The Value of Mortgage Choice: Payment Structure and Contract Length

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Abstract

We study how households choose between three mortgage contracts with different payment structures: fixed-rate fixed-payment, variable-rate variable-payment, and a hybrid variable-rate fixed-payment mortgage where interest rate changes affect principal repayment rather than payment size. This hybrid contract, which is offered in only a few countries around the world, gives households additional flexibility to insure against payment risk while exposing them to the risk of larger future mortgage balances. We model these mortgage types simultaneously and show that welfare is substantially improved when all three contracts are available for households to choose from. Our calibrated model matches mortgage choice patterns in Canada, where all these options are offered with short terms. We demonstrate that restricting contract choice or mandating long terms, as in the U.S. system, can lead to substantial welfare losses by limiting risk management strategies and increasing mortgage pricing ex-ante.

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1 Introduction

Mortgages represent the largest component of household liabilities in developed economies and play a crucial role in household risk management. Mortgage markets around the world have evolved into remarkably different structures dominated by two main contract types. Most countries, especially in Europe, feature adjustable-rate mortgages with shorter contract terms, with households bearing the brunt of interest rate risk. In contrast, the dominant contract in the United States is a 30-year fixed rate mortgage, where interest rate risk is transferred to lenders and households pay significant mortgage premiums for this payment certainty.

However, a third option exists that has received far less attention in the academic literature: variable-rate fixed-payment mortgages, which maintain payment certainty for households while reducing long-term interest rate risk for lenders. This hybrid structure allows interest rate changes to affect the allocation between interest and principal rather than changing payment amounts. Countries like Canada have developed markets where this hybrid structure is available alongside traditional fixed-rate and adjustable-rate mortgages, creating a more diverse menu of mortgage options for households.

The existence of this hybrid contract invites us to revisit fundamental questions about optimal mortgage design: What drives household preferences for different mortgage payment structures? How do payment structure and contract length interact to influence household risk management? For which types of households and economic conditions might each contract structure be optimal? To address these questions, we build a quantitative life-cycle model in which households choose between three distinct contracts when they originate or refinance their mortgages. We include standard fixed-rate fixed-payment mortgages (FF) where both interest rates and payments are fixed for the contract term and variable-rate variable-payment mortgages (VV) where both float with market rates.

The primary contribution of our analysis is modeling variable-rate fixed-payment mortgages (VF) where rates float but payments remain fixed. The VF contract represents a middle ground between traditional FF and VV mortgages: interest rate changes affect the speed of principal repayment, not payment size. When interest rates increase, for example, principal payments decrease, but total payments remain the same. This contract was advocated for by Black (1998), who noted that this type of contract can appease both households that value payment certainty and lenders who charge premiums for carrying interest rate exposure.

A key insight of our analysis is that the properties of each contract type for household risk management depend fundamentally on contract length. When contract terms are shorter than amortization periods, as is common in many countries outside the U.S., this creates additional considerations for household risk management that interact differently with each payment structure. This is especially true for Variable-Fixed mortgages, where shorter terms create a new consideration: when interest rates rise, fixed payments mean less principal is repaid, leading to larger balances at renewal. For Fixed-Fixed mortgages, shorter terms limit the horizon of rate commitments, which has implications for both the demand and supply of mortgage debt, while shorter terms have little effect on payment patterns for Variable-Variable mortgages. This interaction between payment structure and contract length has received little attention in previous work on optimal mortgage design (Guren et al., 2021).

Using our model, we show that all three contract types can coexist in equilibrium, serving different household types depending on their circumstances. Building on insights from Koijen et al. (2009), who demonstrate the importance of bond risk premia for mortgage choice, we examine how both aggregate factors (interest rates and term premia) and household characteristics (leverage, income, and wealth) drive mortgage choice. Our model captures the rich dynamics of the Canadian mortgage market between 2014 and 2022, including significant shifts in mortgage type origination shares in response to changing market conditions. Consistent with recent evidence from Denmark (Andersen et al., 2023), we find substantial heterogeneity in household preferences over mortgage types, driven by differences in their financial circumstances and risk management needs.

The model generates two main findings about mortgage contract design and welfare. First, we show that different mortgage contracts serve distinct and valuable purposes, and can coexist in equilibrium because they offer different forms of risk management that appeal to different household types. Fixed-rate fixed-payment contracts provide complete certainty in both payments and balance evolution, making them particularly valuable when term premiums are low and for highly leveraged households who prioritize payment stability. Variable-rate variable-payment contracts offer potentially lower costs but require households to manage payment uncertainty, making them attractive when term premiums are high and for households with sufficient financial buffers. Variable-rate fixed-payment contracts provide a middle ground by fixing payments, particularly valuable for households managing short-term liquidity constraints, but creating long-term uncertainty in balance evolution. The welfare gains from having all options available are substantial, ranging from 1% to 6% in consumption-equivalent terms depending on the levels of interest rates and term premia.

Second, our framework allows us to analyze alternative mortgage market structures, including the U.S. system that combines long-term fixed-rate contracts with costly refinancing. Recent work has highlighted how market structure can affect both household welfare and macroeconomic stability (Keys et al., 2016; Greenwald, 2018; Greenwald et al., 2020; Campbell et al., 2021). Our model, recalibrated to match key features of the U.S. mortgage market, generates the observed distribution of mortgage rates and refinancing patterns documented in the literature (Campbell, 2006; Chen et al., 2020), including the recent ”lock-in” effect that occurs when rates rise rapidly (Fonseca and Liu, 2024; Aladangady et al., 2024; Fonseca et al., 2024).

We show that the U.S. approach leads to welfare losses through two channels: limited contract choice prevents households from selecting optimal payment structures, while the combination of long-term fixed-rate contracts and refinancing options forces lenders to price refinancing risk into rates ex-ante, effectively making all borrowers pay for an option that benefits only some. This ex-ante pricing of optionality parallels findings in Berger et al. (Forthcoming), who show that automatic refinancing programs would lead to higher mortgage rates as lenders price in the certainty of refinancing. The Canadian system, with its menu of contracts and shorter terms, better allows households to manage their mortgage risk while reducing the costs that lenders must price into rates.

These findings speak to important current policy debates about mortgage market design. Countries with predominantly short-term contracts, like Canada and Australia, face concerns that mortgage renewal cycles align with monetary policy cycles, potentially amplifying policy effects as many households reset their mortgages simultaneously. This concern relates to a growing literature on monetary policy transmission through mortgage markets (Di Maggio et al., 2017; Beraja et al., 2019; Berger et al., 2021). Conversely, countries with long-term contracts like the United States face different challenges: as evident in the recent high-rate environment, long-term fixed-rate mortgages can create “lock-in” effects where households become reluctant to move or refinance, potentially reducing labor market mobility and housing market liquidity. While our model focuses primarily on household choices and welfare, it provides a framework for thinking about these trade-offs. For instance, our analysis shows that different contract structures affect monetary policy transmission, with variable-rate fixed-payment contracts showing intermediate consumption sensitivity between that of fixed-rate and variable-rate variable-payment contracts.

Our paper is most closely related to recent work using structural models to study mortgage choice and design. Campbell and Cocco (2003) pioneered the use of life-cycle models to study mortgage choice between FRMs and ARMs, while Guren et al. (2021) extended this framework to study optimal mortgage design for macroeconomic stability. Campbell et al. (2021) analyze how alternative mortgage structures could enhance financial stability during crises, and Elenev and Liu (2024) study financial stability with endogenous risk premia under FRM and ARM regimes. Like these papers, we employ a quantitative life-cycle framework, but we make two key methodological advances: we introduce the Variable-Fixed contract as a hybrid between FRMs and ARMs and we allow households to switch between multiple contract types throughout their lifecycle. Liu (2022) studies FRM contracts of varying "fixation" lengths and shows that demand for short- vs. long-term contracts depends on loan-to-value ratios. In our setting, we focus on a single fixation period length and study mortgage contracts that have different payment structures. These innovations yield our central contribution: showing how payment structure and contract length interact to determine household risk management options and welfare. By analyzing these features in a unified framework that can accommodate different market structures, we provide new insights for mortgage market design and regulation.

The paper proceeds as follows. Section 2 presents our model of mortgage choice and Section 3 describes the benchmark model calibration to the Canadian mortgage market. Section 4, the core of our paper, describes the economics underlying mortgage type choice. Section 5 details the welfare benefits of having a menu of different mortgage contract types available. Finally, Section 6 recalibrates the baseline model to reflect the U.S. mortgage market and discusses welfare costs of a single long-term fixed-rate contract relative to the menu of contracts available in Canada. Section 7 concludes.

