KU LEUVEN

CENTER FOR ECONOMIC STUDIES

DISCUSSION PAPER SERIES
DPS13.15

SEPTEMBER 2013

The myopic choice between fixed and adjustable rate mortgages in Flanders

Sven DAMEN and Erik BUYST

Economic History

Faculty of Economics
And Business

The Myopic Choice between Fixed and Adjustable Rate Mortgages in Flanders

Damen Sven and Buyst Erik *

September 10, 2013

Abstract

Many households have only one major asset, a house, which is usually financed through a mortgage contract. One of the most important financial decisions a household has to make is therefore the choice of mortgage type. These can be broadly described as falling into one of two categories: the fixed rate mortgage (FRM) and the adjustable rate mortgage (ARM). We use data from Flanders (Belgium) to study the choice between FRMs and ARMs. Belgium is of special interest as the structure of the Belgian mortgage market varied significantly during the last decade. From 2003 to 2012, the Belgian share of mortgages with an initial rate fixation period up to one year fell from 62% in 2004 to 8% in 2006, recovered to 58% in 2010, and fell again to 5% in 2012. This is a remarkably large variation in comparison to other countries. The results indicate that the FRM-ARM interest rate spread explains almost all the variation of the ARM share from 2003:01 to 2012:12. However, households do not distinguish between changes in the premium that lenders demand for holding the riskier long-term FRM or expected changes in the ARM rate. Mortgage choices can thus be described as short-sighted decisions, based on initial mortgage payments. We furthermore find evidence that high and low income households in Flanders choose an ARM for different reasons. Whereas the high income segment chooses an ARM if they can afford changes in interest payments, the low income households prefer an ARM if they are financially constrained.

JEL classification: D14, E43, G11, G21

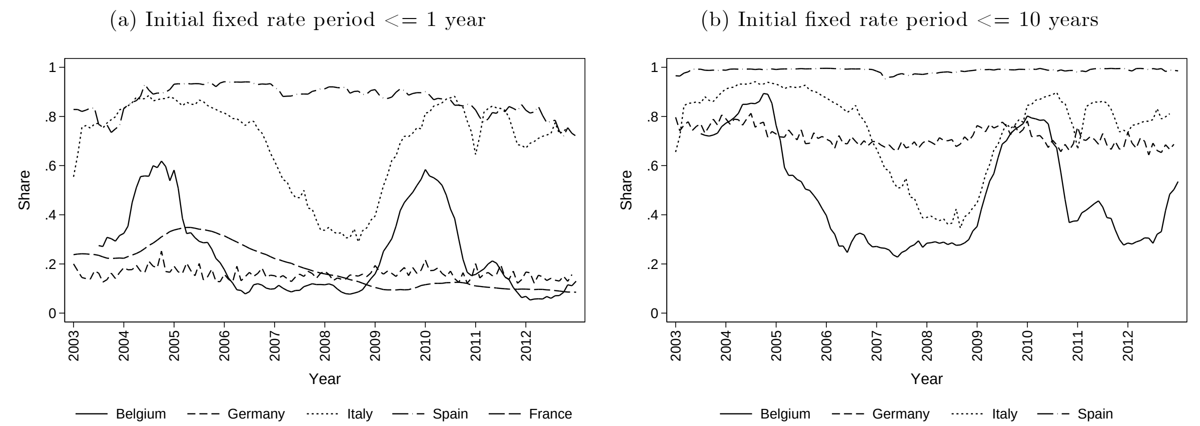
Keywords: mortgage choice, fixed and adjustable rate mortgages, household finance, bond risk premia

*Damen: KU Leuven, Naamsestraat 69, 3000 Leuven, Belgium, sven.damen@kuleuven.be (corresponding author). Buyst: KU Leuven, Naamsestraat 69, 3000 Leuven, Belgium.
The authors would like to thank all participants of the ENHR housing economics work group in Tarragona (June, 2013) for their valuable suggestions.

1 Introduction

Many households have only one major asset, a house, which is usually financed through a mortgage contract. One of the most important financial decisions a household has to make is therefore the choice of mortgage contract. Most consumers make this complex choice only a few times in their lives. Borrowers are thus likely to be ill-informed, which can lead to an inefficient equilibrium if they make suboptimal decisions (Woodward and Hall, 2012). The major decision borrowers have to make is the choice between the fixed rate mortgage (FRM) and the adjustable rate mortgage (ARM). The former has known nominal payments over the whole mortgage term, whereas the latter exposes the borrower to interest-rate risk. The resulting aggregate interest risk from individual mortgage choices has important policy implications for the transmission of monetary shocks through the effect of mortgage payments on household budgets. Miles (2004), Maclennan et al. (1998) and others have argued that a larger share of adjustable rate mortgages causes a higher exposure to changes in the interest rate. The International Monetary Fund (2004) pointed out that countries with high ARM shares typically have more volatile housing markets. Rubio (2011) developed a New Keynesian dynamic stochastic general equilibrium model and showed that for given monetary policy, a higher proportion of fixed rate mortgages is welfare enhancing. The dominant share of adjustable rate mortgages in the UK renders their economy susceptible to different shocks than other European countries (HM Treasury, 2003a). The resulting asymmetric effect of monetary policy was mentioned as an important reason by the United Kingdom's economics and finance ministry (HM Treasury, 2003a, 2003b) for opting out in the third stage of the Economic Monetary Union to introduce the euro.

Figure 1: Share of adjustable rate mortgages



Note: Figure 1a shows the share of mortgages with an initial fixed rate period smaller than or equal to 1 year from 2003:1 to 2012:12 in Belgium, Germany, Italy, Spain and France. Figure 1b shows the share of mortgages with an initial fixed rate period smaller than or equal to 10 years. As the available statistics do not allow us to compute the statistic for France, this country is excluded from Figure 1b. Source: ECB (own calculations).

Notwithstanding the different ways shocks are propagated, there still remains large cross-country heterogeneity in mortgage structure within the Eurozone as shown in Figure 1. FRMs are traditionally predominant in France and Germany[1], whereas Italy and Spain[2] are often highlighteded as countries with adjustable rate mortgage debt. According to the European Mortgage Federation (2006, 2012) and the IMF (2004) country-specific institutional features play an important role in the historical structure of the mortgage market in a particular country. The country-specific characteristics include cultural characteristics such as the borrowers' risk aversion or the funding sources of lenders. Countries with

[1] and Denmark (not shown in Figure 1)

[2] and Ireland, Portugal and Sweden (not shown in Figure 1)

well-developed covered bond markets or mortgage-backed securities markets tend to have a higher share of FRMs (e.g. Denmark, Germany and the United States of America). ARMs traditionally make up a higher proportion of the mortgage market in countries where funding is based on short-term deposits (e.g. United Kingdom, Spain, Portugal). The proportion of a mortgage type thus varies around a level that is dependent upon the country-specific institutional features. Whereas the variation around the country-specific level is small in most countries (see Figure 1), the structure of the Belgian mortgage market varied significantly during the last decade. From 2003 to 2012, the Belgian share of mortgages with an initial rate fixation period of up to one year fell from 62% in 2004 to 8% in 2006, recovered temporarily to 58% in 2010, and fell again to 5% in 2012, a remarkably large variation in comparison to other countries. In this paper we seek to understand this variation in the mortgage structure.

The choice between fixed and adjustable mortgages has been extensively studied in the United States (e.g. Dhillon, Shilling and Sirmans, 1987; Brueckner and Follain, 1988; Coulibaly and Li, 2009) and the United Kingdom (Leece, 2000; Bacon and Moffatt, 2012). Within the Eurozone, the FRM-ARM choice has been examined by Paiella and Pozzolo (2007) in Italy, a country with a relatively low developed mortgage market in comparison to the rest of Europe. To the best of our knowledge, no other study has empirically examined the choice between adjustable and fixed rate mortgages within the Eurozone. Most studies lack, however, one integrated theoretical framework and use different control variables, so that comparison of the results becomes difficult. We therefore study the theoretical expectations of optimal mortgage choice and examine the rise and fall of the ARM share in Belgium: one of the core Eurozone countries with a remarkably large variation in mortgage structure over time.

Belgium is of special interest to study mortgage choice as it is the only Member State of the European Union that implemented a ceiling on the variability of the mortgage rate (iff/ZEW, 2010). As required by law, it is now standard practice for adjustable rate mortgages to have a lifetime cap of 3% according to the Financial Stability Review of the National Bank of Belgium (2012). While borrowers are protected from large shifts in interest rates, an increase in the interest rate of 3% might still have a significant effect on households' finances. A survey in the United Kingdom that asked a large sample of households how they would cope with a rise of interest rates of 2.5%, found that less than half of the borrowers said they would be able to cope with all of their borrowing commitments without any difficulty (FSA, 2004 as cited in Miles, 2004). Borrowers should thus attach importance to interest rate expectations. Another characteristic of Belgian mortgages is the portability to a new residence if the homeowner chooses to move. American mortgages have different characteristics: interest increases above interest rate caps can be carried over to future periods[3] and the homeowner has to repay their fixed rate mortgage and take out an entire new mortgage when they decide to move.

In the next section we give an overview of the related literature. As optimal mortgage choices could differ from the USA, we simulate a model of optimal mortgage choice in section 3 using plausible parameters for Flanders. We furthermore analyze how exogenous changes in these parameters affect the optimal mortgage choice. Once the theoretical predicted effects are known, we examine whether or not households in Belgium and Flanders behave according to theory in section 5. The results indicate that households could be making mortgage choices that are far from optimal.

[3] See the Consumer Handbook on Adjustable-Rate Mortgages (2007), published by the Federal Reserve Board.

2 Overview of the literature

Dhillon, Shilling and Sirmans (1987) empirically examine the choice between fixed and adjustable rate mortgages in the USA. Data was limited to a local office from a mortgage provider in a limited time period (1983 - early 1984). The authors found that pricing variables played a significant role in the decision of which mortgage to choose. Borrower characteristics played a limited role for the mortgage choice. Households with co-borrowers, married couples and short expected housing tenures are *ceteris paribus* more likely to choose ARMs. The insignificant relationship between the mortgage payment ratios and the probability of choosing an ARM indicates that households look beyond the initial payments, according to the authors. The empirical findings indicate that a *ceteris paribus* increase in net worth increases the likelihood of taking out an ARM, suggesting that wealthy households are able to handle the uncertainty connected to ARMs.

Brueckner and Follain (1988) estimate an empirical model using 1985 data from a national database in the USA with 475 observations. The most important determinants of mortgage choice were pricing variables. The spread between the FRM and ARM rates and the level of the FRM rate played a key role in mortgage choices. According to the estimation results for borrower characteristics, ARMs are more preferred by high income households or by those who are likely to move. Brueckner and Follain use family size as a proxy for risk aversion and the number of years at the current address as a proxy for future mobility, which may be poor indicators.

