Interest Rates and Consumer Choice in the Residential Mortgage Market

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ABSTRACT

This paper estimates a coefficient of substitution between fixed rate mortgages (FRMs) and adjustable rate mortgages (ARMs), exploiting a discontinuity in legal rules governing the secondary market purchases of Fannie Mae and Freddie Mac. It is found that consumer choice between these mortgage types is strikingly price sensitive: a 20 basis point increase in retail FRM interest rates reduces the FRM market share by 17 percentage points, holding the yield curve and other macroeconomic factors constant. Based on this coefficient, it is calculated that around half of the high FRM share in the US relative to the UK can be accounted for as a consumer response to differences in retail mortgage interest rates.

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1. Introduction

Home mortgage debt represents a large and growing share of US consumer balance sheets. As of March 2007, US households owed 9.8 trillion dollars in loans secured by residential dwellings, making up 73 percent of consumer liabilities outstanding (source: Flow of Funds). The majority of US mortgages are long-term fixed-rate contracts prepayable at little or no cost, a contract popular in few countries outside the United States. Home mortgages in other Anglo-Saxon countries such as the UK, Canada and Australia are generally closely tied to short-term interest rates. Fixed-rate contracts are more common in continental Europe and Japan, however they generally involve significant prepayment penalties and shorter repricing periods than in the US (Green and Wachter, 2005; European Mortgage Federation, 2006).

The popularity of prepayable FRMs in the US has significant implications for consumer portfolios, bank balance sheets and the transmission of monetary policy. The effect on monetary transmission is asymmetric due to the nature of the prepayment option. Overall a high share of FRMs is thought to dampen monetary transmission (IMF, 2004; Miles, 2004), although FRM refinancing is estimated to significantly stimulate consumption during periods of falling long-term interest rates (Hurst and Stafford, 2004). From a lender's perspective, FRMs generate significant interest rate and prepayment risk, stimulating growth in secondary mortgage-backed securities (MBS) markets to help diversify these risks. In the UK, the high level of adjustable-rate mortgage debt is considered to be a key impediment to the adoption of a common European currency, since it implies that UK consumption is sensitive to short-term interest rates relative to Euro-zone member countries (UK Treasury, 2003; Miles, 2004).

This paper estimates a coefficient that measures the interest rate sensitivity of consumer choice between FRMs and adjustable rate mortgages (ARMs), the main alternative contract type. I find that substitution between these two contracts is strikingly sensitive to movements in retail mortgage interest rates. Holding fixed the the term structure of interest rates and other time-series factors, a 20 basis point increase in the retail FRM interest rate is estimated to cause a 17 percentage point decline in the FRM market share at the mean of the data.

My empirical estimates exploit a discontinuity in mortgage supply generated by legal rules governing which mortgages that may be purchased by the housing GSEs Fannie Mae and Freddie Mac (F&F). These institutions are prohibited from purchasing jumbo mortgages larger than a fixed amount known as the conforming loan limit. This limit adjusts on January 1 of each year; in 2005, the final year of my sample, it is $359,650.

I interpret the conforming loan limit as an instrument that exogenously shifts retail mortgage interest rates faced by consumers. Since the change in interest rates is larger for FRMs, it causes some consumers who would otherwise take out a fixed rate contract to switch to an ARM. Comparing the resulting change in market shares around the limit to the size of the shift in relative interest rates indicates the slope of consumers' demand curve for FRMs relative to ARMs, or put differently, their willingness to substitute between mortgages in response to a change in relative prices. The key identifying assumption underlying this strategy is that the large shifts in interest rates and loan shares observed close to the conforming loan limit are due to a shift in mortgage supply, rather than any discontinuous change in demand.

A challenge for this methodology is that mortgage size is a choice variable for the borrower, and is therefore potentially endogenous. In particular, since FRM rates are lower below the conforming loan limit, a household with a strong preference for an FRM has incentives to reduce the size of their first-lien mortgage to an amount below the limit, for example by taking out a second mortgage, or increasing the size of their downpayment. I use an instrumental variables approach to account for this endogeneity. Loans in the data are strongly clustered at a loan-to-valuation ratio of 0.8 (that is, a significant fraction of loans are very close to 80 per cent of the value of the underlying property). I thus construct a dummy variable that indicates whether the 80 per cent of the property value is above or below the conforming loan limit. I then use this dummy variable as an instrument for whether the loan itself is above the limit. In other words, my instrumental variables estimates are based on variation in loan size that is due only to variation in the underlying property value, and not by the size of the downpayment or the splitting of mortgage debt into a first-lien and second-lien component.

My central estimates imply that FRM mortgage interest rates shift by 26.5 basis points at the conforming loan limit, compared to 9.7 basis points for ARMs, a difference of 16.8 basis points. This change in relative interest rates is associated with a 14.3 percentage point decline in FRM market share. This implies a coefficient of substitution between ARMs and FRMs of around 0.85 percentage points of market share per basis point shift in mortgage interest rates. These estimates are based on econometric analysis of data from the Monthly Interest Rate Survey, a large microeconomic dataset of loan contract terms, the Survey of Consumer Finances, as well as quoted mortgage interest rate survey data from Bankrate, a private data vendor.

The observed sensitivity of mortgage choice to movements in interest rate spreads suggests that institutional factors such as differences in taxes, secondary market liquidity or retail market structure may have significant effects on equilibrium mortgage contracts. As an application of this principle, I consider differences in mortgage pricing between the US and UK. Although these two countries have common legal origins, comparable financial systems and a similar ratio of mortgage debt to GDP, FRMs in the UK, although available, have a negligible market share.

Using hand-collected retail interest rate data, I find that US FRM interest rate spreads are relatively low after controlling for differences in contract features. Using ARMs as a baseline, I estimate that interest rate spreads on FRMs are 46 basis points lower in the US non-jumbo market than in the UK, and 29 basis points lower in the US jumbo market. Applying the coefficient of substitution estimated in this paper, this interest rate differential is large enough to account for about half of the higher FRM US market share. Namely, my estimates imply that if US mortgages were priced by lenders at the same margins to the risk free rate as in the UK, the average US FRM share in the non-jumbo market would decline from 76 per cent to only 37 per cent. I suggest that differences in secondary market liquidity are the most plausible explanation for these pricing differences. Even in the non-agency market, US lenders are able to originate FRMs without retaining the interest rate and prepayment risk embedded in such loans. This option is not available to UK lenders, since there is no liquid secondary market for FRMs in that country.

Results in this paper contribute to the literature on retail mortgage choice, where previous empirical papers generally focus only on time-series variation in mortgage rates (Dhillon, Shilling and Sirmans, 1987; Brueckner and Follain, 1988). Several recent papers present structural models of mortgage choice, in which mortgage interest rates enter as a model parameter (e.g. Campbell and Cocco, 2003; Van Hemert, 2006; Koijen, Van Hemert and Van Nieuwerburg, 2006). Results in this paper present an empirical parameter estimate against which these structural models can be evaluated.

From a policy perspective, the high coefficient of substitution estimated in this paper suggests that shocks to secondary market liquidity, or policy innovations that shift mortgage supply, such as recent UK efforts to promote a covered bond market, may have substantial effects on the types of mortgages purchased by consumers. In the UK, a government enquiry, the 'Miles Commission', was formed to study reasons for the low FRM market share and to recommend ways to increase their popularity (Miles, 2004). Results in this paper suggest that efforts to shift the FRM supply curve could significantly increase the FRM market share, assuming that UK mortgage demand is similarly elastic to the US.

Finally, results herein speak to the role played by F&F in shaping the US mortgage market. These institutions often cite their role in promoting the FRM, for example in the following quote in congressional testimony by Fannie Mae CEO, Daniel Mudd: *'By creating two companies that invest only in residential mortgages, Congress laid the foundation for the 30-year fixed-rate pre-payable mortgage, which is an important tool for wealth creation, stabilizing communities and neighborhoods, and allowing low-and middle-income homeowners to manage other financial obligations without having to worry about their mortgage costs changing.'*

(Mudd, 2005). My central estimates suggest that FRMs are indeed more popular in the non-jumbo sector, with a 14 percent higher market share. However, this differential accounts for only a modest fraction of the popularity of FRMs in the US, since such contracts are still popular in the jumbo market where F&F do not operate. One hypothesis is that F&F were historically important to the development of secondary markets for hedging risks associated with FRMs, but have become less necessary over time to support the continued availability of FRMs at competitive interest rates.

It should be emphasized that the results do not speak directly to the net welfare costs or benefits of F&F. Frame and White (2005) present an overview of the F&F policy debate, while a well-developed literature estimates the extent to which F&F reduce FRM mortgage interest rates (Blinder, Flannery and Lockhart 2006; Passmore, Sherlund and Burgess 2005; Ambrose, LaCour-Little and Sanders, 2004; Hendershott and Shilling, 1989).

The rest of this paper proceeds as follows. Section 2 reviews background information and academic literature on F&F. Section 3 explains the empirical strategy. Section 4 estimates how the FRM share shifts around the conforming loan limit. Section 5 estimates how interest rates on FRMs and ARMs shift around the conforming loan limit. Section 6 calculates and discusses the coefficient of substitution between these two contract types. Section 7 compares mortgage pricing in the UK and US markets. Section 8 concludes.

2. Background on F&F and Related Literature

Fannie Mae was founded in 1938 to purchase mortgages insured by the FHA. Freddie Mac was founded in 1970. Today, F&F are publicly traded, commercial financial enterprises that underwrite nearly half of outstanding US home mortgage debt. Although no longer government owned, F&F's Congressional charters restrict their range of business activities and the types of mortgages they may purchase, and directs them to make special efforts to improve the availability of mortgage finance to low- and middle-income households. Green and Wachter (2005) present more institutional details and further references.