2 Model

We model the decisions of households that live for $T = T_W + T_R$ periods. In the first T_W working life periods, the household receives stochastic labor income, and during the T_R retirement periods, it receives pension income. At the beginning of their working lives, households take on a mortgage to finance the purchase of a house. In addition to standard consumption and savings decisions, they make mortgage-related decisions that ultimately dictate mortgage principal and interest payments.

The key decision in our model is the mortgage type choice: households choose between three types of mortgages described below and have multiple opportunities to switch between mortgage types via refinancing. The model is general in that it can easily accommodate different mortgage market structures by calibrating different prepayment and refinancing costs, thereby reflecting market structures and capturing behaviors consistent with observed data in different countries such as Canada and the United States

We consider a real economy in which either all mortgages are inflation-indexed or the price level is constant and abstract from inflation dynamics. This allows us to focus on the determinants of mortgage type choice conditional on aggregate interest rate, term-premium and income dynamics. We only model the loan market and otherwise take a partial equilibrium approach.

2.1 Bond Market

Households can save in a one-period bond at rate $R_{1,t}$. Let the log of the one period bond rate be denoted $r_{1,t}$, i.e. $r_{1,t} \equiv \log(1 + R_{1,t})$. The one-period log interest rate follows an AR(1) process:

$$r_{1,t+1} = (1 - \rho_r)\bar{r} + \rho_r r_{1,t} + \epsilon_{r,t+1} \tag{1}$$

The return for an n-period bond combines the expectation hypothesis of interest rates and a time-varying term premium:

$$r_{n,t} = \frac{1}{n}\sum_{j=0}^{n-1} E_t[r_{1,t+j}] + \omega_{n,t} \tag{2}$$

where $\omega_{n,t}$ is a time-varying term premium that is also persistent:

$$\omega_{n,t} = (1 - \rho_\omega)\bar{\omega} + \rho_\omega \omega_{n,t} + \epsilon_{\omega,t+1} \tag{3}$$

2.2 Mortgage Contracts

A representative risk-neutral financial institution elastically supplies mortgage debt to households in the economy. The financial institution offers three types of mortgage contracts: Fixed-Fixed (FF), Variable-Fixed (VF), and Variable-Variable (VV). Fixed-Fixed mortgages have a contractual interest rate that fixes over the length of the term while Variable-Variable mortgages have their interest and total payments determined by the current level of short-term rates. With Variable-Fixed mortgages, two different interest rates are used to set payments: the total payment is fixed according to the contractual interest rate and interest payments fluctuate according to the current level of short-term rates. Each mortgage is designed to amortize after N_A years, and switching between mortgage types does not reset the amortization schedule. The contract is defined by the type, $\chi \in \{\text{FF}, \text{VF}, \text{VV}\}$, and the endogenous contractual interest rate, R^M.

2.2.1 Market Interest Rates and Payment Functions

The financial institution sets the interest rate on each type of mortgage using a combination of bond rates and mortgage risk premia. For each mortgage type $\chi \in \{\text{FF}, \text{VF}, \text{VV}\}$, the mortgage interest is given by:

$$R_{\chi,t} \equiv R_\chi(\{r_{n,t}\}_n, \phi_\chi),$$

where $\{r_{n,t}\}_n$ represents the bond yield curve defined above and ϕ_χ is the mortgage premium chosen by the financial institution. For example, in our Canadian calibration detailed below, we price Fixed-Fixed as a fixed premium over 5-year bond rates while Variable-Fixed and Variable-Variable mortgages are priced as a fixed premium over 1-year bond rates.

The exact interest rate used to calculating mortgage payment for a given household at a given period of time will depend on the mortgage type, market rates, and contract rates, as well as the outstanding mortgage balance and periods remaining in the amortization. Therefore, for a given set of interest rates, we define general mortgage payment functions using standard formulae and then tailor them to each type of mortgage in the next section.

Given the types of mortgages that the financial institution offers, we allow for different interest rates to be used in calculating the total mortgage payment and the interest payment. Letting R_T denote the total payment interest rate, the total mortgage payment is given by:

$$TP(R_T) = \frac{R_T}{1 - (1 + R_T)^{-T_A}} M,$$

where M is the outstanding balance and T_A is the number of periods remaining in the amortization. Letting R_I denote the interest rate for the interest payment, interest is given by:

$$IP(R_I) = R_I M,$$

and the principal payment is the residual from the total payment after interest has been paid:

$$PP(R_T, R_I) = TP(R_T) - IP(R_I) = \left(\frac{R_T}{1-(1+R_T)^{-T_A}} - R_I \right) M.$$

2.2.2 Contract Rates and Payment Structure

In this section, we detail the differences between the three types of mortgages in terms of how the contract rate is set and how the payments depend on market and contract rates. We allow for a fully flexible refinancing system that will eventually nest the Canadian renewal system described in the previous section, where a Canadian renewal is equivalent to a penalty-free refinancing. Table 1 summarizes the three types of mortgages.

1. **Fixed-Fixed Mortgages**
When the household chooses a Fixed-Fixed mortgage in period s, the contract rate is set to the market rate in that period, $R_s^M = R_{FF,s}$. This is incorporated into the mortgage contract rate and remains in effect until the household refinances into a new mortgage. The total and interest payments for the mortgage are both calculated using the mortgage contract rate. In period t for a contract that was signed in period t^*, total and interest payments are $TP(R_{t*}^M)$ and $IP(R_{t*}^M)$.

2. **Variable-Fixed Mortgage**
As with a Fixed-Fixed mortgage chosen in period s, the contract rate is set to the market rate, $R_s^M = R_{VF,s}$, and remains effective until the household refinances. The key difference is that in each period the household has this mortgage, the contract rate is used to calculate the total payment, but the market rate is used to calculate the interest payment. In period t for a contract signed in period t^*, the total payment is $TP(R_{t*}^M)$, and does not vary with market rates. The interest payment, $IP(R_{VF,t})$, varies with the current market rate for a Variable-Fixed mortgage. As such, while the total payment does not fluctuate, the share of the total payment going towards principal will change as the market rate changes.

3. **Variable-Variable Mortgage**
With a Variable-Variable mortgage, there is no contract rate. The market interest rate is used to calculate both the total and interest payments for the mortgage in each period, $TP(R_{VV,t})$ and $IP(R_{VV,t})$.

2.3 Households

2.3.1 Homeowners with Mortgages

Homeowners with mortgages are characterized by their age, Age_{it}, cash-on-hand, W_{it}, persistent income component, Z_{it}, mortgage debt, M_{it}, the mortgage type chosen in the previous period, $\chi_{i,t-1} \in \{FF, VF, VV\}$, and (for Fixed-Fixed and Variable-Fixed mortgages) the corresponding mortgage contract rate, $R^M_{i,t-1}$. The aggregate economy state variables are the interest rate for a one-year bond, R_{1t}, and the term-premium, ω_t. To ease exposition, we define the household's idiosyncratic state variables, $S_{it} \equiv \{Age_{it}, W_{it}, Z_{it}, M_{it}, \chi_{i,t-1}, R^M_{i,t-1}\}$, and the aggregate state variables, $A_t \equiv \{R_{1,t}, \omega_t\}$.

Mortgage Value Function We begin with a general value function for homeowners with mortgages, $V^{Mortgage}$, that takes in as arguments the two interest rates used to calculate the total and interest payments, $\{R_T, R_I\}$, and the household and aggregate state variables:

$$V^{Mortgage}(\{R_T, R_I\}, S_{it}, A_t) = \max_{C_{it}} F(C_{it}, V^{Owner,Mortgage}(S_{i,t+1}, A_{t+1})),$$

where F is the Epstein-Zin operator over current consumption and future value, the value function $V^{Owner,Mortgage}$ is defined in the next section, and subject to the budget constraint:

$$W_{i,t+1} = Y_{i,t+1} + (1 + R_{1,t})(W_{it} - C(\cdot) - TP(R_T)).$$

Income, $Y_{i,t}$, contains both a deterministic lifecycle profile and stochastic shocks detailed in the next section. The consumption policy function, $C_{it} \equiv C(\{R_T, R_I\}, S_{it}, A_t)$, depends on the mortgage interest rates, household state variables, and aggregate state variables. Mortgage debt, M_{it}, is measured at the beginning of the period, and evolves as the existing balance less principal payment, $P(R_T, R_I) = TP(R_T) - I(R_I)$:

$$M_{i,t+1} = M_{it} - P(R_T, R_I).$$

Homeowner Optimization In each period, the household makes a choice to *Continue* in the same mortgage contract, *Refinance* into a new contract, or sell it's home and *Rent* instead. If the household chooses to rent, it permanently enters the rental market. Otherwise, it faces this same menu of options in each period. The household problem is given by:

$$\begin{aligned} V^{Owner,Mortgage}(S_{it}, A_t) = \max\{&V^{Continue}(S_{it}, A_t), \\ &V^{Refinance}(S_{it}, A_t), \\ &V^{Owner,Rent}(S_{it}, A_t)\}. \end{aligned}$$

Continuing in the Same Mortgage Contract The household can continue in the same mortgage, which uses the contract rate when relevant:

$$V^{Continue}(S_{it}, A_t) = \begin{cases} V^{Mortgage}(\{R^M_{i,t-1}, R^M_{i,t-1}\}, S_{it}, A_t) - \gamma_t(FF) & \text{if } \chi_{t-1} = FF, \\ V^{Mortgage}(\{R^M_{i,t-1}, R_{VF,t}\}, S_{it}, A_t) - \gamma_t(VF) & \text{if } \chi_{t-1} = VF, \\ V^{Mortgage}(\{R_{VV,t}, R_{VV,t}\}, S_{it}, A_t) - \gamma_t(VV) & \text{if } \chi_{t-1} = VV, \end{cases}$$

where $\gamma_t(\chi)$ is the utility cost the household pays to continue in the same contract in period t with mortgage type χ. These expressions highlight the difference between each of the three mortgage types if the household chooses to continue in the existing contract.