Leece (2000) presents an econometric analysis on the choice of mortgage instrument using data from the British Household Panel Survey from 1991 to 1994. The study contributes to the literature as it is the first to use data outside the USA. A drawback of the data is that choice of the mortgage instrument is not observed and has to be derived using an algorithm. A methodology involving the estimation of the probability of misclassification is therefore used. The econometric results suggest a negative age effect, a positive time trend and a negative effect of the difference between the ARM rate and short run government bond on the probability of choosing a FRM. Income, further education, self-employment (as a measure of risk) and the FRM-ARM spread were not found to have a significant effect. Expectations to move were not considered. Leece concludes that mortgage choices of individuals are a gamble against anticipated changes in variable mortgage rates.

Campbell and Cocco (2003) provide a theoretical framework for analysing the characteristics of households that prefer one mortgage form over another. The authors argue that the choice involves a basic trade-off between two types of risk: wealth risk and income risk. The FRM is subject to the former as its real capital value is dependent upon unknown future inflation. The prepayment option protects the borrower against the risk of a decreasing nominal interest rate, but this option does not come for free. The wealth risk is not present in the ARM. The risk of an ARM is the variability in necessary mortgage payments due to the variability in interest rates. Variability in mortgage payments can result in unpleasant consumption variability as most households are risk-averse and hence want a smooth consumption pattern. Campbell and Cocco write:

> "While an ARM is generally an attractive form of mortgage, a household with a large mortgage, risky labor income, high risk aversion, a high cost of default, and a low probability of moving is less likely to prefer an ARM."

Campbell and Cocco report a strong negative correlation between long-term interest rates and the FRM share over time. American households thus believe long-term interest rates to be mean reverting against the expectations theory of the term structure, which implies almost unpredictable long-term rates.

The study of Coulibaly and Li (2009) overcomes some of the data limitations in previous empirical studies. The authors use the Survey of Consumer Finances, which contains information on mortgages, household finances, demographics, attitudes toward risk and moving expectations for a large sample of US mortgages. The results indicate that more financially constrained households are more likely to choose adjustable rate mortgages. Using the same Survey of Consumer Finances, Johnson and Li (2011) find that ARM borrowers demonstrate certain characteristics that suggest they are borrowing-constrained. Due to data limitations, the authors do not attempt to identify a causal relationship between choosing an ARM and being borrowing-constrained. Johnson and Li argue that further work should address this causality issue, as empirical evidence on whether ARM borrowers are borrowing-constrained is thin and inconclusive.

Koijen, Van Hemert and Van Nieuwerburgh (2009) study the link between the term structure and mortgage choice. A major contribution to the literature is that the bond term premium is the key theoretical determinant of rational mortgage choice. This risk premium reflects the extra yield lenders demand for holding the riskier long term bonds. The authors show that the FRM rate or the FRM-ARM spread are poor proxies for the premium, as they introduce an errors-in-variables problem. This problem is the reason that the government bond spread explains almost no variation in the ARM share, whereas the risk premium explains 35% of the variation. Koijen et al. argue that American households could be making close-to-optimal mortgage decisions.

3 Theoretical predictions

We analyze optimal mortgage choice in a similar framework as Campbell and Cocco (2003). The borrower is assumed to choose the mortgage $i \in \{ARM, FRM\}$ that gives him the highest expected lifetime utility of real consumption. The household's objective function is thus:

$$\max_{i \in \{ARM, FRM\}} E_0 \sum_{t=1}^{T} \delta^t \frac{\left(C_t^i\right)^{1-\gamma}}{1-\gamma} \tag{1}$$

$$C_t^i = L_t - \frac{MP_t^i}{P_t}$$

Where δ is the household's discount factor, γ is the coefficient of relative risk aversion. Real consumption at time t (C_t^i) is constructed by subtracting the real mortgage payments of contract i ($\frac{MP_t^i}{P_t}$) from the households' real disposable income (L_t). The price index (P_t) is constructed from inflation with $P_0 = 1$. We assume that there is no savings market such that the household consumes what is left from income after mortgage payments. Borrowers are risk-averse in the model such that they prefer a smooth consumption path. We assume that the borrower can refinance the FRM mortgage at a fixed cost of 4000 euro which is added to the outstanding loan balance[4]. The borrower evaluates every period whether or not a refinance gives lower mortgage payments. The assumptions for the inflation, interest and labor income processes are described in detail in Appendix 1. The lender prices the FRM rate with maturity n ($Y_t^{FRM}(n)$)[5] such that it equals the expected average of future one-period ARM rates ($Y_t^{ARM}(1)$) plus a premium ($\Phi_t^{FRM-ARM}(n)$) over the ARM:

$$Y_t^{FRM}(n) = \frac{1}{n} \sum_{i=0}^{n-1} E_t \left[Y_{t+i}^{ARM}(1)\right] + \Phi_t^{FRM-ARM}(n)$$

[4] ECB (2009) indicates that charges when taking out a loan for house purchase in Belgium equal 3.5% of the loan amount in 2007. For a loan amount of 115000 this is approximately equal to 4000 EUR.

[5] The maturity n is set to 20 years.

The premium is thus a cost over the whole mortgage term for FRM borrowers. It can be written as the sum of the term premium ($\Phi_t(n)$) and an additional component (e_t). The former is the excess yield that investors demand for holding the long term bond. The latter is an additional premium the lender might demand over the term premium depending on their willingness to accept long term debt.

$$\Phi_t^{FRM-ARM}(n) = \Phi_t(n) + e_t$$

In an environment with an upward sloping yield curve, the ARM could be an attractive contract for households that can expect their income to increase in future years. Due to the expected increase in short term interest rates, the borrower is able to smooth consumption as they will make larger mortgage payments when their real income has grown. Another advantage of the ARM is that the borrower does not have to pay the risk premium that lenders demand for holding the longer-term bond. However, volatility in real interest rates can make the ARM less attractive due to a higher variability in real mortgage payments. The main risk of the FRM is inflation risk. Although borrowers do know their future nominal mortgage payments, the real cost of these mortgage payments is influenced by uncertain inflation, and the borrower has to pay a cost if they wish to refinance at a lower interest rate.

As the Belgian market is likely to be different to the USA, we estimate all parameters using Belgian data. The model is then able to simulate a whole range of paths for inflation and real interest rates. We drop all paths with nominal interest rates that are lower than 0% or higher than 17.5% (the highest short term interest rate since the 1960s). For each of these 749 paths we simulate 50 different realizations in labor income shocks, which yields a total of 37,450 different paths. In the baseline case we assume a risk premium of 1%, disposable household income of 30,000 EUR, an expected growth rate of real disposable income of 1.5% which has a standard deviation of 2%, a loan amount of 115,000 EUR and coefficient of relative risk aversion of 3. Other parameters are described in Appendix 1. In the baseline case, the household who takes out an FRM makes initial mortgage payments of, on average, 36% of income in year 1. We calculate the difference between the realized lifetime utility of the ARM and the FRM in each path. We then model 6 exogenous changes in household or mortgage characteristics to study how these affect the FRM-ARM difference in realized lifetime utility using the same 37,450 paths. The change in the FRM-ARM difference in realized lifetime utility then indicates how the parameters affect optimal mortgage choice. Table 1 shows how an exogenous change in parameter values affects the relative attractiveness of an ARM relative to the FRM. In the baseline case, the ARM is slightly preferred above the FRM: it has a slightly higher expected lifetime utility and dominates the FRM contract in 58% of the realized paths.

When we change the risk premium from 1% to 2% while keeping the other parameters constant, the FRM contract becomes more expensive. The increase in the FRM rate decreases the expected lifetime utility of the FRM contract such that the ARM becomes more attractive. A regression of the difference in realized lifetime utility between the ARM and FRM on the FRM-ARM spread yields a positive sign for the coefficient of the spread. A higher FRM-ARM spread thus increases the expected realized lifetime utility of the ARM relative to the FRM. As the higher spread is driven by higher expected inflation in the future, the expected short term interest rate increases. The expectation increases the current long term interest rate which induces high real mortgage payments in the initial period. The ARM's smooth path of expected real mortgage payments increases its relative attractiveness. Including both the risk premium and the FRM-ARM spread in the regression of the difference in realized lifetime utility indicates that the borrower should be much more responsive to the risk premium than the spread. This is not surprising given that the risk premium is a cost over the whole mortgage term, whereas expected interest increases are only a cost in future years. The coefficient of the risk premium is almost 5 times higher in comparison to the coefficient of the spread. A rational mortgage borrower will thus be more responsive to changes in the risk premium than changes in the spread.

Table 1: Effect of changes in variables on expected lifetime utility

Description	Variables	Baseline	New value	$P(ARM\_choice)$
Risk premium	$\Phi_t(n)$	1%	2%	+
FRM-ARM spread	$Y_0^{FRM}(n){-}Y_0^{ARM}(1)$	NA	NA	+
Real disposable income (RDI)	L_0	30,000	20,000	-
Growth rate of RDI	g_L	1.5%	3%	+
Standard deviation of RDI	σ_L	2%	4%	-
Loan amount	HP_0	115,000	150,000	-
Coefficient of RRA	γ	3	5	-

Note: The table shows how exogenous changes in the risk premium, real disposable income (RDI), the growth rate of RDI, standard deviation of RDI, loan amount or the coefficient of relative risk aversion affect the attractiveness of the ARM relative to the FRM contract. We first simulate 749 interest rate paths. For each of these paths we simulate 50 different realizations in labor income paths, which yields a total of 37,450 paths. We then calculate the difference in realized lifetime utility for every path. We simulate the model for all different cases and calculate the difference in realized lifetime utility between the FRM and ARM for each of these cases. The sign in the last column then indicates how each change in parameter value affect the attractiveness of the ARM relative to the FRM.

When initial disposable income decreases from 30,000 EUR to 20,000 EUR, the household's initial mortgage payments increase on average from 36% to 53% of yearly income. As the borrower has a lower real consumption and decreasing marginal utility in real consumption, their lifetime utility will be more sensitive to changes in real consumption. The household's lifetime utility is therefore more sensitive to real interest rate risk. The increase in risk is so severe that the FRM contract has a higher expected lifetime utility for the borrower. As a risk-averse household prefers smooth consumption, a borrower with a higher expected growth rate of real disposable income will prefer to make larger mortgage payments in future years, when income has increased. In an environment with an upward sloping yield curve this is the ARM. In addition, the borrower's lifetime utility is less sensitive to changes in future real mortgage payments when income has grown faster. A higher growth rate of real disposable income therefore increases the probability of choosing an ARM.

