests that risk-averse households prefer a long-term mortgage contract with no repricing risk, to rolling over two short-term mortgage contracts with a zero-mean risk in mortgage payments, with the same expected cost. I assess this prediction in UK administrative data. I find that the share of relatively long-term mortgages is decreasing in the loan-to-value (LTV) ratio, a measure of credit risk, meaning that riskier borrowers with smaller down payments insure less against repricing risk. What can explain the reduced take-up of long-term mortgage contracts relative to the simple insurance benchmark?

This paper provides a novel explanation in two steps. First, I investigate the relative cost of longer-term mortgage contracts empirically, by computing the expected yield difference between the longer-term mortgage contract compared to rolling over a sequence of short-term contracts. I find that low-LTV borrowers pay a long-term contract premium corresponding to a standard bond term premium, i.e. the yield difference between a longer-term government bond and a sequence of short-term bonds. High-LTV borrowers, however, pay an additional premium that I call "collateral term premium", meaning a term premium that is increasing in the credit dimension. Compared to the simple insurance benchmark, this introduces an additional cost for riskier borrowers. How does this affect household contract take-up and welfare? The effect on relative contract take-up by riskier borrowers is ambiguous: while riskier borrowers pay a larger long-term contract premium, they may also benefit more from insurance. Hence as a second step, I jointly evaluate households' cost and benefit of longer-term contracts using a life-cycle model of optimal mortgage fixation choice. The model takes into account the distribution and evolution of risks, as well as household risk aversion. I show that collateral term premia indeed reduce contract take-up across the LTV distribution, matching the pattern in the data.

[1] The paper abstracts from inflation risk (see Campbell and Cocco (2003) who study mortgage choice trade-offs with inflation risk). Fixed-rate mortgages are hence implicitly treated as inflation-indexed, as in Campbell et al. (2021).

I also show that they reduce the value[2] of the longer-term contract for high-LTV borrowers by half, and by an even larger proportion for contracts with longer fixation lengths. Collateral term premia hence reverse the intuition that the benefit of longer-term contracts could increase with borrower riskiness. Overall, I find that credit risk affects insurance demand for long-term mortgage contracts, leading riskier borrowers to insure less against interest rate risk.

Credit risk is an important pricing factor in mortgage contracts. Existing analysis on mortgage choice has largely focused on the US market context (Campbell and Cocco, 2003; Koijen et al., 2009; Mayer et al., 2013; Badarinza et al., 2018), where most prices embed a public credit risk guarantee provided by government-sponsored entities (Campbell, 2013). To overcome this limitation, I exploit the institutional setting of the UK, a market where high-LTV mortgage issuance is common, but where contracts reflect market pricing of credit risk. I show that market prices for high-LTV long-term mortgage contracts are relatively expensive. Another feature of the UK mortgage market is that there is frequent choice of fixation lengths, a contracting structure shared with most of the world's largest mortgage markets.[3] UK mortgage rates are typically fixed for two to five years,[4] after which the rate resets to a more expensive floating rate. These rate resets provide a regular economic incentive to refinance into new fixed-rate contracts, exposing households to intermittent repricing and contract fixation choices.

To study contract pricing and household behavior over time, I use two datasets provided by the Financial Conduct Authority (FCA), comprising the universe of UK residential mortgage originations, and stock of all outstanding mortgages. I use the full origination data to study contract pricing and choice, and build a panel dataset for a subset of borrowers between 2013 and 2017 that allows me to track refinancing behavior and loan performance for these borrowers over time.

I start by documenting the motivating fact, that longer-term contract take-up is decreasing in LTV in the data. A 95%-LTV borrower is around three times less likely than a 70%-LTV borrower to take out a 5-year contract, compared to a 2-year contract. LTV is the strongest cross-sectional predictor of 5-year contract choice when controlling for other characteristics such as loan-to-income, borrower age and loan maturity. In the UK, collateralization as measured

[2]The "value" added from a longer-term contract is defined as the consumption certainty equivalent that households would be willing to pay to add the contract to the choice set.

[3]Including Canada, Australia, Germany, Italy, Spain, Sweden, Denmark and Ireland.

[4]Throughout the paper, I refer to a long-"term" contract as a contract with a relatively longer fixation period, to indicate the interval between repricing. I focus on the most prevalent mortgage fixation lengths of two and five years, which make up around 90% of the UK market. UK variable-rate mortgages also feature rate resets, but issuance is very low in my sample period.

by LTV is the main measure of credit risk,[5] rather than household-specific creditworthiness.[6] Riskier borrowers from a credit risk perspective are hence less likely to insure against repricing risk.

I further show that the level of LTV has a large effect on the mortgage rate paid. Lenders charge a credit spread that is increasing and convex in the LTV ratio in the region between 70 and 95% LTV, i.e. mortgage rates are increasingly "collateral-sensitive" for an LTV above 70%. This credit spread is sizeable, the mortgage rate at an LTV of 95% for instance is 220 basis points higher than at 70% LTV. Credit risk pricing matters for the relative cost of long-term mortgage contracts, since the contract locks in not only the riskless interest rate, but also the credit spread.

In order to quantify the relative cost of longer-term mortgage contracts in the data, I compute the expected yield difference between the longer-term mortgage contract compared to rolling over a sequence of short-term contracts. For low-LTV borrowers, I find that the yield difference reflects the standard bond term premium, the term premium pertaining to the riskless interest rate.[7] For high-LTV borrowers, the yield difference contains the bond term premium, plus a term premium pertaining to the credit spread, which I refer to as "collateral term premium", defined as the expected mortgage yield difference above the bond term premium.[8] Forming an expectation over the path of short-term mortgage rates requires forming an expectation over future LTV. Expected loan repayment and positive house price growth imply an expected trend decline in LTV, as the numerator decreases, and the denominator, the house value, appreciates over time. For high-LTV mortgages, this means that the short-term contract sequence implies a decreasing expected mortgage rate path, reflecting the trend decline in LTV. Collateral term premia arise if this expected decline in mortgage rates is not priced into the longer-term contract.

My first main finding is to document the presence of collateral term premia, and that they significantly raise the relative cost of long-term mortgages across LTV. Given calibrated expected house price growth of 2.6 percent per annum, the rate on a 5-year 95% LTV contract held over 5 years would have to be 69 basis points lower than the 2-year rate at 95% LTV, as

[5] Mortgages are secured loans, with the house value serving as collateral, allowing lenders to sell the house to recoup the remaining loan value in case of borrower default, so the higher the LTV, the greater the loss that the lender may incur at default. LTV could also be positively correlated with the probability of default (Gupta and Hansman, 2021).

[6] Lenders have "full recourse" in the UK, meaning they can recover losses from defaulted borrowers though their assets and incomes for up to seven years, until the debt is paid (Aron and Muellbauer, 2016), which may help explain why measures of household-specific creditworthiness such as the FICO score are only accounted for via a minimum threshold at loan application, but result in minimal price variation conditional on LTV (as shown by Robles-Garcia (2020)).

[7] I indeed find that this measure tracks banks' funding cost spread between longer and shorter maturity interest rate swap rates.

[8] This can be thought of as an extension of the expectations hypothesis of the term structure (Campbell and Shiller, 1991) for mortgage rates, which depend on LTV, in addition to aggregate interest rates.

the latter is expected to be refinanced with 2-year contracts at lower LTV levels. The shorter-term mortgage contract sequence hence allows high-LTV borrowers to capitalize decreases in credit spreads over time. Translating collateral term premia into a total cost measure for a representative household, inclusive of bond term premia and refinancing cost, implies that borrowers with an LTV greater than 80% expect to pay between 8 to 13 percent more for a 5-year contract, compared to a sequence of 2-year contracts. This number is only 4 percent for borrowers with an LTV of 70% or less.

What could cause collateral term premia in longer-term mortgage rates? I evaluate a range of potential mechanisms. The relative pricing of longer-term contracts seems consistent with lenders requiring compensation for the inability to reprice evolving risks, and bearing house price risk. A collateral term premium of zero for high-LTV contracts would require lenders to price in a forward-looking LTV path, and implicitly bear risk of future house price developments over the fixation horizon of the longer-term contract. The findings may be consistent with the lack of financial instruments available to hedge aggregate house price risk, as observed by Shiller (2014) and Fabozzi et al. (2020).

I also consider information frictions. Borrowers may strategically select into fixation lengths (Flannery, 1986; Diamond, 1991; Hertzberg et al., 2018) if they have private information about future repricing risks, which could be more relevant at higher LTV bands. I find limited evidence for net adverse selection into longer-term contracts. I find that ex ante measures of risk such as local house price volatility are weakly negatively correlated with 5-year take-up. Ex post default rates within a given LTV band are similar across contract types, with the caveat that the sample window reflects a time period with relatively stable house price growth and low overall rates of default. A related long-term contracting problem is selective household attrition over time (Hendel and Lizzeri, 2003; Handel et al., 2015; Nelson, 2018): households who receive better shocks ex post can leave the borrower pool over time, such that lenders retain an adversely selected pool. In contrast, I find that attrition is minimal over the initial fixation length, likely due to significant prepayment penalties in this market.[9]

How do collateral term premia affect household contract take-up and welfare? Intuitively, they drive a cost wedge into the simple insurance framework, as they imply that longer-term mortgage contracts are priced above the expected cost of the short-term contract sequence. However, the effect on relative contract take-up by riskier borrowers is ambiguous: while riskier borrowers pay a larger long-term contract premium, they may also benefit more from insurance. To address this, I jointly evaluate households' cost and benefit of longer-term contracts using a life-cycle model of optimal mortgage fixation choice given house price, income and interest rate

[9] Mortgages in the UK have prepayment penalties of about 3 to 5% of the loan value throughout the initial fixation period.

risk, and taking into account the degree of household risk aversion and the distribution of risks and their evolution over time.

In the model, households optimally choose between two contract fixation lengths throughout the life of the loan, with repricing based on realized loan-to-value ratios and aggregate interest rates at the end of each fixation period. For a given level of net wealth and aggregate interest rate state, the model generates boundaries in the LTV-time space for optimal fixation choice. In the baseline calibration with moderate house price growth and volatility, households prefer the 2-year to the 5-year contract whenever the LTV is in the collateral-sensitive pricing region. I then use the optimal mortgage choice function to simulate household behavior.

The model generates two further findings. First, the model results in decreasing 5-year contract take-up across the LTV distribution, matching the pattern in the data. In the baseline calibration, 5-year mortgage take-up for borrowers with an initial LTV of 95%, measured over the initial ten years since loan origination, is around 30% compared to low-LTV borrowers with an LTV of 70%. Second, I use the model to compute households' value of being able to access a longer-term contract in addition to a shorter-term contract, as a standard consumption certainty equivalent. I find that collateral term premia reduce the value of longer-term contracts for high-LTV borrowers by half, and by an even larger proportion for contracts with longer fixation lengths. This is done by comparing contract choice taking collateral term premia as given, with a counterfactual pricing scenario where longer-term contracts are priced at the expected cost of the shorter-term contract sequence, i.e. setting the collateral term premium to zero. As a second type of counterfactual, the model allows me to assess the net benefit of hypothetical mortgage contracts with fixation lengths longer than five years.[10] I evaluate household demand for an even longer-term contract, a 10-year contract. While the insurance benefit doubles for low-LTV borrowers, to 2.03% of lifetime consumption, the value is only a third of this, 0.74%, for high-LTV borrowers, a larger proportional decrease compared to the 5-year contract.

To summarize, I find that credit risk affects insurance demand for long-term mortgage contracts. I highlight a tension between households' insurance motive, and the term premia they incur when they lock in their rates for longer. Collateral term premia reduce the benefit of having longer-term contracts available to riskier borrowers.

The results shed light on cross-country differences in mortgage market outcomes (Campbell, 2013). In a setting where contracts reflect market pricing of credit risk (and with binding prepayment penalties), collateral term premia may help explain why the most common mortgage fixation lengths are relatively short, up to ten years. I show that collateral term premia generate decreasing 5-year contract take-up across the LTV distribution. With borrowers above 85%

[10] Holding credit pricing constant, in this case assuming pricing as for 5-year fixed-rate contracts.

LTV accounting for around half of new origination volume by first-time buyers in the UK, they reduce demand for longer-term contracts for a significant and policy-relevant part of the borrower population. The findings also raise the question to what extent house price risk is borne by households, rather than lenders, and open questions for future research on the role of insurance provision by financial intermediaries.

The results are important from a policy perspective and highlight potential issues for market reform. A common policy goal is to encourage homeownership, which often involves supporting the availability of high-LTV mortgages. Long-term contracts may further aid affordability if they allow riskier borrowers to lock in low interest rates for longer and mitigate repricing risk. This paper suggests that in the presence of substantial collateral term premia, the insurance benefits of longer-term contracts largely accrue to low-LTV borrowers, which is important from an inequality perspective. Extending these to high-LTV borrowers may require additional policy measures or changes to contract design.[11] Collateral term premia are further relevant from a monetary policy perspective, as the relative cost of long-term contracts for high-LTV borrowers influences the length over which their mortgage rates are locked in, and hence the monetary transmission mechanism.

1.1. Related Literature

The paper contributes to several strands of literature. Household choice of mortgage fixation length is an important part of the household risk management problem. This paper adds to the existing literature which has focused on the US institutional framework (Campbell and Cocco, 2003; Koijen et al., 2009) and the choice between fixed and adjustable-rate mortgages (Badarinza et al., 2018). In a setting without public credit risk guarantees, the paper highlights the role of credit risk and collateral pricing for mortgage fixation choice.

The findings further relate to long-term contracting and contract choice given dynamic repricing risks (Harris and Holmstrom, 1982, 1987; Hendel and Lizzeri, 2003; Brunnermeier and Oehmke, 2013; Handel et al., 2015, 2017; Hertzberg et al., 2018; Nelson, 2018).[12] Previous papers have studied the front-loaded nature of pricing (e.g. Hendel and Lizzeri, 2003) to overcome dynamic contracting problems. In the mortgage market setting with prepayment penalties, I show that lender pricing places a collateral term premium on the long-term contract, which reduces take-up for riskier borrowers despite effective commitment over the fixation horizon.

[11] For instance in Denmark, collateralized mortgage loans are only available up to an LTV of 80%. Borrowers can then borrow an unsecured loan to raise their LTV up to 95%. This way, aggregate interest rates can be locked in at origination, while the risky portion of the loan can be repaid separately.

[12] Also referred to as rollover risk in corporate finance (e.g., Acharya et al., 2011; He and Xiong, 2012; Choi et al., 2018), and reclassification risk in insurance markets (e.g., Handel et al., 2015; Hendel, 2017).

This seems to reflect the importance of house price risk and lender willingness to bear that risk (Shiller and Weiss, 1999; Shiller, 2014) in this market.

The findings are in line with research emphasizing the role of house price risk and collateral sensitivity for household behavior in the mortgage market (Palmer, 2015; Fuster and Willen, 2017; DeFusco and Mondragon, 2018; Ganong and Noel, 2020). Frequent repricing has large effects on mortgage rates for high-LTV borrowers, which are very collateral-sensitive, overriding their insurance demand against interest rate risk. The paper hence also emphasizes the interactive effects of competing sources of repricing risk on mortgage contract choice.

The length over which households lock in their interest rates further affects the macroeconomic transmission mechanism from monetary policy to households (Greenwald, 2018; Beraja et al., 2019; Wong, 2019; Andersen et al., 2020) and is relevant for the on-going policy debate about optimal mortgage contract and market design (Lucas and McDonald, 2006; Mayer et al., 2009; Campbell, 2013; Eberly and Krishnamurthy, 2014; Mian and Sufi, 2015; Greenwald et al., 2017; Campbell et al., 2021; Piskorski and Seru, 2018; Guren et al., 2018). The most closely related papers are by Dunn and Spatt (1985, 1988) and Mayer et al. (2013) who study the risk-sharing effects of enforcing commitment with long-term mortgage contracts via prepayment penalties in the US context. My paper suggests that pooling in longer-term contracts in the high-LTV segment may be difficult to sustain under market pricing of credit risk, even with binding prepayment penalties, as collateral term premia provide strong incentives for high-LTV borrowers to choose shorter-term contracts.

I further quantify the net insurance benefit of longer-term mortgage contracts using comprehensive micro-data and a life-cycle model of mortgage fixation choice, linking to influential work on mortgage choice by Campbell and Cocco (2003, 2015), and similar approaches in other insurance markets (see e.g., Brown and Finkelstein, 2008).

This paper is organized as follows. Section 2 introduces the institutional framework and data. Section 3 outlines stylized facts. Section 4 provides a decomposition of the relative cost of longer-term mortgages and an empirical mapping. Section 5 evaluates mechanisms that could explain the relative cost of longer-term mortgages. Section 6 develops the model and discusses results, and Section 7 concludes.

2. Institutional Setting and Data

This section provides background on the UK mortgage market and the typical mortgage contract structure, and provides a brief summary of the data, with more detail provided in appendix B.

2.1. UK Fixed-Rate Mortgages and Institutional Setting

Fixed-Rate Mortgage Contract Structure. The dominant mortgage product in the UK is a fixed-rate contract that resets automatically to a revert rate at the end of the initial fixation period, for the remainder of the loan maturity, unless the borrower refinances into a new contract.[13] The initial fixation period is typically two or five years. The revert rate is priced at a spread to a floating base rate, the Bank of England's Bank Rate, and this spread has been around 300 to 400 basis points since 2009. Figure A.1 in the appendix illustrates the payment profile for a typical fixed-rate mortgage and is further explained below. The rate reset provides a regular economic incentive to refinance into another fixed rate contract,[14] in which case the contract is repriced.[15] 80 to 90% of first-time buyers refinance within six months of the reset date, consistent with findings by Cloyne et al. (2019), as the loan balance especially in the initial years since loan origination is usually sufficiently high to warrant refinancing.

Mortgage Contract Characteristics. Mortgage contracts typically specify the maturity over which the loan is repaid, most commonly between 25 and 35 years; the interest rate; initial fixation period; the rate type over the initial period (fixed or floating); and prepayment penalty due if households prepay and terminate the contract within the initial fixation period. Mortgage interest rates differ by rate type, loan-to-value ratio, and sometimes borrower type (first-time borrower, home mover or refinance), but not other borrower characteristics. Borrowers go through an approval process where lenders screen applications using minimum criteria related to the current age, age at loan repayment, loan maturity, loan-to-income ratio, credit score and credit history. Subject to passing these lender criteria, risk-based pricing is predominantly done across the LTV dimension, in contrast to the US which features variation in mortgage guarantee fees along the LTV and FICO score dimensions (Gerardi, 2017). UK mortgage rates are priced across LTV bands in steps of five percentage points, starting from an LTV pricing threshold of 60 to 70%, up to an upper bound of 95% LTV.[16] In addition, rates are typically posted prices that apply across the UK and not further negotiated, in contrast to the US and other markets.

[13]The paper focuses on fixed-rate as opposed to floating or adjustable-rate mortgages, but the contract structure is analogous in adjustable-rate mortgages which reset at regular time periods. In the UK, adjustable-rate mortgages feature an initial spread over a floating base rate, which can reset to a larger spread after an initial discounted period and hence provides similar incentives to refinance intermittently. Over the sample window, the share of floating-rate mortgages is very low, at about 4% of all mortgages originated.

[14]Depending on other factors that affect optimal refinancing such as loan size, the interest rate incentive, and the cost of refinancing (Agarwal et al., 2013; Fisher et al., 2021).

[15]In the US mortgage market, this type of product would typically be referred to as a "hybrid" adjustable-rate mortgage (ARM).

[16]The resulting step function pricing schedule can be verified in posted prices on offer, as well as realized interest rates (see e.g. Best et al., 2020).

Repricing. Around two thirds of mortgages are refinanced with their existing lender, while the remaining third change lenders. Lenders typically do not carry out new credit or affordability checks for their existing customers (FCA, 2018), meaning that the majority of households only faces repricing risk based on aggregate interest rates and LTV, rather than changes to household-specific creditworthiness and income. For these borrowers, the property value is also typically not externally re-appraised but adjusted based on changes to local property prices.

Prepayment Penalties. Mortgage contracts feature prepayment penalties over the initial fixation period in case of early repayment, and vary from around 3 to 5% of the outstanding loan balance. Some prepayment terms offer free partial early repayment, such as 10% of the loan value per year. Prepayment terms are not collected as part of the administrative mortgage data, but previous research using complementary data on the universe of mortgage contracts on offer shows that they do not vary substantially and systematically over time or across lenders (Liu, 2019).