Reflecting their history and special status, F&F are classified as Government Sponsored Enterprises (GSEs). Debt issued by F&F is often perceived as carrying an implicit government guarantee, partially because of F&Fs background as government agencies, and partially due to their size and systemic importance. F&F enjoy other advantages also; for example, during this sample period mortgage-backed securities (MBS) issued by F&F attract a lower risk rating than MBS issued by other financial institutions for the purposes of calculating bank risk-weighted capital.

F&F's charters disallow them from purchasing 'jumbo' loans larger than a conforming loan limit set by OFHEO, their regulator. OFHEO adjusts this limit on January 1 of each calendar year to reflect movements in average house prices. In 2005, the last year of my sample, the conforming loan limit for a single unit dwelling is $359,650 (in 2007 the limit is $417,000).

Several papers study whether F&F improve mortgage affordability by comparing mortgage interest rates on 30 year FRMs above and below the conforming loan threshold (Blinder, Flannery and Lockhart 2006; Passmore, Sherlund and Burgess 2005; Ambrose, LaCour-Little and Sanders, 2004; Hendershott and Shilling, 1989). Estimates vary across these different studies, but in general suggest that F&F reduce 30-year FRM rates in the non-jumbo sector by 15-30 basis points. This spread likely reflects a combination of inter-related factors, including: (i) market perceptions that MBS issued by F&F carry little or no credit risk (ii) F&F's low cost of debt finance, (iii) the liquidity of the secondary market for MBS issued by F&F (iv) any comparative advantage that F&F have in managing interest rate risk and prepayment risk for mortgages held on-balance-sheet.[1] Also related, Loutskina and Strahan (2006) find that liquidity-constrained banks apply more stringent loan approval standards to jumbo loans, which are more illiquid due to the smaller size of the non-agency MBS market.

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[1] This paper remains agnostic on which of these factors are most important, and on the debate over the existence and size of F&Fs implicit government guarantee. See Frame and White, 2005, Blinder, Flannery and Kamihachi, 2004 and Passmore, 2003 for contributions to this debate and links to further literature.

Relatively little research attention has been directed towards studying how F&F affect the contractual structure of US mortgages, the focus of the identification strategy used in this paper. One related contribution is Berkovec, Kogut and Nothaft (2002), which estimates time-series models of the ARM share in the conforming, jumbo and FHA markets. They find some differences in the way the ARM share moves with interest rates across these different markets, and note that that the raw share of ARMs is substantially higher in the jumbo market. Berkovec, Kogut and Nothaft's focus on time series variation in the ARM share is, however, quite different to the analysis in this paper. There are also substantial differences in methodology; for example, they do not use microeconomic data, or examine behavior around the conforming loan limit.

2.1 F&F and the mortgage contract mix

One plausible hypothesis is that F&F actually have little or no effect on the market shares of different mortgage contracts in the non-jumbo market. Perhaps F&F simply provide a proportionate subsidy for all types of mortgages, leaving the market shares of different contracts unchanged?

The most likely alternative hypothesis is that the gains from trade between mortgage originators and F&F are largest for long-maturity FRMs, because such contracts expose the originator to a substantial amount of interest rate risk and prepayment risk. Bank balance sheets are generally characterized by maturity mismatch, where medium and long term fixed rate assets such as FRMs are funded by short-term deposits, leaving bank profits exposed to rising interest rates. Wright and Houpt (1996) and Sierra and Yaeger (2004) present evidence that commercial banks and particularly savings banks are subject to maturity mismatch. The interest rate risk embedded in an FRM is particularly complex, since it depends on the non-linear relationship between mortgage prepayment rates and the term structure of interest rates, borrower demographics, the age structure of the mortgage portfolio, and the distribution of original coupon rates.

FRMs also expose the mortgage originator to pure prepayment risk, that is, systematic fluctuations in prepayment rates that are orthogonal to movements in interest rates. Gabaix, Krishnamurthy and Vigneron (2006) present evidence that prepayment risk is priced in MBS yields, reflecting financial constraints amongst MBS arbitrageurs.

Since interest rate risk and prepayment risk are most significant for long-duration FRMs, lenders have strong incentives to securitize such mortgages. This is consistent with the data; between 1990 and 2002, ARMs made up around 25 per cent of mortgage originations, but only 10 per cent of securitization activity (Gabriel, 2003). By this argument, any factor that makes mortgage securitization cheaper or easier, such as the market presence of F&F, should disproportionately affect the supply of FRMs, for which the risk sharing benefits of securitization are relatively larger.[2]

3. Empirical strategy

In the next two sections I estimate how the market share of FRMs and the mortgage interest rate on FRMs relative to ARMs shift at the conforming loan limit. By comparing market shares and interest rates on either side of the conforming loan limit, we are tracing out the slope of the demand curve for FRMs, and can calculate a coefficient of substitution between the two contracts. I assume the data is generated by the following reduced form model of mortgage choice:

$$[1] \quad P(FRM) = f\,[\, b_0 + b_1.(m.rate_{FRM} - m.rate_{ARM}) + b_2 \text{ borrower \& loan controls} + b_3 \text{ time dummies} + e \,]$$

This equation posits that the probability of selecting a FRM rather than an ARM depends on the mortgage interest rate differential between the two mortgage types ($m.rate_{FRM} - m.rate_{ARM}$), a set

[2] In addition to their role in the passthrough market, F&F hold around $1.5tr of mortgages and agency MBS on-balance-sheet (OFHEO, 2006, Table 24). One explanation for the size of these portfolios is that F&F have a comparative advantage in managing mortgage prepayment risk and interest rate risk due to their size and sophistication, and that F&F perform a buffer-stock role by purchasing mortgages during periods of MBS market illiquidity, such as during the 1998 LTCM crisis (Syron, 2005). An alternative perspective is that F&F have incentives to hold excessive interest rate and prepayment risk because part of the risk is implicitly government guaranteed.

of borrower and loan controls, and time dummies. This model can be viewed as a reduced form approximation to a structural model of mortgage choice such as Campbell and Cocco (2003).

$m.rate_{FRM}$ and $m.rate_{ARM}$ in equation [1] are measured conditional on borrower characteristics (i.e. these interest rates should be thought of as quoted interest rates for a borrower with a reference level of credit risk, prepayment risk and so on), while borrower characteristics that shift the household's mortgage interest rate relative to these reference rates would then be reflected in 'borrower & loan controls'. A primary coefficient of interest in equation [1] is the coefficient of substitution b_1, which measures the sensitivity of demand for FRMs to a given change in FRM interest rates relative to ARM rates.

Data on ($m.rate_{FRM} - m.rate_{ARM}$) is needed to estimate equation [1] and identify b_1. One possible strategy would be to use time-series variation in the spread of different mortgages over an appropriate risk free rate. However, this approach is not feasible if time dummies are included in the specification, as they are in equation [1]. Including the time dummies seems essential, to soak up time series variation in expectations about future interest rates, shifts in mortgage preferences and so on.

The alternative approach pursued here is to consider the presence of F&F in the non-jumbo market as an exogenous shock that differentially shifts interest rates on FRMs relative to ARMs. The identifying assumption underlying this strategy is that any discontinuous shift in the FRM share exactly at the limit reflects only a supply-side shift in mortgage interest rates, rather than discontinuity in household preferences. Denoting by Δ the shift in interest rates on FRMs relative to ARMs at the conforming loan limit [i.e. $\Delta = (m.rate_{FRM,jumbo} - m.rate_{FRM,non\text{-}jumbo}) - (m.rate_{ARM,jumbo} - m.rate_{ARM,non\text{-}jumbo})$], then equation 1 can be rewritten as:

[1a] $P(FRM) = f\,[b_0 + B_1 \,.\, jumbo + b_2 \,.\, borrower\ \&\ loan\ controls + b_3\ time\ dummy + e]$

where $B_1 = b_1.\Delta$, and 'jumbo' is a dummy variable equal to 1 if the loan size is above the conforming loan limit. In Section 4, I estimate equation [1a] and obtain an estimate of B_1. In Section 5, I estimate Δ, the shift in interest rates on FRMs compared to ARMs at the conforming loan limit. Taking the ratio B_1 / Δ recovers the coefficient of substitution b_1.

This discussion assumes that the choice of a jumbo or non-jumbo loan is uncorrelated with omitted variables. In practice though, loan size is likely to be correlated with omitted borrower characteristics. Since FRM rates are lower below the conforming loan limit, a household with a strong preference for an FRM has incentives to reduce the size of their first-lien mortgage below the limit, by taking out a smaller second mortgage, borrowing from family or friends, or putting down a larger downpayment. Estimates that ignore the endogeneity of loan size would tend to overstate the coefficient of substitution between ARMs and FRMs at the conforming loan limit.

In my preferred specification, an instrumental variables approach is used to account for the endogeneity of loan size. Loans in the data are strongly clustered at a loan-to-valuation ratio of 0.8 (that is, many loans are near 80 per cent of the value of the underlying property). I construct a dummy variable that identifies whether the 80 per cent of the home value is larger than the conforming loan limit. I use this dummy as an instrument for whether the loan itself exceeds the limit. Thus, instrumental variables estimates reflect variation in loan size that is *only* due to variation in the value of the underlying property, and not variation in loan size due to changing the size of the downpayment, or by splitting the loan into several mortgages.

As a second strategy, I estimate the model described above by OLS, but simply drop mortgages that are close to the conforming loan limit (those between 98% and 104% of the limit), the area where most of the substitution described above is likely to occur. The two strategies yield broadly similar estimates, although the OLS coefficients are somewhat larger, apparently reflecting the fact that dropping loans close to the limit does not fully account for the omitted variable bias described above.

4. FRM market share effects around the conforming loan limit

This section analyzes how the share of FRMs and ARMs shifts around the conforming loan limit. The primary source of data is the Monthly Interest Rate Survey (MIRS), a large microeconomic dataset of mortgage loan terms. As a robustness check, I also re-estimate results using data from the Survey of Consumer Finances (SCF), that allows additional controls for borrower covariates.