If the standard deviation of the real disposable income shock increases, the uncertainty and the variability of the real consumption path increases. The simulations indicate that the ARM becomes less attractive relative to the FRM. Introducing a positive correlation between the real disposable income shock and the interest rate could make the ARM more attractive for borrowers with high income risk. However, Belgium is characterized by strong real wage rigidity (Du Caju, Fuss and Wintr, 2007) and the share of companies that use variable pay was rather small during the period in which we study cross sectional variation in mortgage choices (2001-2005). According to the TOA-survey (Technology, Organization and Labor) only 24.6% of Flemish companies with at least 10 employees used variable pay in 2004 (Bamps, Hellings and Roelandt, 2008). Since 2008, there has, however, been an increase in the popularity of non-recurring performance related bonuses, which are mainly concentrated toward high-income employees (Meessen, 2011).

A higher loan amount increases the necessary mortgage payments and makes the household more sensitive to changes in real capital payments. The results indicate that borrowers with higher loan amounts are negatively affected by the variability in real capital payments of the ARM such that the probability of choosing an FRM increases.

Borrowers with a higher coefficient of relative risk aversion prefer smoother real consumption patterns.

The simulations for the case where γ equals 5 indicate that these borrowers are more likely to prefer the FRM contract in the 37,450 simulated paths.

4 Data

The previous section provided some theoretical expectations of optimal mortgage choice. We now want to examine whether or not these determinants can explain the enormous variability in the ARM share during the last decade, and examine whether or not households make rational mortgage choices. We are thus interested in the variation in mortgage choice over time and cross-sectional variation between households. To examine the rise and fall of the ARM share in Belgium we use data from the Professional Association of Credit Providers (Beroepsvereniging van het krediet - BVK). The series provides business volumes of new mortgages for different initial fixed-rate periods. We classify a mortgage as an adjustable rate mortgage if the initial period of rate fixation is smaller than 10 years. As most mortgages in Belgium have fixed rates over the whole mortgage term or for one year only, this ARM share is highly correlated (95%) with a series constructed from ARMs with an initial fixed rate period smaller than 1 year (which is the legal minimum in Belgium). Mortgage interest rates were taken from the Monetary Financial Institutions Interest Rates (MIR) survey. The main purpose of the MIR survey is to obtain harmonized European aggregates of rates intended for households and non-financial firms. The statistics include the mortgage interest rates for loans that cover house purchases from 2003:01 to 2012:12 for different periods of initial rate fixation[6].

Belgian 10-year and 1-year government bond yields are taken from the OECD main economic indicators database. The government bond spread is calculated as the difference between these two series. The OECD database also provides inflation rates for Belgium. Data is available at monthly intervals spanning 1960:01 to 2012:12.

To examine which borrower characteristics lead the household to prefer one mortgage type over the other, we use data from the Flemish[7] Housing Survey 2005 (*Woonsurvey*)[8]. The survey was designed to actualize data of the external quality of Flemish housing and to assess the needs and preferences for housing. A sample of 7,770 households was drawn from the National Register, which resulted in a sample of 5,216 valid interviews. The interview included 310 questions about the profile of the household, characteristics of the house and neighborhood, housing costs, method of finance, history of housing and mobility motives. As the households are randomly drawn from the whole Flemish population, they are not subject to a selection bias, which is an important advantage over data from single mortgage providers. Data from a single mortgage provider would constrain our study to the financial advice of the lender, while the Flemish Housing Survey allows us to study the mortgage choices of the whole population. Mortgage information includes the current interest rate, whether or not this rate is fixed, sale price of the house and the amount that the household chose to borrow. The survey includes detailed household characteristics: employment status, disposable income, occupation category, education levels, age, presence of children in the house and the likelihood of moving. We limit the sample, as we are only interested in choices by households that are in the early years of mortgage payments. We thus select households who bought a house since 2001 and examine how their characteristics at the time of

[6] For the FRM rate we use the average monthly rate of mortgages for house purchases with an initial fixed rate period longer than 10 years. For the ARM rate we use the rate with an initial fixed rate period equal to 1 year.

[7] Flanders is the Dutch-speaking northern part of Belgium. The region covers 58% of the Belgian population. Similar housing surveys from the other regions are not available.

[8] More information on the survey and results can be found in: Heylen K., Le Roy M., Vanden Broucke S., Vandekerckhove B. & Winters S. (2007). "Wonen in Vlaanderen; De resultaten van de woonsurvey 2005 en de Uitwendige Woningschouwing 2005," Departement Ruimtelijke Ordening, Woonbeleid en Onroerend Erfgoed, Woonbeleid, Brussel.

the interview (in 2005 or early 2006) affect their mortgage type in that year. This results in a sample of 301 households for which all information is available. Whereas a small sample often leaves the null hypothesis unchallenged, our empirical analysis will be able to answer some important questions. In future work we plan to include additional housing surveys to increase the sample size. The FRM-ARM spread is taken from the MIR and Retail Interest Rate survey[9].

To measure the household's financial constraint we include the yearly mortgage payments as percentage of income ($\frac{YearlyPaymentFA_{t,j}}{income_{t,j}}$) that household j faces at time t. To allow maximum comparison between households we compute the yearly mortgage payments given a loan-to-value ratio of 80%, mortgage term of 20 years, the long-term interest rate ($Y_t^{FRM}(n)$) and the net tax relief the household would receive in the year of mortgage origination given these mortgage characteristics. Before 2005, the tax deduction for homeowners was mainly based on capital repayments that were limited to the first 60,910 euros of the borrowed amount per dwelling in 2004. The limit was higher for households with children, and increased in accordance with the consumer price index over time. The fiscal advantage was furthermore limited in function of income and could not exceed 1,870 EUR in 2004. Since 2005, the fiscal advantage for homeowners is extended to a tax deduction (*woonbonus*) that includes both interest payments and capital repayments. The new fiscal advantage limits the tax deduction to 2,490 euros per year per person in the first ten years, starting in 2005. For the average household the net tax relief more than doubled. The tax relief is dependent upon the marginal tax rate of the borrower, which is not observed in the survey. The marginal tax rate had to be computed based on the net income reported by households. The formula for the yearly mortgage payments is given in equation (2). The variable is divided by income to obtain a measure of the household's financial constraint.

$$YearlyPaymentFA_{t,j} = \frac{0.8 * houseprice_j}{\frac{(1-(1+Y_t^{FRM})^{-20})}{Y_t^{FRM}}} - netTaxRelief_{t,j} \tag{2}$$

According to the American literature, households that are likely to move in the near future are more likely to choose an adjustable rate as they are not subject to most of the interest rate risk due to their expected early repayment (Brueckner and Follain, 1988). In Belgium, every household has the right to transfer their mortgage to a new residence. The borrower can choose to keep the existing mortgage terms if the value of the new house is high enough to serve as security in the mortgage contract. The main advantage is that the costs are limited as the borrower does not have to take out an entire new mortgage. On the other hand, the borrower can repay the mortgage and obtain a whole new contract at the time of the move. This option is attractive when the cost of taking out a whole new mortgage can be covered by a lower interest rate. The incentive to use an ARM when the household is more likely to move is thus lower, as the household is able to lock-in a favorable fixed interest rate over the whole mortgage term. In the USA, portable mortgages are a rarely-used option, as borrowers must have exceptional credit, and interest rates are typically higher than for standard fixed-rate mortgages. Whereas other studies have to use a proxy for the likelihood to move (Dhillon, Shilling and Sirmans, 1987; Brueckner and Follain, 1988), the Flemish Housing Survey directly enquires about the borrowers' moving plans. We code the household as expected to move when the answer to the question "Do you have plans to move?" is "Yes".

Campbell and Cocco (2003) point out that households choose to default when negative income shocks cause unpleasant reductions in consumption. If the income shock is negatively correlated with the interest rate shock, the household is more likely to choose the FRM. Unfortunately, it is not possible to

[9] The RIR survey was a monthly survey among credit institutions undertaken by the National Bank of Belgium, which ended in 2003. FRM rates for 2001 and 2002 were taken from the RIR survey. ARM rates for 2001 and 2002 were imputed from a regression of the ARM rate on the short term government bond rate and government bond spread (including quadratic terms).

Table 2: Summary statistics

Variables	Full sample	Below median income	Above median income
Higher education (dummy)	0.40	0.22	0.60
Age	33.35	33	33.7
Children living in the house (dummy)	0.51	0.46	0.57
Moving plans (dummy)	0.06	0.04	0.07
Loan-to-value ratio	0.75	0.80	0.70
Borrowers	1.79	1.82	1.74
Spread	1.64	1.63	1.66
Income volatility/income	0.04	0.04	0.03
$\frac{YearlyPaymentFA_{t,j}}{income_{t,j}}$	0.28	0.29	0.28

Note: The table presents descriptive statistics for all variables. Column 2 presents the mean for the full sample. Columns 3 and 4 present, respectively, mean values for the subsample of households with below and above median income per working household member.

compute the correlation between income and interest shocks using the cross sectional study. Household income risk is approximated using a similar approach as in Coulibaly and Li (2009). We create a dummy variable $D_{k,m}$ that equals 1 if household member $m \in \{1, 2\}$ can be categorized in occupation category[10] $k \in \{1, 2, ..., 11\}$. We regress household income on occupation category dummies per working household member ($D_{k,m}$), age and age squared of the reference person in the household interacted with $D_{k,m}$, a higher education dummy interacted with $D_{k,m}$ and the sex of the reference person of the household.

$$\begin{aligned} income &= \sum_{k=1}^{11}\sum_{m=1}^{2}\left(\gamma_{0,k}.D_{k,m} + \gamma_{1,k}.D_{k,m}.age + \gamma_{2,k}.D_{k,m}.age^2 + \gamma_{3,k}.D_{k,m}.higher\_education_m\right) \\ &\quad +\gamma_4.sex + \epsilon \end{aligned} \tag{3}$$

The standard error of the prediction of equation (3) is then divided by income as a measure of income risk. Table 2 shows summary statistics of the data for the full sample and for those below and above median income.

5 Empirical results

In this section we empirically examine how the theoretically expected determinants affect mortgage decisions over time and between households. We first analyze the role of the FRM premium that lenders demand, the bond term premium and the initial mortgage spread in the evolution of the ARM share from 2003:01 to 2012:12. Given a fixed distribution of households, the FRM premium that lenders demand should be the key determinant of variation in the mortgage structure over time. Section 3 furthermore indicates that the FRM-ARM spread should have a positive effect on the ARM choice, but this effect should be less strong as it is a combination of the FRM premium that lenders demand and expectations of future ARM rates. In subsection 5.3 we examine how households choose their mortgage type using micro-data from the Flemish Housing Survey.

[10] The categories are laborer, skilled laborer, overman/foreman, lower clerk, middle management clerk, management, government official, middle management (government official), management (government official), self-employed, unemployed.