With a Fixed-Fixed mortgage, the contract rate, $R^M_{i,t-1}$, which is a state variable for the household, is used to calculate both the total and interest payments. With a Fixed-Variable mortgage, the contract rate is used to calculate the total payment, but the market rate, $R_{VF,t}$, which is calculated as a function of the aggregate state variables, is used to calculate the interest payment. With a Variable-Variable mortgage, the market rates are always used to calculate both types of payments.

If the household chooses to continue, then the mortgage type and mortgage contract rate are the same as in the previous period:

$$\chi_{it} = \chi_{i,t-1}, \quad R^M_{it} = R^M_{i,t-1}.$$

Refinancing The household can refinance into a new mortgage, subject to the refinancing costs that depend on the new mortgage type and the current mortgage type. We also include a preference shock over each type of refinancing option that represents other factors which influence mortgage choice but are not captured in our model. Specifically, the household solves:

$$\begin{aligned} V^{Refinance}(S_{it}, A_t) = \max \{ & V^{Mortgage}(\{R_{FF,t}, R_{FF,t}\}, S_{it}, A_t) - \kappa_t(FF|\chi_{t-1}) + \sigma\epsilon_{FF,it}, \\ & V^{Mortgage}(\{R_{VF,t}, R_{VF,t}\}, S_{it}, A_t) - \kappa_t(VF|\chi_{t-1}) + \sigma\epsilon_{VF,it}, \\ & V^{Mortgage}(\{R_{VV,t}, R_{VV,t}\}, S_{it}, A_t) - \kappa_t(VV|\chi_{t-1}) + \sigma\epsilon_{VV,it}, \end{aligned}$$

where $\kappa_t(\chi|\chi_-)$ is the utility cost that a household with mortgage type χ_- pays to refinance into a new contract with mortgage type χ in period t. These expressions emphasize that with respect to the mortgage calculations, the framework for calculating the value from refinancing is the same as for the value of continuing except for the interest rate used to construct the mortgage payments.[1] Note also that refinancing into the same type of mortgage is essentially a means of resetting the contract rate, while refinancing into a new mortgage type both resets the contract rate and changes the structure of payments. In each of the refinancing options, $\chi \in \{\text{FF}, \text{VF}, \text{VV}\}$, the relevant interest rate is the market rate for each mortgage type. When the household chooses to refinance, the mortgage type is set to the new choice, and the new contract rate is the market rate for the new mortgage type:

$$\chi_{it} = \chi, \;\; R_{it}^{M} = R_{\chi,t}.$$

Renting The homeowner also considers becoming a renter. This entails selling the home, which yields (potential) profit $\pi_{it}^{H} = (1 - \phi_S - \tau_S)(H - M_{it})$, where ϕ_S is the transaction fee charged by a real estate agent, τ_S is the tax rate on real estate transactions, and $(H - M_{it})$ is the net equity in the home. The proceeds from the home sale are added to cash-on-hand and total value is calculated using the renter's value function defined in Section 2.3.3:

$$V^{Owner,Rent}(S_{it}, A_t) = V^{Renter}(W_{it} + \pi_{it}^{H}, Z_{it}, R_{1t}, \omega_t).$$

2.3.2 Homeowners without Mortgages

After fully amortizing the mortgage, homeowners live in their homes with no mortgage payments. However, they may still choose to transition to the rental market, which yields the net profit from the home sale but then requires paying rent in each period. Thus for $t > N_A$, the value function for a homeowner is given by:

$$V_t(W, z, R) = \max\{V_t^{\text{Owner,NM}}(W, z, R), V_t^{\text{Renter}}(W + \pi_H, z, R), \}$$

with the same home sale profit equation above, except that, by virtue of not having a mortgage, net equity is equal to the value of the house. The value of renting is compared against the value of owning without a mortgage:

$$V_t^{\text{Owner,NM}}(W, z, R) = \max_{c_t^{\text{Owner,NM}}} F(c_t^{\text{Owner,NM}}(W, z, R), V_{t+1}(W', z', R')),$$

with wealth evolving according to $W' = Y' + (1 + R')(W - c_t^{\text{Owner,NM}}(W, z, R))$.

[1] The choices will also differ based on the continuation and refinancing costs set by the FI. If the continuation cost of a Variable-Variable mortgage and the refinancing cost from Variable-Variable to Variable-Variable are equal, i.e., $\gamma_t(VV) = \kappa_t(VV|VV)$, then the choice between continuing and refinancing is identical.

2.3.3 Renters

In the model, all households are initially homeowners, but may choose to make a permanent transition into the rental market at any point in the lifecycle. The cost of renting is equal to the user cost of housing plus a rental premium.

During the working periods of life, renters occupy the same size house as that available to homeowners. The date $t \leq J_w$ rental cost, RC, is defined as:

$$RC_t = (R_{1t} + \tau_r^H + \mu_r^H + \phi_r^H)H_t,$$

where τ_r^H and μ_r^H are the property tax rate and maintenance costs of rental housing, respectively, and ϕ_r^H is the rental premium of rental housing.

In retirement, renter households move to an assisted living facility whose quality is proportional to their retirement income. Rental cost during retirement, $t > J_w$, is defined as:

$$RC_t = (R_{1t} + \tau_r^A + \mu_r^A + \phi_r^A)A(Y_t),$$

where $A(Y_t) = \bar{A}Y_t$, τ_r^A and μ_r^A are the property tax rate and maintenance costs of assisted living housing, respectively, and ϕ_r^A is the premium paid for assisted living.

2.3.4 Preferences and Income

As in Campbell (2006) we assume that preferences are separable between housing and non-housing consumption and that house size is fixed throughout each household's lifetime. Under these assumptions, we can drop housing from the preference specification. Our agents have Epstein and Zin (1989) preferences,

$$V_{it} = F(C_{it}, V_{i,t+1}) = \left\{(1-\beta)C_{it}^{1-1/\psi} + \beta E_t(V_{it+1}^{1-\gamma})^{\frac{1-1/\psi}{1-\gamma}}\right\}^{\frac{1}{1-1/\psi}}, \tag{4}$$

where γ is the coefficient of risk aversion, β is the subjective discount factor, and ψ is the elasticity of intertemporal substitution.

During the work life agents are endowed with stochastic labor income Y_{it}. Income during the household's working life is modeled following Guvenen et al. (2021). In period t of household i's working life, income is given by:

$$Y_{it} = (1-\nu_{it})\exp(g(t) + \alpha_i + z_{it} + \epsilon_{it}), \tag{5}$$

where $g(t)$ captures the age profile of the household's earnings and α_i is a household fixed effect calibrated to match average earnings. The unemployment shock, ν_{it}, generates a large decrease in income when the household is unemployed, while the stochastic processes, z_{it} and ϵ_{it}, capture, respectively, persistent and transitory income shocks for employed households.

The persistent income process, z_{it}, follows an AR(1),

$$z_{it} = \rho z_{i,t-1} + \eta_{it}, \tag{6}$$

with innovations drawn from a mixture of normal distributions. The persistent shock η_{it} is $\mathcal{N}(\mu_{\eta,1}, \sigma_{\eta,1})$ with probability p_z and $\mathcal{N}(\mu_{\eta,2}, \sigma_{\eta,2})$ otherwise.

The transitory shock, ϵ_{it}, is also a mixture of normal distributions drawn from $\mathcal{N}(\mu_{\epsilon,1}, \sigma_{\epsilon,1})$ with probability p_ϵ and $\mathcal{N}(\mu_{\epsilon,2}, \sigma_{\epsilon,2})$, otherwise. In both cases, the expected value of the mixed distribution is zero.