2.2. Dataset Construction

Data Overview. This subsection describes the data and provides a brief overview of the main dataset construction. A more detailed description is provided in appendix B. My main data source is the Product Sales Database (PSD), a comprehensive loan-level dataset on residential mortgages in the UK, collected by the Financial Conduct Authority (FCA), and accessed via a data-sharing agreement with the Bank of England. The data comprise the universe of new loan originations at quarterly frequency (PSD001), and also track the stock of all outstanding mortgage loans issued by all regulated financial institutions in the UK at semi-annual frequency (PSD 007). The datasets have been used in a range of academic studies (e.g. Cloyne et al., 2019; Best et al., 2020; Robles-Garcia, 2020; Belgibayeva et al., 2020; Benetton, 2021). I use both the PSD001 loan origination data from January 2013 to December 2017, and a merged subset of the data that combines the information at loan origination with the stock of all outstanding mortgages between 2015 and 2017 in the PSD007 data, which further includes information on refinancing status, interest rate paid and loan performance reported in semi-annual snapshots. The merged data forms a borrower-level panel that is tracked at semi-annual frequency.

Data on New Mortgage Originations (PSD001). The dataset collects detailed borrower characteristics such as income, age, address, loan amount, property value, and detailed loan characteristics such as the loan maturity, interest rate, fixed-rate window, and which lender originated the mortgage. I use the origination data between 2013Q1 to 2017Q4 for the pricing analysis and results that do not require the borrower panel dimension, containing around 2.9 million loans. I further use the data to identify first-time buyer cohorts who newly originate their mortgage between 2013H2 to 2015H1 to create the borrower panel. The origination data prior to 2015H1 does not require to report the fixed-rate window, so I do not observe the fixed-rate window for about 40% of first-time borrowers. The sample for which fixed-rate windows are observed appears to be a highly balanced sample compared to where it is not observed, as noted by Best et al. (2020) and demonstrated in Table A.3 in the appendix. The sample for which the fixed-rate window is observed contains 414,643 first-time borrowers.

Data on the Stock of All Outstanding Mortgages (PSD007). The stock data contains information on the current interest rate type, current interest rate paid, current loan amount, current lender, and whether the loan is in arrears. I create the borrower panel by merging first-time buyer cohorts from the origination data with stock data waves 2015H1 to 2017H2, to track refinancing behavior and outcomes over time.[17]

Data Merge. The origination and stock datasets do not have unique borrower identifiers, but a borrower can be identified up to an (anonymized) date of birth and six-digit postcode, which is approximately the building block in which a UK household resides. The merge using this borrower identification is almost comprehensive, with only 1.8% of first-time borrowers in 2015H2 not matched to the stock data in 2015H2, which provides an estimate of unmatched observations driven by pure merging error. This results in a panel of around 2.8 million borrower-half-year observations. Lastly, I supplement the merged dataset with administrative data on UK house prices from HM Land Registry, using house price indices at local-authority administrative unit-level (with data going back to 1995), and merging these at the local-authority level based on borrower location.

3. Stylized Facts

This section presents three stylized facts to motivate the results in the following sections.

3.1. Longer-Term Contract Take-Up Is Decreasing in LTV

Which households choose a 5-year relative to a 2-year fixed rate contract? The following illustrates broad patterns in the data. A striking relationship is that the 5-year contract share is

[17]This builds on and extends previous research that has used the loan origination data (Cloyne et al., 2019), and a merged snapshot of the mortgage stock data (Belgibayeva et al., 2020).

decreasing in LTV. Figure 1 shows the initial fixation period chosen by borrowers across different initial LTV bands. At 50-70% LTV, contract choice is roughly split, with 57% of borrowers choosing a 2-year contract,[18] and 43% of borrowers choosing a contract with a fixation period of 5 years or longer. The 5-year contract share decreases consistently across LTV bands, with only 16% of borrowers at an LTV of 90-95% choosing a 5-year fixation window, which are thus about a third as likely to choose the longer-term contract relative to the borrowers in the lowest LTV band.

This effect holds when controlling for other covariates. Table 1 estimates the effect of household covariates on the probability of choosing a 5-year contract relative to a 2-year contract, using a linear probability model. The dependent variable is an indicator that takes the value 1 if a household chooses a 5-year contract, and 0 otherwise. Household covariates include the loan-to-value ratio, loan-to-income (LTI) ratio, borrower age (linear and square term), mortgage maturity, local house price growth, house price volatility and house price beta, and are converted to standard deviations of the variable. Local house price growth is measured as growth two years prior to the choice of contract, local house price volatility is computed as the rolling 10-year volatility in log house price returns, while house price beta is computed as a rolling 10-year beta of local house price returns with respect to aggregate UK house price returns.[19] Columns (1) and (2) include local house price volatility and beta, respectively, and control for time (year-month), region, region×time, lender, lender×time, and borrower-type fixed effects. Column (3) further includes local-authority×time instead of region×time fixed effects.

Households who choose a 5-year contract relative to a 2-year contract tend to have a lower LTV, slightly higher LTI,[20] lower mortgage maturity, and lower local house price growth and house price beta. 5-year choice also has an inverse-u-shaped relationship with age, as the linear coefficient on age is positive, but the squared coefficient is negative. This provides suggestive evidence that 5-year contract choice seems to be negatively correlated with measures of financial constraints, such as older age and mortgage maturity, but also negatively correlated with household riskiness, based on measures of local house price risk and LTV. In particular, LTV seems to be the most quantitatively important variable, as a one standard deviation increase in LTV decreases the probability of taking out a 5-year contract by around 20%, controlling for these other channels.

[18] This includes few contracts that have 1 to 3-year fixation windows.

[19] "Local" refers to a local-authority-level of aggregation which is a typical administrative unit in the UK, with 415 local authorities with an average population of around 200,000, similar to counties in the US.

[20] Using UK survey data, Cocco (2013) finds that future income growth is most closely correlated with LTI.

3.2. LTV Is The Main Mortgage Pricing Variable

The importance of LTV in contract choice may be related to LTV being the main pricing variable and measure of credit risk in the UK. I verify this institutional feature by replicating analysis by Benetton (2021); Robles-Garcia (2020) who regress observed mortgage rates on a range of fixed effects, including time, lender, buyer type, fixation length, and all interaction effects. Figure A.3 in the appendix reports the adjusted R^2s from these regressions. When comparing the inclusion of different household covariates, the marginal increase in R^2 is highest when including the LTV band fixed effects, with the adjusted R^2 rising from about 55% to around 85%, while the inclusion of income and age deciles leads only to an increase of a few percentage points.

Figure A.4 illustrates the pricing of LTV by showing the credit spread paid on 2-year fixed-rate mortgages across loan-to-value (LTV) bands, extracted as LTV-band fixed effects from a regression of interest rates on LTV bands and fixation period length (2 or 5 years), controlling for year-month, lender, buyer-type, year-month$\times$lender fixed effects. Below the lower LTV threshold of 70% LTV, interest rates typically do not vary with changes in LTV, which I refer to as the "collateral-insensitive" pricing region. Starting from an LTV of 70% LTV, mortgage rates become increasingly sensitive to the level of LTV and rise in LTV bands of 5 percentage points, up to the highest LTV band of 90-95% LTV, above which very few mortgages are originated and households pay the revert rate. The region between 70% to 95% LTV can be thought of as the "collateral-sensitive" mortgage pricing region.

3.3. Initial Fixed-Rate Periods Across Countries Are Relatively Short

In the UK, fixation periods are predominantly two or five years, with less than 1% of borrowers taking out products with longer fixation windows. These numbers seem comparable across a range of advanced economies, as shown in Figure A.2. The average fixation period is around 2 to 2.5 years in the UK, Greece and Spain, around five years in the Netherlands and Italy, around ten years in Denmark and Germany, followed by a significant jump to almost 25 years for the US. The data is taken from Badarinza et al. (2016) and so does not include averages for Canada and Australia, where the most common range of products is between 2 and 5 years.[21] This demonstrates that findings in the context of the UK mortgage market may have broader applicability across most mortgage markets in the world.

As a first step towards understanding these patterns in mortgage choice, the next section studies the relative cost and pricing of longer-term mortgage contracts.

[21] In addition, France seems to be one of the few other countries to have similarly long fixation periods as the US.

4. Relative Cost of Longer-Term Mortgages

This section shows that the relative cost of longer-term mortgages, the expected yield difference between the longer-term mortgage and sequence of shorter-term contracts, can be decomposed into two parts: a standard bond term premium, and a collateral term premium. Intuitively, the latter reflects an additional term premium in the credit dimension, in this case a collateral term premium that is increasing in the initial LTV level, which raises the cost of longer-term mortgage contracts for riskier borrowers, over and above the bond term premium.

The decomposition can be thought of as an extension of the expectations hypothesis of the term structure (Campbell and Shiller, 1991) for mortgage rates, which depend on LTV, in addition to aggregate interest rates. Under the assumption that mortgages with an LTV below the lower pricing threshold are essentially collateral-risk free, the expected mortgage yield difference measured at the lowest LTV band of 70% reflects the standard bond term premium. In the data, I indeed find that this measure closely tracks the funding cost spread between longer and shorter maturity interest swap rates.

The collateral term premium is the term premium over and above the bond term premium, for mortgages with an LTV above 70%. It arises from two sources. First, there could be pure credit pricing differences across mortgages of different fixation lengths, e.g. the 5-year 95% LTV mortgage rate could be higher than the 2-year 95% LTV rate (referred to as $\Delta\rho$). Second, computing the expected yield difference for mortgage rates requires forming an expectation over the future LTV path. With expected loan repayment and positive house price growth, there is an expected trend decline in LTV, as the numerator decreases, and the denominator, the house value, appreciates over time. For higher-LTV mortgages, this means that the shorter-term contract sequence reflects an expected decline in mortgage rates with LTV repricing, relative to no LTV repricing (with the difference referred to as Δr), due to the trend decline in LTV. For the collateral term premium to be zero, i.e. for long-term mortgages to be priced at the expected cost of the shorter-term contract sequence, long-term mortgages would have to price in the expected declining rate path of the shorter-term contract sequence ($\Delta\rho = -\Delta r$). The result of the decomposition is summarized in Figure 2.

In the data, for high-LTV loans, I find that the second channel dominates and raises the collateral term premium with initial levels of LTV. I compute the expected short-term rate path with LTV repricing every two years, given calibrated expected house price growth of 2.6 percent per annum. To offset the decreasing expected short-term rate path over time, the rate on a 5-year 95% LTV contract held over 5 years would have to be 69 basis points lower than the 2-year rate at 95% LTV, respectively. In the data, the actual 5-year rate is very similar to the 2-year rate at 95% LTV. Translating this into a total cost measure for a representative household, inclusive of bond term premia and refinancing cost, observed prices imply that high-LTV borrowers (with an LTV greater than 80%) expect to pay between 8 to 13 percent more for a 5-year contract, compared to taking out a sequence of 2-year contracts. This number is only 4 percent for borrowers with an LTV of 70% or less. The following outlines the decomposition in more detail.

4.1. Decomposition

Denote the per-period mortgage rate $r_t^{m,\theta}$ where superscript m refers to the mortgage rate, and $\theta \in \{\theta^{ST}, \theta^{LT}\}$ is the length (in years) over which the rate stays fixed. Further denote the expected difference between the longer-term θ^{LT}-period mortgage rate, and the average rate when rolling over a sequence of shorter-term θ^{ST}-period contracts given an initial LTV as $\Delta^{\theta^{LT},\theta^{ST}}(LTV_t)$:[22]

$$\Delta^{\theta^{LT},\theta^{ST}}(LTV_t) \equiv E_t\left[r_t^{m,\theta^{LT}}(r_t, LTV_t) - \frac{1}{n}\sum_{i=0}^{n-1} r_{t+\theta^{ST}\times i}^{m,\theta^{ST}}(r_{t+\theta^{ST}\times i}, LTV_{t+\theta^{ST}\times i})\right], \quad n = \theta^{LT}/\theta^{ST}. \tag{1}$$

For notational simplicity, let $\theta^{LT} = n \cdot \theta^{ST}$ where n is an integer. Both the longer-term mortgage rate $r_t^{m,\theta^{LT}}$ and the shorter-term rates $r_t^{m,\theta^{ST}}$ depend on the base (i.e. aggregate) interest rate r_τ, and LTV_τ at the time of pricing τ. For the longer-term mortgage rate, the mortgage is priced in the initial period t. For the shorter-term rate sequence, the rate gets repriced with each new contract, i.e. every θ^{ST} years. By adding and subtracting the average of the sequence of shorter-term rates at current LTV levels, the expression can be rewritten as:

$$\begin{aligned}\Delta^{\theta^{LT},\theta^{ST}}(LTV_t) = {} & E_t\left[r_t^{m,\theta^{LT}}(r_t, LTV_t) - \frac{1}{n}\sum_{i=0}^{n-1} r_{t+\theta^{ST}\times i}^{m,\theta^{ST}}(r_{t+\theta^{ST}\times i}, LTV_t)\right] \\ & + E_t\left[\frac{1}{n}\sum_{i=0}^{n-1}\left(r_{t+\theta^{ST}\times i}^{m,\theta^{ST}}(r_{t+\theta^{ST}\times i}, LTV_t) - r_{t+\theta^{ST}\times i}^{m,\theta^{ST}}(r_{t+\theta^{ST}\times i}, LTV_{t+\theta^{ST}\times i})\right)\right]\end{aligned} \tag{2}$$

The first term in equation 2 can further be split into an LTV-insensitive part of the mortgage rate, where $LTV \leq \underline{x}$, with the LTV pricing threshold $\underline{x}$ typically being 60 to 70%, and the remaining LTV-sensitive part for which $LTV > \underline{x}$. Define $r_t^{m,\theta}(r_t) \equiv r_t^{m,\theta}(r_t, LTV_t \mid LTV_t \leq \underline{x})$, i.e. assuming that mortgage rates in the lowest LTV band are essentially collateral risk-free, LTV can be omitted in the notation for mortgage rates with an LTV below $\underline{x}$. And denote

[22] This builds on the framework by Campbell and Shiller (1991) for risk-free bonds.

$\rho_t^{\theta,LTV}$ the credit spread, i.e. the rate difference between a mortgage with fixation length θ with some LTV, and the LTV-insensitive mortgage rate with an LTV below $\underline{x}$:

$$\rho_t^{\theta,LTV} = r_t^{m,\theta}(r_t, LTV_t) - r_t^{m,\theta}(r_t). \tag{3}$$

Combining equations 2 and 3, we obtain

$$\begin{aligned}\Delta^{\theta^{LT},\theta^{ST}}(LTV_t) = {} & \underbrace{E_t\left[r_t^{m,\theta^{LT}}(r_t) - \frac{1}{n}\sum_{i=0}^{n-1} r_{t+\theta^{ST}\times i}^{m,\theta^{ST}}(r_{t+\theta^{ST}\times i})\right]}_{\text{(I) Bond Term Premium } \kappa^{\theta^{LT},\theta^{ST}}} \\ & + \underbrace{E_t\left[\rho_t^{\theta^{LT},LTV_t} - \frac{1}{n}\sum_{i=0}^{n-1} \rho_{t+\theta^{ST}\times i}^{\theta^{ST},LTV_t}\right]}_{\text{(II) LTV Pricing Differential } \Delta\rho^{\theta^{LT},\theta^{ST}}(LTV_t)} \\ & + \underbrace{E_t\left[\frac{1}{n}\sum_{i=0}^{n-1}\left(r_{t+\theta^{ST}\times i}^{m,\theta^{ST}}(r_{t+\theta^{ST}\times i}, LTV_t) - r_{t+\theta^{ST}\times i}^{m,\theta^{ST}}(r_{t+\theta^{ST}\times i}, LTV_{t+\theta^{ST}\times i})\right)\right]}_{\text{(III) Rate Path Differential with LTV Repricing } \Delta r^{m,\theta^{ST}}(LTV_t)}.\end{aligned} \tag{4a}$$

Combining the last two terms (II and III) as the collateral term premium

$$\phi^{\theta^{LT},\theta^{ST}}(LTV_t) \equiv \Delta\rho^{\theta^{LT},\theta^{ST}}(LTV_t) \; + \Delta r^{m,\theta^{ST}}(LTV_t) \tag{4b}$$

we can write

$$\Delta^{\theta^{LT},\theta^{ST}}(LTV_t) = \underbrace{\kappa^{\theta^{LT},\theta^{ST}}}_{\text{(I) Bond Term Premium}} + \underbrace{\phi^{\theta^{LT},\theta^{ST}}(LTV_t)}_{\text{(II) + III = Collateral Term Premium}}. \tag{4c}$$

Equation 4 decomposes the expected yield difference between the longer-term mortgage contract and sequence of shorter-term contracts into two parts: the first is a familiar-looking expression based on the expectations theory of the term structure of interest rates (Campbell and Shiller, 1991), i.e. a bond term premium κ that is independent of the level of LTV. I later show that this bond term premium in mortgage rates of differing fixation lengths maps to the funding cost differential between interest rate swap rates of differing maturities. The second term is a collateral term premium ϕ, i.e. a term premium over and above the lowest LTV band, which depends on the level of collateral, captured by LTV. It has two components: first, the expected credit pricing differential in interest rate premia for a given current LTV (i.e. initial LTV at origination time t) between the longer-term and shorter term contracts ($\Delta\rho^{\theta^{LT},\theta^{ST}}(LTV_t)$). And second, the yield difference between the shorter-term mortgage sequence with and without LTV repricing ($\Delta r^{m,\theta^{ST}}(LTV_t)$). This component reflects the short-term rate path differential due to changes in credit risk over the long-term contracting horizon. In the data, I show that the collateral term premium is positive and increasing in LTV, due to a positive or zero LTV pricing differential, and a positive rate path differential given a declining LTV risk profile over time, with positive expected house price growth and loan repayment. In contrast, for the collateral term premium to be zero, the pricing differential between long-and short-term mortgages would have to be negative, in order to offset the expected declining rate path of the shorter-term contract sequence.

4.2. Mapping Pricing Decomposition to the Data

This subsection maps the components of the mortgage term premium to the data, and summarizes the results in Table 2.

To provide a concrete example of equation 4 and to map it to the data on 2 and 5-year fixed-rate mortgages, let $\theta^{LT} = 5$ and $\theta^{LT} = 2$. For t=0 and an initial LTV (LTV_t) of 90% we get:[23]

(5)

$$\Delta^{5,2} = \underbrace{E_0\left[r_0^{m,5}(r_0) - \frac{1}{2.5}\left(r_0^{m,2}(r_0) + r_2^{m,2}(r_2) + \frac{1}{2}r_4^{m,2}(r_4)\right)\right]}_{\text{(I) Bond Term Premium } \kappa^{5,2}}$$

$$+ \underbrace{E_0\left[\rho_0^{5,90} - \frac{1}{2.5}\left(\rho_0^{2,90} + \rho_2^{2,90} + \frac{1}{2}\rho_4^{2,90}\right)\right]}_{\text{(II) LTV Pricing Differential } \Delta\rho^{5,2}(90)}$$

$$+ \underbrace{E_0\left[\frac{1}{2.5}\left(r_0^{m,2}(r_0,90) + r_2^{m,2}(r_2,90) + \frac{1}{2}r_4^{m,2}(r_4,90) - \left(r_0^{m,2}(r_0,90) + r_2^{m,2}(r_2,LTV_2) + \frac{1}{2}r_4^{m,2}(r_4,LTV_4)\right)\right)\right]}_{\text{(III) Rate Path Differential with LTV Repricing } \Delta r^{m,\theta^{ST}}(LTV_t)}$$

The following discusses the empirical equivalents of equation 5 for different levels of initial LTV.

(I) Bond Term Premium and Funding Cost Spread (κ). I shows that variation in the bond term premium over time is captured well by variation in duration-matched swap rates and hence maps to lenders' relative funding cost. Lenders typically enter a swap contract which matches the initial fixation period of the mortgage contract to hedge interest rate exposure, by paying a floating rate plus premium and receiving a fixed rate for funding. The 5-year mortgage contract requires a 5-year swap rate, while the 2-year contract requires a 2-year swap rate. Figure A.5a shows the time-series variation in 5-year and 2-year fixed rate mortgage rates from 2013 to 2017 using monthly averages, based on an LTV less or equal to 70%. The 5-year rate lies above the 2-year rate throughout, consistent with a positive bond term premium included in the 5-year mortgage rate relative to the 2-year rate. Figure A.5b shows the difference between the 5-year and 2-year mortgage rate at 70% LTV, i.e. the term premium κ as defined above, as well as the funding cost spread between 5-year and 2-year interest swap rates which appear strongly

[23] Note that because in this case θ^{LT}/θ^{ST} is not an integer, the last 2-year contract is divided by two to reflect the same contract horizon as $\theta^{LT} = 5$.

correlated. The bond term premium is around 50 basis points over this period.