5.1 The bond term premium as key theoretical determinant of rational mortgage choice

Koijen et al. (2009) derive the optimal mortgage choice within a lifetime utility framework. Within this framework, households trade off higher expected real consumption against higher variability in real consumption. With all else equal, households prefer the mortgage that gives them the highest expected real consumption. When the risk premium on long term bonds is high, the FRM becomes more expensive, such that the ARM becomes more attractive. The important role of the risk premium was also confirmed by our own simulations in Section 3. In order to derive the risk premium, note that the government bond spread can be written as

$$Y_t(n) - Y_t(1) = \underbrace{\frac{1}{n}\sum_{j=1}^{n} E_t[Y_{t+j-1}(1)] - Y_t(1)}_{\text{Pure EH-spread}} + \underbrace{\Phi_t(n)}_{\text{Risk premium}} \tag{4}$$

The first term is the spread under the pure expectations hypothesis and equals the average expected increase in short term rates. The second term is the risk or term premium. If we include the spread and do not differentiate between both components, we thus observe an errors-in-variables problem with a downward-biased estimate of the risk premium effect.

In order to disentangle both terms in (4) we jointly model the dynamics of government bond yields and inflation in a vector error-correction model (VECM). This model will be able to forecast future values of the short term rate, such that the risk premium can be calculated as a residual value from equation (4). The VECM takes the form

$$\Delta \mathbf{X}_t = \mathbf{v} + \mathbf{\Pi X}_{t-1} + \sum_{i=1}^{p-1} \mathbf{\Gamma}_i \Delta \mathbf{X}_{t-1} + \boldsymbol{\varepsilon}_t$$

where $\mathbf{X}_t$ is a k dimensional column vector of k state variables, $\boldsymbol{\nu}$ is a $k \times 1$ vector of constants, $\mathbf{\Pi}$ and $\mathbf{\Gamma}_i$ are $k \times k$ matrices of coefficients and $\boldsymbol{\varepsilon}_t$ is a vector white noise process. $\mathbf{\Pi}$ contains long-run information of the data and can be written as $\mathbf{\Pi} = \boldsymbol{\alpha\beta}'$ under the hypothesis of cointegration. $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ are $k \times r$ matrices, where r equals the number of linear combinations of the elements of $\mathbf{X}_t$ that are stationary. The matrix $\boldsymbol{\beta}$ can be interpreted as a matrix of r cointegrating vectors, while matrix $\boldsymbol{\alpha}$ consists of error-correction parameters. Ang, Piazzesi and Wei (2006) argue that two yield-curve factors are sufficient to model the dynamics of yields. The state vector $\mathbf{X}_t$ therefore includes the short term government bond rate and the 10-year government bond spread. Ang and Piazzesi (2003) show that incorporating both yield-curve factors and macroeconomic factors are important to capture the dynamics of the yields. As a macroeconomic variable we include the realized one-year inflation (π_t) such that the complete state vector $\mathbf{X}_t$ is equal to

$$\mathbf{X}_t^{'} = \begin{pmatrix} Y_t(1) & Y_t(10) - Y_t(1) & \pi_t \end{pmatrix}$$

We use a VECM instead of a vector autoregressive model (VAR) as the one year government bond rate and inflation rate are integrated of order one, or I(1). Two baseline models are used for estimation, we refer to them as models A and B. The main differences are summarized in Table 3. Model A uses a sample of monthly data from 1960:01 to 2012:12, but uses an expanding window of the estimation sample. Therefore we estimate the VECM using a subsample from 1960:01 to 2002:12 and forecast the one-year government bond rate over the next 10 years, starting from 2003:01. The dynamic forecasts deliver a measure of the expected average short rate over the next 10 years. We then increase the subsample to include 2003:01, re-estimate the model, forecast the short rate and calculate the expected average short rate over the next 10 years starting from 2003:02. The procedure is repeated until we obtain a series of the expected average short rate from 2003:01 until 2012:12. Model B estimates the VECM using a fixed estimation sample from 1999:01 to 2012:12. As monetary policy is conducted independently by the European Central Bank since 1999, model B can be seen as a robustness check using a recent estimation sample.

Table 3: Comparison of models A and B

	Model A	Model B
Estimation sample	1960:01- 2002:12	1999:01-2012:12
Expanding / fixed window?	Expanding to 2012:12	Fixed
Lags included	24	12

The Johansen test for cointegration indicates that there exists one cointegration equation with cointegration vector $\boldsymbol{\beta}' = \begin{pmatrix} 1 & 4.28 & -0.72 & -7.84 \end{pmatrix}$ when the VECM is estimated over the whole sample period. The coefficients refer respectively to the one year government bond rate, the 10-year spread, the realized one-year inflation rate and a constant. The eigenvalue stability condition is also satisfied given that all eigenvalues are inside the unit circle except two (which equals the number of I(1) variables). A graphical representation is given in Figure 4 in the appendix. We therefore assume one cointegration vector in both model A and B.

As it is now standard practice for adjustable rate mortgages to have a lifetime cap of 3% according to the National Bank of Belgium (2012) we limit the forecast of future interest rate expectations such that the absolute deviation from the initial interest rate cannot exceed 3 percentage points. The adjusted measure of expected changes in interest rates is then equal to the true expectations that households face.

In Belgium, the lender is unable to change the ARM rate at its own discretion during the contract. The ARM rates are linked to a reference index, which is computed from the government bond rates. The expected increase in the government bond rate is thus exactly equal to the expected increase in ARM rate such that:

$$\frac{1}{n}\sum_{j=1}^{n} E_t[Y_{t+j-1}^{ARM}(1)] - Y_t^{ARM}(1) = \frac{1}{n}\sum_{j=1}^{n} E_t[Y_{t+j-1}(1)] - Y_t(1)$$

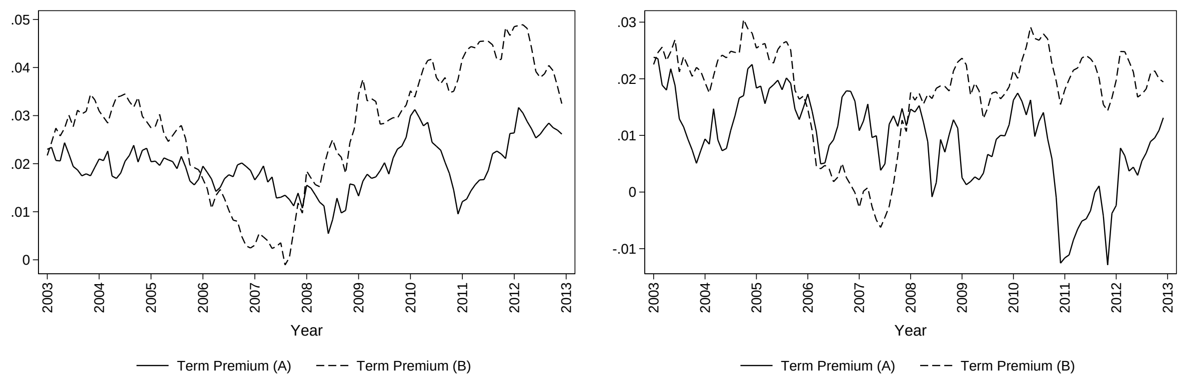
We are now able to calculate the risk premium ($\Phi_t^{FRM-ARM}(n)$) as a residual value from equation (4) in the bond market and the premium that is present in the FRM-ARM differential ($\Phi_t^{FRM-ARM}(n)$) as a residual value from equation (5):

$$\begin{aligned} \Phi_t^{FRM-ARM}(n) &= Y_t^{FRM}(n) - Y_t^{ARM}(1) - \left(\frac{1}{n}\sum_{j=1}^{n} E_t[Y_{t+j-1}^{ARM}(1)] - Y_t^{ARM}(1)\right) && (5) \\ &= Y_t^{FRM}(n) - \frac{1}{n}\sum_{j=1}^{n} E_t[Y_{t+j-1}^{ARM}(1)] && (6) \end{aligned}$$

As lenders might demand an additional premium, $\Phi_t^{FRM-ARM}(n)$ may better capture the true cost of the FRM contract that borrowers face. If we rewrite $\Phi_t^{FRM-ARM}(n)$ as in equation (6), we can see that it is equal to the FRM-ARM interest spread adjusted for expected changes in the ARM rate. If borrowers are not myopic and attach value to future ARM rates, $\Phi_t^{FRM-ARM}(n)$ should have a higher explanatory power of the variation in the ARM share than the FRM-ARM interest spread. The estimated measures of $\Phi_t(n)$ and $\Phi_t^{FRM-ARM}(n)$ are graphically represented over time in Figure 2. We can see that risk premia fell until the eruption of the recent financial crisis, followed by an increase in risk premia.

Figure 2: Risk premium

(a) $\Phi_t(n)$ (b) $\Phi_t^{FRM-ARM}(n)$



Note: This figure shows (a) the bond risk premium and (b) the FRM premium that lenders demand. Both measures are calculated for models A and B.

Now that we have a measure for the risk premium, we can examine its role upon the variability of the ARM share in Belgium. The results of a regression with the ARM share as dependent variable and the risk premium (where n equals 10 years) as regressor are shown in Table 4. A 1 percentage point increase in the risk premium ($\Phi_t(n)$) increases the ARM share by 15 percentage points, according to model A. A 1 standard deviation increase in the risk premium increases the ARM share by 8 percentage points. The predictive power of the risk premium is furthermore unsatisfactory. The R-squared of 17% and 14% teaches us that the explanatory value of the risk premium alone is relatively small. Koijen et al. (2009) report stronger sensitivities of a 1 standard deviation increase in risk premia and higher explanatory power in the USA. The FRM premium that lenders demand ($\Phi_t^{FRM-ARM}(n)$) has a smaller effect according to model A: a 1 standard deviation increase in $\Phi_t^{FRM-ARM}(n)$ increases the ARM share by 6.75 percentage points. According to model B the effect is more important: a 1 standard deviation increase in $\Phi_t^{FRM-ARM}(n)$ increases the ARM share by 18.31 percentage points according to model B. The R-squared increases to 39%, such that a larger part of the variation in the ARM share can be attributed to variation in $\Phi_t^{FRM-ARM}(n)$. In Section 5.2 we examine other factors that could explain the variation in the ARM share.

If $\Phi_t^{FRM-ARM}(n)$ is mean-reverting, the borrower can temporarily choose the ARM when risk premia are high in order to repay the entire loan and choose an FRM when risk premia have reverted. If the variation in $\Phi_t^{FRM-ARM}(n)$ is high enough to cover the cost of taking out an entirely new mortgage, this can be a profitable strategy[11]. Whether or not households employ this strategy is an empirical question. If they do, a decrease in $\Phi_t^{FRM-ARM}(n)$ will, *ceteris paribus*, cause an increase in refinance volumes. Table 12 in the appendix presents regression results with the volume of refinances as dependent variable and $\Phi_t^{FRM-ARM}(n)$ as explanatory variable. We thus expect a significant negative effect if borrowers exploit this strategy. The estimated coefficient of the FRM-ARM premium is, however, positive in all specifications. Borrowers thus do not temporarily choose the ARM when risk premia are high in order to refinance and obtain a FRM when $\Phi_t^{FRM-ARM}(n)$ decreased.