4.1 The Monthly Interest Rate Survey (MIRS)

The MIRS is a lender survey of home mortgage terms collected and maintained by the Federal Home Financing Board. Each month, the MIRS surveys a sample of commercial banks, savings banks and finance companies, which report terms and conditions on first-lien mortgages closed out during the last five business days of the previous month. The MIRS survey includes only single-family, fully amortized, purchase-money, nonfarm loans, and also excludes FHA-insured and VA-guaranteed loans, multifamily loans, mobile home loans, and refinancings. Although data is available from the 1970s onwards, the sample used in this paper begins in January 1992, after the survey methodology was reformed, and the MIRS began to report additional information on the repricing of ARMs.

The MIRS has several attractive features for studying patterns in mortgage contracts. It is a large dataset; my sample consists of around three million mortgage observations collected monthly over a continuous period between January 1992 and December 2005. Also, the MIRS surveys lenders rather than borrowers, an advantage in terms of data accuracy, since lenders are likely in a better position to report precise information about mortgage characteristics. The survey reports many key features of the mortgage contract, such as the mortgage size and term, the initial interest rate, the date at which the interest rate first adjusts, the frequency of subsequent adjustments, and the value of the property that secures the loan. The lender institution type is reported (e.g. commercial bank, finance company etc.), although the individual identity of the lender is not. The main disadvantage of the dataset is the lack of mortgageholder characteristics.

In particular, there is no explicit measure of borrower creditworthiness such as a FICO score, or a measure of total household income or wealth.

From the original MIRS dataset, I drop loans not within 20-200 per cent of the conforming loan threshold, and loans where the loan-to-valuation ratio (LTV, i.e. the ratio of the loan size to the mortgaged property value) is below 20 per cent or above 97 per cent. These LTV filters are applied because loans with a very low loan-to-valuation ratio are likely to be refinancings that are mistakenly reported as new loans, while on the other end, omitted variable problems due to the lack of credit risk controls are likely to be most important for highly leveraged mortgages. I also drop loans made in November or December, because Blinder, Flannery and Lockhart (2005) report that the pricing of such loans is heavily influenced by the conforming loan limit in the following calendar year.

[INSERT TABLE 1 HERE]

Weighted summary statistics are presented in Table 1. 76 per cent of sample mortgages are FRMs. Mortgages have an average real principal of $148.7 thousand, the average LTV is 77.6 per cent, and the average loan term is 27.2 years. Around 9 per cent of originations are for amounts above the conforming loan threshold. The table also shows how the conforming loan limit has evolved over the sample period; in nominal dollars increasing from $202,300 in 1992 to $359,650 in 2005. The lower parts of the table present summary statistics for the subsamples of FRMs and ARMs. ARMs are substantially larger on average, $188,000 compared to $132,000 for FRMs. Nearly all ARMs have a 30-year term (the average is 29.6 years). FRMs have an average term of 26.9 years.

Table 2 breaks down the MIRS sample of mortgages more finely into nine different contract types. [N.B. I use an *x* / *y* nomenclature for ARMs, where *x* is the number of years until the mortgage first reprices, and *y* is the periodicity of subsequent repricings in years]. Table 2 shows that the 30 year FRM is the most popular contract, with nearly a 60 percent average market share, followed by a 15 year FRM and 1/1 ARMs. It should be noted that the MIRS excludes nonamortizing loans, including interest-only and negative amortization mortgages. These products became popular only at the end of this sample period. Even so, their absence from the MIRS implies that the share of 30 year FRMs is somewhat overstated relative to the underlying population.

[INSERT TABLE 2 HERE]

4.2 The FRM share at the conforming loan limit

A simple plot of the data illustrates the striking shift in the FRM share at the conforming loan limit. For each year, I group mortgages into 1 per cent buckets based on loan size relative to the conforming loan limit (e.g. loans with principal between 90-91 per cent of the conforming loan limit in the relevant year are grouped together, and so on.). I then compute the raw percentage of FRMs in each bucket for each year. Results are plotted in Figure 1.

[INSERT FIGURE 1 HERE]

The y-axis of the chart is the proportion of fixed rate mortgages, while the x-axis is loan size divided by the conforming loan limit, minus 1. The FRM share is plotted separately for each year between 1992 and 2005, along with the average across all years (the thick black line).

Differences for a given bucket across different years reflect the substantial time series variation in the FRM share. The average across years reveals a slight but steady negative relationship between loan size and the market share of FRMs. More striking however is the sharp drop in the FRM share observed at the conforming loan limit. This decline in the FRM share occurs exactly at the limit in every year, and resembles a step function; the share of FRMs falls by approximately 20 percentage points, and remains permanently lower for all loan buckets above the conforming loan limit.

Also evident is a spike in the FRM share for loan sizes just below the conforming loan limit, and an excess dip for loans just larger than the limit, flattening out at around 104 per cent of the conforming loan limit. This instability reflects the endogeneity of loan size near the limit described in Section 3. Namely, a subset of households who would otherwise take out a loan above the limit, but who prefer an FRM, take steps to reduce their loan size to take advantage of lower FRM interest rates in the conforming market. Households who prefer an ARM have less incentive to engage in such behavior since, as I show later, the difference in interest rates between the jumbo and non-jumbo sectors is much smaller for ARMs.

4.3 Linear probability model

I estimate the following model of mortgage choice, which is an empirical version of equation [1a] discussed in section 3:

[2] $P(FRM) = b_0 + b_1.\text{loan size dummies} + b_2.\ln(\text{loan size}) + b_3.\ln(\text{loan size})^2 + b_4.\text{loan size}$
$+ b_5.LTV + b_6.\ln(1+LTV) + b_7.LTV>0.8$
$+ b_7.\text{lender type dummies} + b_8.\text{new house dummy}$
$+ b_9 . \text{month x year dummies} + b_{10} . \text{geography dummies} + e$

'Loan size dummies' is a series of dummies defined relative to the conforming loan limit for the calendar year in question. Separate dummies are defined for loans less than 80% of the conforming loan limit, between 80% and 90%, 100% to 110%, 110% to 120% and >120% of the limit. (N.B. As shorthand, I refer to the dummy for loans between 80% and 90% of the limit as 'dummy80', and so on.). The omitted dummy variable category is loans between 80-90% of the conforming loan limit. Therefore, the discontinuity in the FRM share at the loan limit is measured by the coefficient on dummy100.

The three other loan size variables are loan size (measured in 2001 dollars), ln(loan size) and $\ln(\text{loan size})^2$. These are intended to capture any smooth underlying relationship between loan size and mortgage choice outcomes. Conditional on these controls, the loan size dummies will reflect any discontinuity in mortgage choice at the conforming loan limit. If the model is correctly specified, the coefficients on the loan size dummies should resemble a step function. Namely, the coefficients on dummy0 and dummy80 will be economically close to zero, and there will be a statistically significant coefficient of approximately similar size on dummy100, dummy110 and dummy120, reflecting a permanent shift in the FRM share once the conforming loan threshold has been crossed.

The model also includes dummies for whether the lender is a commercial bank or savings bank (finance company is the omitted category) and a dummy for whether the loan is secured against a new rather than existing home. To control for the location of the mortgaged property, the regression includes state dummies and dummies for each metropolitan statistical area (MSA) observed in the sample. In addition, separate dummies for MSA x state are included for MSAs that span state boundaries (e.g. for the New York MSA, separate dummies are included for New York area homes located in New York and in New Jersey). Finally, the equation includes 168 dummies for each calendar month in the sample (i.e. month x year), which absorbs all aggregate time-series variation in the FRM share.

4.4 Empirical estimates

Results from estimating equation [2] using a linear probability model are presented in Table 3. As described in Section 3, two models are estimated, reflecting different approaches to dealing with the endogeneity of loan size relative to the conforming loan limit. Column 1 excludes loans between 90-104% of the conforming loan limit, the region where the endogenous substitution between ARMs and FRMs appears to occur based on Figure 1. Column 2, the preferred specification, uses a dummy variable for whether 80 per cent of the property value is between 100-110% of the conforming loan limit as an instrument for dummy100. To account for cross-sectional dependence in the error term, coefficients are clustered by time period (i.e. month x year). Standard errors are also adjusted for heteroskedasticity.

[INSERT TABLE 3 HERE]

As the table shows, the coefficients on the loan size dummies do resemble a step function as predicted. Coefficients on dummy0 and dummy80 are close to zero, while coefficients on dummy100, dummy110 and dummy120 are negative and significantly significant at the 1% level. The coefficient on dummy100 measures the effect of the discontinuity at the conforming loan limit. This estimate indicates that the FRM share falls discontinuously at the conforming loan limit by 20.4% in column 1, and 14.3% in the preferred IV specification in Column 2. Since the non-jumbo ARM share is 22.5 per cent, this implies that conditional on other covariates, ARM contracts have around a fifty percent larger market share above the conforming loan limit than below it (36.8 per cent compared to 22.5 per cent).

4.5 Housing affordability and time trend

The above estimates measure consumers' willingness to substitute between ARMs and FRMs at a particular point in the mortgage size distribution. Since the conforming loan limit is significantly larger than the average mortgage in the sample ($253,200 compared to $145,500, as shown in Table 1), loans around the limit are likely to be associated with high income or high wealth households. It is of interest to test whether the degree of substitution is different for poorer households.

To provide some evidence on this question, I make use of variation in housing affordability across cities. In cities where home prices are high relative to incomes due for example to supply constraints, households spend a higher fraction of their incomes on consumption of housing services. Therefore, for a given mortgage size or house value, household income will be lower in such cities. For example, a household from San Francisco who purchases or rents a $350,000 home will on average be at a lower point in the income distribution than a household from rural New York who purchases a home of the same value.