(II) Interest Premium for a Given LTV and LTV Pricing Differential ($\Delta\rho$). Column 1 in Table 2 compares pricing across 5-year and 2-year contracts by computing the credit pricing differential $\Delta\rho$ across the LTV distribution. This differential is positive at an LTV up to 85%, and around zero and similar to 2-year contracts, for high LTV levels greater than 85%. In order to arrive at this result, I first compute $\rho_t^{\theta,LTV}$ by extracting the credit spread paid across LTV bands for 2 and 5-year contracts relative to the lowest LTV band ($\leq 70\%$) from the data. I follow the typical pricing schedule which varies across LTV bands in steps of five percentage points, starting from the LTV pricing threshold $\underline{x} = 70\%$. Figure 3a plots the credit spread paid across LTV bands, [0-70]%, (70-75]%, (75-80]%, (80-85]%, (85-90]%, and (90-95]%), extracted from a pooled regression of interest rates on LTV bands and fixation period length (two or five years), controlling for year-month, lender, buyer-type and year-month$\times$lender fixed effects, using data from 2013 to 2017.[24] The interest rate premia are estimated jointly for 2-year and 5-year fixed rate contracts in the same regression, with 2-year fixed rate contracts as the base category, and 5-year fixed rate contracts with an additional interaction term.[25] For a borrower with an LTV up to 80%, the credit spread paid relative to a mortgage up to 70% LTV is between 15 and 32 basis points, and for an LTV up to 95%, these numbers rise to 213 and 217 basis points. This means that LTV credit spreads at origination are also quantitatively important and relatively high for most borrowers - more than half of borrowers take out a mortgage with an initial LTV greater than 80 and up to 95%. For comparison, the standard deviation in real interest rates in the UK is 0.0193, or 193 basis points, between 1987 and 2017.

(III) Expected Rate Path Differential with LTV Repricing ($\Delta r(LTV)$). Column 2 in Table 2 shows the expected rate path differential $\Delta r^{m,\theta^{ST}}(LTV_t)$ by computing the difference between the short-term rate given the initial LTV, and the average short-term rate path with repricing of LTV over time. This rate path differential is close to zero for an LTV below 85%, and rises to 69 basis points for an LTV of 95%. In order to compute the expected rate path with LTV repricing, I calibrate the house price process using UK data from 1987 to 2017. Real house prices are assumed to follow a lognormal distribution and are calibrated to have mean $\mu_h = 0.0258$ and standard deviation $\sigma_h = 0.0770$. Nominal house prices are deflated using RPI. The simulation is done for a fully-amortizing loan, repaid over 30 years.

[24] As a robustness check, the magnitudes remain very similar when estimating the regression on the full origination data between 2005Q2 and 2017Q4, and including more loan-specific fixed effects and household controls.

[25] In addition, the term premium κ can also be directly extracted from this regression, as the average difference between 2 and 5-year fixed rate contracts for the $\leq$70% LTV band, yielding 53 basis points, which is very similar to aggregate data of 52 basis points using the Bank of England Database.

Collateral Term Premia. Column 3 in Table 2 computes the collateral term premium as the sum of the LTV Pricing Differential (in column 1) and Rate Path Differential (in column 2), and is plotted in Figure 3. The collateral term premium rises from 18 basis points at 75% LTV, to 72 basis points at 95% LTV. The overall mortgage term premium is hence increasing in LTV, implying that the cost of insurance via longer-term contracts is increasing in borrower riskiness. Two alternative ways of framing the magnitude of the collateral term premium are outlined in the following.

Expected Cost Pricing (Collateral Term Premium of Zero). An alternative way to interpret Column 2 in Table 2 is to think of the rate path differential as the magnitude by which the 5-year contract should be cheaper than the 2-year contract - i.e. for the collateral term premium to be zero, 5-year contracts would have to price in the declining expected rate path of the 2-year contract sequence, and the 5-year LTV pricing curve would be weakly lower than the 2-year curve at each LTV band. This effect would be even more pronounced when comparing the short-term rate path with LTV repricing over a 10-year fixation window. This counterfactual pricing scheme is shown for 5- and 10-year contracts in Figure 3a.

Collateral Term Premia Expressed as Percentage of Mortgage Cost. Column 4 in Table 2 expresses the collateral term premium as a percentage of mortgage cost for a representative household, as an alternative measure for the magnitude of the premium. Column 5 in Table 2 provides an all-in cost measure of the total term premium, by including a fixed cost of refinancing k whenever a new contract is originated, and the bond term premium κ. The expected cost comparison is based on the expected mortgage payments over a window of 5 years.[26] The detailed computation is outlined in the appendix. With bond term premia and refinancing cost included, households with an LTV below 70% pay 4.1% more in mortgage payments over the initial 5 years, while households with an LTV of 95% pay 12.8% more for the 5-year contract compared to rolling over a 2-year contract sequence.

What factors could be driving the collateral term premium? The following section discusses potential mechanisms.

[26]Results are similar when comparing a 10-year window with two 5-year contracts, and five 2-year contracts.

5. Discussion of Mechanisms

This section discusses potential mechanisms behind the collateral term premium, i.e. why the cost of a longer-term mortgage contract compared to a sequence of shorter-term mortgage contracts is increasing in LTV. Collateral term premia seem consistent with lenders requiring compensation for the inability to reprice evolving risks and bearing house price risk over the length of the contract fixation period. There is less direct evidence for information and contracting frictions.

5.1. Pricing of House Price Growth

The collateral term premium is more sensitive to the rate of expected house price growth at higher LTV bands. Tables A.5 and A.6 in the appendix show variation in the collateral term premium estimate under an assumption of no house price growth, and doubling baseline house price growth, respectively. The collateral term premium for 5-year 95% LTV mortgages reduces to 41 basis points under the assumption of no house price growth, and rises to 96 basis points when doubling the baseline growth assumption. A collateral term premium of zero for high-LTV contracts would require lenders to price in a forward-looking LTV path, and implicitly bear risk of future house price developments over the fixation horizon of the longer-term contract. The findings may be consistent with the lack of financial instruments available to hedge house price risk as observed by Shiller (2014) and Fabozzi et al. (2020), and lenders requiring compensation for exposure to house price risk as a systematic source of risk.

5.2. Information Value of Repricing

Another way to assess the value of repricing to the lender, i.e. that 2-year contracts may reflect the option value to reprice the contract after two years, in case a borrower's fundamentals have changed, is implemented as follows. Collateral term premia suggest that this information value may be higher at higher LTV. To test this hypothesis, I set up a simple logit regression to predict default, and compare the relative predictive ability of default across LTV bands when excluding and including new information on LTV which I infer from changes in local house prices. Results on the area-under-the-curve (AUC), as a summary measure of predictive ability aggregating across different prediction cut-offs, are shown in Table A.7. I find that the increase in AUC when including recent LTV is indeed higher at higher LTV bands (greater than 80%), by around 1 to 2 percentage points, suggesting that changes in house prices are more predictive of default at higher levels of LTV. This is consistent with repricing being more valuable to the lender at higher LTV bands. The results do not extend to the highest LTV band, however, and appear quantitatively small.

5.3. Selection and Screening

Borrowers may strategically select into longer-term contracts if they have private information about future repricing risks, and those with worse future risks may adversely select into longer-term contracts. Lenders may charge a premium on 5-year contracts to screen for that type of selection. In order to test this channel, I evaluate both ex ante and ex post measures of borrower risk. Reviewing the covariates that correlate with 5-year contract choice in the choice regressions in Table 1 suggest that there is limited adverse selection into longer-term contracts based on ex ante observables. Local house price beta as a measure of local house price risk is slightly negatively correlated with 5-year contract take-up.

As a measure of realized risk, I assess ex post default rates that I track in the borrower panel data. Ex post default rates over the sample period are fairly similar across contract types conditional on a given LTV band, shown in Figure 4.[27] If anything, 2-year borrowers at higher LTV who stay with their lender have a slightly higher ex post default probability compared to 5-year borrowers.[28] The share of borrowers who stay should receive a larger weight in the lender's profit function, and so this channel does not help explain the collateral term premium for 5-year high-LTV contracts, but rather exacerbates the discrepancy, with the caveat that the sample window reflects a time period with relatively stable house price growth and low overall rates of default. The finding is consistent with the intuition that one would expect less asymmetric information in a market where the main measure of credit risk is the value of house price collateral, which is considered largely observable due to observable changes in local house price indices.[29] This is in contrast to unsecured credit markets where information asymmetries have been shown to affect contract maturity choice (see e.g., Hertzberg et al., 2018).

5.4. Selective Early Prepayment and Adverse Retention

Another canonical long-term contracting problem is selective household attrition over time (Hendel and Lizzeri, 2003; Handel et al., 2015; Nelson, 2018): households who receive better shocks ex post can leave the borrower pool over time, such that lenders retain an adversely

[27] There is evidence of "ex post" selection, i.e. 2-year borrowers who leave a lender's borrower pool after 2 years and refinance to a different lender are less than half as likely to default compared to the borrowers who stay (Panel B).

[28] It is useful to note that ex post default outcomes reflect net selection effects: other factors that affect contract choice, such as financial constraints, could be positively correlated with default, inducing "advantageous" selection into 5-year contracts that may offset adverse selection incentives. Lenders could also use historical data to price default that differs from current default rates.

[29] UK lenders in fact use changes in local house prices to re-evaluate collateral values for refinances with existing customers, without new credit or affordability checks (see FCA Mortgage Market Study, Interim Report 2018).

selected pool, potentially leading to market unravelling à la Akerlof (1970) in a dynamic sense. 5-year contracts could price in this adverse retention relative to 2-year contracts, and this effect may be more pronounced at higher LTV. In contrast, I find that attrition is limited over the initial fixation window, likely due to significant prepayment penalties. Mortgages in the UK have prepayment penalties of about 3 to 5% of the loan value.

I use the borrower panel to study refinancing behavior over time. Figure 5 plots the cumulative share of borrowers who have refinanced at least once over time, by contract fixation period.[30] For borrowers with an initial 5-year contract, the share is very low throughout the sample window between 2013H2 and 2017H2, with only around 5% of borrowers refinancing out of their initial contract by the end of 2017, i.e. after four years since origination. For borrowers with an initial 2-year contract, there is a slight increase in refinancers in 2015H1, and a large jump in refinancers in 2015H2 as expected, as the initial fixation period ends and borrowers are moved onto the revert rate unless they refinance at this point.[31] At 2015H2, in the half-year reporting window that tracks outcomes two years after the initial contract origination, the share of refinancers jumps to around 75%. If one takes a 6-month window around the scheduled refinance date, i.e. including 2016H1, that share rises to around 85%. The share rises further to around 90 to 95% when looking at the full four-year reporting window.[32] In sum, almost all first-time borrowers remain in the contract until the end of the initial fixation window, and only around 5% of borrowers exit the contract early and pay a prepayment penalty.[33]

In the appendix, I further illustrate the binding nature of prepayment penalties during a period of strong house price growth. Figure A.10 shows ex post interest rate realizations for the cohort of 2013H2 first-time borrowers, split by initial fixation window. Consistent with contract features, average rates remain stable over the sample window from 2013H2 to 2017H2 for borrowers with a 5-year contract who lock in the initial rate at 2013H2. For borrowers with a 2-year fixation window, the interdecile range widens visibly in 2015H2. Panel B shows that for borrowers with a high initial LTV (85-90% LTV band), borrowers with a 2-year fixed rate window experience a sharp decrease in average rates paid in 2015H2, while borrowers with a

[30] I focus on the first-time borrower cohort of 2013H2 in order to maximize the sample window over which outcomes can be observed (four years until 2017H2), and confirm that the results are robust when using other cohorts or when pooling all cohorts.

[31] The slight increase in 2015H1 is partly driven by some 2-year windows ending in that half-yearly reporting period, but that were originated in 2013H2, so comprises many "on schedule" refinances.

[32] This gradual increase over time comprises both refinancers who exhibit inertia, i.e. refinance late but could have refinanced and potentially saved cost relative to the revert rate, and borrowers who were not able to refinance at that time, for instance if their LTV exceeded 100%, but were able to do so at a later point (Keys et al., 2016; Andersen et al., 2020; Fisher et al., 2021).

[33] Inspecting this subset of borrowers further, these households have larger incomes and smaller loan balances, which could also be consistent with prepayment in order to move. Mortgages are portable in the UK and so some of the households that exit early could be porting their mortgage to another property without paying a prepayment penalty. I cannot verify the share of porters as these transactions would show up as a new loan in the data with a different location, and the data does not allow to track households across locations.

5-year contract continue to pay the fixed rate, despite the incentive to switch into a lower 2-year fixed rate, absent prepayment penalties.

5.5. Summary and Motivation for Model

So far, the analysis has established that the cost of insurance when taking out a 5-year fixed-rate contract is increasing in LTV due to collateral term premia. Collateral term premia seem consistent with lenders requiring compensation for the inability to reprice evolving risks and bearing house price risk over the length of the contract fixation period. In order to evaluate the *net* benefit of longer-term contracts to households given cost and the joint distribution and evolution of risks, I develop a model of optimal mortgage fixation choice in the following section.

6. Life-cycle Model of Optimal Mortgage Fixation Choice

In this section, I develop a partial equilibrium life-cycle model of household consumption and mortgage contract choice. The model allows me to evaluate the net insurance benefit of longer-term contracts, taking into account realistic features of the household choice problem such as income, interest and house price risk, and how these risks evolve over the life cycle. The model features household choice of interest rate fixation length over the life of the loan, and subsequent repricing based on realized loan-to-value ratios and aggregate interest rates, as an extension to existing models of optimal mortgage choice. The model matches the mortgage contract structure in the UK which is common in many countries. It hence differs from influential work by Campbell and Cocco (2003), who evaluate mortgage choice in the US market context with 30-year fixed-rate and adjustable rate mortgages that are held over the life of the loan, with the option to refinance, by introducing frequent repricing and allowing for contract choice across two fixed-rate periods throughout the life of the loan.

6.1. Model Setup

Overview. In the model, households optimally choose consumption and mortgage contracts given two different fixation periods until the loan is repaid, and only consumption thereafter. Households have a finite time horizon, with a working life, after which they retire and die. For simplicity, I focus on homeowners, and assume the size of the house is fixed.[34] Households buy the house at the beginning of their working life with a mortgage and repay it over the maturity of the loan T. Mortgage rates depend on the relative value between the outstanding

[34]The model does not endogenize the decision to buy a house or rent, and the choice of the size of the house, which is assumed to be fixed. Hence households are assumed to strictly prefer buying a house to renting and cannot adjust their house size in response to shocks, as in Campbell and Cocco (2003).

loan balance and the value of the house price as collateral, i.e. the loan-to-value (LTV) ratio, and the aggregate interest rate (r), at the time when the loan was last repriced. Since the utility derived from the house is fixed, it can be omitted from the household optimization problem.[35]

Utility. Households maximize expected utility with time discount rate δ and discount factor $\beta = \frac{1}{1+\delta}$. Households have constant relative risk aversion (CRRA) utility over consumption:

$$U(C) = \frac{C^{1-\gamma} - 1}{1-\gamma} \tag{6}$$

Dynamic Budget Constraint. Households face idiosyncratic income risk. At each time period, households pay mortgage payment $M_t = L_t \cdot \frac{r_t^m}{1-(1+r_t^m)^{-T}}$, where L_t is the remaining loan balance outstanding at time t. The mortgage interest rate r_t^m depends on the aggregate interest rate r_t^τ plus a time-invariant premium over the base rate ρ^m, which compensates the lender for the cost of issuing a given loan independent of LTV, and the LTV ratio LTV_t^τ locked in at the last instance of repricing (at time $t = \tau$), tracked in superscript:

$$r_t^m = \rho^m + r_t^\tau + f(LTV_t^\tau, \theta^\tau).$$

$f(\cdot)$ is the lender credit pricing function which is increasing and convex in LTV, and which may differ across contract fixation length θ. This component can be thought of as the credit spread for a given level of LTV. The LTV ratio at time t is determined by the outstanding loan value L_t relative to the current value of the house:

$$LTV_t = \frac{L_t}{H_t}$$

House prices H_t follow a lognormal distribution, and the change in log house prices is given by

$$\Delta \log H_t = g + \eta_t \tag{7}$$

with constant g and an i.i.d normally distributed shock with mean zero and variance σ_η^2. The expected log real return on a one-period bond $r_t = \log(1 + R_t)$ follows an AR(1) process:

$$r_t = (1-\rho_r)\mu_r + \rho_r r_{t-1} + \xi_t, \tag{8}$$

where ξ_t is a normally distributed white noise shock with mean zero and variance σ_ξ^2. Household

[35] This assumption is justified when households have separable utility between housing and consumption (Campbell and Cocco, 2003) or CES utility with a unitary elasticity of substitution (Laibson et al., 2021).

net wealth X_t evolves according to the following dynamic budget constraint:

$$X_{t+1} = (1 + r_t)(X_t - C_t) - M_t(LTV_t^\tau, r_t^\tau) + Y_{t+1},$$

subject to the borrowing constraint $(1 + r_t)(X_t - C_t) - M_t \geq \bar{B}$.[36] Next period net wealth is net savings compensated at the risk-free rate, less mortgage payments, plus income. Log income $\ln(Y_t)$ has a deterministic component $f(t)$ that is a function of time t, and is subject to transitory shocks ϵ_t. ϵ_t is an i.i.d normal shock with mean 0 and standard deviation σ_ϵ.[37]

Mortgage Contract Choice. Households choose the fixation length θ over which they lock in the current mortgage rate, and hence the point in time at which they get repriced next, i.e. θ periods from when the contract is chosen. A longer θ exposes household less frequently to repricing risk, but overall house price and aggregate interest rate changes accrue over the repricing window and are repriced at the end of the repricing window. Since house price shocks are i.i.d., multi-period house price risk over the duration of the fixation period can be expressed with mean and variance:

$$\begin{aligned} E\left(\eta_{t,t+\theta}\right) &= E\left(\sum_{i=1}^{\theta} \eta_{t+i,t+i-1}\right) = \sum_{i=1}^{\theta} E\left(\eta_{t+i,t+i-1}\right) = \theta\mu_h \\ \text{Var}\left(\eta_{t,t+\theta}\right) &= \text{Var}\left(\sum_{i=1}^{\theta} \eta_{t+i,t+i-1}\right) = \sum_{i=1}^{\theta} \text{Var}\left(\eta_{t+i,t+i-1}\right) = \theta\sigma_h^2. \end{aligned}$$

In the baseline model, mortgages are assumed to be fully amortizing, i.e. households repay both capital and interest over the life of the loan, and so the loan value L_t decreases over time, i.e. $\Delta L_{t,t+\theta} \leq 0$. Households can choose between a relatively longer-term fixation period θ^{LT}, and relatively shorter-term fixation period θ^{ST}. Once they make a choice, the mortgage rate is locked in over the fixation length chosen, and a new contract can be chosen at the end of the fixation period. In order to economize on state variables, the model assumes that the loan balance can be tracked using time t alone.[38] The model tracks LTV as a state variable, which is then sufficient to track the house price evolution over time.[39]

[36] The model abstracts from the ability to extract home equity, and housing wealth does not enter household utility directly. This would introduce additional variation in the cost of borrowing across the LTV distribution, as this would be captured in the mortgage rate that is increasing in LTV. This also leaves out an additional benefit of shorter-term mortgage rates, as they may give borrowers greater flexibility to cash out at shorter time intervals (given costly prepayment penalties over the initial fixation period).

[37] Income shocks are assumed to be i.i.d in order to simplify the problem and economize on state variables.

[38] This is a common and quantitatively small approximation that abstracts from small variations in the loan amortization path due to differences in interest rates (Campbell and Cocco, 2003, 2015).