We provide robustness checks in the appendix. Hjalmarsson and Österholm (2007) argue that there is little *a priori* reason to believe that interest rates and inflation rates have an exact unit root. Conventional

[11]The authors would like to thank Viggo Nordvik for this suggestion.

unit root tests have very limited power to distinguish a unit root from a near-integrated process. The authors argue that the risk of concluding that completely unrelated near-integrated series are cointegrated cannot be ignored, such that the VECM specification becomes inappropriate. We therefore frame the state variables in a VAR framework to check the structural validity. Our findings are robust to all different specifications.

Table 4: The ARM share and the risk premium

Variables	Model A		Model B	
Constant	-0.02	0.20 ***	0.12	0.03
	(0.04)	(0.04)	(0.09)	(0.04)
FRM-ARM Risk premium ($\Phi_t^{FRM-ARM}(n)$)		8.51 **		14.33 ***
		(3.33)		(2.92)
Risk premium ($\Phi_t(n)$)	15.27 *		5.76	
	(9.21)		(3.65)	
R^2	0.17	0.12	0.14	0.39
State vector (X_t)	$\begin{pmatrix} Y_t(1) & Y_t(10){-}Y_t(1) & \pi_t \end{pmatrix}$			
VAR / VECM	VECM			
Lags	24		12	
Estimation sample of risk premia	1960:1 - 2012:12 (E)		1999:1-2012:12 (F)	

Note: This table represents the estimation results from 2003:01 to 2012:12 of the ARM share regressed on the risk premium (for $n = 10$ years) estimated from two models (A and B). Model A is estimated with a sample from 1960:01 to 2002:12 that expands to 2012:12. Model B uses a fixed estimation sample from 1999:01 to 2012:12. (E) and (F) indicate respectively whether an expanding or fixed sample was used for the estimation. The share of ARMs is defined as the mortgages with an initial fixed rate period smaller than 10 years as a percentage of all new mortgages. The state vector of the VECM includes the short term government bond, 10-year government bond spread and inflation. The VECM is then able to dynamically forecast the short rate, which is used to calculate the risk premium as a residual value from (4) and (5). Newey-West standard errors are reported in parentheses (12 lags). *, **, *** refer respectively to p-values lower than 0.10, 0.05 and 0.01

5.2 The role of initial mortgage payments in the rise and fall of the ARM share

We have shown that changes in the risk premium are insufficient to explain the variation in the ARM share in Belgium. Theoretical work by Alm-Follain (1987) and Brueckner (1986) suggests that households should respond to the spread between FRM and ARM rates. A higher spread increases the current cost of the FRM, but also the expected future ARM rates. Brueckner (1986) indicates that the former effect is likely to dominate such that more households would prefer ARMs. Our own simulations confirm these expectations for the Belgian market: a higher spread due to an expected increase in short term interest rates increases the FRM rate and the expected future cost of the ARM, but allows the household to smooth consumption as he will make larger payments when income has grown. The overall effect is that we can expect an increase in the ARM share. The FRM-ARM interest spread is, however, a combination of $\Phi_t^{FRM-ARM}(n)$ and the expected increase in ARM rates. The responsiveness of the ARM share to the FRM-ARM spread should thus be smaller than the effect of $\Phi_t^{FRM-ARM}(n)$ on the ARM share, as the latter only has a cost effect. Column (1) in Table 5 presents regression results for the share of adjustable rate mortgages as dependent variable and the FRM-ARM spread as regressor. The FRM-ARM rate spread is highly positively correlated (0.89) to the share of adjustable rate mortgages over the period 2003:01 to 2012:12. A higher spread thus increases the demand for adjustable rate mortgages. A 1 percentage point increase in the FRM-ARM spread causes an increase in the ARM share of 26 percentage points. Berkovec, Kogut and Nothaft (2001) report a similar long-run effect of a change in the FRM-ARM spread on the ARM share of +30 percentage points in the USA. The predicted ARM share with regression (1) is shown in Figure 3 [Predicted (1)]. The series tracks the evolution of the actual ARM share remarkably closely.

Table 5: ARM share predicted by FRM-ARM spread, FRM rate and government bond spread

Variables	(1)	(2)	(3)	(4)
Constant	0.13 ***	0.15 ***	0.11 ***	0.08 ***
	(0.02)	(0.03)	(0.02)	(0.02)
FRM-ARM spread	26.06 ***	28.38 ***	27.77 ***	26.84 ***
	(3.27)	(3.98)	(3.79)	(3.04)
Yield spread		-2.24		
		(1.65)		
$\frac{1}{n}\sum_{j=1}^{n} E_t[Y_{t+j-1}^{ARM}(1)] - Y_t^{ARM}(1)$			-2.53	-3.28 *
			(1.82)	(1.79)
R^2	0.80	0.81	0.81	0.81
Risk premium model?			A	B

Note: This table presents the estimation results from 2003:01 to 2012:12 of the ARM share regressed on the FRM-ARM interest spread in combination with interest expectations from the yield spread or ARM forecasts estimated from two models (A and B). Model A is estimated with a sample from 1960:01 to 2002:12 that expands to 2012:12. Model B uses a fixed estimation sample from 1999:01 to 2012:12. The state vector of the VECM includes the short term government bond, 10-year government bond spread and inflation. The VECM is then able to dynamically forecast the short rate. The share of ARMs is defined as the mortgages with an initial fixed rate period smaller than 10 years as a percentage of all new mortgages. Newey-West standard errors are reported in parentheses (12 lags). *, **, *** refer respectively to p-values lower than 0.10, 0.05 and 0.01

Regressions (2), (3) and (4) in Table 5 include the government bond spread and our estimated change in ARM rates from the VECM of models A and B. The coefficient of yield curve in (2) is negative, but insignificant. We are thus unable to reject that the responsiveness of the ARM share to changes in the yield curve is statistically different from zero. A remarkable difference is the effect of a change in the government bond spread between the USA and our data. Berkovec, Kogut and Nothaft (2001) found that a 1 percentage point increase causes a 13.33 percentage point decrease in the ARM share. The same increase in the government bond spread in Belgium would only cause the ARM share to decrease by 2.24 percentage points (although this is not significant). Borrowers in the USA are thus six times more responsive to the slope of the yield curve. A possible explanation could be that the government bond spread is not a good measure of the interest expectations that households face. The Belgian Mortgage Credit Act requires the use of a lifetime cap over the whole mortgage duration[12], which often takes the form of maximum changes of 3 percentage points, according to the National Bank of Belgium (2012). Mortgages in the USA may also have interest rate caps and life-of-loan rate caps are also obligated by law, but an increase in interest rate above the cap might *carry over* to future periods[13] and life-of-loan rate caps are generally higher than 3%. The *carry over* property and higher life-of-loan rate caps can explain why borrowers in the USA are more responsive to changes in the government bond spread. The interest rate cap in Belgium can lead to an errors-in-variables problem in the yield spread such that the estimated coefficient is biased towards zero. We therefore include the estimated change in ARM rates from the VECM of models A and B. As the variable is constructed such that the absolute difference between the ARM rate and every forecast of the ARM rate cannot exceed 3%, it is equal to the true expectations that households have. The estimated coefficients in (3) and (4) have indeed larger negative values, but only the interest expectation in (4) is statistically significant. Whereas the estimated coefficient in (4) is statistically significant, Figure 3 shows that its economic significance is small. An increase in $\frac{1}{n}\sum_{j=1}^{n} E_t[Y_{t+j-1}^{ARM}(1)] - Y_t^{ARM}(1)$ of 1 standard deviation decreases the ARM share by only 2.31 percentage points. Given the important role of the FRM-ARM spread in the choice of mortgage type, we choose to include it as a main pricing variable in our micro data analysis using the Flemish

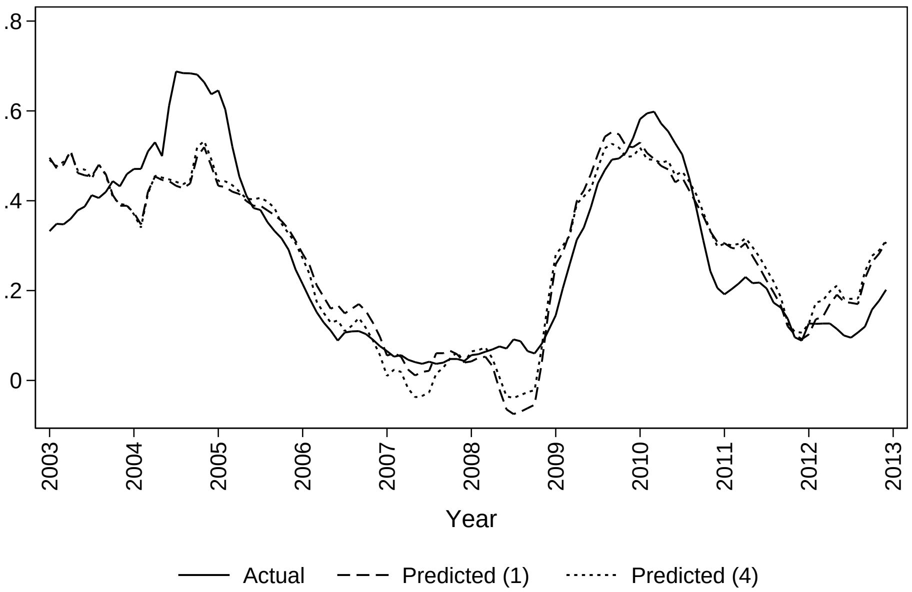
[12] See article 9, §1, 8° of the Belgian Mortgage Credit Act (Wet Hypothecair Krediet)

[13] See the Consumer Handbook on Adjustable-Rate Mortgages (2007), published by the Federal Reserve Board.

Housing Survey in Section 5.3.

Bacon and Moffatt (2012) argue that factors that influence demand might at the same time influence the supply through the price that lenders demand. An increase in expected interest rates might, *ceteris paribus*, increase demand for the FRM. However, as lenders will increase the price of the FRM, the overall effect is ambiguous, and depends on the strength of both effects. To obtain consistent estimates of the exact responsiveness of demand to changes in the FRM-ARM interest spread and expected changes in interest rates we need to use the method of instrumental variables (IV). Two-stage least squares estimation results are presented in Table 11 in the appendix. The results do not change our conclusion.

Figure 3: Actual and predicted share of ARM mortgages



Note: The figure shows the actual share of mortgages with an initial period of interest rate fixation smaller than 10 years (black line) from 2003:01 to 2012:12. The broken lines present the fitted values of regression (1) and (4) in Table 5.