The index of housing affordability used measures median family income relative to the value of a median-valued dwelling, measured at the MSA level at an annual frequency. The source of the data is Moodys economy.com. I re-estimate the two regressions from Table 3 including this affordability variable, as well as affordability interacted with a jumbo dummy (i.e. a dummy for whether the loan is larger than the conforming loan limit). A positive coefficient on this interaction term would indicate greater substitution at the conforming loan limit in areas with higher affordability, and therefore where household income is higher for loans around the limit. Unrelated to housing affordability, I also interact the jumbo dummy with a linear time trend. This allows an inspection of whether the discontinuity in mortgage choice at the conforming loan limit is becoming larger or smaller over time. Other regressors are the same as Table 3. Since housing affordability is only available for MSAs, non-urban households are dropped for the sample. Results are presented in Table 4.

[INSERT TABLE 4 HERE]

The interaction term housing affordability x jumbo dummy is positively signed in column 1, and negatively signed although not statistically significant in the preferred IV specification in column 2. Thus, there appears to be no clear relationship between incomes at the conforming loan limit, as proxied by affordability, and the degree of substitution at the conforming loan limit. Notably, however, the time trend interaction is negative and statistically significant in both models, indicating that the discontinuity at the conforming loan limit in fact became larger over the period 1992-2005, despite the growth in the non-agency mortgage secondary market over the sample period.

4.6 SCF evidence

The primary drawback of the MIRS dataset is that it does not include any detailed borrower covariates. Although it seems unlikely that these omitted variables could account for the sharp discontinuity in mortgage choice documented above, as an additional robustness check, I re-estimate results using a second, independent source of data, the Survey of Consumer Finances (SCF). The SCF is a triennial survey of the balance sheet, pension, income, and other demographic characteristics of U.S. families, collected by the Federal Reserve Board. This survey contains microeconomic data on mortgages held by individual families, and also includes a large set of borrower covariates.

Following the same methodology used above, I estimate two models of the ARM-FRM choice, one which excludes loans near the conforming loan limit, the other which uses a dummy variable equal to one if 0.8 x the home value exceeds the conforming loan limit as an instrument for the jumbo dummy. For each of these models, I estimate a pair of regressions. One specification in each pair includes only the right-hand-side variables available in the MIRS, using a somewhat more parsimonious functional form because of the smaller sample size (the log of loan size, jumbo dummy, LTV and dummies for type of lender, year of mortgage and Census region are included). The other specification includes these variables plus a range of household covariates, including household income, household size, sex and age of household head, a self-employment dummy, proxy for household mobility, two proxies for credit constraints and so on.

The sample size is 4265, which represents first lien mortgages pooled from six SCF surveys conducted triennially between 1989 and 2004. Mortgages originated more than three years from the survey year are excluded. A weighted probit is used, using the weights provided with the SCF and employing the repeat imputation procedure recommended for SCF data (see Kennickell, 1998, for details). Estimates are presented in Table 5.

[INSERT TABLE 5]

The estimated jumbo dummy ranges between -0.102 and -0.134 depending on the specification. Notably, for both pairs of regressions the coefficient estimate barely changes when additional household covariates are added to the model. This suggests the lack of household covariates in the MIRS does not significantly bias the coefficient estimates presented there. This finding is consistent with a supply-side interpretation of the discontinuity in loan choice observed at the conforming loan limit.

The coefficient estimates in Table 5 are on average smaller than in the MIRS. This is likely in part due to measurement error. The SCF asks households to self-report the initial size of their mortgage; any error in these self-reports will cause misclassification between jumbo and non-jumbo mortgages, leading to attenuation bias in the estimated coefficient.

In unreported regressions, I also repeat this exercise using data from a third data source, the Residential Finance Survey conducted by the Census bureau. Results are similar to those shown here (available on request). Also as an additional robustness exercise, I re-estimate the SCF probit regression using a sample of all outstanding mortgages, not just mortgages originated in the past three years. Again, results are similar to those shown here.

5. Interest rate effects around the conforming loan limit

The evidence in Section 4 shows that the market share of ARMs discontinuously shifts upwards at the conforming loan limit. I interpret this shift as being due to households moving along their mortgage demand curve in response to a shift in relative interest rates on ARMs compared to FRMs. This section estimates the size of these interest rate effects. In terms of the econometric model in Section 3, our goal is to estimate the parameter Δ, the change in FRM rates at the conforming loan limit relative to the change in ARM rates. Two sources of data are used, quoted mortgage interest rates from Bankrate, and econometric estimates from MIRS data.

5.1 Bankrate estimates

Quoted mortgage interest rate data is drawn from Bankrate, a private company that collects, aggregates and reports interest rate information on financial services products. Bankrate conducts a weekly national survey of quoted mortgage rates for the most popular home mortgage contract types in the conventional and jumbo markets. An important feature of the survey is that Bankrate stipulates in detail the contractual details of the mortgage to be priced. For conventional mortgages originated in 2005, a partial list of the stated terms include the following: 0-2 point mortgage, LTV of 0.8, a customer with whom the bank has no prior relationship, loan size between $165,000-$359,650, lock-in period of 30-60 days, and FICO score in the range 650-719. Up-front points or administrative charges are amortized into the quoted interest rate assuming a loan life of 10 years. For jumbo mortgages, the same putative contract terms are used, except that the loan size range is $359,651 – $650 000. Thus, the Bankrate mortgage interest rate is conditioned on an exhaustive set of variables not available in the MIRS.

Interest rate data is collected from Bankrate's website (bankrate.com) for four popular mortgage contracts: 30 year FRMs, 15 year FRMs, 5/1 ARMs and 1/1 ARMs. Monthly observations were downloaded for a 12-month period between November 2004 and October

2005. Summary statistics are presented in Table 6.

[INSERT TABLE 6 HERE]

The table shows a monotonically declining relationship between the repricing interval of the mortgage, and the wedge between interest rates in the conforming and jumbo markets. For 30 year FRMs, the average difference between the two markets is 27 basis points. For 15 year FRMs it is 24 basis points. For 5/1 ARMs it is 11 basis points while for 1/1 ARMs it is only 9 basis points. Weighting this data by the market shares of each contract, this data implies that the conforming loan limit shifts interest rates on FRMs by 26.5 basis points, and interest rates on ARMs by 9.7 basis points, a difference of 16.8 basis points. These results confirm the hypothesis that F&F do not simply subsidize all mortgages equally. Instead, the results show that these two institutions disproportionately act on the supply of FRMs, since interest rates on FRMs change disproportionately as the conforming loan limit is crossed.

5.2 MIRS estimates

The MIRS also includes data on mortgage interest rates. Unlike the Bankrate data, the MIRS is not conditioned on borrower credit quality, bank-firm relationships, or most of the other loan terms listed in the Bankrate survey. The mortgage market share results were shown to be nearly invariant to the inclusion of borrower controls. However for modelling interest rates, the lack of borrower controls in the MIRS may be a more serious problem, since mortgage interest rates are likely to be very sensitive to these omitted factors relative to the size of the interest rate shock induced by the conforming loan limit.

With this caveat in mind, I firstly plot interest rates on two mortgages, 30 year FRMs and 1/1 ARMs around the conforming loan limit, similar to Figure 1. These graphs are presented in Figure 2.

[INSERT FIGURE 2 HERE]

I next estimate interest rate regressions for each of the 9 mortgage categories from Table 2. The dependent variable in each regression is the effective mortgage interest rate on the loan.

This effective interest rate amortizes any up-front fees or points into the mortgage interest rate over a 10 year period. I use the same set of right-hand side variables as in Equation 1. Estimates are presented in Table 7.

[INSERT TABLE 7 HERE]

The key coefficient is the difference between the coefficients on dummy90 and dummy100, which measures the effect of the conforming loan limit on mortgage interest rates. This estimated coefficient is positive in every case, and statistically different from zero for six of nine contracts. More importantly, as with the Bankrate data, the shift in supply is largest for the FRM contracts. The difference [dummy100 – dummy90] is 19.0 basis points and 18.8 basis points for the 30 year and 15 year FRM contracts respectively, the two most popular FRM categories. For the three most popular ARM contracts (5/1 ARM, 1/1 ARM and ARM with initial repricing period of less than 1 year) the shift in interest rates is substantially smaller, 10.7, 13.7 and 0.18 basis points respectively. The weighted average effect of the conforming loan limit on FRM interest rates is 18.3 basis points, on ARM interest rates it is 9.9 basis points.

Thus, MIRS and Bankrate produce similar estimates for ARMs, but for FRMs the Bankrate estimates are about 8 basis points larger. The existing literature measuring the passthrough of F&Fs funding advantage to mortgage consumers suggests a possible reason for this divergence. This literature estimates regressions similar to the first column of table 7 (i.e. they study the conforming-jumbo interest rate spread for 30 year FRMs). Using the MIRS, Passmore, Sherlund and Burgess (2005) estimate a coefficient of 15-17 basis points, similar to Table 7 (19.0 basis points). However, Sanders (2005) argues that this estimate is biased downwards because the MIRS does not allow controls for borrower credit quality. He cites Ambrose, LaCour-Little and Sanders (2004) who estimate a larger effect of the limit (28 basis points) based on a bank dataset that allows them to control for the borrower's FICO score. This estimate is consistent with Blinder, Flannery and Kamihachi (2004), who conclude that the jumbo-conforming spread for 30 year FRMs is 26-29 basis points. Blinder, Flannery and

Lockhart (2006) estimate the jumbo-conforming spread for 30 year FRMs to be 25 basis points using MIRS data, but applying a different empirical approach to Passmore, Sherlund and Burgess (2003). Since these estimates are very close to the Bankrate estimate of 27 basis points, I focus on the Bankrate estimates as the preferred measure of the interest rate spread above and below the conforming loan limit.