[39] The model abstracts from an explicit strategic default decision given the full recourse regime of the UK. Default behaviour is implicitly captured by the household utility maximization problem that avoids states with high mortgage payments (and hence low consumption). In the robustness check with high revert rates, this rate could be considered a penalty rate that serves as a proxy for the expected cost of default, which becomes more

Value Function and Repricing States. In order to determine optimal mortgage choice (stored in policy function $\mathcal{R}$), the household value function tracks two auxiliary value functions, the value function if the household chooses the short-term contract V^{ST}, which implies repricing in θ^{ST} periods, and new choice of fixation length at the end of the current fixation period; and the value function if the long-term contract is chosen, V^{LT}, with repricing and new choice in θ^{LT} periods. Both take into account that the current rate is locked in and repriced at the end of the chosen fixation window. Rather than tracking the time at which repricing next takes place (τ), repricing depending on contract choice is tracked more parsimoniously by repricing state variables $\mathcal{S}_t^\theta$ which take θ states defined as follows: for each fixation window, interest rates are locked in at a given LTV level for θ periods ($\mathcal{S}_t^\theta = \theta$), locked in for $\theta - 1$ periods ($\mathcal{S}_t^\theta = \theta - 1$), up until when the remaining fixation window reaches 1 period, at the end of which there is θ-period repricing ($\mathcal{S}_t^\theta = 1$), for $\theta \in \{\theta^{LT}, \theta^{ST}\}$. V^{LT} and V^{ST} are further defined in the following. The vector of state variables is $\Omega = \{X, t, LTV, r, \mathcal{S}^{\theta^{LT}}, \mathcal{S}^{\theta^{ST}}\}$, representing household net wealth, time, LTV, aggregate interest rate, repricing state for the longer-term contract, and repricing state for the shorter-term contract, respectively. To simplify notation, the θ-superscripts for the repricing state variables are omitted if the information is not required. First, in order to capture the temporal dependence of repricing states for the value function when choosing a contract with fixation window θ, it is useful to note that in θ periods from choosing the contract, the value function is

$$\begin{aligned} &V_{t+\theta-1}\left(X_{t+\theta-1}, LTV_{t+\theta-1}, r_{t+\theta-1}, \mathcal{S}_{t+\theta-1} | \mathcal{S}_{t+\theta-1} = 1\right) \\ &\quad = \max_{C_{t+\theta-1}, R_{t+\theta-1}} U(C_{t+\theta-1}) + \beta E_{t+\theta-1}\left[V^*_{t+\theta}\left(X_{t+\theta}, LTV_{t+\theta}, r_{t+\theta}\right)\right], \end{aligned} \tag{9}$$

with θ-period repricing if $\mathcal{S}_t = 1$, and no repricing if $\mathcal{S}_t \in \{2, ...\theta\}$. Note that the continuation value, where $V_t^* = \max\left\{V_t^{ST}, V_t^{LT}\right\}$, takes into account that the household can optimally choose a short- or long-term contract after this period, and does not depend on the repricing state. In $\theta - 1$ periods, the value function is

$$\begin{aligned} &V_{t+\theta-2}\left(X_{t+\theta-2}, LTV_{t+\theta-2}, r_{t+\theta-2}, \mathcal{S}_{t+\theta-2} | \mathcal{S}_{t+\theta-2} = 2\right) \\ &\quad = \max_{C_{t+\theta-2}, R_{t+\theta-2}} U(C_{t+\theta-2}) \\ &\quad + \beta E_{t+\theta-2}\left[V^{LT}_{t+\theta-1}\left(X_{t+\theta-1}, LTV_{t+\theta-1}, r_{t+\theta-1}, \mathcal{S}_{t+\theta-1} \mid \mathcal{S}_{t+\theta-1} = 1\right)\right], \end{aligned} \tag{10}$$

which can be extended analogously for each period up until (and including) the current period.

likely at an LTV exceeding 95%.

In the current period, the value function for choosing the long-term contract is

$$\begin{aligned} & V_t\left(X_t, LTV_t, r_t, \mathcal{S}_t \mid \mathcal{S}_t=\theta\right) \\ & =\underset{C_t, R_t}{max}\, U(C_t)+\beta E_t\left[V_{t+1}^{LT}\left(X_{t+1}, LTV_{t+1}, r_{t+1}, \mathcal{S}_{t+1} \mid \mathcal{S}_{t+1}=\theta-1\right)\right] . \end{aligned} \tag{11}$$

For notational simplicity, the value functions for choice of the short-term and long-term contract are respectively defined as

$$\begin{aligned} V_t^{ST} & \equiv V_t\left(X_t, LTV_t, r_t, \mathcal{S}_t^{\theta^{ST}} \mid \mathcal{S}_t^{\theta^{ST}}=\theta^{ST}\right), \\ V_t^{LT} & \equiv V_t\left(X_t, LTV_t, r_t, \mathcal{S}_t^{\theta^{LT}} \mid \mathcal{S}_t^{\theta^{LT}}=\theta^{LT}\right). \end{aligned} \tag{12}$$

The dependencies across time and repricing states are further illustrated for V^{LT} with $\theta^{LT}=5$ in Figure A.11 in the appendix, with arrows to indicate the dependencies of the value function and continuation values as described above.
The dynamic budget constraint can then be rewritten without τ, and using the repricing state variable instead:

$$X_{t+1}=(1+r_t)(X_t-C_t)-M_t(LTV_t, r_t, \mathcal{S}_t)+Y_{t+1}. \tag{13}$$

Policy Functions. Households choose optimal consumption and the optimal mortgage contract in the model. Let policy function C denote household optimal consumption in state $\Omega=\{X, t, LTV, r, \mathcal{S}^{\theta^{LT}}, \mathcal{S}^{\theta^{ST}}\}$ where $C: \Omega \rightarrow [0, \infty)$, and $\mathcal{R}$ denote optimal mortgage choice of either the long-term ($\mathcal{R}=1$) or short-term contract ($\mathcal{R}=2$) where $\mathcal{R}: \Omega \rightarrow \{1,2\}$.

Bellman Equation. The resulting Bellman equation for the household problem is

$$\begin{aligned} V_t\left(X_t, LTV_t, r_t, \mathcal{S}_t^{\theta^{ST}}, \mathcal{S}_t^{\theta^{LT}}\right) & =\underset{C_t, R_t}{max}\, U(C_t)+\beta E_t\left[V_{t+1}^*\left(X_{t+1}, LTV_{t+1}, r_{t+1}\right)\right] \text{ with} \\ V_t^* & =\max \left\{V_t^{ST}, V_t^{LT}\right\} \\ V_t^{ST} & =\underset{C_t, R_t}{max}\, U(C_t)+\beta E_t\left[V_{t+1}^{ST}\left(X_{t+1}, LTV_{t+1}, r_{t+1}, \mathcal{S}_{t+1}^{\theta^{ST}}\right)\right] \\ V_t^{LT} & =\underset{C_t, R_t}{max}\, U(C_t)+\beta E_t\left[V_{t+1}^{LT}\left(X_{t+1}, LTV_{t+1}, r_{t+1}, \mathcal{S}_{t+1}^{\theta^{LT}}\right)\right] \\ \text{s.t.} \quad X_{t+1} & =(1+r_t)(X_t-C_t)-M_t(LTV_t, r_t, \mathcal{S}_t)+Y_{t+1}, \\ (1+r_t)(X_t-C_t)+M_t & \geq \bar{B}. \end{aligned} \tag{14}$$

6.2. Calibration and Solution

Table 3 provides an overview of the parameters used for the baseline calibration of the model.

House Prices. The house price process is calibrated using aggregate UK house price from 1987 to 2017, with nominal house prices deflated using RPI, yielding an average log house price growth of 0.0258 and standard deviation $\sigma_h = 0.0770$.[40] The initial house price level is set to fit the average loan-to-income (LTI) ratio of borrowers with an initial LTV of 85% in the data, yielding an LTI ratio of 3.56.[41]

Interest Rate. The real log interest rate is calibrated using UK data from 1987 to 2017, with mean $\mu_r = 0.0164$, standard deviation $\sigma_r = 0.0193$ and autocorrelation coefficient $\rho_r = 0.95$. Real rates are calibrated using 5-year UK inflation-indexed gilts and deflating 1-year nominal rates by 1-year ahead survey-based household expectations of inflation.

Simulation of Repricing Risks. Figure 6 illustrates the distribution of repricing risks over time, for a 90% LTV mortgage. Panel A shows the distribution of LTV, which is decreasing with loan amortization and positive expected house price growth. Up to around 7 to 8 years since loan origination, the median household's LTV is in the collateral-sensitive pricing region, meaning that repricing risk in mortgage rates due to house price risk alone are concentrated in the initial years since loan origination, illustrated in Panel B. Panel C shows the effect of both house price and aggregate interest rate risk on the mortgage rate distribution, reflecting both the trend decline in LTV in the years since loan origination and the effect of interest rate risk.

Income and Mortgage Contract. Working age is set to 30 to 60, after which households retire and die at age 80. The deterministic hump-shaped component of income over the life cycle is adopted from Cocco et al. (2005), following standard life-cycle models (Carroll, 1997).[42] The standard deviation of the transitory income shock σ_ϵ is set to 0.1 based on the literature.[43] The maturity of the loan T is set to 30 years. The fixation windows that households can choose from are set to 5 (θ^{LT}) and 2 (θ^{ST}) years, respectively, matching the UK institutional setting and the two most common types of contracts available. For some counterfactuals, θ^{LT} is set to

[40] As an alternative, local authority-level house price indices are used to capture cross-sectional variation in house price risk which yields similar magnitudes.

[41] Because all values are standardized in terms of units of permanent income, the loan-to-after-tax-income ratio of 4.82 is used after applying a tax rate of 35.5%, based on 2017/2018 effective UK tax rates.

[42] The deterministic income profile is based on a simple average of households with college education and households with high school education in Cocco et al. (2005), to approximate the population with a mortgage.

[43] See e.g. Blundell (2014); Belgibayeva et al. (2020) for the UK, and Carroll et al. (2017); Gomes (2020) for a more general range of estimates and alternative specifications.

10, reflecting a 10-year fixed-rate contract.

Mortgage Pricing. The mortgage rate premium ρ^m is set to the difference between the average 2-year mortgage rate at an LTV of 60% or lower and the real rate, and uses data between 2013 and 2017 to match the LTV premia derived from the loan-level data. Consistent with the empirical mapping proposed in section 4, I use the same credit spreads across LTV in the model calibration, estimated as LTV-band fixed effects in steps of 5 percentage points from 70% to 95% LTV, controlling for time (year-month), lender, region, time$\times$lender and buyer-type fixed effects between 2013 to 2017.[44] The revert rate premium is obtained from the Bank of England database, as the difference between the average revert rate and the average 2-year mortgage rate at an LTV of 60%. Based on this calibration, the real mortgage rate with an aggregate rate of 1% for a 2-year 80% LTV contract is 2.24%, while it is 2.96% for a 2-year 90% LTV, and 4.07% for a 2-year 95% LTV contract.

Summary and Model Solution. To summarize, the household decision problem is tracked using the state variable vector $\Omega = \{X, t, LTV, r, \mathcal{S}^{\theta^{LT}}, \mathcal{S}^{\theta^{ST}}\}$ and contains household net wealth, time/age, LTV, aggregate interest rate, repricing state for the longer-term contract, and repricing state for the shorter-term contract. The model solution is briefly outlined in the following, with more detail provided in appendix section E. The state space is discretized in an equal-spaced grid for the continuous state variables X and LTV, interest rates are discretized using five states, and the model is solved recursively by setting $V_T = C_T$ in the last period, i.e. assuming households consume all wealth in the last period. Household consumption, also discretized, and mortgage choice functions are obtained as optimal choices across each combination of the discretized points on the state space using a grid search. The policy functions are then used to simulate consumption and mortgage choice given simulated realizations of income, house price and interest rate shocks for 10,000 households.

6.3. Results

This subsection provides an overview of the model results, and outlines the two main counterfactuals. First, I compare contract take-up and the value of adding the choice of a 5-year fixed-rate contract while taking collateral term premia as given, with a counterfactual pricing scenario where 5-year contracts are priced at expected cost, i.e. setting the collateral term premium to zero. Second, I use the model to assess the net insurance benefit of hypothetical

[44] The calibration assumes that the relative differences in interest rate premia across the LTV distribution are preserved in real terms. Collateral term premia would likely be larger if interest rate premia apply to nominal LTV, as nominal LTV may decrease more quickly over time given nominal rather than real house price growth.

mortgage contracts, allowing me to evaluate household demand for a 10-year fixed-rate contract.

Optimal Mortgage Fixation Policy Varies with LTV and Over Time. To provide intuition on the model results, I discuss patterns in the policy function for optimal mortgage fixation choice. I focus on optimal mortgage choice in the LTV and time dimensions, the latter capturing changes in the loan size as the loan amortizes, holding other state variable dimensions constant. For a given level of net wealth and interest rate state, the model generates boundaries in the LTV-time space where borrowers prefer the long-term contract (with $\theta^{LT} = 5$), or the short-term contract (with $\theta^{ST} = 2$). This is illustrated in Figure 7, which shows the optimal fixation length choice for discrete steps of LTV on the y-axis, and time (in years since loan origination) on the x-axis. The policy function space is depicted for the second lowest interest rate state, reflecting the current interest rate environment with an emphasis on the risk of rising rates.

Panel A shows the results under the baseline calibration. There are two distinct choice regions. For households between 70% to 95% LTV, the mortgage rate is in the collateral-sensitive pricing region and the optimal choice is the shorter-term contract. For an LTV below or equal to 70%, the mortgage rate is in the collateral-insensitive pricing region, i.e. there are no further interest rate reductions for an LTV lower than 70%, and the optimal choice is to lock in this rate for longer. This pattern illustrates the trade-off households make between the insurance motive against upward interest rate (and downward house price) risk, and cost reductions using shorter-term contracts given collateral term premia.

Panel B shows results under the baseline calibration, but with expected cost pricing, i.e. imposing a collateral term premium of zero. The long-term contract choice region is now much expanded, and less monotonic. Intuitive reasons behind the non-monotonic choice rules are: mortgage rates only change in 5 percentage point intervals of LTV, which households internalize; 2-year contracts embed an option value relative to 5-year contracts, as they allow households to choose a new (short-term or long-term) contract sooner, so 2-year contracts may be valuable at an LTV below the 70% pricing boundary; and as the loan value amortizes, any given change in house prices has a greater effect on LTV. Most households with an LTV below 85%, and households close to the upper range of the 85-90%, and 90-95% LTV band now choose the long-term contract. Because base interest rates may still decrease and house prices may increase, the LTV region in which households choose a short-term contract expands somewhat over time. Above 95% LTV, households pay the revert rate which is the same as in the baseline scenario.

Expected cost pricing undoes the cost reduction motive, making long-term contract demand more attractive regardless of LTV. Panels C and D show how contract choice differ in a scenario with no house price growth, and higher interest rate risk ($\sigma_r = 0.0193 \times 2$), respectively. Relative to the baseline scenario, there are more long-term contract choice spaces within the broader short-term choice region. In the scenario with no house price growth, they follow the LTV step-function pricing: up to an LTV of 90%, households prefer to lock in the long-term contract if they are towards the upper edge of the LTV band at 75%, 80%, 85% and 90% LTV, and close to the initial loan origination time, i.e. within the first 5 to 10 years. In the scenario with greater interest rate risk, the long-term choice spaces are denser.

Life-Cycle Pattern in Simulated Mortgage Choice. Figure 8 shows the simulated mortgage choices for an initial LTV of 70% (Panel A) and 90% (Panel B) for the baseline calibration. In line with the policy function space, borrowers at 70% LTV start off with a 5-year contract, but those who receive negative house price or positive interest rate shocks move onto a short-term contract. Borrowers at 90% LTV start off with a 2-year contract, but the majority of borrowers moves onto a 5-year contract after about seven years, as the LTV reaches the long-term choice boundary at 70%.

6.3.1. Counterfactual Using Expected Cost Pricing

I evaluate contract take-up and the net benefit to households under a counterfactual with expected cost pricing as computed in section 4. The 5-year LTV pricing schedule is hence modified to price in the expected shorter-term contract path with LTV repricing, by subtracting the collateral term premium. Expected cost pricing embeds assumptions about house price growth, and a representative loan repayment schedule over time. It is also computed for the maximum of a given LTV band, e.g. for an LTV band from (90-95]%, it assumes an initial LTV of 95%.[45]

Total Long-Term Contract Take-Up. Table 4 summarizes long-term contract take-up over the initial first 10 years of the loan (Panel A) and over the entire loan maturity of 30 years (Panel B). Take-up is computed as the share of borrower-year observations under the 5-year fixed-rate contract, relative to the 2-year fixed-rate contract. Each row represents a different scenario, while columns 1 and 2 show results for low (70%) and high (90%) LTV contracts under observed pricing, and columns 3 and 4 show the equivalent under zero collateral term premium pricing. Long-term contract take-up for low-LTV borrowers is close to 100% throughout. High-LTV take-up under the baseline is about half that of low LTV borrowers, and rises in particular

[45] This assumption is consistent with findings in Cloyne et al. (2019), who show that most borrowers bunch at the upper edge of a given LTV band, in line with the incentives from the discrete notches in the mortgage rate schedule. However, it does imply that pricing is not exactly at expected cost for loans not starting at the upper LTV bound.

for combinations of no house price growth and higher house price risk (second row), and higher house price and interest rate risk (fifth row). In addition, Figure 9 shows take-up over the first 10 years across all LTV bands under the baseline calibration (Panel A). Long-term contract take-up is close to 100% for the lowest LTV band ($\leq 70\%$), and decreases across LTV bands under the baseline calibration. At the highest LTV band, take-up is only around 30%. With higher interest rate risk, take-up rises to close to 100% across all LTV bands except for the highest, which rises to around 70%.

The model thus qualitatively and to some extent quantitatively matches the striking decreasing 5-year contract take-up across the LTV distribution in the data. In the model and simulation, households are homogeneous other than their initial starting LTV. I show that this dimension of heterogeneity alone generates a substantial decrease in 5-year contract take-up. This is consistent with the empirical findings from the multivariate linear probability model of predicting 5-year contract choice – 5-year contract choice is strongly decreasing in LTV, holding fixed measures of financial constraints such as loan-to-income, age and maturity.

Household Valuation of Long-Term Contract. Figure 9 Panel B shows results on the net benefit or value of being able to access a longer-term contract ($\theta^{LT} = 5$) in addition to a shorter-term contract ($\theta^{LT} = 2$) , expressed as a standard consumption certainty equivalent. The consumption certainty equivalent is computed as the percentage increase in consumption across states that a household would require to reach the same life-time expected utility when a longer-term contract is available, in addition to the shorter-term contract. For the lowest LTV band in the baseline scenario, this is 0.85% under the baseline calibration, but this declines to 0.36% for households with an LTV of 90%. The number rises to 1.47% in the scenario with higher interest risk for low-LTV borrowers and 1.44% for high-LTV borrowers. Table 5 shows results from a comparison of consumption certainty equivalents under different scenarios, mirroring Table 4 for take-up.

Effect of Expected Cost Pricing on Take-Up and Household Value. Figure 9 Panel B also shows take-up and value of longer-term contracts in a counterfactual with expected cost pricing, setting the collateral term premium to zero. Take-up is close to 100% across LTV bands in both the baseline and high interest rate risk scenario. In addition, the net benefit of long-term contracts is moderately rising in LTV rather than declining, as higher LTV borrowers benefit at least as much from the insurance against interest rate risk than low-LTV borrowers, but are also more exposed to house price risk. That means that the consumption certainty equivalent for adding a 5-year fixed rate contract more than doubles for higher-LTV borrowers under zero collateral term premium pricing, to around 0.86% in the baseline scenario. The results illustrate how expected cost pricing raise take-up and enable welfare benefits of longer-term contracts to accrue to higher-LTV borrowers, in addition to low-LTV borrowers.

6.3.2. Counterfactual Evaluating 10-Year Fixed-Rate Contract

I further use the model to evaluate a counterfactual product with a longer fixation period. I choose 10 years because this window is occasionally offered by lenders in the UK, and frequent in some countries such as Germany and Denmark. At the same time, effective commitment over the initial fixation window is still credible using a binding prepayment penalty.[46] I further assume the same LTV pricing schedule as for 5-year contracts, and an expected cost pricing schedule based on 2-year prices rolled over for 10 years. Results are shown in Tables 4 and 5, Panel B. The magnitudes for the value of 10-year contracts in Table 5 are larger in absolute and relative terms compared to the 5-year contract: while the value is 2.03% of lifetime consumption for low-LTV borrowers, this value is only a third, 0.74%, for high-LTV borrowers, a larger proportional decrease compared to the 5-year contract. The value rises to 2.04% under a counterfactual with expected cost pricing.

6.3.3. Robustness and Alternative Scenarios

Tables 6 and 7 shows results on take-up and household valuation under alternative scenarios. Take-up for high-LTV borrowers compared to the baseline is lower in the scenario with a higher time discount rate, and a higher revert rate, but is unchanged with greater risk aversion, suggesting that the cost reduction motive weighs strongly against households' insurance motive. Relative value-added compared to the baseline is lower with a higher revert rate and discount rate. The insurance value is raised with greater risk aversion for low-LTV borrowers, but unchanged for high-LTV borrowers.

6.4. Discussion of Results

Overall, the findings suggest that collateral term premia reduce demand for longer-term mortgage contracts by riskier borrowers, exposing them to interest rate risk. I highlight a tension between households' insurance motive, and a cost savings motive by repricing more frequently to avoid collateral term premia. This reduces take-up of longer-term contracts by high-LTV borrowers. The findings further suggest that collateral term premia limit the insurance benefits of having longer-term contracts available to riskier borrowers.

[46]In conversations with lenders, prepayment penalties have taken schedules such as 5% of the loan value over the initial 5 years, which are then decreasing by 1 percentage point per additional year.

From a policy perspective, one way to interpret implementation of lower collateral term premia is government insurance of house price risk, as seen in the US. Centralized pricing by government-sponsored entities has been shown to have regionally redistributive effects (Hurst et al., 2016). A flattening of the LTV pricing curve for longer-term contracts could be interpreted as an additional dimension of redistribution: cross-subsidization from low to high-LTV borrowers, or younger and older cohorts of borrowers, as the collateral term premium is spread out over time and across LTV groups. An alternative policy could be structuring mortgages into a non-risky, i.e. LTV-insensitive, tranche, and a risky tranche. In Denmark, mortgage fixation lengths are amongst the highest outside of the US. However, collateralized mortgage loans are only available up to an LTV of 80%. Borrowers can then borrow an unsecured loan to raise their LTV up to 95%. This way, base rates can be locked in at origination, while the risky portion of the loan can be repaid separately. One disadvantage is that these unsecured loans are potentially quite expensive. The paper hence highlights novel considerations and challenges for mortgage contract design and market reform.