Given the data and the current time period, all results seem to suggest that Belgian households could be making mortgage choices that are not optimal, as they attach too much weight to initial mortgage payments. To summarize: the results show that **1)** The ARM share is more responsive to changes in the FRM-ARM spread than to changes in the risk premium; a remarkable result that contradicts the theoretical expectations from Section 3. **2)** The explanatory power of the FRM-ARM spread is furthermore much higher than the predictive power of the FRM premium that lenders demand. **3)** The economic significance of interest rate expectations is small.

5.3 Who chooses the ARM?

In this section we examine how household characteristics influence mortgage choices. A comparison with the theoretical expectations of optimal mortgage choice in Section 3 allows us to conclude whether or not households make optimal decisions. We estimate a binary logit model where the dependent variable equals 1 if the household has an ARM. Empirical results are presented in Table 6. The first column presents the results for the full sample. The FRM-ARM spread is not found to be a statistically significant determinant of mortgage choice[14]. A possible explanation can be found in an errors-in-variables problem,

[14] The risk premium, FRM rate and yield curve are not included, as earlier results indicate that their economic significance is small.

as the FRM-ARM spread had to be approximated using the average spread in the year of house purchase according to the MIR and RIR surveys. The estimated coefficients of the borrower characteristics indicate that borrowers with higher education are more likely to choose a mortgage with an adjustable interest rate. Households with better long-term career perspectives thus prefer mortgages with variable interest rates, according to theory, as they can handle an unexpected increase in interest rates. The loan-to-value ratio indicates that borrowers who are more financially-constrained (in terms of lower down payments) are more likely to choose a variable interest rate. Conditional upon the other variables, a higher loan-to-value ratio demands higher mortgage payments as the loan amount is higher. The result that mortgages with, *ceteris paribus*, higher mortgage payments are more likely to be adjustable rate mortgages is not in accordance with the theoretical predictions. Yearly mortgage payments as percentage of household income, on the other hand, are not a significant determinant of mortgage choice in the full sample. Borrowers who are more likely to move in the near future are not more likely to choose an adjustable rate mortgage. This is in accordance with our theoretical expectations, as all mortgages are portable to the new residence by law. The borrower can thus lock-in favorable long term interest rates. Age, income volatility and whether or not children are living in the house do not seem to influence mortgage choice.

Table 6: Logit estimation results

Variables	(1)	(2)	(3)
FRM-ARM spread	0.614	0.670	0.753
	(0.457)	(0.691)	(0.673)
Higher education (dummy)	0.530**	0.408	0.846**
	(0.261)	(0.430)	(0.390)
Mortgage payment to income	-0.934	0.714	-4.884***
	(0.901)	(1.132)	(1.883)
Loan-to-value ratio	1.574**	2.049**	0.970
	(0.614)	(0.860)	(0.904)
Income volatility / income	5.152	0.792	14.82
	(7.131)	(7.775)	(13.53)
Moving plans (dummy)	-0.891	-0.306	-1.732**
	(0.603)	(0.839)	(0.827)
Age	-0.00889	-0.0152	0.00791
	(0.0170)	(0.0227)	(0.0273)
Children in the house (dummy)	0.118	-0.108	0.420
	(0.259)	(0.368)	(0.378)
Constant	-1.713*	-2.062	-1.545
	(0.976)	(1.388)	(1.398)
Observations	301	150	151

Note: This table presents logit estimation results where the dependent variable equals 1 if the household has an ARM. Mortgage payment to income refers to $YearlyPaymentFA_{t,j}/income_{t,j}$ defined in section 4. Income volatility equals the standard error of the prediction of equation (3). Robust standard errors are reported in parentheses. *, **, *** refer respectively to p-values lower than 0.10, 0.05 and 0.01

Following the work of Schwartz (2009) and Bergstresser and Beshears (2010) we divide the sample into two segments: a below median income (column 2) and an above median income segment (column 3).[15] In the below median income segment, 48% of the households say that they are unable to save money. In the above median income segment, only 28% of the households are unable to save. The division into two segments thus allows a comparison of the determinants of mortgage choice between the wealthy and financially constrained households. A comparison reveals that the statistically significant coefficient of LTV in the full sample is mainly driven by low income households. While financially constrained households in the lower income segment should not prefer a mortgage whose monthly payments can

[15] We use income per working household parent to split the sample. We do this to ensure that single borrowers are not necessarily in the low income group.

fluctuate, lower income households with higher loan-to-value ratios prefer adjustable rate mortgages against theoretical expectations. The high income households, on the other hand, behave according to our *a priori* expectations as shown in column 3. Households whose income is lower relative to the required mortgage payments – in terms of yearly mortgage payments for a mortgage term of 20 years as percentage of household income – prefer a fixed interest rate conditional upon the other variables. The empirical finding from the full sample that higher educated households are more likely to choose an adjustable rate mortgage is entirely driven by the high income segment.

Table 7: Logit estimation results (term included)

Variables	(1)	(2)	(3)
FRM-ARM spread	0.508	0.622	0.621
	(0.469)	(0.704)	(0.717)
Higher education (dummy)	0.598**	0.498	1.011**
	(0.262)	(0.437)	(0.413)
Mortgage payment to income	-1.324	0.558	-6.447***
	(0.991)	(1.073)	(1.963)
LTV	0.817	1.452	-0.217
	(0.672)	(0.927)	(1.079)
Term	0.0938***	0.0750	0.153***
	(0.0336)	(0.0489)	(0.0580)
Income volatility / income	2.994	-1.783	14.62
	(7.122)	(7.657)	(14.17)
Moving plans (dummy)	-0.761	-0.454	-1.236
	(0.602)	(0.834)	(0.833)
Age	0.00718	-0.00423	0.0446
	(0.0177)	(0.0233)	(0.0314)
Children in the house (dummy)	0.0253	-0.213	0.298
	(0.262)	(0.378)	(0.387)
Constant	-3.226***	-3.241**	-4.341**
	(1.101)	(1.555)	(1.855)
Observations	301	150	151

Note: This table presents logit estimation results where the dependent variable equals 1 if the household has an ARM. Mortgage payment to income refers to $YearlyPaymentFA_{t,j}/income_{t,j}$ defined in section 4. Income volatility equals the standard error of the prediction of equation (3). Robust standard errors are reported in parentheses. *, **, *** refer respectively to p-values lower than 0.10, 0.05 and 0.01

Campbell (2013) argues that borrowers who are currently borrowing-constrained tend to prefer ARMs. With an upward-sloping yield curve, the FRM rate may be too expensive during the initial payments such that the lender is unwilling to provide this mortgage. Johnson and Li (2011) find evidence that ARM borrowers in the USA are currently borrowing-constrained. The authors show that ARM borrowers are more likely to be turned down for credit than FRM borrowers. The Flemish Housing Survey directly asks whether or not the mortgage provider granted the loan smoothly. From the FRM and ARM borrowers, respectively 96% and 97% answered they were easily granted credit. Flemish ARM borrowers thus do not report being borrowing constrained. An explanation can be found in the possibility to lengthen the maturity of the mortgage. If the household fears having a repayment-to-income ratio that is too high, it can take a mortgage with a longer term to lower the monthly payments.

The risk premium that lenders demand for the FRM has a more substantial role as the mortgage term becomes longer. Fixed rate mortgages with longer terms are thus more subject to risk premia in the bond market. We therefore include the mortgage term as control variable. The results of the logit estimations in Table 7 indicate that people who borrow on longer terms are more likely to choose adjustable rate mortgages. The statistically significant coefficient of LTV in the lower income segment disappeared, indicating that financially-constrained households borrow on longer terms in order to decrease initial mortgage payments. Scanlon, Lunde and Whitehead (2008) argue that, as borrowers choose mortgages with longer terms, they are exposed to interest-rate and other economic shocks for a longer time period, which could make the housing finance system more fragile.

6 Estimation of the underlying rational choice model

In this section we evaluate the degree of inappropriate contracts, and whether or not we are able to recover an underlying rational choice model. We therefore use the modified maximum likelihood estimator proposed by Hausman, Abrevaya and Scott-Morton (1998). The estimation technique is a solution for the inconsistent parameter estimates of the logit or probit model when the binary dependent variable is recorded in the wrong category. Leece (2000) uses the statistical approach of Hausman et al. (1998) to study the inappropriate sales of endowment mortgages in the UK. The author describes three degrees of 'misselling': incidental, systematic and pathological. With incidental 'misselling' the influence on the parameter estimation can be significant but is small-scale. Systematic 'misselling' has a larger impact, but the underlying rational choice model is recoverable. When the estimation procedure that allows for inappropriate choices cannot rationalize economic behavior, 'misselling' becomes pathological. The author is unable to recover a rational choice model in case of the sales of endowment mortgages in the UK and concludes that the 'misselling' is 'pathological'.

We use a similar approach as Leece (2000) and Hausman et al. (1998). Let y_j denote the observed binary dependent variable of household j ($j \in (1, ..., J)$) that equals 1 if the observed contract type is an ARM, and FRM otherwise. The probability that a borrower inappropriately chose the ARM while the FRM would be the optimal contract is given by a_0. Let $F(.)$ be the cumulative distribution function of the i.i.d. error disturbance. $\mathbf{x}_j$ denotes the vector of independent variables and $\mathbf{b}$ the vector of parameters of interest. We maximize the log-likelihood function in equation (7) over $\mathbf{b}$ conditional on the probability that the FRM-optimal borrower makes the inappropriate ARM choice (a_0)

$$\begin{aligned} L &= J^{-1}\sum_{j=1}^{J}\{y_j \ln\left(a_0 + (1-a_0)\, F\left(\mathbf{x}_j^{'}\mathbf{b}\right)\right) \\ &\quad + (1-y_j)\ln\left(1-a_0-(1-a_0)\, F\left(\mathbf{x}_j^{'}\mathbf{b}\right)\right)\} \end{aligned} \tag{7}$$

We thus assume that borrowers knew their mortgage terms and did not misreport them to the Flemish Housing Survey. If they misreported whether or not the interest rate could change over time, this could result in a high amount of misclassification that is not necessarily due to inappropriate choices. Bucks and Pence (2008), however, provide evidence that most borrowers (in the USA) know their basic mortgage terms (ARM vs. FRM, maturity). The main problem according to them is that ARM borrowers do not know other characteristics of their contract, such as the degree that their interest rate can change. The participants of the Flemish Housing Survey were furthermore questioned by trained professionals who could always use the "don't know" option in cases where the households did not know their contract type. We therefore expect that the degree of misclassification is not influenced by incorrect classification of the dependent variable, but by irrational choices that hide the estimation of the underlying rational choice model.

Table 8 reports results of the probit estimation conditional on different degrees of misclassification (a_0). If $a_0 = 0$, the coefficient of the repayment-to-income ratio is only slightly negative and the loan-to-value is positive. Both parameter estimates are, however, not significant. When the probability of inappropriate ARM choices (a_0) increases, the coefficient of the repayment-to-income ratio becomes more negative and statistically significant when a_0 equals 40% or 50%. The coefficient for the loan-to-value ratio decreases when a_0 becomes larger than 30%. It even takes the theoretically expected negative sign for $a_0 = 50\%$ but remains statistically insignificant.