6. Coefficient of substitution between ARMs and FRMs

Results from the previous two sections are summarized in Figure 3, which plots the demand and supply for FRMs and ARMs in the jumbo and non-jumbo markets. The identifying assumption is that the shift in mortgage interest rates at the conforming loan limit is due only to the supply-side effect of F&F. Under this assumption, the observed differences in mortgage interest rates and market shares observed at the conforming loan limit reflect consumers moving along their demand curves in response to a change in relative interest rates on FRMs and ARMs, as plotted in the diagram.

[INSERT FIGURE 3 HERE]

The preferred Bankrate estimates imply that conforming loan limit shifts mortgage interest rates on FRMs by 26.5 basis points, and interest rates on ARMs by 9.7 basis points, a differential of 16.8 basis points (the distance between the two supply curves on the diagram). Based on the estimates in Section 4, this change in relative mortgage interest rates induces a 14.3 percentage point fall in the FRM share, as shown on the x-axis on the diagram.

The ratio of these two numbers is the coefficient of substitution between ARMs and FRMs, defined as the percentage point change in the FRM market share for a one basis point increase in FRM interest rates relative to ARM interest rates. This is the parameter b_1 from equation [1], expressed in terms of a marginal effect on the aggregate FRM market share. This parameter is $b_1 = 14.3 / (26.5 – 9.7) = 0.85$. This coefficient implies that a 20 basis point increase in FRM relative interest rates ($m.rate_{FRM} – m.rate_{ARM}$) will lead to a 17 percentage point decline in the FRM market share, holding fixed the shape of the yield curve, macroeconomic conditions and other time-series variables.

The size of this estimated coefficient suggests that small changes in relative mortage interest rates may have significant effects on the types of mortgage contracts that predominate in the primary market. Some examples of factors that may influence retail mortgage rates are highlighted below:

(i) Taxes. Mortgage interest payments are tax deductible. Since FRM interest rates exceed ARM rates, changes in income tax rates or tax deductibility rules will have larger effects on the after-tax interest rate on FRMs.

(ii) Secondary markets. Because of their embedded interest rate and prepayment risk, a disproportionate fraction of FRMs are securitized rather than held on-balance sheet. Secondary market disruptions, or improvements in secondary market liquidity, may therefore have larger effects on the funding rate for FRMs.

(iii) Lender financial frictions. Lenders are often unwilling to hold FRMs on balance sheet, in part because they have longer duration than deposit liabilities. For example, Vickery (2007) shows that savings banks, which are most exposed to maturity mismatch, originate a smaller share of FRMs and price such contracts more conservatively. Innovations in interest rate risk management, such as the use of derivatives, may therefore reduce the FRM interest rate spread charged by lenders. Improved access to capital markets may have similar effects, since lenders are only concerned with interest rate risk if external finance is costly (Froot, Scharfstein and Stein, 1993).

(iv) Institutional environment. Governments and regulators shape the mortgage market in a variety of ways, through the FHA, through portfolio restrictions and other regulatory decisions on F&F, and by regulatory guidances on bank mortgage lending. Such factors may have significant effects on equilibrium mortgage rates.

It is beyond the scope of this paper to evaluate the relative effects of these factors on the pricing and market share of different mortgage contracts. However, the evidence in Section 7 suggests that overall, FRM mortgage spreads are significantly lower in the US than in the UK, and that this pricing is large enough to account for much of the high FRM market share in the US.

In addition to the supply-side factors listed above, the interest rate spread between ARMs and FRMs moves significantly through time due to changes in the term structure of risk-free interest rates. These changes in turn are driven by changes in bond risk premia and expectations about future short-term interest rates. Koijen, Van Hemert and Van Nieuwerburgh (2006) find that changes in bond risk premia induce large swings in the aggregate time-series share of FRMs. This result is complimentary to the evidence presented here, since it also suggests that consumer mortgage choice is highly sensitive to movements in relative prices.

Finally, although the high estimated coefficient of substitution suggests many consumers are nearly indifferent between ARMs and FRMs, small interest rate differentials are significant expressed in dollar terms. For a household who borrows $360,000 (i.e. the 2005 conforming loan limit), an interest rate rise of 20 basis points amounts to an increase in mortgage payments of $720 per year. This amount appears large enough to plausibly induce 17 per cent of households to switch between an ARM and FRM, consistent with the estimated coefficient in this paper.

7. Application: Comparison of UK and US mortgage markets

The enduring popularity of long-term, prepayable FRMs in the US is quite striking by comparison to other advanced economies. Green and Wachter (2005) document the diversity of mortgage contracts across a sample of 13 industrialized countries. The US is one of only two countries where long-term FRMs without substantial prepayment penalties predominate. Campbell and Cocco (2003) note that: '*long-term nominal fixed-rate mortgages are almost unknown in the United Kingdom and Canada. An interesting area for future research will be to relate these international differences in prevailing mortgage contracts to differences in the risk management problem that households face*'.

This section applies the coefficient of substitution estimated above to shed further light on international differences in mortgage contracts, focusing on a comparison of the US and UK. First, I compare interest rate spreads on different types of mortgages in the US and UK. I find that US FRM rate spreads are relatively low compared to the UK. I then consider the folllowing thought experiment: How much would the US FRM share decline if FRM and ARM mortgage interest rate spreads were the same as in the UK?

The UK is chosen as a benchmark because it is an advanced economy with a developed financial system and a comparable ratio of mortgage debt to GDP ratio to the US, as well as readily available mortgage interest rate data. UK policymakers have also focused substantial policy attention on fixed rate mortgages in recent years. For example, the Miles Review was commissioned in 2003 to study policy options for increasing the FRM share (Miles, 2004). High levels of adjustable rate debt in the UK are perceived to be a source of economic and housing market instability, and a significant impediment to joining the Euro, since fixed rate contracts and smaller mortgages are the norm in existing Euro-zone countries (UK Treasury, 2003).

I first compare FRM and ARM mortgage interest rate spreads in the US and UK. Using the estimated coefficient of substitution between these two mortgage types, I calculate the predicted effect of this pricing differential on the US FRM share. That is I calculate how much the US FRM share would fall I find that the average FRM market share would decline by

7.1 Details of calculation

Step 1: Mortgage interest rate data. Data on UK ARM and FRM interest rates is drawn from two sources. First, the Bank of England conducts a monthly survey of quoted mortgage interest rates for four popular ARM products (those with repricing intervals of 2, 3, 5 and 10 years). This data is then supplemented with mortgage quotes hand-collected from the websites of 15 major UK mortgage lenders at two different dates, November 2005 and February 2006. This hand-collected data allows comparison of a wider range of mortgage products than the Bank of England survey, namely mortgages with an initial repricing period of 15, 20 and 25 years, which are excluded from the BOE survey, most likely because their historical share of the UK mortgage market is very low. US data comes from Bankrate. I take daily averages of mortgage interest rates over a period from mid-November 2005 to mid-February 2006.

Step 2: Calculate spreads. I calculate mortgage interest rate spreads for ARMs and FRMs in the US and UK relative to a Treasury security with the same repricing period. Since US FRMs allow borrowers to strategically prepay when interest rates fall, I adjust the reference treasury rate for US FRMs for the value of the mortgage prepayment option embedded in the loan. UK FRMs involve large prepayment penalties, generally at least one year of interest payments (source: private communication with BOE staff), and therefore UK Treasury rates are not adjusted in this way.

The prepayment option is calculated as the difference between the spread-to-maturity and option-adjusted-spread (OAS) of agency FRM MBS pools. The OAS measures the component of the MBS spread that is left over after accounting for the mortgage prepayment option. The OAS is calculated by estimating prepayment probability distributions using a prepayment model, then calculating the present value of those payments using a term structure model (e.g. see Gabaix, Krishnamurthy and Vigneron, 2006). Raw and option-adjusted spreads for 30-year and 15-year agency FRM pools are taken from Bloomberg, using data from January 2006.

[INSERT TABLE 8 HERE]

Estimated mortgage spreads are presented in Table 8. To calculate an overall ARM spread, I take the average spread on 2 year and 3 year ARMs. For FRMs, I take the average of spreads on 15, 20, 25 and 30 year contracts. The 30 year UK FRM spread is set equal to the value for the 25 year contract, since 30 year contracts are not available in the UK.

Data in Table 8 suggests that FRMs are priced relatively conservatively in the UK. FRMs are priced at an average premium of 77.3 basis points relative to the risk free rate, compared to only 40.6 for ARMs, a difference of 36.7 basis points. In the US, however, FRM spreads are slightly smaller than ARM spreads after accounting for the prepayment option; 41.9 bp for FRMs compared to 50.9bp for ARMs, a difference of -9.0 basis points. Comparing these two estimates implies that FRMs are 45.7 basis points (i.e. 36.7 + 9.0 = 45.7) more expensive than ARMs in the UK, compared to the corresponding FRM-ARM differential in the US.

Step 3. Apply coefficient of substitution. I now consider the following thought experiment: How would the market share of FRMs in the US change if mortgages were priced at the same spreads as in the UK? The coefficient of substitution between ARMs and FRMs estimated in Section 4 is 0.85. Thus, a change in FRM interest rates relative to ARM rates implies a 45.7 x 0.85 = 39 percentage point lower FRM share of mortgage originations in the US. This implies that the average FRM share in the non-jumbo US market would fall from 76% to 37% if UK mortgage pricing were applied. The actual UK FRM share is very low, around 1 percent. Thus, this calculation suggests that around half of the popularity of FRMs in the US can be directly accounted for by differences in relative mortgage spreads between the two countries.