The unemployment shock, $1 - \nu_{it}$, is given by

$$1 - \nu_{it} = \begin{cases} 1 & \text{with prob. } 1 - p_\nu(t, z_t^i), \\ \lambda & \text{with prob. } p_\nu(t, z_t^i), \end{cases} \tag{7}$$

where

$$p_\nu^i(t, z_t) = \frac{\exp(a_\nu + b_\nu t + c_\nu z_t^i + d_\nu z_t^i t)}{1 + \exp(a_\nu + b_\nu t + c_\nu z_t^i + d_\nu z_t^i t)}. \tag{8}$$

This shock depends on the household's age and the persistent component of the income process. When the unemployment shock is realized, the household's income is scaled down by a constant fraction, λ.

Following Cocco et al. (2005), retired households receive a deterministic fraction, ω, of their income in the last period of their working lives. More precisely, for retired household i in period t, income is given by

$$Y_{it} = \omega \cdot \exp(g(T^r) + \alpha^i + z_{i,T^r}) \tag{9}$$

where T^r is the final working period. Income is taxed at a constant rate τ_Y.

2.4 Financial Institutions and Mortgage Supply

We assume there is a representative, deep-pocketed, risk-neutral lender supplying mortgages. In t, the lender has a portfolio of mortgages that are chosen by households acting as outlined above. Total lender profit is defined as:

$$\Pi_t(\Phi) \equiv \sum_i \pi(\Phi, S_{i,t}, A_t),$$

where $\Phi = \{\phi_{FF}, \phi_{VF}, \phi_{VV}\}$ are the mortgage premiums determined in equilibrium. For each individual household mortgage contract, profit is given by:

$$\pi(\Phi, S_{i,t}, A_t) = E_t \sum_{s=0}^{T_i} M_{t,t+s}(\chi_{i,t+s}, A_{t+s}) \cdot \mathcal{F}(\Phi, (\chi_{i,t+s}, R^M_{i,t+s}), S_{i,t+s}, A_{t+s}).$$

This equation combines two elements. First, the mortgage cashflow to the lender, $\mathcal{F}$, depends on the set of mortgage premia, Φ, the mortgage type and contract rate, (χ_i, R_i^M), and aggregate state variables, A. The cashflow may stem from either a regular mortgage payment or, when refinancing, the full prepayment of the existing contract. When evaluating expected future mortgage cash flows, the lender properly internalizes future refinancing of the contract into either the same or a different type. As such, mortgage cashflows also depend on the household's characteristics, S_i, and these enter as an argument into the cashflow function.

Second, the lender calculates the net present value of these flow payments over time, from the current period until the end of the household's mortgage contract, denoted by T_i. The lender uses the appropriate risk-neutral discount factor, $M_{t,t+s}$, that depends on the type of the mortgage being discounted, χ_i, and the aggregate state of the world, A_{t+s}. The discount factor varies by mortgage type and reflects the appropriate term structure for each contract:

$$M_{t,t+s}(\chi_i, A_t) = \prod_{j=1}^{s} \left(1 + \tilde{R}_{\chi_i,t+j-1}\right)^{-1},$$

where $\tilde{R}_{\chi_i,t} = R_\chi(\{r_{n,t}\}_n, 0)$. This is the mortgage pricing function with the mortgage premium set to zero, leaving only the bond interest rates used to price the mortgage. For example, in the Canadian calibration, this is the 5-year bond for FF mortgages and the 1-year bond for VF and VV mortgages. This formulation captures the rolling forward curve of rates used to discount future cash flows based on the lender's expectations at each point in time. For fixed-rate contracts, the discount factor incorporates the term structure over the length of the contract, while for variable-rate contracts, the discount factor tracks the path of short-term rates.

3 Model Calibration

In this section, we describe the Canadian mortgage market that serves as the empirical foundation for our model and detail how we calibrate the model parameters to match this market's key features. Our model has four key sets of parameters that need to be calibrated: the institutional features of mortgage contracts, the stochastic processes for interest rates and term premia, household income dynamics, and preference parameters. We calibrate the first three sets of parameters using historical market data, loan-level microdata, and household survey evidence from Canada. We then set household preference parameters to match the observed distribution of mortgage type origination shares between 2014 and 2021. The calibrated model successfully replicates key features of the Canadian mortgage market, including the relative shares of different mortgage types and their variation with interest rates and term premia.

3.1 Institutional Details

3.1.1 The Canadian Mortgage Market

The Canadian mortgage market is relatively concentrated in the traditional banking sector, with the dominant "Big 6" banks responsible for the largest share of mortgage originations and balances outstanding. This market offers an ideal laboratory for studying mortgage choice because it features a menu of contract types with significant heterogeneity in household choices over time.

The Canadian mortgage market is characterized by contracts with short terms (2-5 years, with the 5-year term being the most prevalent) and long amortization period (25-30 years). The term is the length of time over which a financial institution commits to extending a loan to a borrower under certain conditions, while the amortization period is the length of time it takes to pay off a mortgage. Thus, with a mortgage term that is shorter than the amortization period, the contract is amortized only partially.

At the end of the term, borrowers may renew their current mortgage, rolling over the outstanding balance and having their mortgage rate reset to the level of current market rates. The renewal usually takes place with the current lender, which is the case for 90% of borrowers, with the remaining 10% choosing to switch to another lender. Alternatively, if not renewed, the balance must be repaid in full through home sale or from other proceeds (e.g., inheritance). The Canadian system of mortgage renewals at the end of the term eliminates the refinancing inertia observed in other markets.

Unlike the U.S. mortgage market, where long-term fixed rate mortgages (FRMs) are dominant, households in Canada at origination or renewal of their mortgage can choose between the three types of contracts modelled above: Fixed-Rate Fixed-Payment (FF), Variable-Rate Variable-Payment (VV), and Variable-Rate Fixed-Payment (VF). Prepayment of mortgages in full and refinancing outside of renewal periods is rare in Canada due to significant penalties, especially for fixed-rate mortgages when interest rates fall below the contractual rate. As such, while it is technically possible for households to switch between mortgage types during a contract term, the overwhelming majority only switch during renewal periods.

Overall, these institutional features make the Canadian mortgage market an excellent setting for studying how households choose between different mortgage contracts in response to changing economic conditions. Appendix A contains more details on the Canadian mortgage market.

3.1.2 Data

Our two main sources of data for the Canadian mortgage market are the administrative mortgage-level data from the Canadian Office of the Superintendent of Financial Institutions (OSFI) and the Survey of Financial Security, which is a Canadian equivalent of the Survey of Consumer Finances in the US.

The OSFI data provides information for all mortgages originated by federally regulated financial institutions in Canada, where, given the short-term nature of mortgages, originations include not only purchase mortgages, but also mortgage renewals, whether with the same or a different lender. The information at origination and switch renewals includes both current borrower and contract characteristics, while same lender renewals get updated contract information, but not borrower characteristics, as in these cases mortgages are not underwritten at renewal and therefore do not require updated borrower information.

We observe loan-level characteristics such as origination date, lender, type of mortgage, both in terms of the duration of the term and interest rate type, balances outstanding, and purchase or appraisal value of a home. We restrict our sample to the Big 6 Canadian banks given their dominant role in the mortgage market in terms of both originations and balances outstanding. We use OSFI data for the period from 2014, which is when its collection started, and until the end of 2022.

The Survey of Financial Security collects information on household income and different balance sheet items, housing and mortgage tenure, as well as demographic characteristics. We use this information to obtain a picture of the household finances at the time of home purchase, which is not complete when only using OSFI data for mortgage originations.

3.2 Financial Markets

3.2.1 Mortgage Rates

In Canada, mortgage rates are priced directly off the yield curve plus a mortgage premium that differs across types. Specifically, Variable-Fixed and Variable-Variable mortgage rates are equal to the one-period bond rate and a fixed mortgage premium:

$$R_{VV,t} = R_{1,t} + \phi_{VV}$$

$$R_{VF,t} = R_{1,t} + \phi_{VF}.$$

On the other hand, the five-year Fixed-Fixed mortgage rate has a premium over the 5-period risk-free bond:

$$R_{FF,t} = R_{5,t} + \phi_{FF}.$$

We calibrate the mortgage premia, i.e. the spread over the government bond, to the average mortgage premia in the data during our sample. For VV and VF contracts we take the average difference between the mortgage rate and the one-year bond yield. For FF contracts we take the average difference between the mortgage rate and the five-year bond yield. In all three cases, the spread has been 1.50% on average over the sample period, with very little variance. As such, we set $\phi_{FF} = \phi_{VF} = \phi_{VV} = 0.0150$. Importantly, when we run counterfactual experiments, the loan premia endogenously adjust so that financial institutions are indifferent between the status quo and the counterfactual world. The mortgage is used to finance the purchase of a house worth $330,000 CAD, which matches the average house purchase for first time home buyers under 40 years old in the Canadian Survey of Financial Security. We set ϕ_S, the transaction cost of selling a house to 5% and τ_S, the tax rate on capital gains to 1%.