While this paper quantifies potential welfare gains and distributional effects of long-term contract pricing on high-LTV borrowers, certain general equilibrium concerns are outside of its scope. Different types of policy implementations require additional welfare-relevant considerations. For instance, government insurance of house price risk and securitization may contribute to moral hazard and systemic risk (Acharya et al., 2009; Keys et al., 2010; Allen et al., 2015). Reducing the cost of long-term contracts for high-LTV borrowers may interact with the transmission mechanism of monetary policy, as borrowers would have longer fixation lengths, with costly prepayment. The results are also based on the assumption of a relatively low-interest rate regime. The benefits of long-term contracts (with binding prepayment penalties) in a regime where interest rate risk is symmetric or skewed towards the downside are smaller.

7. Conclusion

This paper studies household mortgage fixation choice in a setting with frequent repricing and market pricing of credit risk, the UK mortgage market. I find that long-term mortgage rates exhibit two types of term premia, compared to a sequence of shorter-term contracts: standard bond term premia, and collateral term premia, the latter raising the cost of longer-term contracts for borrowers at higher LTV. I build a life-cycle model of optimal fixation choice and find that collateral term premia reduce the insurance benefit of longer-term contracts to high-LTV borrowers, lowering take-up and raising exposure to interest rate risk, compared to a counterfactual without collateral term premia. Taken together, the findings suggest that policy interventions and alternative contract designs may be required to increase long-term contract take-up for riskier borrowers.

The lack of long-term contract take-up in the mortgage market was noted by Miles (2004) in a comprehensive review of the UK mortgage market commissioned by the UK government. In the US mortgage market context, mortgage contracts have historically evolved from short-term balloon-mortgages with substantial repricing risk in the 1930s, to the institutional framework surrounding the 30-year fixed-rate mortgage today (Green and Wachter, 2005). This has remained a subject of on-going discussion on mortgage market reform (Campbell, 2013) given the large public cost externalities posed by public credit risk guarantees following the 2008/09 financial crisis. One way to interpret the role of public credit risk guarantees is that they may redistribute high initial interest rate premia due to LTV from high to low LTV borrowers and over a longer-term contracting horizon, flattening the LTV pricing curve and thereby lowering the cost of insurance against interest rate risk for high-LTV borrowers. Another important policy goal in many countries is to encourage homeownership, which often involves supporting the availability of high-LTV mortgages, and selected mortgage guarantee schemes for very high-LTV borrowers have been considered or implemented in the UK.[47] Long-term contracts may aid affordability if they allow riskier borrowers to lock in low interest rates for longer and mitigate repricing risk. This paper suggests that in the presence of substantial collateral term premia, the insurance benefits of longer-term contracts largely accrue to low-LTV borrowers. Current pricing incentivizes higher-LTV borrowers towards shorter-term contracts, rendering the combination of high-LTV borrowing and long-term contracting particularly challenging, and may help explain continued government interventions observed in mortgage markets.

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[47]See the 2013 Help To Buy: Mortgage Guarantee scheme, and most recently, the "mortgage guarantee scheme", 3 March 2021, https://www.gov.uk/government/publications/the-mortgage-guarantee-scheme).

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Figure 1: Contract Choice by LTV band

This figure shows the share of newly originated fixed rate contracts by fixation length and LTV band, for loans originated between 2013 to 2017.

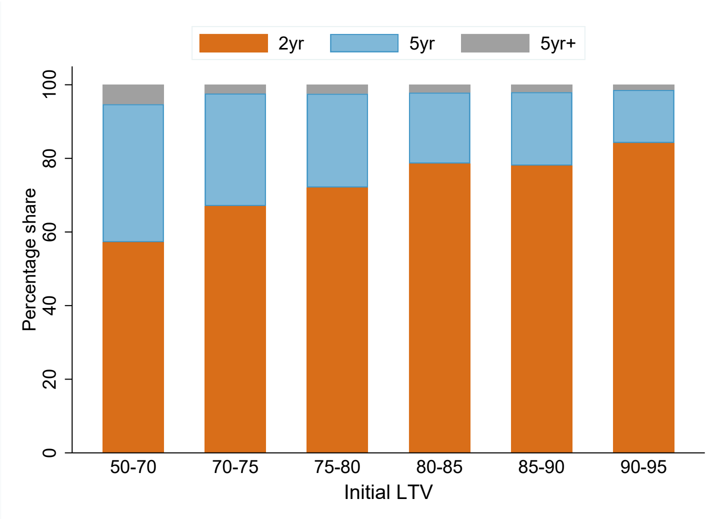


Figure 2: Illustration of Expected Yield Difference ($\Delta^{5,2}$) Decomposition

This figure illustrates the decomposition of the expected yield difference between a 5-year fixed-rate contract and a sequence of 2-year contracts into the bond term premium and collateral term premium, following equation 4c. The bond term premium is measured as the expected yield difference between the 5-year fixed-rate contract at 70% LTV, and the sequence of 2-year contracts starting at 70% LTV, with aggregate interest rate repricing. The collateral term premium depends on the credit pricing differential between 5-year and 2-year contracts at a given level of LTV ($\Delta\rho$) and the yield differential between the 2-year contract with and without LTV repricing ($\Delta r(LTV)$), illustrated for an initial LTV of 90%.

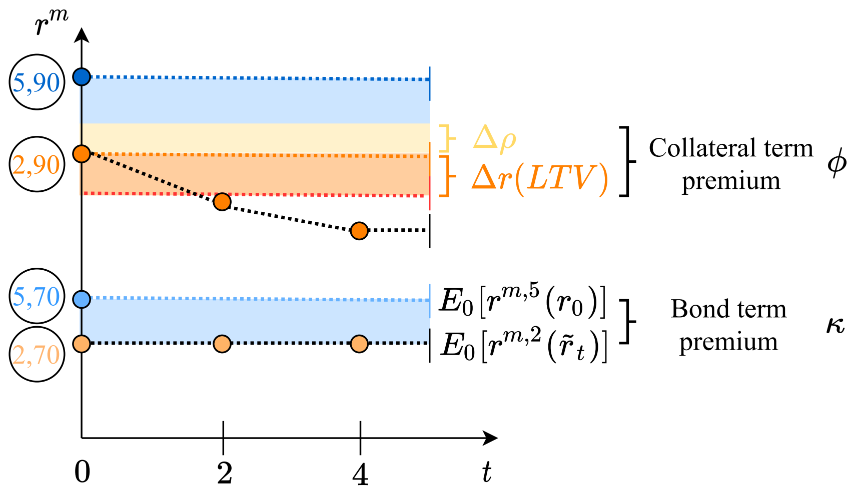
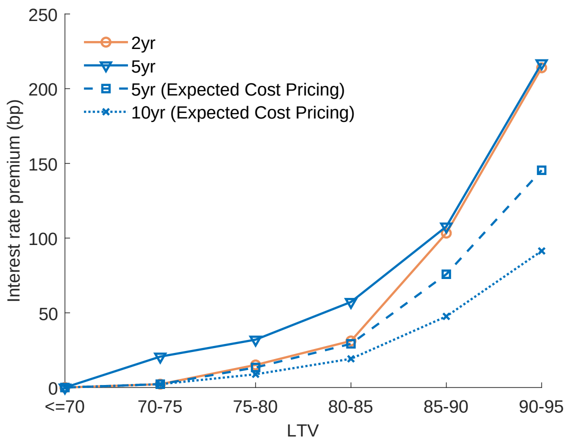


Figure 3: Collateral Term Premium

Panel A of this figure plots the credit spread paid across loan-to-value (LTV) bands ($\leq$70%, (70-75]%, (75-80]%, (80-85]%, (85-90]%, and (90-95]%), by extracting LTV-band fixed effects from a regression of interest rates on LTV bands and fixation period length (2 or 5 years), controlling for year-month, lender, buyer-type, year-month$\times$lender fixed effects, using data from 2013 to 2017. The credit spreads are estimated in the same regression for 2-year and 5-year fixed rate contracts, with 2-year fixed rate contracts as the base category, and 5-year fixed rate contracts with an additional interaction term. Panel A further shows counterfactual interest rate premia for 5-year and 10-year fixed-rate contracts that would equalize the expected average cost of rolling over a matching sequence of 2-year fixed rate contracts given 2-year fixed rate LTV premia over five and ten years ("expected cost pricing", i.e. imposing a collateral term premium of zero), respectively. Panel B shows the decomposition of the collateral term premium following equation 4c into the interest rate differential due to LTV repricing (as illustrated in Panel A) and the interest rate pricing differential across 2-year and 5-year contracts (the difference between the 5-year and 2-year fixed-rate pricing curve in Panel B), across LTV bands.

(A) LTV Pricing (ρ^2 and ρ^5)



(B) Collateral Term Premium ($\phi^{5,2}$)

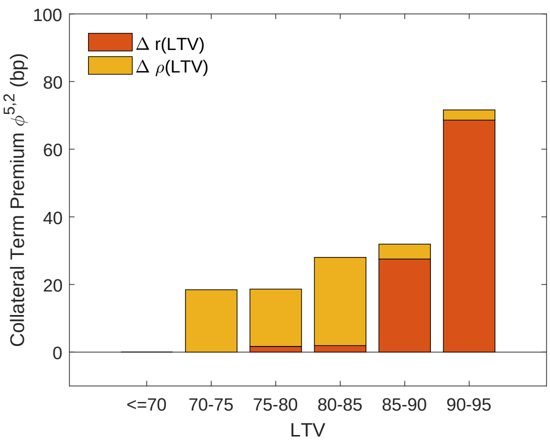
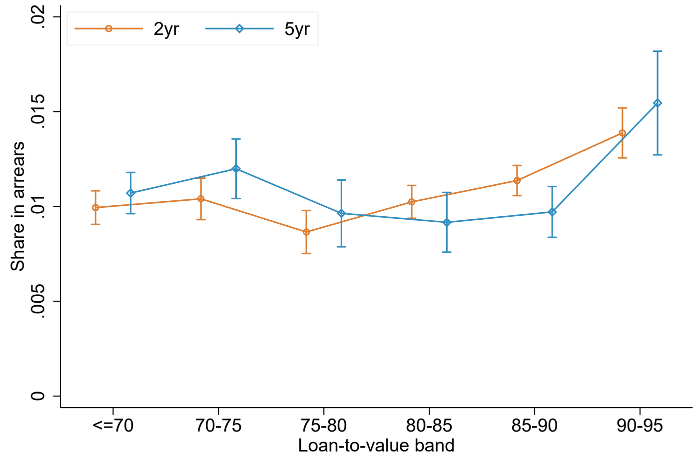


Figure 4: Ex post default risk across LTV bands and borrower groups

These figures plot the ex post share of loans in arrears, across LTV bands and initial fixation length (2 and 5 years), for first-time borrower cohorts between 2013H2 to 2015H2. The share refers to a loan being in arrears at any point in the sample window (2013H2 to 2017H2). Panel A pools all borrowers with 2 and 5-year contracts, respectively. Panel B splits the 2-year borrower pool by those who stay with their initial lender, and those that externally refinance and switch lender.

(a) 5-year and 2-year fixed-rate borrowers (pooled)



(b) 5-year and 2-year fixed-rate borrowers (borrowers that stay vs. switch lender)

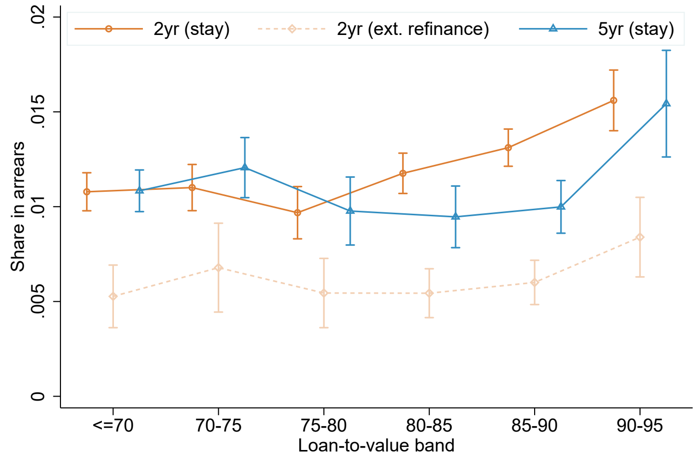


Figure 5: Refinancing behavior

This figure shows the cumulative share of borrowers who refinance (either with their existing lender or with a different lender), for borrowers who chose a contract with an initial 2-year, or 5-year fixation length, respectively, based on the 2013H2 cohort of first-time borrowers.

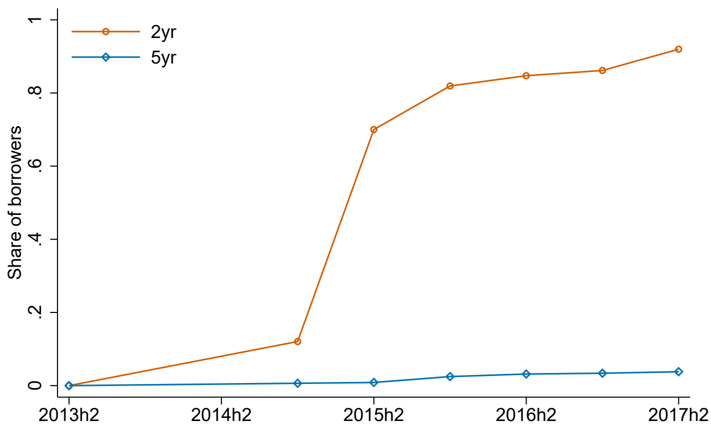
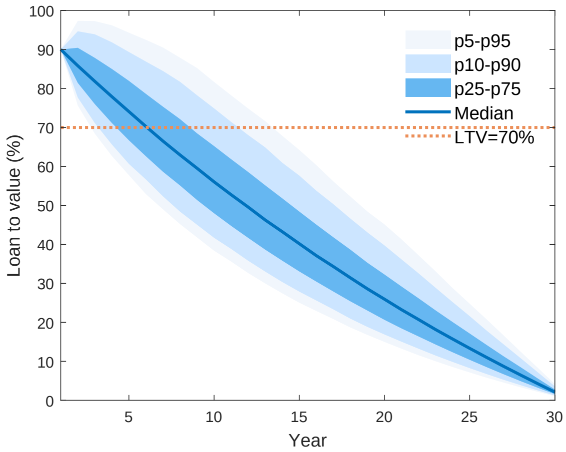


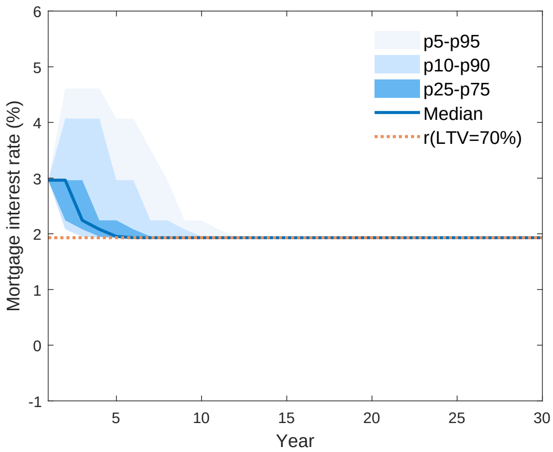
Figure 6: Repricing Risks

These figures illustrate the distribution of repricing risks over the life of the loan. The simulation is based on a fully-amortizing loan, repaid over 30 years, using LTV pricing estimated from the data, and a calibrated house price and interest rate process as shown in Table 3. Panel A shows the distribution of LTV, Panel B shows the mortgage rate distribution with house price risk but no interest rate risk, while Panel C shows the mortgage rate distribution with both house price risk and interest rate risk, for a loan with an initial 90% LTV. The dark blue line indicates the median (50th percentile) of the distribution, the dark blue swathe indicates the interquartile range (25th to 75th percentile), the light blue swathe indicates the interdecile range (10th to 90th percentile), and the grey swathe the 5th to 95th percentile range. The dotted orange line indicates the LTV pricing boundary at 70% LTV, and the interest rate associated with the LTV pricing boundary, respectively.

(a) LTV



(b) Mortgage rate (House Price Risk Only)



(c) Mortgage rate

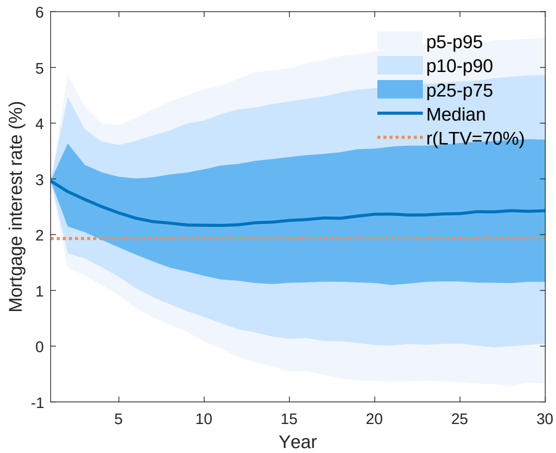
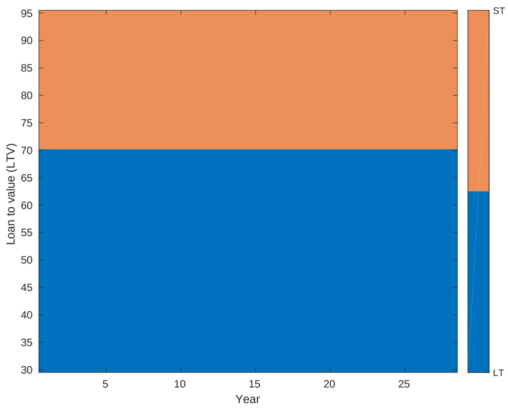


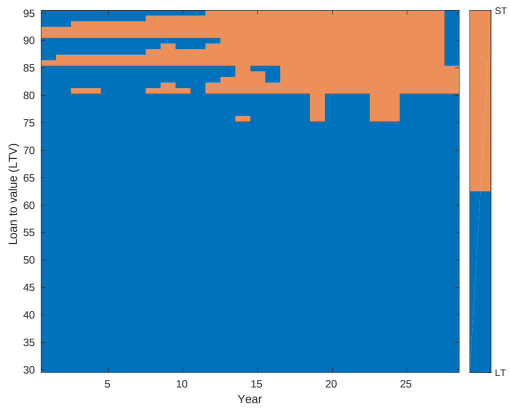
Figure 7: Optimal Mortgage Choice - Policy Function Space Across Scenarios

These figures show the policy function space for optimal mortgage choice between a relatively long-term contract with fixation length $\theta^{LT} = 5$ and a shorter-term contract with $\theta^{ST} = 2$, across the LTV and time (years since loan origination) dimensions, while holding household net wealth X and the interest rate state (set to the second lowest out of five) fixed. Panel A shows the policy function space under the baseline calibration and regular pricing, while Panel B shows the space under expected cost pricing (imposing a collateral term premium of zero). Panel C shows the policy function space for the scenario with 0% house price growth ($\mu_h = 0$), while Panel D shows the space with double the interest rate volatility (σ_r=0.0193*2).