What explains these differences in mortgage pricing? The evidence in section 4 suggests that 16.8 basis points, equivalent to 36 percent of the differential, is due to the wedge in mortgage interest rates between the conforming and jumbo markets (i.e. 16.8bp is 36 per cent of 45.7bp). This suggests that the other 64 percent of the differential is not due directly to the activities of F&F, but instead other supply-side factors. One plausible explanation is the differential ability of lenders to securitize FRMs. UK MBS markets are less liquid in general than the US, representing only around 5 per cent of mortgage balances (UK Treasury, 2003) compared to 65 per cent of mortgages outstanding in the US (source: Flow of Funds). More directly relevant, there is no UK secondary market for long-duration FRMs (private communication, BOE staff), forcing lenders who offer such products to hold them on balance sheet. In contrast, a liquid secondary market exists in the US for securitizing jumbo loans that cannot be purchased by F&F.

An intriguing possibility is that there may be some path-dependence in the FRM share. If a country starts from an equilibrium in which FRMs are rare, then the secondary market for such mortgages is likely to be small and illiquid, and there will also be less product market competition for these instruments. These factors in turn make FRMs more expensive, keeping their market share low, and reinforcing the illiquidity of the secondary mortgage market.

8. Conclusions

The choice of home mortgage is a primary determinant of a households' exposure to interest rate risk and prepayment risk. This paper finds that mortgage choice is strikingly sensitive to movements in retail interest rates. Exploiting a discontinuity in mortgage supply, I estimate that a 20 basis point increase in FRM interest rates increases the probability that the household will choose an ARM by 17 percentage points at the mean of the data, holding the yield curve and other macroeconomic factors constant.

As an empirical application, a comparison of mortgage data suggests that FRM interest rate spreads in the US are relatively low compared to the UK; the difference in spreads is 46 basis points. Applying the estimated coefficient of substitution suggests that these lower interest rate spreads are large enough to account for half of the US FRM market share. In other words, because households are willing to substitute between contracts in response to small interest rate movements, supply side differences across countries may lead to significant differences in equilibrium contract shares.

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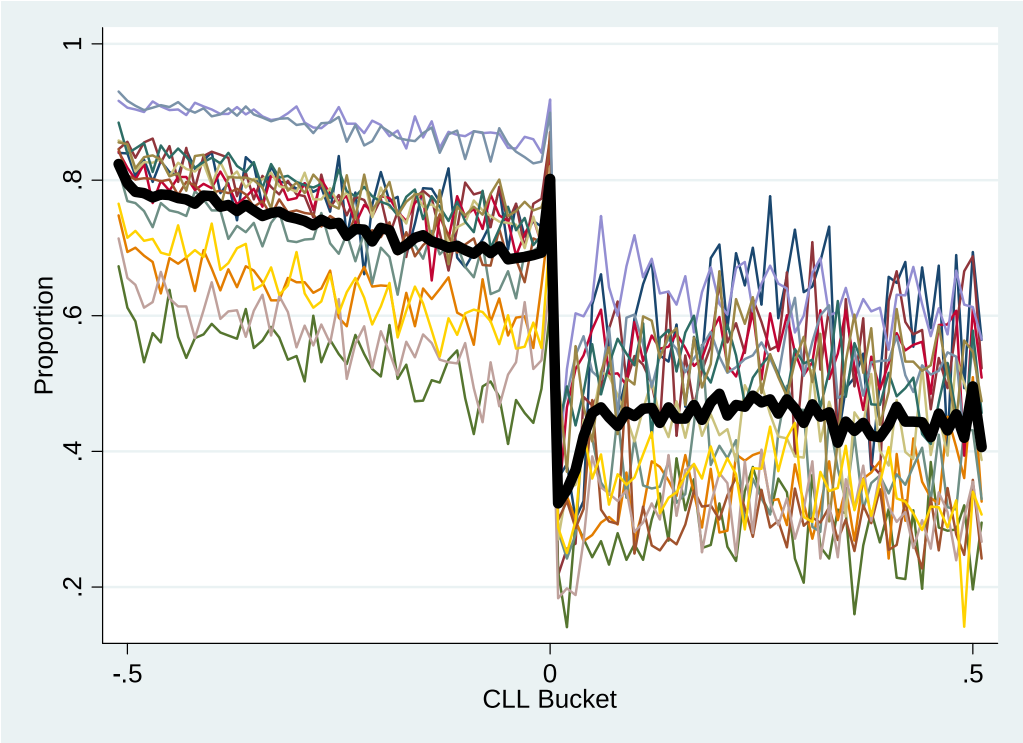
Figure 1: Effect of conforming loan limit on market share of fixed rate mortages



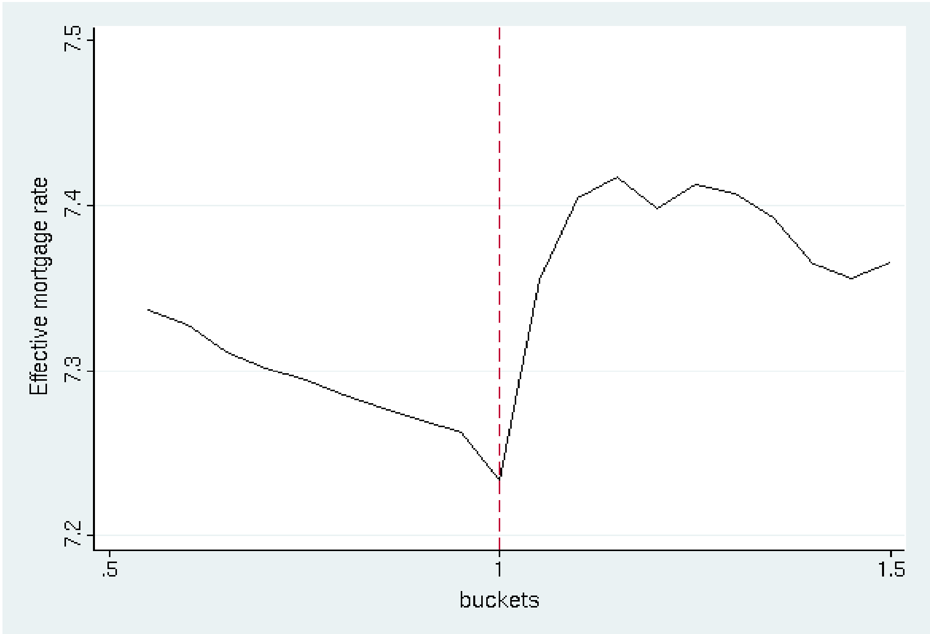
<u>Notes:</u>

1. 'CLL Bucket' is defined in percentage terms relative to the conforming loan limit. For, example, CLL bucket = 0 refers to the proportion of fixed rate mortgages for loans between 99 and 100 per cent of the CLL in that calendar year.

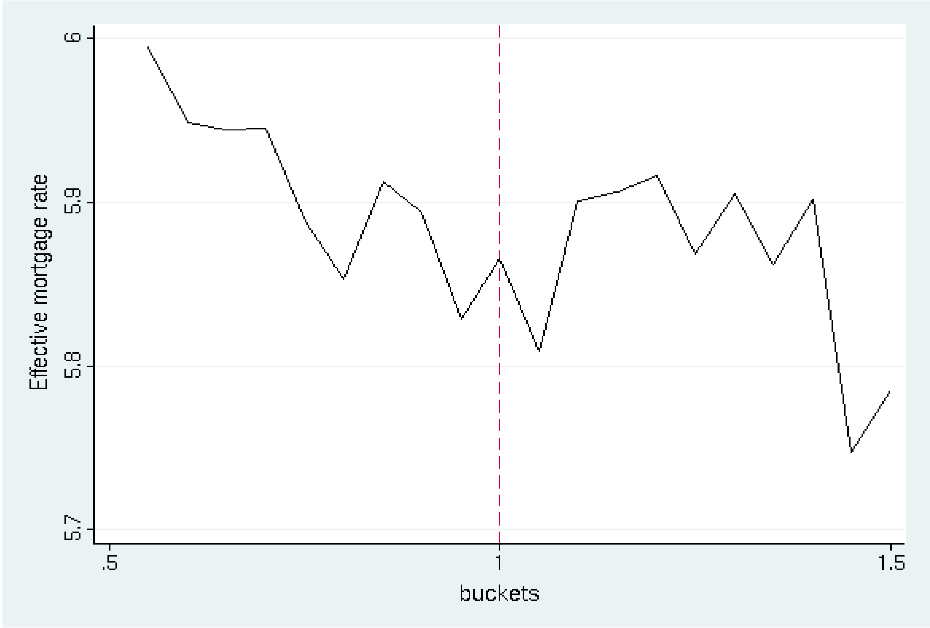
2. Graph is based on MIRS data from 1992 to 2005.

Figure 2: Effect of conforming loan limit on mortgage interest rates

30 year FRMs



1/1 ARMs



Notes:

1. 'CLL Bucket' is defined in percentage terms relative to the conforming loan limit. For, example, CLL bucket = 1 refers to the proportion of fixed rate mortgages for loans between 99 and 100 per cent of the CLL in that calendar year.
2. Graph is based on MIRS data from 1986 to 2005.