While lenders may incorporate other factors into their pricing decisions, we believe the spread relative to government bonds is most relevant for understanding mortgage pricing and origination dynamics. Panel (a) of Figure 1 plots the spread between five-year and one-year bond rates compared to the spread between FF and VF mortgage rates. The two move almost in lockstep, with a correlation of 0.71 (which increases to 0.77 if we use VV mortgage rates instead of VF). In Panel (b), we compare the same mortgage spread with the fraction of new mortgage originations into FF. As the spread increases and FF mortgages become relatively more expensive, the fraction of new FF originations decreases. The correlation between these lines is -0.67 (-0.76 for VV mortgages). Altogether, our calibration of mortgage rates exogenously captures that mortgages are primarily priced off of bonds, which will help the model endogenously generate that mortgage choice is a function of these aggregate states.

3.2.2 Bond Rates

We calibrate the stochastic interest rate and term-premia processes in the following manner. We use Canadian 1-year government bond yields (GOC-1) between 1980 and 2023 to estimate equation (1). We estimate the average 1 year risk-free rate to be 2.977%, the persistence parameter of interest rates to be 0.896 and the standard deviation to be 1.21%. Given our estimates of the AR(1) process for interest rates, we can estimate equation (3). We use data on 5-year Canadian government bond yields, the estimated parameters for equation (1) and the expectation hypothesis of interest rates to get a time-series for the term-premium. We then estimate the average term-premium to be 0.4%, its persistence to be 0.74 and volatility 0.52%. We report all of these parameters in Table 2.

3.3 Mortgage Contracts

We set the mortgage amortization to $N_A = 25$ years for all contracts. The origination cost for each type of mortgage is zero, $\kappa(FF) = \kappa(VF) = \kappa(VV) = 0$, so that each household can originate its preferred mortgage type.

We implement the Canadian "renewal" and "non-renewal" framework in the following way. Households with mortgages must renew their contracts every five years, and we denote these renewal periods as the set $\tau_R = \{6, 11, 16, 21\}$. In all other periods, denoted by the set $\tau_N = \{1, 2, \ldots, 25\} \setminus \tau_R$, households must stay in the same contract.

To model this, we set continuing and refinancing costs in the following way. For each mortgage type χ, the continuing cost is zero in non-renewal periods and infinity in the renewal periods, and, conversely, the refinancing cost is infinity in non-renewal periods and zero in renewal periods:

$$\gamma_t(\chi) = \begin{cases} 0 & \text{if } t \in \tau_R \\ \infty & \text{if } t \in \tau_N \end{cases}, \quad \kappa_t(\chi|\chi_-) = \begin{cases} \infty & \text{if } t \in \tau_R \\ 0 & \text{if } t \in \tau_N \end{cases},$$

where the second equation is for each χ_-, which implies that the new mortgage choice is independent of the previous mortgage choice.

3.4 Income and Preferences

The income process is calibrated in two steps. The stochastic component is specified following Guvenen et al. (2021) and uses the estimated parameters from that paper. The deterministic lifecycle component of the income process is estimated using Canadian data from the Survey of Financial Security for mortgage holders. The full set of parameters for the income process are reported in Table 3.

Finally, we are left with calibrating preference parameters: discount factor β, coefficient of risk aversion γ, the elasticity of intertemporal substitution ψ, and the volatility of the EVT shocks σ, which smooth the policy functions and account for taste-based preferences of households (i.e. preferring a bank or a product to another).

We calibrate these four parameters using a very large grid search in order to minimize the distance to a set of target moments. In particular we are interested in matching mortgage share originations over time, i.e., given the path of interest rates and term premiums between 2014 and 2022 (the range of our mortgage origination data), we do a grid search for β, ψ, γ, and σ to minimize the distance between mortgage originations shares in the model and in the data. We use the 2016 Canadian Survey of Financial Security to calibrate initial mortgage balances, debt-to-income ratios, financial savings to income ratios, and then feed our model with the observed interest rate path and term premiums during the 2014 and 2021 period. Our estimation yields: $\beta = 0.95$, $\psi = 0.75$ and $\gamma = 10$. We simulate the model in an OLG fashion. Figure 2 plots the average share of FF mortgages originated (top panel), VF mortgages originated (middle panel) and VV mortgages originated (bottom panel) between 2014 and 2022.

The model matches mortgage originations composition over time fairly well. For most of our sample period, most mortgages originated in Canada were fixed-rate mortgages. There is a significant dip in the proportion of fixed-rate mortgages originated in 2018 and after 2020. These were periods where term premiums in Canada were increasing.

4 Drivers of Mortgage Choice

In this section we use our model to illustrate the economics of mortgage type choice. The household mortgage choice policy function is the key object of interest that emerges from our model since it allows us to understand the factors driving mortgage choice. The policy function takes as input the aggregate state variables, $A_t \equiv \{R_{1,t}, \omega_t\}$, and the household state variables, $S_{it} \equiv \{Age_{it}, W_{it}, Z_{it}, M_{it}, \chi_{i,t-1}, R^M_{i,t-1}\}$, and we analyze each set of factors separately. We consider a household's initial mortgage choice when the state variable for persistent income is set to the median of the stochastic process.

4.1 Aggregate State Variables

Figure 3 shows the policy functions of mortgage type choice as a continuous function of the aggregate state variables, short term interest rate (x-axis) and term premium (y-axis), for four combinations of household leverage and cash-on-hand. We focus on extreme cases of leverage (high and low) and cash-on-hand (high and low) since they help convey intuition for household behavior.

In the figure, for a given combination of state variables, each color represents the household's optimal mortgage choice: blue is Fixed-Fixed, red is Variable-Fixed, yellow is Variable-Variable. The optimal choice of exiting the homeowner market and becoming a renter is represented by the color green.

The four panels in the figure illustrate the stark role that the term premium plays in driving mortgage choice. For essentially all households, when the term premium is small or negative, the optimal mortgage choice is Fixed-Fixed. A low term premium makes the Fixed-Fixed mortgage very competitively priced relative to the Variable-Fixed and Variable-Variable mortgages, whose pricing is independent of the term premium. In other words, a low term premium decreases the spread between Fixed-Fixed and both Variable mortgages, and thus locking in the low interest rate over the contract term is better for all households, regardless of cash-on-hand or leverage.

In each panel, as the term premium increases, the Fixed-Fixed mortgage is dominated for all households by one of the Variable rate mortgages. In Panel A, when households have low cash-on-hand and low leverage, a low interest rate motivates households to choose Variable-Variable, while a higher interest rate makes it optimal to choose Variable-Fixed. While the same pattern holds true in Panels C and D, the opposite is true in Panel B.

Overall, aggregate factors are crucial for determining the choice between Fixed-Fixed versus the Variable mortgage types. This is consistent with the well-documented empirical fact that the spread between mortgage rates, which in our model is governed primarily by the term premium, is a key driver of mortgage choice. The choice between the two types of Variable mortgages then depends on household-specific factors and we turn to these in the next section.

4.2 Household State Variables

Figure 4 shows the policy functions of mortgage type choice as a continuous function of the household state variables, cash-on-hand (x-axis) and leverage (y-axis), for four combinations of the 1-year bond rate and term premium. We again focus on extreme cases of the 1-year rate and term premium to help convey intuition behind household behavior in the model. As above, each color represents an optimal choice: blue is Fixed-Fixed, red is Variable-Fixed, yellow is Variable-Variable, and green is rent.

The top two panels of Figure 4 show the choices when the term premium is low. For low levels of cash-on-hand the agent moves to the rental market. These are the agents who do not have enough liquidity to make their mortgage payments. As discussed in the previous section, when the term premium is low the agent always prefers a fixed-rate mortgage for both high and low levels of interest rate and for any level of cash-on-hand.

Figure 5 helps us to understand the mortgage choices for different levels of interest rate and term premium. The left panels of this figure show the average paths of payments (interest and principal) agents can expect over the next 5 years. The right panels show the speed of debt repayment or deleveraging.

When the term premium is low and interest rate is low (Panel A.1), the fixed-rate mortgages allows agents to make smaller payments compared to Variable-Fixed and Variable-Variable mortgages. Because interest rates increase (in expectation), the Variable-Variable contract payments increase over time. The variable fixed payments are constant, but due to increasing interest rates, deleveraging is much slower under this contract compared to the Fixed-Fixed contract (Panel A.2). Thus, agents trivially opt for the Fixed-Fixed contract, which is the one with lowest payments in expectation over the next 5 years and provides the fastest deleveraging. This contract is the best in terms of liquidity and wealth effects (lower payments and fastest deleveraging).