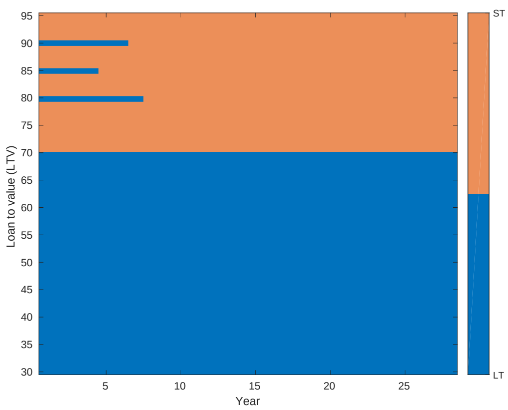
(a) Baseline



(b) Baseline (Expected Cost Pricing)



(c) No House Price Growth



(d) Higher Interest Rate Risk

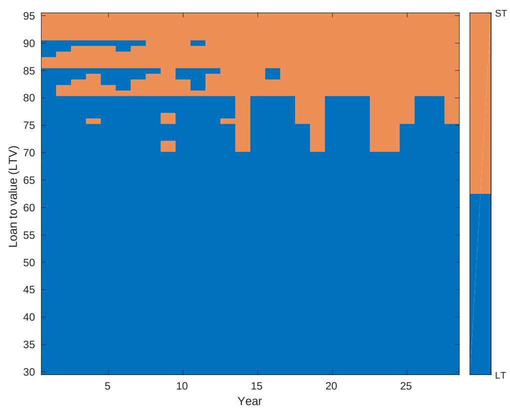
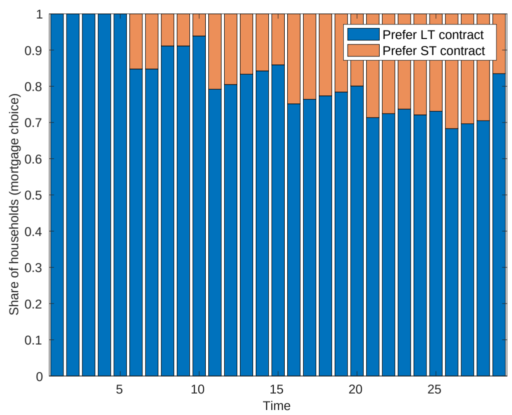


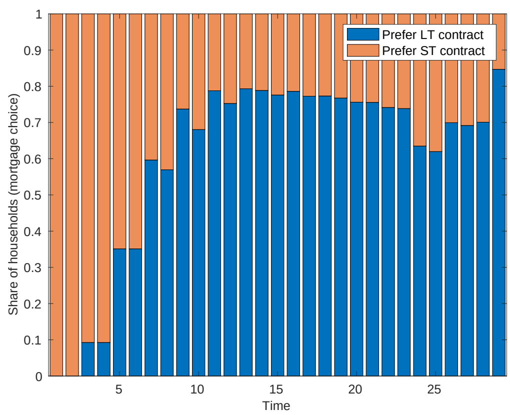
Figure 8: Optimal Mortgage Choice Over the Life of the Loan

These figures show simulated optimal mortgage choice for a relatively long-term contract with fixation length $\theta^{LT} = 5$ against a shorter-term contract with $\theta^{ST} = 2$, under the baseline calibration for households with an initial LTV of 70% (Panel A) and 90% (Panel B), and for households with an initial LTV of 90% for the baseline calibration and the baseline under expected cost pricing (imposing a collateral term premium of zero, Panel C).

(a) Low LTV (Baseline)



(b) High LTV (Baseline)



(c) High LTV (Expected Cost Pricing)

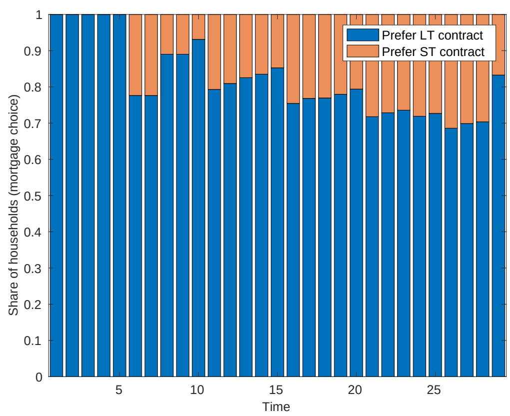
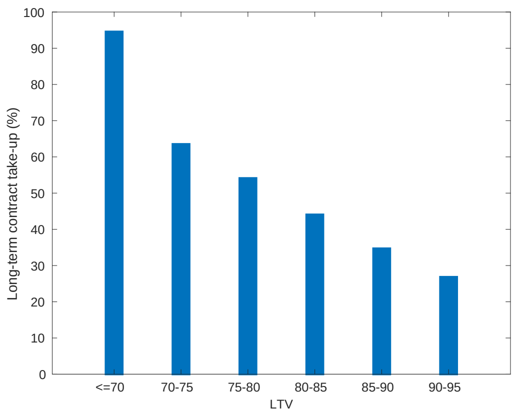


Figure 9: Take-Up and Value of Longer-Term Contracts

This figure shows 5-year contract take-up over the first 10 years since loan origination (Panel A) across initial LTV bands. Panel B further shows the consumption certainty equivalent, i.e. the increase in consumption (in per cent) across states that a household would require to reach the same life-time expected utility when a longer-term contract ($\theta^{LT} = 5$) is available, in addition to a shorter-term contract ($\theta^{ST} = 2$), under the baseline calibration.

(a) Take-Up



(b) Value

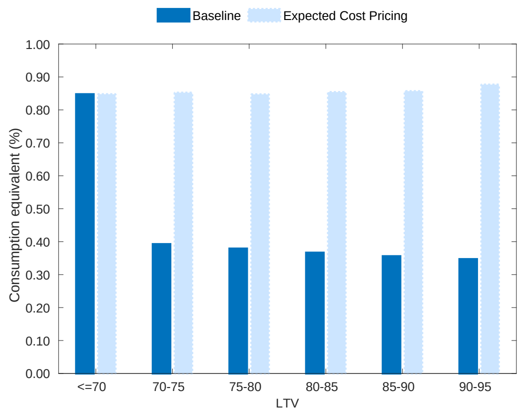


Table 1: 5-year Contract Choice Regressions

This table shows three regressions of the probability of taking out a 5-year contract, compared to taking out a 2-year contract, on a set of covariates that could be related to 5-year contract choice. The dependent variable is an indicator that takes the value 1 if the contract fixation length is 5 years, and 0 if the fixation length is 2 years. All independent variables are expressed in standard deviations of the variable. Column (1) uses past (10-year) local quarterly house price volatility, while column (2) uses a rolling (10-year) beta of the local house price index with respect to the aggregate house price index. Column (3) instead includes local-area×time fixed effects. Local area refers to local authority districts, while region refers to 12 administrative regions in the UK. Borrower types are first-time borrowers, second-time borrowers and remortgagors.

	(1) I[5yr]	(2) I[5yr]	(3) I[5yr]
Loan to Value	-0.193***	-0.193***	-0.195***
	(0.003)	(0.003)	(0.003)
Loan to Income	0.020***	0.020***	0.022***
	(0.002)	(0.002)	(0.002)
Age	0.054***	0.054***	0.060***
	(0.011)	(0.011)	(0.010)
Age (sq.)	-0.086***	-0.087***	-0.095***
	(0.012)	(0.012)	(0.011)
Mortgage term	-0.088***	-0.088***	-0.088***
	(0.003)	(0.003)	(0.003)
Local house price growth (2yr pre)	-0.010*	-0.010	
	(0.006)	(0.006)	
Local house price volatility	0.002		
	(0.004)		
Local house price beta		-0.006**	
		(0.003)	
Year-Month FE	✓	✓	✓
Region×Time FE	✓	✓	
Local-Area×Time FE			✓
Lender FE	✓	✓	✓
Lender×Time FE	✓	✓	✓
Borrower-type FE	✓	✓	✓
Observations	2,865,661	2,865,661	2,865,661
R^2	0.12	0.12	0.13

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2: Collateral Term Premium and Total Cost

This table shows the components of the collateral term premium, the pricing differential across 5- and 2-year fixed rate contracts ($\Delta\rho$), the interest path differential of the shorter-term rate (Δr), and the collateral term premium expressed in basis points (column 3) and as a percentage of mortgage cost (column 4) over the first five years of the loan, across LTV bands, under the baseline calibration. Column 5 shows a total cost measure over the first five years of the loan, taking into account mortgage cost, the fixed cost of refinancing at each new loan origination, and the bond term premium κ.

			Collateral Term Premium		Total Cost
LTV band	$\Delta\rho$	Δr	ϕ (bp)	% (Cost)	%
[0-70]	0	0	0	0.0	4.1
(70-75]	18	0	18	2.4	6.5
(75-80]	17	2	19	2.5	6.7
(80-85]	26	2	28	3.7	7.9
(85-90]	4	28	32	4.0	8.1
(90-95]	3	69	72	8.7	12.8

Table 3: Baseline Calibration of Model Parameters

This table provides an overview of calibrated model parameters for the baseline lifecycle model. Real interest rate parameters are estimated using UK average annual rates on 5-year inflation-indexed gilts between 1987 to 2017, and 1-year real rates deflated using 1-year ahead inflation expectations. House price parameters are estimated using the UK annual house price index between 1987 to 2017. The average loan-to-income ratio is estimated based on PSD data between 2013 and 2017 of first-time buyers within the LTV band of 80-85%, and is converted to an loan-to-after-tax-income ratio using the 2017 effective UK tax rate. The long-term and short-term contract fixation lengths are based on the two most common types of products in the PSD data. The 5-year to 2-year swap rate premium is based on average UK swap rates between 2013 and 2017 using yield curve data from the Bank of England. The mortgage rate premium is computed as the difference between the 2-year 60% LTV mortgage rate and the 2-year UK swap rate over the same time period. The interest rate premia are extracted from a regression (see specification in Figure 3a) using PSD loan-level data between 2013 and 2017. The revert rate premium is computed as the difference between the average revert rate and the 2-year 60% LTV mortgage rate.

Parameter		**Value**	**Source**
Panel A: Household preferences			
Risk aversion	γ	3	Literature
Time discount rate	δ	0.02	Literature
Panel B: Interest rates			
Mean of log real rate	μ_r	0.0164	UK (1987-2017)
Standard deviation of log real rate	σ_r	0.0193	UK (1987-2017)
Autoregression coefficient of log real rate	ρ_r	0.95	UK (1987-2017)
Panel C: House prices			
Mean of house price shock	μ_h	0.0258	UK (1987-2017)
Standard deviation of house price shock	σ_h	0.077	UK (1987-2017)
Loan-to-income ratio (85% LTV)	LTI	3.56	PSD (2013-2017)
Loan-to-after-tax-income (85% LTV)		4.82	Computed (tax rate of 35.5%)
Panel D: Income			
Standard deviation of transitory income shock	σ_ϵ	0.1	Literature
Panel E: Mortgage rates and fixation length			
Fixation length of long-term contract (years)	θ_{LT}	5	PSD
Fixation length of short-term contract (years)	θ_{ST}	2	PSD
Mortgage rate premium (bp)	ρ^m	93	Bank of England database, 2yr 60% LTV rate (2013-2017)
2yr 70-75% LTV premium (bp)	$\rho^{2,75-75}$	2	PSD (2013-2017)
2yr 75-80% LTV premium (bp)	$\rho^{2,75-80}$	15	PSD (2013-2017)
2yr 80-85% LTV premium (bp)	$\rho^{2,80-85}$	31	PSD (2013-2017)
2yr 85-90% LTV premium (bp)	$\rho^{2,85-90}$	103	PSD (2013-2017)
2yr 90-95% LTV premium (bp)	$\rho^{2,90-95}$	214	PSD (2013-2017)
5yr 70-75% LTV premium (bp)	$\rho^{5,75-75}$	21	PSD (2013-2017)
5yr 75-80% LTV premium (bp)	$\rho^{5,75-80}$	32	PSD (2013-2017)
5yr 80-85% LTV premium (bp)	$\rho^{5,80-85}$	57	PSD (2013-2017)
5yr 85-90% LTV premium (bp)	$\rho^{5,85-90}$	108	PSD (2013-2017)
5yr 90-95% LTV premium (bp)	$\rho^{5,90-95}$	217	PSD (2013-2017)
Revert rate premium	ρ^{REV}	269	Bank of England database (2013-2017)

Table 4: Long-Term Contract Shares

This table shows the simulated long-term contract shares given optimal household choice under different scenarios. The columns show results taking pricing as given for low-(70%) and high-(90%) LTV borrowers, and under expected cost pricing (imposing a collateral term premium of zero), respectively. The rows show different scenarios for house price growth and risk, and interest rate risk. The long-term contract shares are computed as the share of household-year observations that are under a long-term, compared to a short-term contract, over the first ten years since loan origination (Panel A) and over the entire maturity of the loan, 30 years (Panel B). The simulation tracks household optimal behavior given realization of shocks, based on 10,000 households for each scenario and LTV band.

	Baseline		Expected Cost Pricing	
	Low LTV	High LTV	Low LTV	High LTV
Panel A: Share on Long-Term Contract Over Initial 10 Years				
Baseline	0.95	0.35	0.96	0.93
No house price growth ($\mu_h = 0$)	0.89	0.66	0.95	0.84
No house price growth and higher risk ($\mu_h = 0$, $\sigma_h = 0.0770 * 2$)	0.87	0.80	0.86	0.81
Higher interest rate risk ($\sigma_r = 0.0193 * 2$)	0.97	0.93	0.97	0.96
No house price growth & higher interest rate risk	0.96	0.82	0.97	0.93
Panel B: Share on Long-Term Contract Over 30 Years				
Baseline	0.83	0.62	0.84	0.83
No house price growth ($\mu_h = 0$)	0.80	0.66	0.83	0.77
No house price growth and high vol ($\mu_h = 0$, $\sigma_h = 0.0770 * 2$)	0.77	0.71	0.78	0.72
Higher interest rate risk ($\sigma_r = 0.0193 * 2$)	0.91	0.89	0.89	0.89
Higher house price & interest rate risk	0.89	0.82	0.89	0.87

Table 5: Value of Long-Term Contract

This table shows the consumption-equivalent of introducing a long-term contract to an existing short-term contract under different scenarios. The columns show results taking pricing as given for low- (70%) and high-(90%) LTV borrowers, and under expected cost pricing (imposing a collateral term premium of zero), respectively. The rows show different scenarios for house price growth and risk, and interest rate risk. The consumption certainty equivalent is computed as the percentage increase in consumption across states that a household would require to reach the same life-time expected utility when a longer-term contract is available, in addition to the shorter-term contract. Life-time expected utility is simulated by tracking household optimal behavior given realization of shocks, based on 10,000 households for each scenario and LTV band.

	Baseline		Expected Cost Pricing	
	Low LTV	High LTV	Low LTV	High LTV
Panel A: Value of 5-year Contract				
Baseline	0.85	0.36	0.85	0.86
No house price growth ($\mu_h = 0$)	0.84	0.73	0.86	0.85
No house price growth and higher risk ($\mu_h = 0$, $\sigma_h = 0.0770 * 2$)	0.96	0.87	1.01	0.96
Higher interest rate risk ($\sigma_r = 0.0193 * 2$)	1.47	1.44	2.60	3.46
Higher house price & interest rate risk	2.60	3.41	2.61	3.43
Panel B: Value of 10-year Contract				
Baseline	2.03	0.74	2.03	2.04

Table 6: Long-Term Contract Shares (Robustness)

This table shows the simulated long-term contract shares given optimal household choice under different scenarios. The columns show results taking pricing as given for low-(70%) and high-(90%) LTV borrowers, and under expected cost pricing (imposing a collateral term premium of zero), respectively. The rows show additional scenarios. The long-term contract shares are computed as the share of household-year observations that are under a long-term, compared to a short-term contract, over the first ten years since loan origination (Panel A) and over the entire maturity of the loan, 30 years (Panel B). The simulation tracks household optimal behavior given realization of shocks, based on 10,000 households for each scenario and LTV band.

	Baseline		Expected Cost Pricing	
	Low LTV	High LTV	Low LTV	High LTV
Panel A: Share on Long-Term Contract Over Initial 10 Years				
Higher risk aversion ($\gamma = 10$)	0.95	0.35	0.96	0.94
Higher time discount rate ($\beta = 0.9$)	0.95	0.35	0.96	0.93
Higher revert rate ($\rho^{REV} = 538bp$)	0.95	0.40	0.96	0.94
Panel B: Share on Long-Term Contract Over 30 Years				
Higher risk aversion ($\gamma = 10$)	0.84	0.63	0.84	0.83
Higher time discount rate ($\beta = 0.9$)	0.83	0.62	0.84	0.83
Higher revert rate ($\rho^{REV} = 538bp$)	0.83	0.63	0.84	0.83

Table 7: Value of Long-Term Contract (Robustness)

This table shows the consumption-equivalent of introducing a long-term contract to an existing short-term contract under different scenarios. The columns show results taking pricing as given for low- (70%) and high-(90%) LTV borrowers, and under expected cost pricing (imposing a collateral term premium of zero), respectively. The rows show additional scenarios. The consumption certainty equivalent is computed as the percentage increase in consumption across states that a household would require to reach the same life-time expected utility when a longer-term contract is available, in addition to the shorter-term contract. Life-time expected utility is simulated by tracking household optimal behavior given realization of shocks, based on 10,000 households for each scenario and LTV band.

	Baseline		Expected Cost Pricing	
	Low LTV	High LTV	Low LTV	High LTV
Panel A: Value of 5-year Contract				
Higher risk aversion ($\gamma = 10$)	1.08	0.31	1.08	0.88
Higher time discount rate ($\beta = 0.9$)	0.91	0.22	0.91	1.04
Higher revert rate ($\rho^{REV} = 538bp$)	0.72	0.21	0.72	0.75

Online Appendix for "The Demand for Long-Term Mortgage Contracts and the Role of Collateral"

A. Additional Figures and Tables

Figure A.1: Illustration of Payment Profile for UK Mortgage Contracts with Initial Fixation Period

This figure illustrates the payment structure of a typical UK fixed-rate mortgage contract. The initial fixed-rate r^{θ} is fixed over the initial fixation length θ, throughout which prepayment penalties apply if the mortgage is prepaid. The interest rate then automatically switches to a revert rate $\tilde{r}$ until the end of the loan repayment window T, which is a floating rate that is priced over a premium over the base rate (Bank Rate). Rather than paying this rate at reset, the borrower can choose to refinance, at which point the new contract is priced.

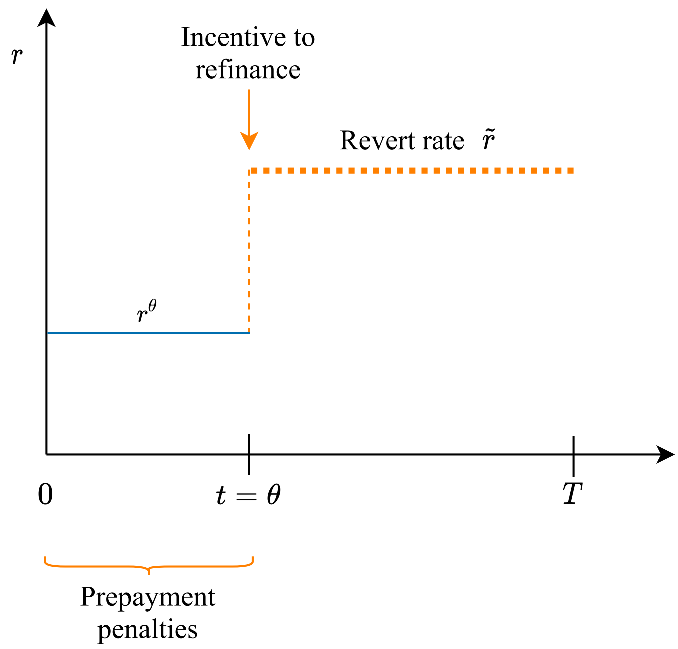


Figure A.2: Mortgage Fixation Period Across Countries

This figure shows average initial mortgage fixed-rate lengths across advanced economies, based on administrative data obtained from Badarinza et al. (2016), as at December 2013 (with the exceptions of Greece and Denmark, which are from 2010). For Canada and Australia, this data was not available so the most frequent range is plotted, which akin to the UK, is 2 to 5 years.

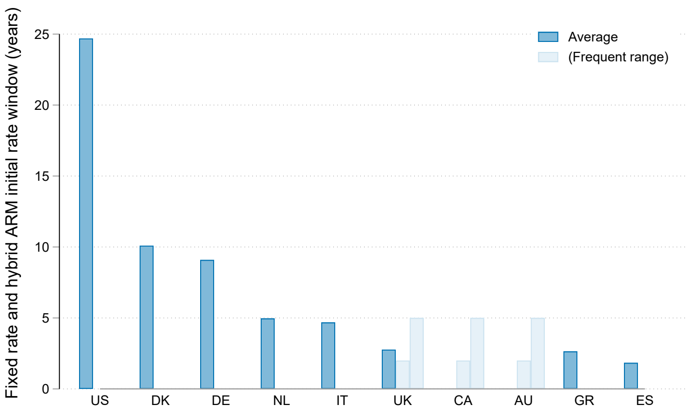


Figure A.3: Mortgage Pricing and Role of LTV

This figure shows the adjusted R^2 from a regression of observed rates on a range of fixed effects. "Base" refers to the regression including year-month, lender, buyer type (first-time buyer, second time buyer or refinance) and fixation length (less than 1, 2, 3 to 4, 5, more than 5) fixed effects, and all interaction effects. "+Income" includes income decile fixed effects and interactions with year-month to the base specification, and "+Age" and "+LTV" do this analogously for borrower age decile, and LTV band ($\leq$70%, 70-75%, 75-80%, 80-85%, 85-90%, and 90-95%) fixed effects.