Figure 3: Effect of conforming loan limit on interest rate and market share of ARMs and FRMs

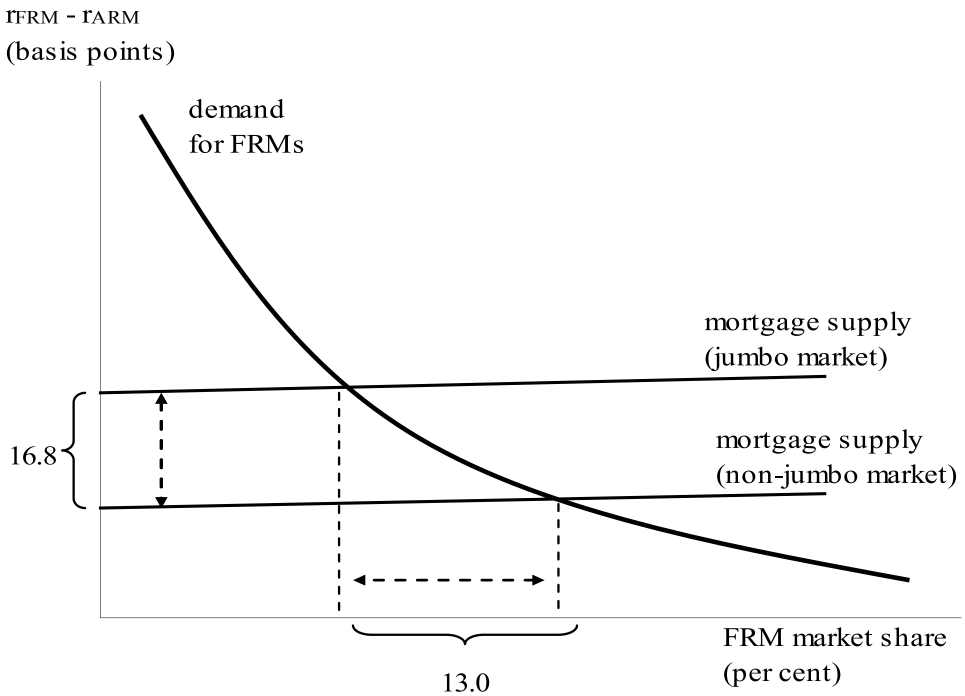


Table 1: MIRS Descriptive Statistics

A: Summary of Loans - All types

year	loan principal (nominal, 000s)	loan principal (real, 000s)	term	LTV	conforming loan limit (000s)	sample size	proportion jumbo loans	market share by lender type: mortgage co.	comm. bank	thrifts	share FRMs
1992	109.4	134.2	25.5	76.5	202.3	125098	7%	51%	22%	27%	80%
1993	107.9	128.5	25.6	77.3	203.2	141444	7%	51%	23%	26%	80%
1994	111.2	129.2	27.2	79.6	203.2	149831	8%	52%	26%	22%	60%
1995	111.6	126.1	27.5	79.8	203.2	125756	8%	52%	27%	21%	68%
1996	120.3	132.1	27.0	79.0	207.0	130001	10%	57%	24%	19%	73%
1997	128.3	137.5	27.6	79.2	214.6	179212	10%	55%	25%	20%	78%
1998	133.8	141.3	27.9	78.8	227.2	268640	9%	58%	17%	25%	88%
1999	141.1	146.0	28.3	78.8	240.0	248016	10%	58%	18%	24%	79%
2000	151.4	151.3	28.8	78.5	252.7	247612	10%	64%	16%	21%	75%
2001	160.3	155.9	27.8	77.1	275.0	291101	8%	64%	17%	20%	88%
2002	170.0	162.7	27.6	75.8	300.7	331679	8%	57%	22%	21%	82%
2003	177.4	166.1	27.4	75.2	322.7	384798	7%	54%	24%	22%	81%
2004	195.8	178.3	28.4	76.2	333.7	250398	11%	53%	24%	23%	63%
2005	218.1	192.9	28.8	75.0	359.7	172673	12%	52%	25%	24%	68%
Average	**145.5**	**148.7**	**27.5**	**77.6**	**253.2**	**217590**	**9%**	**56%**	**22%**	**23%**	**76%**

B: Summary of Loans - FRM only

year	loan principal (nominal, 000s)	loan principal (real, 000s)	term	LTV	conforming loan limit (000s)	sample size	proportion jumbo loans	market share by lender type: mortgage co.	comm. bank	thrifts
1992	105.1	128.9	24.5	76.5	202.3	90563	5%	59%	21%	21%
1993	102.7	122.3	24.8	77.4	203.2	105440	4%	59%	22%	19%
1994	97.6	113.6	25.8	79.3	203.2	74878	4%	63%	24%	13%
1995	100.7	113.7	26.5	79.4	203.2	75858	4%	61%	25%	14%
1996	108.6	119.4	26.2	78.7	207.0	85754	5%	67%	20%	13%
1997	120.5	129.1	27.0	79.2	214.6	133945	7%	62%	26%	13%
1998	127.0	134.1	27.6	79.0	227.2	236346	6%	62%	18%	20%
1999	128.4	133.0	27.9	79.1	240.0	193155	5%	67%	18%	15%
2000	132.4	132.2	28.4	78.9	252.7	175234	4%	74%	16%	10%
2001	148.5	144.4	27.5	77.2	275.0	246847	5%	67%	17%	16%
2002	155.5	148.7	27.1	75.7	300.7	252157	5%	60%	23%	17%
2003	165.5	155.0	26.8	74.9	322.7	301896	5%	56%	25%	20%
2004	169.7	154.6	27.6	75.3	333.7	143751	5%	56%	27%	17%
2005	190.3	168.2	28.2	74.4	359.7	110888	6%	54%	27%	19%
Average	**132.3**	**135.5**	**26.9**	**77.5**	**253.2**	**159051**	**5%**	**62%**	**22%**	**16%**

C: Summary of Loans - ARM only

year	loan principal (nominal, 000s)	loan principal (real, 000s)	term	LTV	conforming loan limit (000s)	sample size	proportion jumbo loans	market share by lender type: mortgage co.	comm. bank	thrifts
1992	126.4	154.9	29.2	76.5	202.3	34535	14%	19%	27%	53%
1993	128.8	153.4	29.0	76.9	203.2	36004	16%	21%	26%	53%
1994	131.7	152.7	29.3	80.0	203.2	74953	15%	35%	29%	36%
1995	134.6	152.4	29.4	80.6	203.2	49898	17%	33%	33%	34%
1996	152.0	166.7	29.1	80.0	207.0	44247	23%	31%	32%	37%
1997	156.6	168.0	29.5	79.5	214.6	45267	22%	33%	22%	45%
1998	182.1	192.4	29.7	77.7	227.2	32294	29%	25%	12%	63%
1999	188.8	194.9	29.8	77.7	240.0	54861	27%	25%	18%	58%
2000	209.4	209.5	29.9	77.1	252.7	72378	30%	31%	14%	55%
2001	244.0	237.2	29.8	76.1	275.0	44254	34%	39%	15%	46%
2002	237.3	227.1	29.8	76.3	300.7	79522	24%	38%	17%	44%
2003	228.4	213.7	29.7	76.8	322.7	82902	19%	49%	20%	32%
2004	240.4	218.8	29.9	77.7	333.7	106647	20%	48%	18%	34%
2005	277.2	245.2	30.0	76.1	359.7	61785	25%	46%	21%	33%
Average	**188.4**	**191.9**	**29.6**	**77.8**	**253.2**	**58539**	**22%**	**34%**	**22%**	**44%**

Table 2: Contract Shares, MIRS

Contract	% of sample
30 year FRM	57.6
FRM with term between 15-30 years	2.5
15 year FRM	12.3
FRMs with term less than 15 years	1.2
ARM, intial repricing period > 5 years	2.9
5/1 ARMs	4.9
ARM, initial repricing period >1 but <5 years	3.3
1/1 ARMs	9.7
ARMs with initial repricing period < 1 year	5.7

Table 3: FRM versus ARM decision: MIRS data

Linear probability regression. Robust standard errors; standard errors are clustered by calendar month (i.e. month interacted with year). Omitted dummy variable categories: loan is 80-90% of conforming loan limit; lender is finance company. Regressions also include dummies for state x MSA, month x year (coefficients not reported).

Dependent variable: =1 if mortgage is FRM; = 0 if mortgage is ARM

RHS variable:	OLS: Exclude loans between 98%-104% of CLL	IV: House size dummies as instrument for loan size dummies
Loan size relative to conforming loan limit (CLL):		
0-80% of CLL	0.007	-0.002
	(1.90)	(-0.39)
80-90% of CLL	-0.001	-0.008
	(-0.32)	(-1.75)
100-110% of CLL	-0.204***	-0.143***
	(-25.13)	(-5.51)
110-120% of CLL	-0.174***	-0.181***
	(-21.16)	(-17.41)
> 120% of CLL	-0.166***	-0.171***
	(-15.29)	(-13.39)
Loan to valuation ratio:		
LTV ratio	-0.060	-0.091
	(-0.64)	(-0.94)
ln(1+LTV)	-0.148**	-0.135**
	(-3.05)	(-2.73)
LTV > 80% dummy	0.048***	0.048***
	(5.01)	(4.94)
Other loan covariates:		
Lender is commercial bank	-0.054***	-0.055***
	(-6.28)	(-6.49)
Lender is savings bank	-0.240***	-0.241***
	(-19.67)	(-19.98)
Real loan size (000s, $2001)	-0.018	-0.019
	(-1.12)	(-1.15)
ln(loan size)	-0.049**	-0.048**
	(-3.18)	(-3.13)
$\ln(\text{loan size})^2$	-0.016	-0.018
	(-0.99)	(-1.06)
New House dummy	-0.060	-0.091
	(-0.64)	(-0.94)
Number of observations	2.23 million	2.31 million
R^2	0.117	0.118

Table 4: Sensitivity Analysis for FRM-ARM decision: MIRS data

Linear probability regression. Robust standard errors; standard errors are clustered by calendar month (i.e. month interacted with year). Omitted dummy variable categories: loan is 80-90% of conforming loan limit; lender is finance company. Regressions also include dummies for state x MSA, month x year (coefficients not reported).

Dependent variable: =1 if mortgage is FRM; = 0 if mortgage is ARM

RHS variable:	OLS: Exclude loans between 98%-104% of CLL	IV: House size dummies as instrument for loan size dummies
Affordability	-0.001***	-0.001***
	(-10.93)	(-10.60)
(Loan > CLL dummy) x affordability	0.001***	-0.000
	(4.54)	(-0.60)
(Loan > CLL dummy) x time in years	-0.007**	-0.014***
	(-3.33)	(-4.44)

Other RHS variables are the same as Columns 1 and 2 (respectively) of Table 2.