Panels B.1 and B.2 show a similar result. When interest rates are high, but term premium is low (possibly negative), a Fixed-Fixed contract has lower payments over 5 years (in expectation) and provides fast deleveraging for households (Variable-Fixed provides faster deleveraging, but this effect is not strong enough for this contract to be chosen).

Panels C and D of Figure 4 show the choices of the agent when the term premium is high. This is the most interesting case. When the term premium is high agents never choose the Fixed-Fixed contract. This is intuitive, since mortgage payments, when the slope of the term structure is high, are very large for a fixed contract. This can be clearly seen in Figure 5: the Fixed-Fixed contract has the largest payments (Panels C1 and D1) and provides the slowest deleveraging (Panels C2 and D2). The choice between a Variable-Variable contract and a Variable-Fixed contract is more subtle. As panels C and D of Figure 4 show, when the interest rate is low, poorer agents choose a Variable-Fixed contract and richer agents a Variable-Variable contract. The opposite happens when the interest rate is high, poorer agents choose a Variable-Variable contract and richer agents a Variable-Fixed contract.

Panels C and D of Figure 5 help understand why this is the case. When interest rates are low (Panel C), the Variable-Variable contract has increasing expected payments (because interest rates are expected to increase), but it also has increasing principal payments and thus provides fast deleveraging. On the other hand, as the Fixed-Variable contract has fixed total payments, expected increasing interest payments mechanically result in decreasing principal payments. Therefore the Fixed-Variable contract provides much lower total payments over the 5-year horizon, but much slower deleveraging as well. As poorer agents value liquidity more, they would pick the Variable-Fixed contract, while richer agents would prefer the Variable-Variable contract.

When the level of interest rates is high (Panel D), in expectation interest payments decrease. Thus payments for the Variable-Variable contract decrease over time. Total payments for the Variable-Fixed contract are fixed (and higher than the payments for the Variable-Variable contract), but interest payments decrease over time, which mechanically implies that this contract provides faster deleveraging. As a result, liquidity constrained poorer agents pick the Variable-Variable contract, while richer agents would prefer the Variable-Fixed contract.

4.3 Discussion

Our analysis of the household mortgage choice policy function yields two main insights related to aggregate and household factors. At the macroeconomic level, a low term premium makes FF mortgages attractive for all households, regardless of idiosyncratic conditions. Conditional on a high term premium, household factors take a central role in determining the optimal choice between VF and VV mortgages.

To understand this latter choice, it is useful to think of mortgages as a form of risk management, with each type of mortgage insuring against different combinations of risk. In our model, there are two forms of mortgage-related risk: payment (liquidity) risk and balance (wealth) risk.

Payment risk is the traditional form of risk associated with any security in which the interest rate used to price payments is indexed to a non-deterministic market interest rate. In our case, only VV mortgages have payment risk, since FF and VF mortgage contracts codify the interest rate that will be used to construct payments. We define balance risk as uncertainty about the outstanding level of mortgage debt that the household will need to refinance at the end of each term. This form of risk only exists because the contract term is shorter than the maturity of the mortgage. Balance risk is directly related to uncertainty regarding principal payments. If principal payments are known with certainty, then the outstanding balance in the renewal period is known with certainty.

Clearly, FF mortgages have no balance risk since the total, interest, and therefore principal payments are all calculated according to the contract rates. VV mortgages also have no balance risk. Although total payments and interest payments in each period both depend on stochastic interest rates, by construction, the total ratio between principal and interest payments remains the same, and therefore total principal paid over the term is known with certainty. The only mortgage type exposed to balance risk is VF, which has contractual total payments and market-varying interest payments. Since principal payments are the residual total payments after interest is paid, they too are stochastic, and thus the total outstanding balance at the end of the term depends on the realization of interest rates.

Subsequently, each mortgage provides a different form of insurance. The traditional FF mortgages insure against both payment risk and balance risk, while traditional VV mortgages insure only against balance risk. VF mortgages complete the menu of options by insuring only against payment risk.

This interpretation of mortgage contracts as forms of insurance can help us reframe the analysis in the previous section. As discussed, poorer households value liquidity more, and therefore they prefer the Variable-Fixed contract more than the Variable-Variable contract (conditional on the aggregate state variables). In other words, a poorer household's welfare is much more sensitive to its immediate liquidity than its long-term wealth, and therefore if it can only afford one form of insurance, it chooses to remove liquidity risk as opposed to wealth risk. In the context of mortgage choice, this means preferring Variable-Fixed to Variable-Variable mortgages. As liquidity increases, the household can afford to take a more long-sighted approach and consider the implications of its choices for lifetime wealth.

5 The Value of Mortgage Choice

In subsections 5.1 and 5.2, respectively, we simulate our model for economies where only one type of mortgage contract is available (a counterfactual world) and where all types of mortgage contracts are available. This will allow us to assess which contracts are more valuable for households conditional on the state of the world and to quantify the impacts of the contract space on household average consumption and volatility of consumption. Section 5.4 shows the passthrough effects of conventional monetary policy and forward guidance on consumption depending on prevailing type of mortgage outstanding in the economy.

5.1 Limited Mortgage Choice: Single Contract Economies

The policy functions show some of the economic drivers of mortgage choice for extreme levels of term premia and interest rates. We highlight some more nuanced drivers of the mortgage choice by simulating our model. We simulate 250 economies, each with 9,000 agents, using an overlapping generations approach. To better understand the main effects, we start by examining four different scenarios: (i) the baseline model, in which agents can endogenously choose any of the three contracts (FF, VF, and VV) in reset periods, (ii) a model with Fixed-Fixed contracts only, (iii) a model with Variable-Fixed contracts only, and (iv) a model with Variable-Variable contracts only. Thus, the first scenario is the one where agents have a larger contract space available. For all the remaining scenarios the loan premiums endogenously adjust such that lenders have the same net present value as in the baseline model.

Panel A of Table 4 shows the welfare losses in consumption equivalent units of economies with only one mortgage contract available compared to economies with all three contracts available. The first column shows the unconditional welfare losses. The remaining columns show the welfare losses conditional on the state of the economy.

The first thing to notice is that welfare losses are between 1% to 6% of annual consumption, and thus economically are very large. If agents had to pick only one contract to be available, they would pick the Variable-Fixed contract. Unconditionally, as shown in the first column, the economy with this contract suffers a welfare loss of 1.82% compared to an economy where all contracts are available. This contrasts with the higher welfare losses in economies with only Fixed-Fixed contracts available (3.18% loss) and economies with only Variable-Variable contracts available (2.79% loss).

These welfare gains from Panel A take into account the equilibrium repricing of loans by the representative lender. In particular, compared to the baseline loan premiums, loan premia decrease when the menu of contracts available for households to choose from is larger. More specifically, in an economy with only FF loans equilibrium loan premium decreases 7 basis points, in an economy with VF only loans equilibrium loan premium decreases 10 basis points and in an economy with VV only loans equilibrium loan premium decreases 9 basis points. Panel B of the same table shows the welfare gains if loan premia were unchanged compared to the baseline - as expected welfare losses are much larger when lenders do not endogenously adjust the premia on loans when they change the menu of contracts they offer.

The remaining columns of panel A of Table 4 and those in Table 5, help to understand why household welfare declines when the menu of contracts offered is smaller. Columns 2-3 of Table 4 show the welfare losses when interest rates are high (and term premium is either high or low) and columns 4-5 show the same when interest rates are low. We define interest rates to be high (low) if they are above (below) the average level of interest rates. We do the same for term premia.

Fixed-Fixed mortgage contracts have the lowest welfare losses when term premium is low. On the other hand, Variable-Variable and Variable-Fixed contracts have the lowest welfare losses when term premium is high. These rankings are consistent with the intuition from Section 4, where mortgage holders choose Fixed-Fixed mortgages when term premium is low, since in this state of the world this contract has the lowest total payments and provides fast deleveraging (actually the fastest deleveraging if interest rates are also low). When term premium is high, households prefer contracts with variable interest rates. The choice between fixed or variable total payments on these variable rate contracts depends mainly on households' wealth at that time.

Overall, agents trivially prefer a world where all three contracts are available. If they had to choose just one contract unconditionally, they would prefer a VF contract to a VV or FF one. We should note, that all our welfare calculations do not take into account the taste shocks, but whether we include them or not makes quantitatively no difference. [2]

Table 5 shows consumption, savings, and leverage over the life-cycle for each of the four scenarios under consideration (an economy with all mortgage contracts available, and economies with only one mortgage contract available). The first column of the table shows income over the life-cycle. Income in our model is exogenous and independent of the type of mortgage contracts available, and thus identical for all four scenarios.