Table 8: Estimation of the underlying rational choice

Misclassification (a_0)	0%	10%	20%	30%	40%	50%
Mortgage payment to income	-0.75	-0.95	-1.52	-3.24	-6.79 *	-10.79 *
	(0.50)	(0.70)	(1.67)	(2.24)	(3.97)	(5.79)
Loan-to-value ratio	0.38	0.46	0.51	0.39	0.06	-0.28
	(0.38)	(0.45)	(0.60)	(0.77)	(1.21)	(1.44)
Maturity	0.05 ***	0.06 ***	0.07 ***	0.08 **	0.10 **	0.11 **
	(0.02)	(0.02)	(0.03)	(0.03)	(0.04)	(0.04)
Constant	-1.19 ***	-1.46 ***	-1.70 **	-1.70 *	-1.37	-1.05
	(0.41)	(0.49)	(0.74)	(0.87)	(1.32)	(1.68)

Note: This table presents logit estimation results where the dependent variable equals 1 if the household has an ARM. Mortgage payment to income refers to $YearlyPaymentFA_{t,j}/income_{t,j}$ defined in section 4. Robust standard errors are reported in parentheses. *, **, *** refer respectively to p-values lower than 0.10, 0.05 and 0.01

When we increase the probability that an optimal FRM-borrower inappropriately chooses the ARM, the estimated preferences are better characterized by rational economic behavior. The results thus confirm our previous results that systematic inappropriate mortgage choices might be an important issue. An issue that arises is the possibility of the misselling of mortgages by financial intermediaries. While borrowers make the complex mortgage choice only a few times in their lives, financial intermediaries have an informational advantage in the financial markets[16]. The mortgage provider might not inform the client that a higher FRM-ARM spread may not be the result of a cheaper ARM, but instead due to higher expected future ARM rates. If the bank does not want to take this interest rate risk, they can easily pass it on to the uninformed borrower. Responses to questions in the Flemish Housing Survey do indeed suggest that borrowers are likely to be uninformed: only 40% of the borrowers in our sample were aware that the Flemish government offers a free insurance that provides an allowance when the borrower loses their income due to involuntary unemployment. The households in the lowest 25 percent of income per working household member are even less informed: only 31% knows that the free insurance exists.

7 Conclusion

One of the most important financial decisions a household has to make is the choice of mortgage contract to finance their home purchase. As mortgage-shoppers make this decision only a few times in their lives, they are likely not well informed, leading to suboptimal financial choices. We therefore empirically examine the choice between adjustable and fixed rate mortgages in Flanders (Belgium). We use monthly data from the Monetary Financial Institutions Interest Rate survey and the Professional Association of Credit Providers to examine the evolution of the ARM share from 2003:01 to 2012:12. The structure of the mortgage market in Belgium shows a remarkably large variation during the last decade in comparison to other countries. The country is furthermore the sole Member State of the EU where variability in interest rates is limited by law.

We theoretically examine optimal mortgage choice in a similar framework as Campbell and Cocco (2003). We simulate a whole range of interest paths. For each of these paths we simulate 50 paths of real disposable income. Thereafter, we study how a change in certain parameters affect the difference in expected lifetime utility between FRM and ARMs. The results indicate that changes in the risk premium,

[16] Bolton, Freixas and Shapiro (2007) studied similar situations of conflicts of interest with information provision.

FRM-ARM spread, real disposable income and expected income growth have a positive effect on ARM choice. The standard deviation of income shocks, loan amount and coefficient of relative risk aversion are however negatively related to choosing an ARM.

Recent contributions to the theoretical literature (Koijen et al., 2009) and our own simulations argue that variation in the bond term premium should be the key theoretical determinant of variation in the ARM share over time. The term premium reflects the extra yield risk averse lenders demand for holding the riskier long term bonds. In order to examine whether or not households make close-to-optimal decisions, we thus differentiate between this risk premium and the expected change in ARM rates. The results indicate that the risk premium explains almost no variation in the mortgage structure. Households in Belgium could thus be making mortgage choices that are far from optimal.

As the risk premium does not appear to be the main driver in the rise and fall of the ARM, we elaborate on the financial decision households actually make. The results indicate that the FRM-ARM spread explains almost 80% of the variation in the ARM share from 2003:01 to 2012:12. The economic importance of the government bond spread is small. A possible explanation can be found in the legally-obliged interest rate caps. As borrowers are protected from large shifts in interest rates, the government bond spread does not capture their true interest rate expectations which leads to a coefficient that is biased towards zero. We compute an adjusted measure of expected changes in interest rates that limits the maximum changes to 3%. The results however indicate that its statistical and economic significance is small. Belgian households thus base their decision on the level of initial mortgage payments, and give only limited importance to future increases in interest rates.

We study the determinants of households that would lead them to prefer the adjustable over the fixed rate mortgage in the Flemish region of Belgium. We use data from the Flemish Housing Survey (2005), as it contains detailed microdata on the household level. Remarkably, we find evidence that high income and low income households choose the ARM for different reasons. High income households choose the ARM if they can afford it due to a higher income or higher education. Low income households choose the ARM if they are financially constrained in terms of a higher loan-to-value ratio. The financial constraint obliges them to borrow over longer terms, such that the premium of the FRM becomes too expensive. Finally, we examine the degree of inappropriate contracts and whether or not we are able to recover an underlying rational choice model. We therefore use the method from Hausman et al. (1998) that allows consistent estimation when there is a probability that the dependent variable is recorded in the wrong category. The results indicate that the underlying preferences become closer to rational behavior for high degrees of misclassification (40% or higher).

References

[1] **Ang, Andrew, Monika Piazzesi and Min Wei.** 2006. "What does the yield curve tell us about GDP growth?" *Journal of Econometrics* 131: 359-403.

[2] **Bacon, Philomena M. and Peter G. Moffatt.** 2012. "Mortgage Choice as a Natural Field Experiment on Choice under Risk." *Journal of Money, Credit and Banking* 44(7): 1401-1424.

[3] **Bamps, Hadewych, Sandra Hellings and Patrick Roelandt.** 2008. "Informatiedossier. Prestatiebeloning," Brussel: SERV/STV-Innovatie & Arbeid.

[4] **Bergstresser, Daniel and John Beshears.** 2010. "Who Selected Adjustable-Rate Mortgages? Evidence from the 1989-2007 Surveys of consumer Finances." Harvard Business School Working Paper, 10-083.

[5] **Berkovec, James A., David J. Kogut and Frank E. Nothaft.** 2001. "Determinants of the ARM Share of FHA and Conventional Lending," *Journal of Real Estate Finance and Economics* 22(1): 23-41.

[6] **Bolton, Patrick, Xavier Freixas and Joel Shapiro.** 2007. "Conflicts of interest, information provision, and competition in the financial services industry." *Journal of Financial Economics* 85: 297-330.

[7] **Brueckner, Jan K. and James R. Follain.** 1988. "The Rise and Fall of the Arm: An Econometric Analysis of Mortgage Choice," *The Review of Economics and Statistics* 70(1): 93-102.

[8] **Bucks, Brian and Karen Pence.** 2008. "Do borrowers know their mortgage terms?" *Journal of Urban Economics* 64: 218-233.

[9] **Campbell, John Y.** 2013. "Mortgage Market Design." *Review of Finance* 17(1): 1-33.

[10] **Campbell, John Y. and Joao F. Cocco.** 2003. "Household Risk Management and Optimal Mortgage Choice." *The Quarterly Journal of Economics* 118(4): 1449-1494.

[11] **Coulibaly, Brahima and Geng Li.** 2009. "Choice of Mortgage Contracts: Evidence from the Survey of Consumer Finances." *Real Estate Economics* 37(4): 659-673.

[12] **Dhillon, Upinder S., James D. Shilling and C. F. Sirmans.** 1987. "Choosing Between Fixed and Adjustable Rate Mortgages: Note," *Journal of Money, Credit and Banking* 19(2): 260-267.

[13] **Du Caju, Philip, Catherine Fuss and Ladislav Wintr.** 2007. "Downward wage rigidity for different workers and firms: an evaluation for Belgium using the IWFP methodology." ECB-WDN Working Paper, 840.

[14] **ECB.** 2009. "Housing Finance in the Euro Area," ECB Occasional Paper Series, 101.

[15] **Hausman, Jerry A., Jason Abrevaya and Fiona M. Scott-Morton.** 1998. "Misclassification of the dependent variable in a discrete-response setting," *Journal of Econometrics* 87: 239-269.

[16] **Hjalmarsson, Erik and Pär Österholm.** 2007. "Testing for Cointegration Using the Johansen Methodology when Variables are Near-Integrated." IMF Working Paper, WP/07/141.

[17] **iff/ZEW.** 2010. "Study on interest rate restrictions in the EU, Final Report for the EU Commission DG Internal Market and Services," Project No. ETD/2009/IM/H3/87, Brussels/Hamburg/Mannheim.

[18] **International Monetary Fund.** 2004. "World Economic Outlook," Chapter 2, September.

[19] **Johnson, Kathleen and Geng Li.** 2011. "Are Adjustable-Rate Mortgage Borrowers Borrowing Constrained?" Board of Governors of the Federal Reserve System (U.S.) Finance and Economics Discussion Series 2011-21.

[20] **Koijen, Ralph S. J., Otto Van Hemert and Stijn Van Nieuwerburgh.** 2009. "Mortgage Timing," *Journal of Financial Economics* 93: 292-324.

[21] **Leece, David.** 2000. "Household choice of fixed versus floating rate debt: a binomial probit model with correction for classification error," *Oxford Bulletin of Economics and Statistics* 62(1): 61-82.

[22] **Leece, David.** 2000. "Inappropriate Sales in the Financial Services Industry: The Limits of the Rational Calculus?" *Managerial and Decision Economics* 21(3/4): 133-144.

[23] **Maclennan, Duncan, John Muellbauer and Mark Stephens.** 1998. "Asymmetries in housing and financial market institutions and EMU," *Oxford Review of Economic Policy* 14(3): 54-80.

[24] **Meessen, Florence.** 2011. "Analyse van het systeem van de niet-recurrente resultaatsgebonden voordelen. Actualisatie (jaar 2009)," Central Economic Council.

[25] **Miles, David.** 2004. "The UK Mortgage Market: Taking a Longer-Term View. Final Report and Recommendations" London: UK Treasury.

[26] **NBB.** 2012. "Financial Stability Review 2012," Brussels: National Bank of Belgium.

[27] **Rubio, Margarita.** 2011. "Fixed- and Variable-Rate Mortgages, Business Cycles, and Monetary Policy," *Journal of Money, Credit and Banking* 43(4): 657-688.