Table 5: FRM-ARM decision, Survey of Consumer Finances

Weighted probit regression based on pooled data from 1989, 1992, 1995, 1998, 2001 and 2004 SCF datasets. Regression also includes year dummies; coefficients not reported.

Dependent variable: Dummy = 1 if mortgage is FRM; = 0 if ARM

	OLS: drop loans near CLL		IV estimates	
	(1)	(2)	(3)	(4)
Household covariates:	Included	Excluded	Included	Excluded
Loan variables				
Dummy: Loan size > CLL	-0.102***	-0.107***	-0.113*	-0.134**
	(0.027)	(0.026)	(0.062)	(0.059)
ln(loan size)	-0.045***	-0.037***	-0.046**	-0.032*
	(0.011)	(0.010)	(0.018)	(0.018)
(Loan size / mortgage year value of dwelling) * 1/ 100	-0.013	-0.013	-0.017	-0.019
	(0.034)	(0.027)	(0.034)	(0.027)
Household controls				
Ln(years hhld head expects to stay at current job)	0.013***		0.012**	
	(0.005)		(0.005)	
Dummy: hhld head is self employed	-0.016		-0.008	
	(0.016)		(0.016)	
Leverage (non-mortgage debt/ assets)	0.037		0.038	
	(0.035)		(0.034)	
Household risk aversion	-0.003		-0.002	
	(0.008)		(0.008)	
Household has been refused credit in past 5 years	-0.015		-0.020	
	(0.018)		(0.017)	
Hhold did not apply for credit in past 5 yrs, expecting rejection	-0.064**		-0.058**	
	(0.029)		(0.025)	
Dummy: Household expects interest rates to rise	-0.000		-0.003	
	(0.012)		(0.011)	
Dummy: Household expects income to increase	0.009		0.011	
	(0.009)		(0.009)	
ln(1+real household income)	0.006		0.007	
	(0.006)		(0.007)	
Age of household head * (1/100)	0.050		0.032	
	(0.069)		(0.066)	
	0.005		0.002	
Dummy: Household head is married	(0.019)		(0.018)	
Household size	0.003		0.003	
	(0.005)		(0.005)	
Dummy: Household head is nonwhite	-0.019		-0.020	
	(0.019)		(0.018)	
Dummies for type of fin. institution	Included	Included	Included	Included
Observations	4156	4156	4265	4265
Pseudo-R2	0.09	0.09	0.10	0.09

Table 6: Bankrate mortgage interest rates

Table gives summary statistics for end-of-month nominal mortgage rates as reported in Bankrate.com's daily survey of lending institutions. Sample period: November 30, 2004 - October 31, 2005 (N=12).

	Sample Average	Sample Deviation	Sample Average - 95% Conf. Int.	
30-year FRM				
jumbo	5.63			
conforming	5.36			
difference	0.27	0.04	0.25	0.30
15-year FRM				
jumbo	5.14			
conforming	4.91			
difference	0.24	0.05	0.21	0.26
5/1 ARM				
jumbo	4.85			
conforming	4.74			
difference	0.11	0.03	0.09	0.13
1/1 ARM				
jumbo	3.86			
conforming	3.77			
difference	0.09	0.07	0.05	0.13

Note.– The Bankrate.com survey controls for borrower risk characteristics in the following manner. Lending institutions are asked what loan rate they are willing to extend to a customer: having no prior relationship with the institution; of average income; with a FICO score between 650 and 719; on a one-unit, single-family, owner-occupied residence. With the exception of the FHA, all loans assume a 20% downpayment.

Table 7: Interest Rate Regressions, Monthly Interest Rate Survey

Dependent variable is effective mortgage interest rate. Sample is split according to whether mortgage is of the type indicated. Regression estimated using a Fama-MacBeth (1973) two step procedure. Coefficients are normalized to reflect marginal effects. First step estimates based on weighted least squares, using the sampling weights provided in the MIRS. Omitted dummy variable categories: loan is less than 80% of CLL, lender is commercial bank. Regressions also include month-year dummies, FHLB sales district dummies, and state dummmies (coefficients not reported, available on request). Regression excludes loans between 98-104 per cent of the conforming loan limit.

	Fixed rate mortgages					Adjustable rate mortgages					
	30 year	15-30 year	15 year	<15 year	**AVG**	> 5 year	5/1	1-5 year	1/1	< 1 year	**AVG**
Loan size relative to conforming loan limit (CLL):											
between 80-90% of CLL	0.007	-0.006	0.001	-0.021	**0.005**	0.000	0.017	0.031	0.063*	0.037**	**0.038****
	(0.003)	(0.017)	(0.007)	(0.034)	**(0.003)**	(0.011)	(0.013)	(0.020)	(0.027)	(0.010)	**(0.010)**
between 90-100% of CLL	0.006	0.014	0.022	0.045	**0.010***	0.030**	0.041*	0.012	0.039	0.018	**0.030****
	(0.006)	(0.029)	(0.012)	(0.049)	**(0.004)**	(0.010)	(0.015)	(0.030)	(0.020)	(0.012)	**(0.009)**
between 100-110% of CLL	0.196***	0.076	0.210***	0.126	**0.193*****	0.137***	0.121***	0.162*	0.176***	0.036	**0.129*****
	(0.017)	(0.057)	(0.038)	(0.151)	**(0.014)**	(0.030)	(0.027)	(0.058)	(0.039)	(0.024)	**(0.013)**
between 110-120% of CLL	0.191***	0.148***	0.217***	0.247	**0.195*****	0.147***	0.114**	0.110	0.203***	0.020	**0.129*****
	(0.033)	(0.030)	(0.017)	(0.270)	**(0.028)**	(0.021)	(0.030)	(0.064)	(0.047)	(0.017)	**(0.018)**
> 120% of CLL	0.175***	0.092	0.148***	0.041	**0.166*****	0.155***	0.119**	-0.003	0.183***	-0.019	**0.102*****
	(0.020)	(0.048)	(0.023)	(0.170)	**(0.018)**	(0.035)	(0.036)	(0.078)	(0.041)	(0.038)	**(0.015)**
100-100 minus 90-100	0.190***	0.061	0.188***	0.081	**0.183*****	0.107**	0.080**	0.150**	0.137**	0.018	**0.099*****
	(0.017)	(0.060)	(0.038)	(0.130)	**(0.014)**	(0.031)	(0.021)	(0.041)	(0.040)	(0.023)	**(0.015)**
Lender is mortgage company	0.091**	-0.009	-0.030	-0.468**	**0.059**	-0.002	0.032	-0.111	0.458*	-0.345	**0.085**
	(0.026)	(0.035)	(0.040)	(0.129)	**(0.028)**	(0.046)	(0.046)	(0.117)	(0.190)	(0.467)	**(0.126)**
Lender is savings bank	0.066*	0.080*	-0.060*	-0.363**	**0.039**	-0.111	-0.026	-0.172*	0.150	-0.562	**-0.105**
	(0.025)	(0.032)	(0.027)	(0.097)	**(0.022)**	(0.056)	(0.049)	(0.069)	(0.188)	(0.414)	**(0.140)**
Real loan principal (000s, $2000)	0.080***	0.133*	0.139***	0.148	**0.093*****	0.076**	0.040	0.164*	0.047	0.056	**0.065*****
	(0.012)	(0.047)	(0.020)	(0.089)	**(0.011)**	(0.021)	(0.024)	(0.056)	(0.037)	(0.038)	**(0.012)**
ln(Loan principal)	-0.281***	-0.304***	-0.367***	-0.398***	**-0.298*****	-0.307***	-0.251***	-0.501***	-0.356*	-0.257***	**-0.327*****
	(0.028)	(0.064)	(0.025)	(0.094)	**(0.024)**	(0.021)	(0.056)	(0.062)	(0.123)	(0.058)	**(0.034)**
LTV ratio	0.486*	0.491	0.971**	0.873*	**0.574***	1.009**	0.538	-0.972	0.977	5.303***	**1.592****
	(0.208)	(0.432)	(0.249)	(0.321)	**(0.207)**	(0.299)	(0.399)	(0.492)	(1.274)	(0.937)	**(0.505)**
ln(1+LTV)	-0.159	-0.177	-0.459*	-0.414	**-0.214**	-0.510*	-0.206	0.835*	-0.357	-2.972***	**-0.763***
	(0.103)	(0.253)	(0.153)	(0.242)	**(0.107)**	(0.175)	(0.221)	(0.289)	(0.722)	(0.542)	**(0.293)**
New House dummy	0.015	0.040	0.058***	0.009	**0.023**	-0.033	-0.054**	-0.041	0.064	0.124	**0.031**
	(0.016)	(0.029)	(0.012)	(0.028)	**(0.013)**	(0.017)	(0.015)	(0.023)	(0.066)	(0.058)	**(0.024)**

Table 8: Mortgage interest rate spreads in US and UK

Table presents mortgage interest rate spreads for US and UK mortgages. Spreads are calculated as mortgage rates minus the yield on a Treasury security with the same repricing period. For the US, the reference rate is adjusted for the value of the mortgage prepayment option, calculated as the difference between the yield-to-maturity on a Fannie Mae (FNMA) MBS pool and the option adjusted spread (OAS) on that same pool. UK data is based on quoted rates collected from websites of UK lenders.

	US	**UK**
ARMs		
2 years	0.361	0.358
3 years	0.657	0.453
Weighted avg, ARMs	**0.509**	**0.406**
FRMs		
15 years	0.376	0.724
20 years	0.457	0.741
25 years	0.425	0.813
30 years	0.443	0.813*
Weighted avg, FRMs	**0.419**	**0.773**
[1] FRM_{US} - ARM_{US} =	**-0.09**	
[2] FRM_{UK} - ARM_{UK} =	**0.367**	
Difference [2] - [1] =	**0.457**	

* Data not available: set equal to to 25 year spread.