Columns 2 to 5 show consumption over the life cycle for each scenario. Consumption is lower than income and inherits the same hump-shape pattern. This is standard in life-cycle models as agents save for retirement.[3] More importantly, over the entire life-cycle the level of consumption is higher when all contracts are available. This happens because agents do less precautionary saving when they have more flexibility in the mortgage contract they can choose, and they can optimally choose contracts that minimize their overall debt burden (more on this below).

Interestingly, VF contracts allow agents to have higher consumption early in their life cycle and lower later in life compared to FF and VV, implying better consumption smoothing (and therefore higher ex-ante welfare). Despite the varying interest payments under this contract, agents know that payments are fixed and can consume more early in life. This contrasts with the FF contract, which despite the fixed payments and rate, yields the lowest consumption for agents early in life. This is because the average term premium is positive in our economy and therefore a fixed-rate contract is more expensive, on average.

Columns 6 to 9 show the average financial savings of agents over the life cycle. Liquid savings, on average, increase over the life cycle as agents save for retirement, this is true for all scenarios under consideration. They are on average lower when all contracts are available (since agents do less precautionary saving) and higher in economies where only

[2] To be more specific in our welfare calculations we use $\tilde{V}^{refinance} = V^{refinance} - \sigma\varepsilon^*_{it}$, where ε^*_{it} is the taste shock on the contract actually chosen. We do this to be conservative, since the presence of taste shocks may increase welfare when we increase the number of options, even if an option is irrelevant or redundant. In such a case even though the borrower effectively has no additional benefit from a new choice, his or her taste shock will increase from ε_{it} to $\max\{\varepsilon^{oldchoice}_{it}, \varepsilon^{newchoice}_{it}\}$, which is on average larger. We also solve our model with no taste shocks and find welfare difference between a world with and without taste shocks to be 0.12 percentage points, so quantitatively very negligible.

[3] Income in the first column is gross of any income taxes.

VV contracts are available. In these economies, agents are very exposed to interest rate risk and thus save more for precautionary reasons.

The last four columns of the table show average leverage over the life cycle. Average leverage in the economy is the lowest when all contracts are available. This is because agents can endogenously choose the contract that helps them minimize interest payments and deleverage the quickest.

Table 6 helps illustrate why agents do more precautionary saving when they have a limited contract choice available. It shows averages and standard deviations of consumption growth, as well as levels of interest payments and total mortgage payments, conditional on agents having a mortgage outstanding. Average consumption growth is the lowest (6.0%) when all contracts are in the choice set of agents, and the highest (6.7%) when only the VV contract is in the choice set. This is consistent with the previous results: having all the contracts available helps agents smooth consumption over the life cycle (and thus lowers consumption growth), whereas the VV contract is the riskiest of all, forcing agents to save more early on in the life cycle. Interestingly, on average total payments are highest under an FF contract (18.7 thousand dollars) and lowest when all the contracts are available (17.8 thousand dollars). Therefore, an FF contract is in dollar terms much more expensive than a VF contract or a VV contract even after the representative lender endogenously adjusts equilibrium loan premiums. The benefit of a FF contract is the certainty of total payments and thus, this is the contract with the lowest standard deviation of total payments (note that the standard deviation of total payments is not zero under a FF contract because agents renew the contract every 5 years and therefore the interest rate resets and so does the total payment).

In the next subsection we describe in more detail a world in which agents can endogenously choose any of the mortgage contracts.

5.2 Multi-Contract Economies

What are the drivers of mortgage choice when several contracts with different characteristics are available and agents choose endogenously which type of mortgage contract to take? Recall that in our economy agents can freely change their contract type in reset periods.

Table 7 shows average income, consumption, savings and proportions of mortgage types outstanding as a function of the aggregate state of the economy (the two aggregate state variables in our model are the level of interest rates and the term premium). All the statistics are conditional on agents having a mortgage outstanding, in other words, we focus on the first twenty-five years of agents lives. The first two rows of the table show income and income growth. The numbers are virtually unchanged across different states of the economy. This is because income is exogenous and uncorrelated with the aggregate state variables of the model. While in practice, the levels of interest rates and term premia can be correlated with income, we do not want the correlation of income and the aggregate state of the economy to drive mortgage choice, or to confound the effects, thus all the heterogeneity in mortgage choice in our model has little to do with income correlation with aggregate states of the world.

The third and fourth lines of the table show the average growth of consumption and the standard deviation of growth of consumption. Consumption growth is higher when interest rates are high and lower when interest rates are low. This result comes straight from the Euler equation for consumption. When interest rates are high, agents save more today and consume more tomorrow.

More importantly, the last three rows of the table show the proportions of agents in each type of contract. The first thing to notice is that there is a mass of agents in each type of contract for all aggregate states of the world. This is mainly due to the overlapping generation feature of the model, which implies that households are able to change their mortgage type in different periods (and thus different aggregate states) and then have to stick with the contract until the next reset period. So unlike Black (1998) who argued that a Variable-Fixed contract would dominate any other type of contract, we show that endogenously there is scope for the three types of contract to co-exist. The second thing to notice is that FF contracts are predominant in periods of low term premia, whereas VF and VV contracts are predominant in periods of high term premia. The intuition is straightforward. When term premium is low the FF contract is the one delivering lower payments over the horizon of the contract and faster deleveraging. Third, VF contracts are more likely to be picked when interest rates are high, whereas VV contracts are more likely to be picked when interest rates are low (for any level of term premium, high or low).

So far we have been focusing on how aggregate states of the economy impact contract choice since the levels of term premia and interest rates have the first order effects on optimal contract choice. However, individual characteristics, such as level of savings, leverage, and income growth, also impact contract choice. Table 8 shows individual agent characteristics as a function of the current type of mortgage contract outstanding. Agents that pick fixed-rate mortgages (first column) tend to have lower income, lower savings and higher debt outstanding (rows 1-3 of the table). These agents have a lot of leverage compared to their income and savings and therefore value the fixed payments that a FF contract delivers. Rows 5-6 show the standard deviation of the ratio of total payment to mortgage debt outstanding and interest payment to mortgage debt outstanding, respectively. Trivially, the FF contract delivers the lower standard deviation of mortgage payments (total and interest). The choice between the two variable rate contracts is more subtle. Households prefer variable rate fixed payment contracts when interest rates are very high. This is because in expectation, interest rates are likely to decrease going forward and therefore the fixed payment implies principal payments are increasing over time, and thus this contract delivers fast deleveraging. When interest rates are lower, agents opt for Variable-Variable contracts.

5.3 Preference Heterogeneity

Allowing households to choose from a menu of mortgage contracts is especially beneficial if households are heterogeneous in preferences. To study this, Table 9 shows mortgage choice statistics for different preference parameters, namely, discount rates, risk aversion, and the elasticity of intertemporal substitution. Panel A of the table shows the heterogeneity in choices for different calibrations of the subjective discount factor β. The lower β is, the more myopic our agents are, thus they consume more early on in life and have on average lower consumption growth and lower savings. These agents also prefer fixed-rate fixed-payment mortgages (the fraction of FF mortgages increases monotonically as the subjective discount factor decreases). More myopic agents prefer less of both Variable-Fixed and Variable-Variable mortgages.

Panel B of the table shows the same statistics for different calibrations of the risk-aversion parameter. The more risk-averse agents are, the more they want to smooth consumption over different states of the world. Naturally, more risk-averse agents prefer mortgages with payments fixed across different states of the world. However, perhaps surprisingly, in the model more risk-averse prefer mortgages with fixed payments and variable rates and not necessarily mortgages with fixed payments and fixed rates. When $\gamma = 5$, the share of VF mortgages outstanding is on average 35.6% (29.4% for FF mortgages outstanding). When $\gamma = 15$ the proportion of VF mortgages outstanding increases to 37.0%, whereas the proportion of FF mortgages decreases to 28.6%. This is mainly driven by the fact that agents dislike states of the world where interest rates and term premia are high. In these states of the world, the fastest deleveraging is achieved with VF mortgages and this is precisely the state of the world when agents want to deleverage.

Panel C of the table shows robustness of the results with respect to the elasticity of intertemporal substitution (EIS) parameter ψ. When agents have a lower EIS, they are less willing to substitute consumption across time. Thus FF mortgages dominate for lower values of EIS. When EIS is low (ψ = 0.6) the average proportion of FF mortgages outstanding is 30.7%, when EIS is high (ψ = 0.9) this proportion decreases to 29.8%. On the other hand, the proportion of VV mortgages outstanding shows the opposite pattern: 33.3% of VV mortgages outstanding when EIS is low, which contrasts with 36.3% when EIS is high. A higher EIS, means higher willingness of households to substitute consumption over time, and therefore more willingness to take on interest rate risk with a VV mortgage.