[28] **Scanlon, Kathleen, Jens Lunde and Christine Whitehead.** 2008. "Mortgage product innovation in advanced economies: more choice, more risk," *European Journal of Housing Policy* 8(2): 109-131.

[29] **Schwartz, Allie.** 2009. "Who takes out adjustable rate mortgages?" Unpublished.

[30] **Woodward, Susan E. and Robert E. Hall.** 2012. "Diagnosing Consumer Confusion and Sub-Optimal Shopping Effort: Theory and Mortgage-Market Evidence," *The American Economic Review* 102(7): 3249-3276.

8 Appendix

8.1 Theoretical model

This appendix describes the assumptions for the inflation, interest and labor income processes that are used for simulation. Assume that expected inflation follows an AR(1) process such that

$$\pi_t = \mu + \phi\pi_{t-1} + \varepsilon_t$$

where ε_t equals a white noise shock with mean 0 and standard deviation σ_ε. As in Campbell and Cocco (2003) we assume that the expected inflation from t to $t+1$ is equal to realized inflation. We estimate the autoregressive parameter of the one year lagged inflation (ϕ) and the standard deviation of the error term (σ_ε) using monthly inflation data from 1960:01 to 2012:12. To obtain real interest rates we subtract inflation from the one year nominal government bond yields ($Y_t(n)$). We then regress the real interest rate ($R_t(1)$) on a constant. The estimate delivers the standard deviation (σ_ψ) of the real rate error term (ψ_t) and the average real rate ($\bar{R}$).

The nominal yield on a one-period bond ($Y_t(n)$) equals

$$\begin{aligned} Y_t(n) &= R_t(1) + \pi_t \\ &= \bar{R} + \psi_t + \pi_t \end{aligned}$$

Log real disposable income ($l_t = \log(L_t)$) is assumed to grow at a constant growth rate g_L. ζ_t is a white noise shock with standard deviation σ_ζ.

$$l_t = l_{t-1} + g_L + \zeta_t$$

Throughout the analysis we assume that the ARM rate is equal to the 1-year government bond rate $Y_t^{ARM}(n) = Y_t(n)$. If we would introduce caps for the possible changes in interest rates, lenders would demand a higher ARM rate to ensure that the net present value of the ARM payments does not change. It would change the relative attractiveness of the ARM relative to the FRM as they become closer substitutes, but the theoretical expectations from Table 1 will remain the same. All estimated or assumed parameters are summarized in Table 9.

Table 9: Parameter values

Description	Parameter	Value
Average real interest rate	$\bar{r}$	2.31%
Standard deviation of real interest shock	σ_ψ	3.02%
Autoregressive parameter of inflation	ϕ	0.74
Standard deviation of inflation shock	σ_ε	1.89%
Average inflation rate	μ	1.01%
Growth rate of real disposable income	g_L	1.5%
Standard deviation of real disposable income shock	σ_ζ	2%

8.2 Robustness checks for risk premia

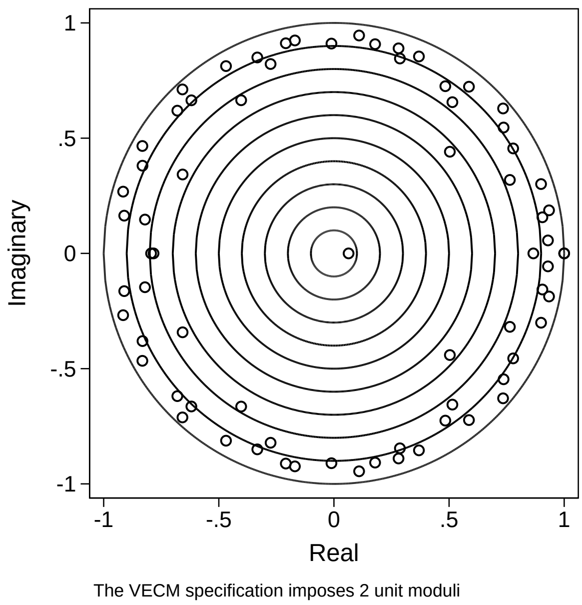
Table 10: The ARM share and the risk premium: robustness checks

Variables	C.1	C.2	D.1	D.2
Constant	0.26 ***	0.38 ***	0.10	-0.10
	(0.06)	(0.10)	(0.13)	(0.07)
FRM-ARM risk premium ($\Phi_t^{FRM-ARM}(n)$)		11.22 **		22.40 ***
		(5.09)		(4.16)
Risk premium ($\Phi_t(n)$)	16.68*		6.52	
	(10.87)		(5.46)	
R^2	0.11	0.10	0.10	0.42
State vector (X_t)	$\begin{pmatrix} Y_t(1) & Y_t(10) & \pi_t \end{pmatrix}$		$\begin{pmatrix} Y_t(1) & Y_t(10){-}Y_t(1) & \pi_t \end{pmatrix}$	
VAR / VECM	VAR		VECM	
Lags	X_{t-12},X_{t-24}		6	
Estimation sample of risk premia	1960:01-2012:12 (E)		1999:01-2012:12 (F)	

Note: This table represents the estimation results from 2003:01 to 2012:12 of the ARM share regressed on the risk premium (for $n = 10$ years) estimated from two models (C and D). Model C is estimated with a sample from 1960:01 to 2002:12 that expands to 2012:12. Model D uses a fixed estimation sample from 1999:01 to 2012:12. (E) and (F) indicate respectively whether an expanding or fixed sample was used for the estimation. The share of ARMs is defined as the mortgages with an initial fixed rate period smaller than 10 years as percentage of all new mortgages. The state vector of the VAR in model C includes the short term rate, 10-year government bond rate and inflation. The state vector of the VECM in model D includes the short term government bond, 10-year government bond spread and inflation. The models are then able to dynamically forecast the short rate, which is used to calculate the risk premium as a residual value. Newey-West standard errors are reported in parentheses (12 lags). *, **, *** refer respectively to p-values lower than 0.10, 0.05 and 0.01

8.3 Roots of the companion matrix

Figure 4: Roots of the companion matrix



8.4 Instrumental variables estimator

In Section 5.2 we indicated the need for an exogenous instrument to estimate the true demand effect due to changes in the FRM-ARM spread. A reliable instrument is a variable which affects the FRM-ARM choice only through the price that lenders set. Note that the FRM-ARM interest spread can be written as:

$$
\begin{aligned}
Y_t^{FRM}(n) - Y_t^{ARM}(1) &= \frac{1}{n}\sum_{j=1}^{n} E_t[Y_{t+j-1}^{ARM}(1)] - Y_t^{ARM}(1) + \Phi_t^{FRM-ARM}(n) \\
&= \frac{1}{n}\sum_{j=1}^{n} E_t[Y_{t+j-1}^{ARM}(1)] - Y_t^{ARM}(1) + \Phi_t(n) + e_t
\end{aligned}
$$

The last equality follows from $\Phi_t^{FRM-ARM}(n) = \Phi_t(n) + e_t$: the premium that lenders demand is equal to the term premium plus an additional premium (e_t) that depends on the lender's preferences for long-term debt. As the term premium (Φ_t) only affects the FRM-ARM choice through the premium that lenders demand ($\Phi_t^{FRM-ARM}(n)$), we are confident that it is a valid instrument. We therefore estimate the regressions of Table 5 via two-stage least squares (2SLS) using the term premium as instrument for the FRM-ARM interest spread. Results are presented in Table 11. The instrument is rather weak in equations (1a), (1b) and (2a) according to the robust Kleibergen-Paap Wald rk F-statistic. In regression (2b) the null hypothesis of a weak instrument is rejected. The results do not alter our conclusion.

Table 11: 2SLS estimation results

Variables	(1a)	(1b)	(2a)	(2b)
Constant	0.15 ***	0.12 ***	0.14 ***	0.12 ***
	(0.03)	(0.04)	(0.03)	(0.03)
FRM-ARM spread	38.02 **	26.35 ***	11.43	22.89 ***
	(19.19)	(5.98)	13.84	(3.02)
Yield spread	-6.15		4.63	
	(7.24)		(7.28)	
$\frac{1}{n}\sum_{j=1}^{n} E_t[Y_{t+j-1}^{ARM}(1)] - Y_t^{ARM}(1)$		-1.98		-2.42
		(2.66)		(1.78)
R^2	0.74	0.81	0.61	0.79
Weak identification test (F-stat):	0.45	4.135	1.689	15.575
Risk premium model?	A		B	

Note: This table represents the 2SLS estimation results from 2003:01 to 2012:12 of the ARM share regressed on the FRM-ARM interest spread in combination with interest expectations from the yield spread or ARM forecasts estimated from two models (A and B). Model A is estimated with a sample from 1960:01 to 2002:12 that expands to 2012:12. Model B uses a fixed estimation sample from 1999:01 to 2012:12. The state vector of the VECM includes the short term government bond, 10-year government bond spread and inflation. The VECM is then able to dynamically forecast the short rate. The share of ARMs is defined as the mortgages with an initial fixed rate period smaller than 10 years as percentage of all new mortgages. FRM-ARM interest spread is instrumented with the bond risk premium. Newey-West standard errors are reported in parentheses (12 lags). *, **, *** refer respectively to p-values lower than 0.10, 0.05 and 0.01

8.5 ARM as option for the FRM

Table 12 presents regression results with the volume of refinances as dependent variable and $\Phi_t^{FRM-ARM}(n)$ as explanatory variable. The results teach us that the amount of refinances does not increase when $\Phi_t^{FRM-ARM}(n)$ decreases. Borrowers thus do not seem to temporarily choose the ARM when risk premia are high in order to repay the entire loan and choose an FRM when risk premia have reverted.

Table 12: Refinance volume explained by risk premium and FRM rate

Variables	(1a)	(1b)	(2a)	(2b)
Constant	254.79	964.76 ***	174.41 ***	876.66 ***
	(50.61)	(148.62)	(42.51)	(130.74)
FRM-ARM risk premium ($\Phi_t^{FRM-ARM}(n)$)	-785.49	1591.94	2925.60 **	1633.92
	(3107.66)	(2676.80)	(1372.58)	(1235.32)
FRM rate ($Y_t^{FRM}(n)$)		-15252.96 ***		-13780.74 ***
		(2676.80)		(2684)
2005-2012 dummy	-67.05	-144.29 ***	-40.53	-132.35 ***
	(46.06)	(33.02)	(42.53)	(35.40)
R^2	0.07	0.45	0.13	0.46
Risk premium model?	A		B	

Note: This table represents the estimation results from 2003:01 to 2012:12 of the refinance volumes as dependent variable on the FRM premium that lenders demand ($\Phi_t^{FRM-ARM}(n)$) and the FRM rate. We set n equal to 10 years. We also include a dummy for the period since 2005 as the refinance volumes only include external refinances since 2005. Newey-West standard errors are reported in parentheses (12 lags). *, **, *** refer respectively to p-values lower than 0.10, 0.05 and 0.01