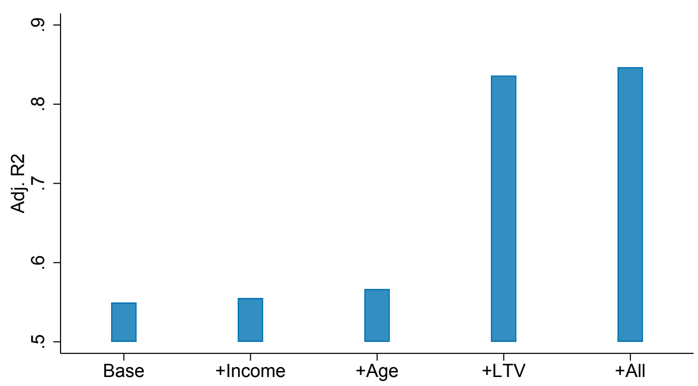


Figure A.4: LTV Pricing

This figure plots the credit spread paid on 2-year fixed-rate mortgages across loan-to-value (LTV) bands ($\leq$70%, (70-75]%, (75-80]%, (80-85]%, (85-90]%, and (90-95]%), by extracting LTV-band fixed effects from a regression of interest rates on LTV bands and fixation period length (2 or 5 years), controlling for year-month, lender, buyer-type, year-month$\times$lender fixed effects, using data from 2013 to 2017.

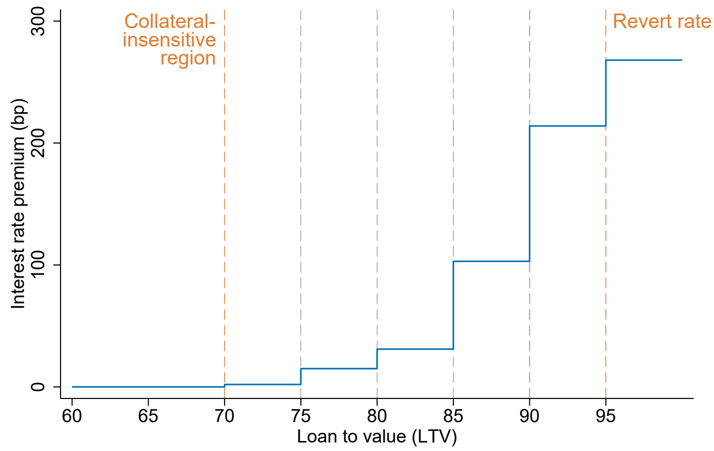
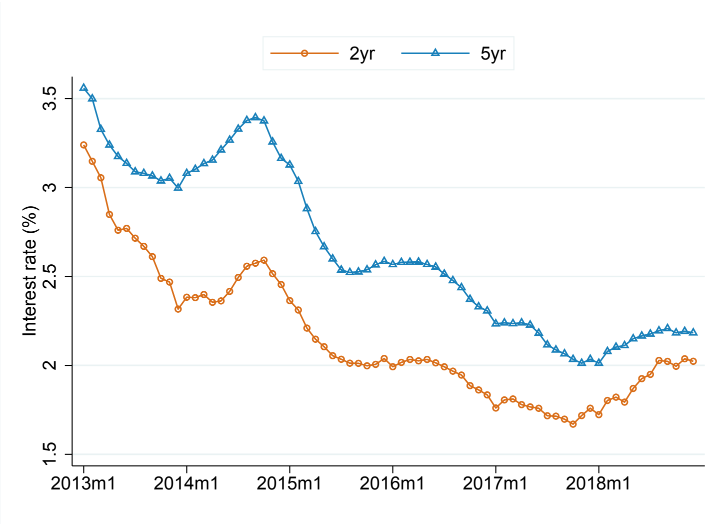


Figure A.5: Bond Term Premium and Swap Rate Spread

This figure shows the time-series evolution of 2- and 5-year fixed rate mortgage rates with ≤70% LTV. Panel A shows the average mortgage rates. Panel B shows the difference between the 5-year and 2-year mortgage rate, expressed in basis points, and overlays the 5-year minus 2-year UK swap rate spread.

(a) Average Interest Rates (Low LTV)



(b) Rate and Swap Rate Differential

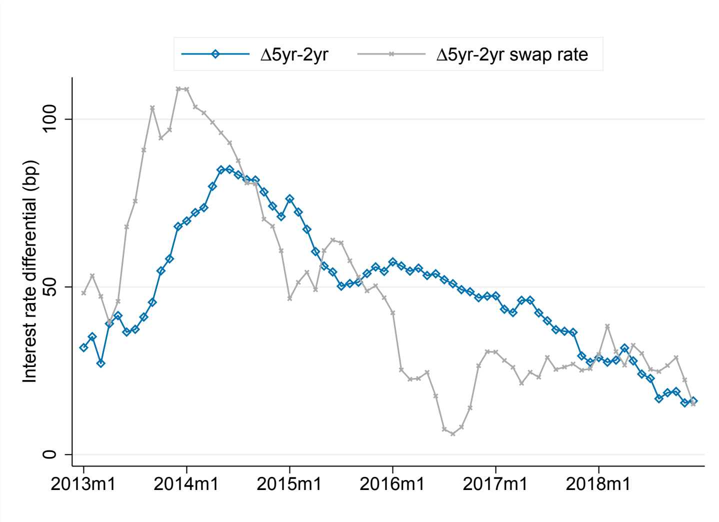


Figure A.6: Expected LTV and Interest Rate Path (Longer Term)

This figure shows the simulated expected LTV (Panel A) and interest rate path (Panel B) for households with an initial LTV of 90% for the full maturity (30 years) and 20 years after origination, respectively. The expected LTV is shown under the baseline scenario. In Panel B, the dotted vertical stalks illustrate the repricing instances when rolling over a 2-year contract. The dashed (gray) line plots the 5-year fixed rate interest rate path that is cost-equivalent to the expected rate path when rolling over a matching series of 2-year contracts.

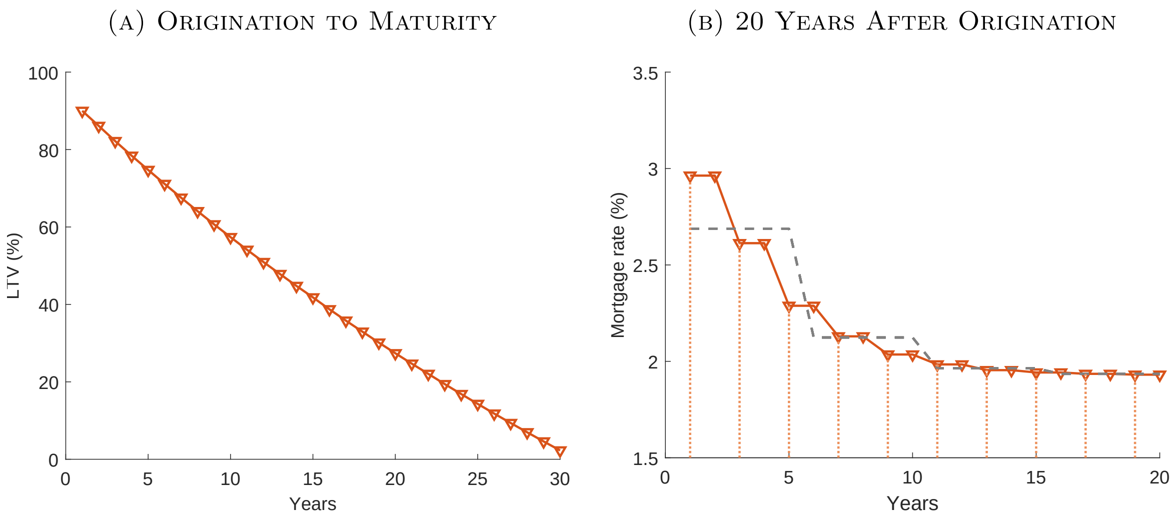
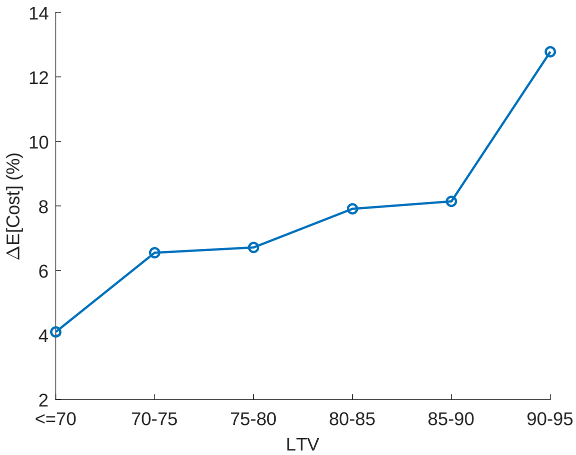


Figure A.7: Expected Cost Differential and Standard Deviation

Panel A of this figure shows the discounted present value of the expected cost differential when comparing the cost of a 5-year fixed rate contract held over the 5-year fixation period, with the expected cost of rolling over a 2-year contract 2.5 times, for the initial 5 years of the loan, accounting for the origination fees incurred for each contract. The computation takes into account both the collateral term premium and bond term premium. The expected cost differential is expressed as a percentage share of the discounted present value of the expected cost under the 2-year contract sequence. Panel B of this figure shows the standard deviation in the expected cost differential of the 2-year contract sequence, again expressed a percentage share of the discounted present value of the expected cost under the 2-year contract sequence, under the baseline scenario with house price risk and interest rate risk (solid blue line) and only house price risk (dotted grey line).

(A) Expected Cost Differential



(B) Standard Deviation

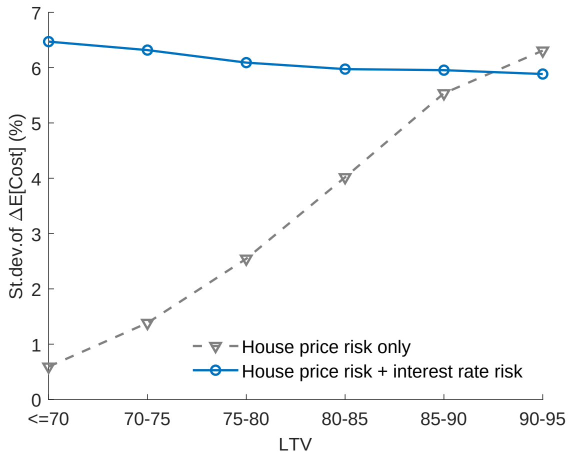
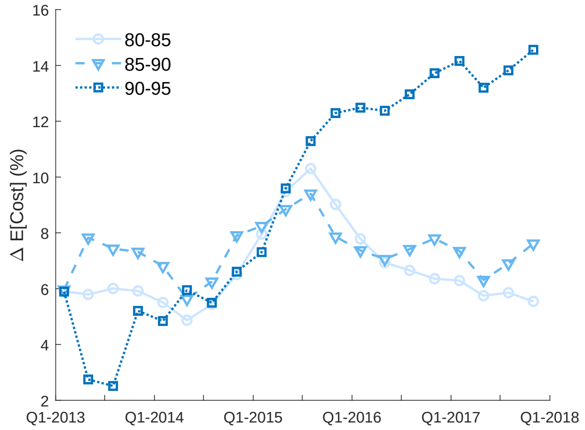


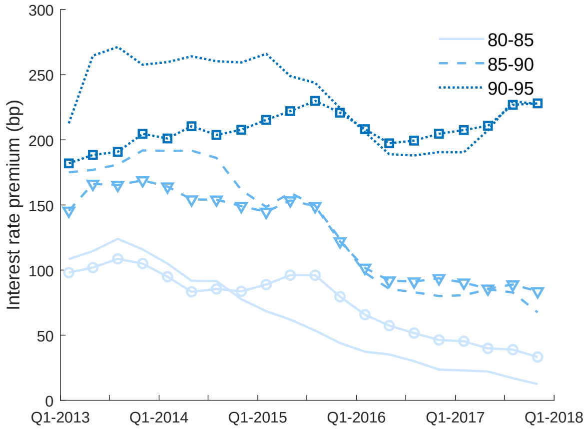
Figure A.8: Time-Series Variation in Expected Cost Differential and LTV Pricing

Panel A of this figure shows time-series variation in the expected cost differential for high initial LTV bands (80-85, 85-90, 90-95) by computing the expected cost using quarterly estimated LTV premia curves. The variation in LTV premia over time across high initial LTV bands is shown in Panel B, with the lines reflecting 2-year contract LTV premia, and the connected lines (with markers) reflecting 5-year contract LTV premia. Variation in interest rate premia across all LTV bands over time is shown in Panel C (for 2-year contracts) and Panel D (for 5-year contracts).

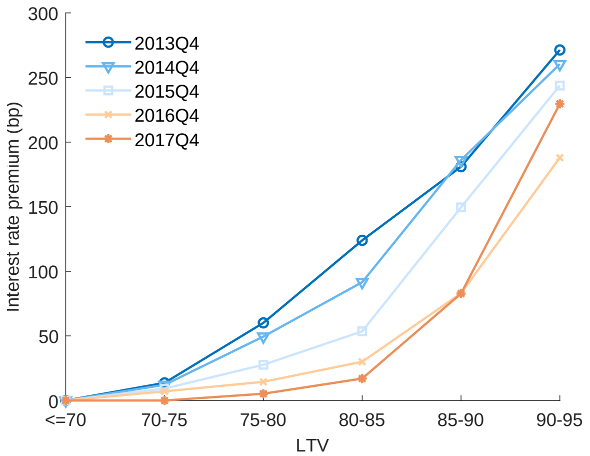
(a) Expected Cost Differential (High LTV)



(b) LTV Premia Levels (High LTV)



(c) LTV Premia Curves (2yr)



(d) LTV Premia Curves (5yr)

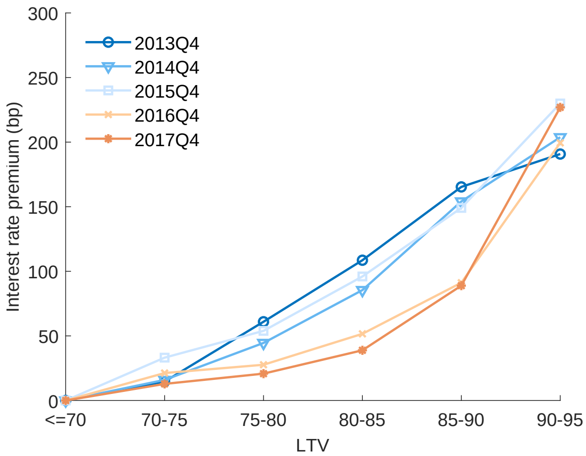


Figure A.9: Distribution of Expected Cost for Short-Term Contract Sequence

This figure shows the simulated distribution of mortgage costs (excluding bond term premia) over the initial 5 years since loan origination under the baseline calibration, based on rolling over a sequence of 2-year contracts, across initial LTV bands. The red vertical line indicates the total mortgage cost for a 5-year contract over the same period.

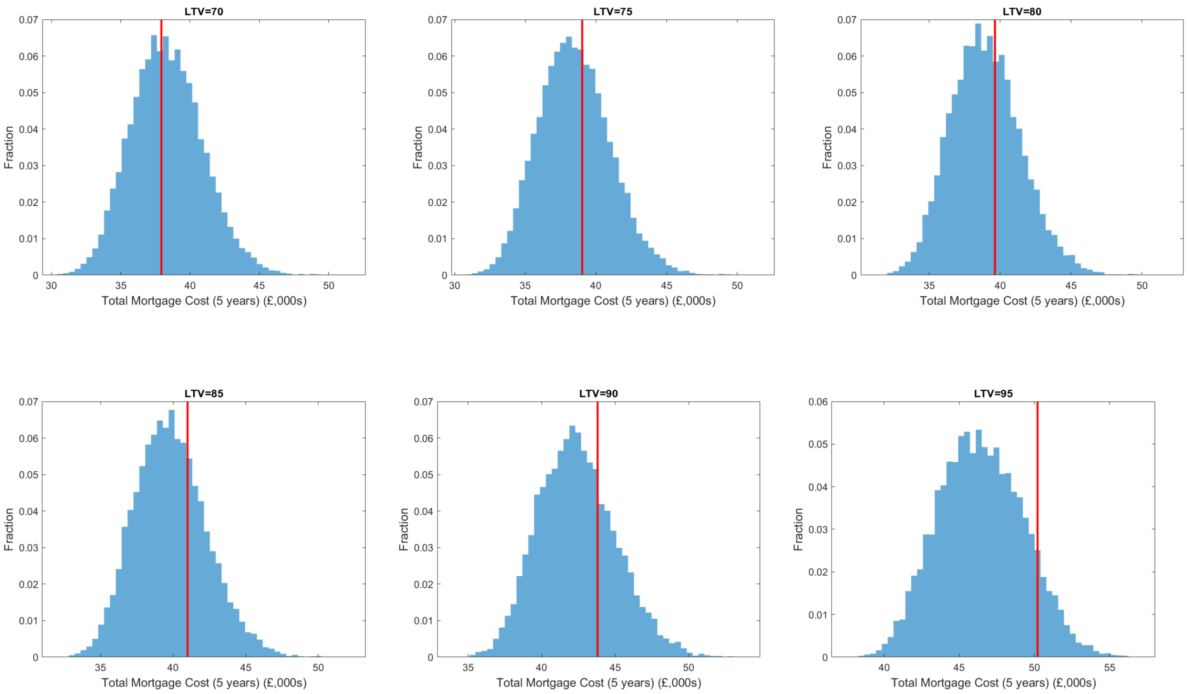
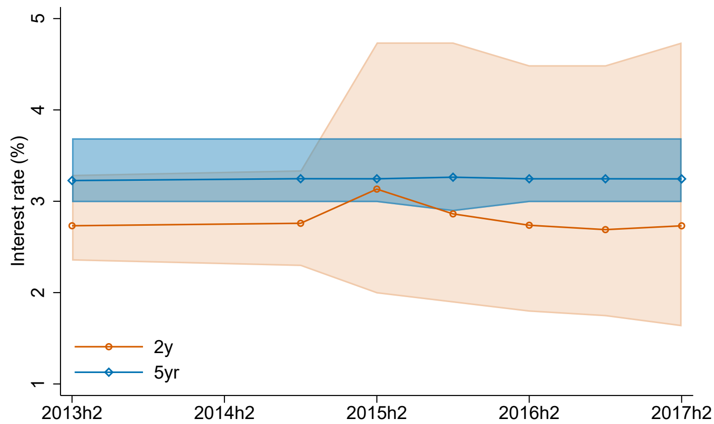


Figure A.10: Ex Post Repricing

This figure tracks the 2013H2 cohort of first-time borrowers and the distribution of mortgage rates paid based on the interdecile range (shaded area), and average rate (connected dots), over time, for 2- and 5-year fixed-rate borrowers who stay with their initial lender, respectively. Panel A shows rates paid for borrowers with an initial LTV between 70-75%, and Panel B shows the equivalent for borrowers with an initial LTV between 85-90%.

(a) Low LTV



(b) High LTV

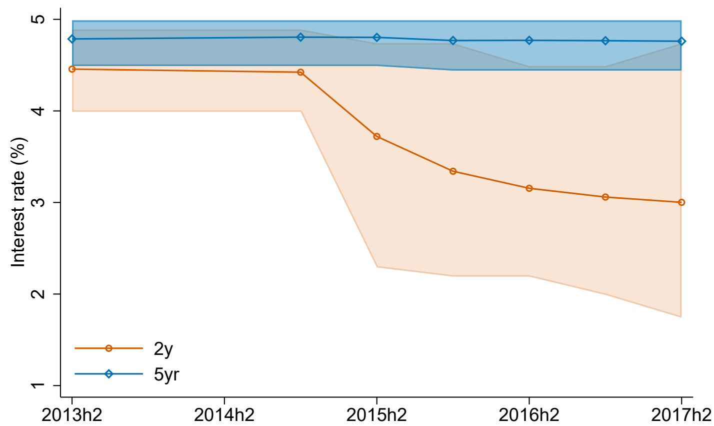


Figure A.11: Illustration of Value Function and Repricing States

This figure illustrates the time×repricing state dependencies of the value function, for $\theta^{LT} = 5$. Horizontally, each box represents a value of the value function in the time dimension. Vertically, each box represents a value of the value function in the repricing state dimension, for V_t^{LT}. Since $V_t^* = \max\{V_t^{LT}, V_t^{ST}\}$, there is only one value across all repricing states for V_t^*. V_t^{LT} tracks the value function if the household chooses a long-term contract at each point in time t, using its value across a linked chain of repricing states from $\mathcal{S} = 1$ to $\mathcal{S} = 5$.

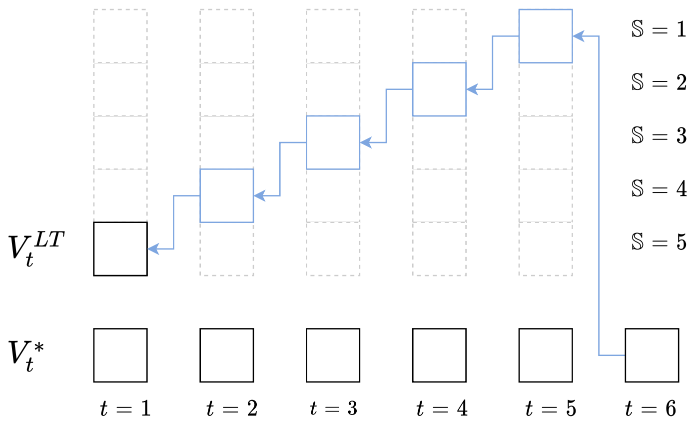


Table A.1: Matching to 2015H2 mortgage stock

This table shows the share of borrowers in each first-time borrower cohort between 2013H2 and 2015H2 in the origination data that can be matched to the stock of all mortgages outstanding in 2015H2.

	2015H2 data					
FTB cohort	Not matched		Matched		Total	
	No.	%	No.	%	No.	%
2013H2	8,641	6.0%	135,156	94.0%	143,797	100.0%
2014H1	5,761	4.1%	134,714	95.9%	140,475	100.0%
2014H2	4,832	3.2%	147,732	96.8%	152,564	100.0%
2015H1	4,208	3.3%	121,642	96.7%	125,850	100.0%
2015H2	2,841	1.8%	155,533	98.2%	158,374	100.0%
Total	26,283	3.6%	694,777	96.4%	721,060	100.0%

Table A.2: Balance of matched observations

This table compares the average and standard deviation (in parenthesis) between the matched and unmatched sample shown in Table A.1 across a range of observable characteristics.

	Not matched	Matched
Age	32.43	31.10
	(8.15)	(7.04)
Joint income	0.62	0.52
	(0.49)	(0.50)
Income	55,941.19	44,730.56
	(37996.93)	(26664.04)
Interest rate	3.44	3.39
	(0.92)	(0.98)
Property value	231813.09	196273.54
	(169120.75)	(128351.37)
Loan size	163466.68	146385.20
	(104402.00)	(87692.48)
Loan term	26.71	28.10
	(6.67)	(6.14)
Loan to value	74.10	77.11
	(17.90)	(16.67)
Loan to income	3.14	3.38
	(1.10)	(0.94)
Origination year	2,013.94	2,014.20
	(0.77)	(0.74)
Observations	26283	694777

Table A.3: Sample selection balance (fixation length observed)

This table compares the average and standard deviation (in parenthesis) between the subset of observations for which the fixation length is observed and that for which it is not, in the matched sample across a range of observable characteristics.

	Observed	Not observed
Age	31.17	31.12
	(7.08)	(7.10)
Joint income	0.53	0.52
	(0.50)	(0.50)
Income	45,519.82	44,562.74
	(27052.27)	(27401.57)
Interest rate	3.35	3.50
	(1.00)	(0.93)
Property value	202989.23	190187.81
	(133625.97)	(125062.78)
Loan size	149795.33	143212.81
	(91227.37)	(84286.01)
Loan term	28.08	28.01
	(6.09)	(6.26)
Loan to value	76.60	77.54
	(17.52)	(15.56)
Loan to income	3.38	3.36
	(0.95)	(0.94)
Origination year	2,014.58	2,013.67
	(0.65)	(0.50)
Observations	414643	306417

Table A.4: Summary statistics for 2-year and 5-year fixed-rate borrowers

This table compares the average and standard deviation (in parenthesis) between borrowers with a 2-year, and borrowers with a 5-year fixed-rate mortgage, across a range of observable characteristics.

	2yr	5yr
Age	36.61	38.79
	(9.03)	(9.75)
Joint income	0.59	0.59
	(0.49)	(0.49)
Income	56,316.30	55,981.29
	(36442.04)	(37203.44)
Interest rate	2.49	2.84
	(0.93)	(0.76)
Property value	254979.79	272843.98
	(168882.49)	(186351.35)
Loan size	172613.09	157630.42
	(109938.94)	(106689.80)
Loan term	25.23	22.64
	(7.50)	(7.96)
Loan to value	71.10	61.76
	(19.95)	(21.74)
Loan to income	3.19	2.95
	(1.03)	(1.09)
Observations	1898727	967047

Table A.5: Collateral Term Premium and Total Cost - Low House Price Growth

This table shows the components of the collateral term premium, the pricing differential across 5- and 2-year fixed rate contracts ($\Delta\rho$), the interest path differential of the shorter-term rate (Δr), and the collateral term premium expressed in basis points (column 3) and as a percentage of mortgage cost (column 4) over the first five years of the loan, across LTV bands, in a scenario with no house price growth ($\mu_h = 0$). Column 5 shows a total cost measure over the first five years of the loan, taking into account mortgage cost, the fixed cost of refinancing at each new loan origination, and the bond term premium κ.

			Collateral Term Premium		Total Cost
LTV band	$\Delta\rho$	Δr	ϕ (bp)	% (Cost)	%
[0-70]	0	0	0	0.0	4.1
(70-75]	18	0	18	1.7	5.9
(75-80]	17	0	17	1.1	5.3
(80-85]	26	0	26	1.3	5.4
(85-90]	4	2	6	0.5	4.7
(90-95]	3	38	41	4.8	8.9

Table A.6: Collateral Term Premium and Total Cost - High House Price Growth

This table shows the components of the collateral term premium, the pricing differential across 5- and 2-year fixed rate contracts ($\Delta\rho$), the interest path differential of the shorter-term rate (Δr), and the collateral term premium expressed in basis points (column 3) and as a percentage of mortgage cost (column 4) over the first five years of the loan, across LTV bands, in a scenario with high house price growth ($\mu_h = 0.0258 \times 2$). Column 5 shows a total cost measure over the first five years of the loan, taking into account mortgage cost, the fixed cost of refinancing at each new loan origination, and the bond term premium κ.

			Collateral Term Premium		Total Cost
LTV band	$\Delta\rho$	Δr	ϕ (bp)	% (Cost)	%
[0-70]	0	0	0	0.0	4.1
(70-75]	18	0	19	2.6	6.8
(75-80]	17	6	23	3.2	7.3
(80-85]	26	11	37	5.1	9.2
(85-90]	4	44	49	6.4	10.5
(90-95]	3	93	96	12.1	16.2

Table A.7: Predicting default and the value of current information by LTV band - AUC differentials

This table reports the area-under-the-curve (AUC) for logit regressions that predict the probability of being in arrears across different LTV bands, excluding and including the current (estimated based on local house price changes) LTV two years after origination, in addition to the initial LTV, in order to assess the informational value contained in an updated LTV. The last column plots the difference between the AUCs with and without current LTV.

	Area Under the Curve (AUC)		
LTV band	Without current LTV	With current LTV	Difference
≤70	0.575	0.583	0.008
70-75	0.550	0.583	0.033
75-80	0.586	0.593	0.007
80-85	0.593	0.610	0.016
85-90	0.590	0.603	0.013
90-95	0.592	0.602	0.010

B. Dataset Construction

B.1. Stock-Flow Merge (PSD007 and PSD001) for Borrower Panel

To analyze borrower refinancing behavior and repricing of rates at the point of refinance, I merge two administrative datasets on the universe of UK mortgage borrowers. First, I observe new mortgage originations in the Product Sales Data (PSD) that is accessed through the Bank of England via a data sharing agreement with the Financial Conduct Authority. The dataset collects detailed borrower characteristics such as income, age, address, loan amount, property value, and detailed loan characteristics such as the loan maturity, interest rate, fixation length, and which lender originated the mortgage. This allows me to identify first-time buyer cohorts who newly originate their mortgage between 2013H2 to 2015H1. The origination data is available from 2005Q2 and updated at quarterly frequency up to today.

I then use a more recent additional dataset that is part of the PSD which tracks the entire stock of UK mortgages outstanding, available from 2015H1 and updated at half-yearly frequency up to today. The stock data contains information on the current interest rate type, current interest rate paid, current loan amount, current lender, and whether the loan is in arrears. I merge the stock data with the origination data to track refinancing behavior and outcomes (e.g. interest rate paid and an indicator whether the borrower is in arrears) between 2015H1 and 2017H2 for the first-time borrower cohorts identified in the origination data.

The final data has a panel format which comprises detailed borrower and loan characteristics at origination, and half-yearly updates on outcomes such as interest rates, loan amount remaining and default status. In addition to the characteristics at origination, each refinance that reflects a switch to a different lender is recorded as a new origination, so I observe updated information on income and other borrower characteristics if the borrower does a so-called "external" refinance. This is in contrast to an "internal" refinance where the lender refinances into a different contract and interest rate, but stays with the current lender. I identify internal and external refinancers as follows: the data records if the borrower is on the revert rate, so a refinance requires the borrower to either move from a revert rate to a fixed-rate contract, or move from an existing fixed-rate contract into a new fixed-rate contract. External refinances are recorded in the origination data, so if a borrower is recorded as a refinancer in the origination data, the lender changes, and the interest rate changes in that period, I classify the borrower as an external refinancer. If only the interest rate changes but there is no entry in the orgination data and the lender remains the same, I classify this as an internal refinance.[48]

[48] Reassuringly, the resulting numbers are very similar to those provided by Belgibayeva et al. (2020) who obtain explicit data on internal refinancing through a survey of the 20 largest UK lenders for 2-year fixed rate borrowers in 2013.

For the 2013H2 first-time borrowers who took out a 2-year fixed rate contract, about 55% refinance internally, and around 30% refinance externally by 2016H1, i.e. within six months of the end of the fixed rate period in 2015H2. Each half-year origination cohort comprises around 150,000 first-time borrowers, leaving me with 721,060 unique borrowers, and around 5.5 million borrower-half-year observations between 2015H1 to 2017H2.

The two datasets do not have unique borrower identifiers, but a borrower can be identified up to an (anonymized) date of birth and six-digit postcode which is approximately the building block in which a UK household resides. Table A.1 illustrates the quality of the merge. The mortgage stock data starts in 2015H1 but in order to observe a longer time-series of outcomes, I start with a borrower cohort in 2013H2. That means that borrowers are not matched in 2015H1 if there is a pure merging error (e.g. because the borrower identification is not unique), or if borrowers prepay or default and leave the sample prior to 2015H1. In addition, the data is less complete in 2015H1 compared to 2015H2 onwards. I hence compare the observations that are not matched to the 2015H2 stock data across first-time borrower cohorts in Table A.1. From the share of "not matched" observations, it can be seen that 1.8% of first-time borrowers in 2015H2 cannot be matched to the stock data in 2015H2, which provides an estimate of unmatched observations driven by pure merging error.

Going from the origination cohort in 2015H1 back to 2013H2, around 1-2% more observations are unmatched from half-year to half-year, providing an estimate of the share of borrowers that leaves the stock data due to prepayment or porting the mortgage (for instance if the borrower moves to another house) or default, at half-yearly frequency. Note that because mortgages are portable in the UK, mortgages could show up in the data with the same borrower but a new house address, which I cannot track due to the borrower identification procedure described above. Table A.2 compares the average characteristics (with standard deviations) of borrowers and loans for matched and unmatched observations. Unmatched borrowers are slightly older, have larger incomes, loan sizes and property values, and lower loan-to-income and loan-to-value ratios, tentatively suggesting that the unmatched borrowers seem to reflect movers rather than more risky borrowers who have defaulted.

Lastly, the origination data prior to 2015H1 does not require to report the fixation length, so I do not observe the fixed-rate period for about 40% of first-time borrowers. The sample for which fixation lengths are observed appears to be a highly balanced sample compared to where it is not observed, as noted by Best et al. (2020) and demonstrated in Table A.3. I hence proceed with the remaining sample of 414,643 first-time borrowers for which this key variable is observed, resulting in a panel of around 2.8 million borrower-half-year observations.

C. Two-Period Framework for Long-Term Contract Pricing and Choice

The following provides intuition for mortgage pricing and household choice of a two-period contract. Households are risk-averse and demand loans of homogeneous size, which are standardized to have the value 1. Lenders are also homogeneous and the market is fully competitive. The price on a mortgage of size 1 is the mortgage interest rate $r(X_{1t}, X_{2t}, \dots)$, which is a function of pricing-relevant fundamentals $X_1, X_2 \dots$ such as the base rate and loan-to-value ratio at time of pricing t. Mortgage rates are set such that lenders break even on every contract. For simplicity, the following assumes a single source of risk X_t which realizes in period 2, and there is no discounting or borrowing. Households can choose between a sequence of short-term contracts with rates $\{r^{ST,1}(X_1), r^{ST,2}(X_2)\}$ and repricing based on realized X_t in period 2, or a long-term contract with a single rate paid over both periods $r^{LT,1}(X_1) = r^{LT,2}(X_1) \equiv r^{LT}(X_1)$ and no repricing in period 2. In a simplified environment where there are only two outcomes for $X_2 \in \{\underline{X}_2, \bar{X}_2\}$, denote π the probability with which $\underline{X}_2$ occurs, and $1-\pi$ the probability with which $\bar{X}_2$ occurs. I further assume full commitment, i.e. households cannot exit the long-term contract early to refinance into a short-term contract in period 2, which can be enforced using sufficiently high prepayment penalties. For risk-neutral lenders, the zero-profit condition implies

$$r^{ST,1}(X_1) + E\left[r^{ST,2}(X_2)\right] = r^{ST,1}(X_1) + \pi r^{ST,2}(\underline{X}_2) + (1-\pi) r^{ST,2}(\bar{X}_2) = 2r^{LT}(X_1), \quad (15)$$

i.e. the expected cost of the sequence of short-term contracts is equal to the expected cost of the long-term contract. If lenders are risk-averse and X reflects a systematic, rather than idiosyncratic, source of risk, then lenders may charge a risk-premium ϕ on the long-term contract:

$$r^{ST,1}(X_1) + \pi r^{ST,2}(\underline{X}_2) + (1-\pi) r^{ST,2}(\bar{X}_2) = 2r^{LT}(X_1) + \phi. \quad (16)$$

Households have a concave utility function $U(\cdot)$ and receive non-risky labor income y in each period and pay the mortgage cost. Using equation 15, the expected utility from the long-term contract payment stream is:

$$\underbrace{E\left[U\left(2y - 2r^{LT}(X_1)\right)\right]}_{\equiv E[U(LT)]} = U\underbrace{\left(2y - r^{ST,1}(X_1) - \pi r^{ST,2}(\underline{X}_2) - (1-\pi) r^{ST,2}(\bar{X}_2)\right)}_{E(\tilde{z})}. \quad (17)$$

The expected utility from the short-term contract payment stream is:

$$E[U(ST)] \equiv \underbrace{\pi U\left(2y - r^{ST,1}(X_1) - r^{ST,2}(\underline{X}_2)\right) + (1-\pi)U\left(2y - r^{ST,1}(X_1) - r^{ST,2}(\bar{X}_2)\right)}_{E[U(\tilde{z})]}. \tag{18}$$

Given concavity of the utility function, by Jensen's inequality we get $E\left[U(\tilde{z})\right] \leq U\left(E[\tilde{z}]\right)$, which implies:

$$E\left[U(ST)\right] \leq E\left[U(LT)\right] \tag{19}$$

i.e. risk-averse households prefer the non-risky long-term contract payment to the risky short-term contract payment stream. The effect is ambiguous once lenders charge a risk premium ϕ, and depends on the size of the premium, the distribution of risks and household risk aversion embedded in $U(\cdot)$. Households prefer the long-term contract iff:

$$\begin{aligned} &\underbrace{\pi U\left(2y - r^{ST,1}(X_1) - r^{ST,2}(\underline{X}_2)\right) + (1-\pi)U\left(2y - r^{ST,1}(X_1) - r^{ST,2}(\bar{X}_2)\right)}_{E[U(ST)]} \\ &\leq \underbrace{U\left(2y - r^{ST,1}(X_1) - \pi r^{ST,2}(\underline{X}_2) - (1-\pi)r^{ST,2}(\bar{X}_2) - \phi\right)}_{E\left[U(LT^{\phi})\right]}. \end{aligned} \tag{20}$$

D. Computation of Collateral Term Premia Expressed as Percentage of Mortgage Cost

Denote the mortgage payment at time t according to the standard annuity formula:

$$M_t(r_t^{m,\theta}, L_0, T) = L_0 \cdot \frac{r_t^{m,\theta}}{1 - \frac{1}{(1+r_t^{m,\theta})^T}}, \tag{21}$$

where $r_t^{m,\theta}$ is the mortgage rate paid with $\theta \in \{\theta^{LT}, \theta^{ST}\}$, L_0 is the initial loan value, and T is the overall maturity over which the loan is repaid. For the total cost measure, $r_t^{m,\theta^{LT}}$ includes κ.

The difference in the net present value of expected cost between the 5-year contract and the sequence of 2-year contracts over a five-year window is:

$$\begin{aligned}
\Delta E[Cost] &= E[Cost]^{LT} - E[Cost]^{ST} \\
&= \underbrace{\left(\sum_{t=0}^{t_c=4} \frac{M_t(r_0^{m,\theta^{LT}}(r_0, LTV_0), L_0, T)}{(1+\bar{r})^t} + k\right)}_{E[Cost]^{LT}} - \\
&\quad \left(M_0(r_0^{m,\theta^{ST}}(r_0, LTV_0), L_0, T) + k + \frac{M_1(r_0^{m,\theta^{ST}}(r_0, LTV_0), L_0, T)}{1+\bar{r}}\right. \\
&\quad + \frac{M_2(r_2^{m,\theta^{ST}}(r_2, LTV_2), L_0, T) + k}{(1+\bar{r})^2} + \frac{M_3(r_2^{m,\theta^{ST}}(r_2, LTV_2), L_0, T)}{(1+\bar{r})^3} \\
&\quad \left. + \frac{M_4(r_4^{m,\theta^{ST}}(r_4, LTV_4), L_0, T) + k/2}{(1+\bar{r})^4}\right),
\end{aligned} \tag{22}$$

where k is the fixed cost of originating a new loan, charged whenever a new loan is originated or rolled over, and $\bar{r}$ is the average base rate used for discounting.[49]

Panel A in Figure A.7 shows the simulated discounted present value of the expected cost differential across initial LTV bands. For the computation, the fixed cost of refinancing k is calibrated as the average total mortgage origination fee in the data, at £573, κ is 52 basis points and T is set to 30 years. The expected cost is expressed as a percentage share of the discounted present value of the expected cost under the 2-year contract sequence. With bond term premia and refinancing cost included, households with an LTV below 70% pay 4.1% more in mortgage payments over the initial 5 years, while households with an LTV of 95% pay 12.8% more for the 5-year contract compared to rolling over a 2-year contract sequence.

Panel B of this figure shows the cross-sectional standard deviation in the cost of the 2-year contract sequence, again expressed as a percentage share of the discounted present value of the expected cost under the 2-year contract sequence, under different house price scenarios. While the standard deviation expressed as a share of the average cost is relatively flat with interest rate and house price risk, the variability of mortgage payments is strongly increasing in LTV in a scenario with only house price risk, given the convexity of LTV premia observed.

[49] As before, the short-term contract sequence implies repricing every two years depending on the LTV_t, and the base rate r_t, at the time of repricing, while the long-term contract locks in the initial LTV LTV_0 and base rate r_0. In the last period, the fixed cost for originating the third two-year contract is split by half to reflect the five-year window over which the expected cost is computed.

E. Model Appendix

E.1. Numerical solution

Discretization. The six state variables are discretized as follows. Net financial wealth (X) is normalized by permanent income at age 35. Grid points are equally spaced on a grid between 0 to 22.5 in steps of 0.025, yielding 901 grid points. Time is measured in years between 30 to 80 (working age from 30 to 60, and retirement from 60 to 80), yielding 51 grid points. The LTV grid takes values between 30 to 150, in steps of 1 percentage points, yielding 121 grid points. The interest rate process is discretized using five states using the method by Rouwenhorst (1995), which has been shown by Kopecky and Suen (2010) to yield better results when approximating very persistent AR(1) processes compared to Tauchen (1986); Tauchen and Hussey (1991). The repricing state variables $\mathcal{S}^{\theta^{LT}}$ and $\mathcal{S}^{\theta^{ST}}$ take 5 (or 10) and 2 states, respectively. Transitory income shocks and house price shocks are discretized on an equal-spaced grid between -4 and 4 standard deviations.[50] Consumption is placed on the same grid as net financial wealth, while mortgage contract choice is discrete with two outcomes (short- or longer-term contract).

Model solution. Optimal consumption and mortgage fixation choice policy functions are found as the maximum for each combination of discretized states in the state space, i.e. $901 \times 51 \times 121 \times 5 \times (5+2)$ (for the 5-year contract) or $901 \times 51 \times 121 \times 5 \times (10+2)$ (for the 10-year contract), yielding around 195 to 334 million combinations. The model is solved separately under different specifications, and under observed vs. expected cost pricing, which is computationally intensive and parallelized on the Imperial HPC cluster.

Simulation. I use the optimal policy functions for consumption and mortgage fixation choice to simulate the model. Households are initialized at $t = 1$ with zero net financial wealth and a random distribution of transitory income shocks, and no house price or interest rate shocks, in order to allow households to start at the same initial LTV band and interest rate. The initial base interest rate places households in the second lowest out of five states, in order to reflect the current environment with greater emphasis on the risk of rising rates. The simulation is done separately for households starting at different LTV levels, but uses the same shocks. Each simulation is done for 10,000 households.

[50] Tail probabilities exceeding the LTV grid are added to the lowest and highest grid point, respectively.