5.4 Mortgage Choice and Monetary Policy

Mortgages serve as an important conduit for the transmission of monetary policy from financial markets to household spending and therefore inflation. Naturally, the type of mortgage contract that is predominant in the economy has important impact on monetary policy passthrough. Monetary policy shocks in an economy like the U.S., where the main type of mortgage contract is a 30-year fixed rate mortgage, have very different effects than in an economy dominated by variable rate contracts. To the extent that the monetary policy authority values passthrough to mortgages, it will also have preferences over the different menus of mortgage contracts available to households.

To understand the impact of monetary policy shocks on the economy depending on the predominant type of contract we run Jordà (2005) type regressions inside our model. Since we use simulated data from the model, we do not require an instrumental variable as is standard in the empirical literature. Within the model, we know exactly each agent's expectations of future interest rates, and therefore computing the surprise (shock) component of an interest rate change is trivial.

Our framework allows us to study both conventional and unconventional monetary policy shocks. Conventional monetary policy works through changes in the expected short-rate, where a positive (negative) monetary policy surprise is a contractionary (expansionary) shock.

$$s_t^r \equiv MP_t^{surprise} = r_t - E_{t-1}[r_t] \tag{10}$$

More recently, unconventional monetary policy aims to affect interest rates on the longer end of the yield curve. We consider a forward guidance program that aims to lower term premia, and construct the surprise component as with conventional monetary policy:

$$s_t^{tp} \equiv TP_t^{surprise} = \omega_t - E_{t-1}[\omega_t] \tag{11}$$

With these shock series in hand, we follow Jordà (2023) and estimate the following equation for each type of shock:

$$y_{t+h} = \alpha_h + \beta_h s_t + v_{t+h}; \qquad h = 0, 1, 2, ...H \tag{12}$$

where y is the outcome variable of interest (e.g. consumption), s is either a monetary policy shock or forward-guidance shock and h is the horizon.

Panel A of Figure 6 shows cumulative consumption change due to a 1 p.p. unexpected increase in the risk-free rate (i.e. a contractionary monetary shock). The dashed lines show changes in consumption for economies where only one type of mortgage contract is available. The solid line shows changes in consumption when all three contracts are available. Conventional monetary policy passthrough is strongest if there are only VV contracts in the economy. A 1 p.p. increase in the level of the risk-free rate leads to a 1.1% decline in consumption on impact. Consumption four years out still has not recovered (absent any other shocks). This is due to the persistence of interest rates.

Conventional monetary policy passthrough is weakest in economies dominated by FF contracts. This is intuitive - if all contracts in the economy have fixed rates, then a change in the level of interest rates only impacts the level of payments on new mortgages or mortgages being renewed, thus a 1 p.p. increase in the level of the risk-free rate only leads to a decline of around 0.2% in consumption on impact (the red dashed line in Figure 6).

Economies with VF contracts lie in-between FF and VV. In these economies, an increase in interest rate means that households with mortgages outstanding will see their payments unchanged. However, a higher fraction of their payments will go towards interest (and a lower fraction towards principal), which is still a negative wealth shock. Thus, consumption declines 0.8% on impact (yellow dashed lines). Finally, an economy with the three types of contracts (the solid blue line) behaves pretty much as an average of the three other scenarios.

Panel B of the figure shows the impact of a "forward guidance" shock, i.e. a change in forward guidance by the central bank that impacts term premia. Consumption is unaffected if only contracts with variable rates are available in the economy (yellow and purple dashed lines). This is intuitive since in economies with mainly variable rate type contracts, forward guidance has limited to no passthrough. On the other hand, in economies where only fixed rate contracts are available, a 1 p.p. increase in term premia leads to a 0.008% decrease in consumption. The impact is small, since when rates in the economy are fixed, many households in the economy are unable to reset their rates.

Overall our model shows that fixed-rate mortgages deliver limited passthrough when compared to variable-rate mortgages. Further, conventional monetary policy has a stronger impact than forward guidance. However, in relative terms, forward guidance has a stronger impact on fixed-rate contracts.

6 The U.S. Mortgage Market

The structure of the U.S. mortgage market differs significantly from that of the Canadian mortgage market. Our model is designed to easily accommodate the key features of the U.S. mortgage system. There are three main differences between these two markets: first the menu of mortgage contract types is different between the two markets. In Canada, households can choose from a variety of mortgage types, including fixed-rate fixed-payment, variable-rate variable-payment, and variable-rate fixed-payment mortgages. In contrast, in the U.S., the predominant mortgage type on offer is the fixed-rate fixed-payment mortgage. Second, amortization and contract lengths are usually the same in the U.S., but not in Canada. In particular, in Canada, the typical fixed-rate fixed-payment mortgage has an amortization period that exceeds the contract length. For example, the average Canadian mortgage has a 25-year amortization period but only a 5-year contract length. Third, fixed-rate contracts in Canada often include severe prepayment penalties, making it costly for households to refinance or prepay their mortgages if the contract has not reached its term end. In the U.S., however, prepayment costs are generally very low. This enables households to refinance their mortgages at lower rates when interest rates drop, creating significant prepayment risk in the U.S. mortgage system. These differences highlight why it is meaningful to quantitatively compare the U.S. and Canadian mortgage markets.

6.1 Model Calibration

We specify the continuation and refinancing fees to reflect these features of the U.S. mortgage market. To focus exclusively on Fixed-Fixed contracts, we set all costs for Variable-Fixed and Variable-Variable mortgages to infinity. In each period, households with Fixed-Fixed mortgages can pay a finite cost, $\kappa(FF|FF)$, to refinance into a new Fixed-Fixed mortgage. We calibrate this refinancing cost to match the refinancing rate in the U.S. of 7% as in Chen et al. (2020).

In addition to matching the average refinancing rate, we verify the model's ability to generate the correct distribution of non-refinancing. Figure 7 summarizes the distribution of rates paid on 30-year FRMs in 2019 and 2023 in the data and in the model. We follow Campbell (2006) and use data from the American Housing Survey (AHS) to calculate this distribution. For each spread over the current mortgage rate, the figure shows the fraction of households that pay more than this rate. We simulate the model and feed into it the specific path of risk-free interest rates and term premiums between 1971 and 2025 in the U.S. and compute for 2019 and 2023 the model counterpart of the distribution of rates paid on fixed-rate mortgages. These are moments that were not targeted in our calibration.

The model generates a distribution of mortgage spreads that is comparable to the data. In 2021 mortgage rates were at historical lows. The fraction of households in the model and in the data with mortgage rates above the current rate was significant. This is due to either refinancing costs or inattention. In stark contrast in 2023 mortgage rates were significantly higher, with a quick increase from the 2019 lows. This led many households to stay put and not refinance their mortgages both in the data and in the model; this "lock-in effect" may have negative implications for mobility and household welfare that outweigh the benefits of lower interest rate payments (Fonseca and Liu, 2024; Aladangady et al., 2024; Fonseca et al., 2024).

6.2 Welfare Analysis

Table 10 shows the ex-ante difference in welfare of the Canadian mortgage system versus the U.S. mortgage system, and decomposes the welfare change into the key main differences between the two mortgage markets. The baseline model is the Canadian system where all 3 types of contract are available. The first row of the table shows the welfare change, the second row of the table shows the loan premia for each scenario under consideration.

The first column of the table shows the welfare change when moving from an economy where FF, VF and VV contracts are available with 5-year contract lengths to an economy where only FF mortgages with 5-year contract lengths are offered. In this scenario, we assume that the representative lender does not adjust the equilibrium loan premia. The welfare loss from having a smaller contract menu to choose from is 3.77% in annual consumption equivalent terms. When fewer mortgage options available, households lose the ability to endogenously choose the contract that allows them to deleverage quickly (if they have liquidity) or that minimizes interest payments. As a result, in equilibrium, the mortgage premium decreases. The second column of the table illustrates this effect: the loan premium decreases 0.07 p.p. making the representative lender indifferent between offering all three contracts or only the FF contract. Consequently the welfare loss is reduced to 3.19%. The third column of the table highlights the welfare gain of an economy where only a long-term fixed-rate contract is available compared to the baseline economy with multiple short-term contracts available, assuming no adjustment in the equilibrium loan premium. In this economy, households optimally exercise their option to refinance their mortgages to benefit from lower interest rates. As a result, the welfare gains are substantial, approximately 7p.p. However, this type of mortgage structure is very risky for lenders due to this refinancing risk. Our representative lender accounts for households' expected prepayment behavior and demands a higher loan premium in equilibrium. The last column of the table shows precisely this. In particular, the mortgage premium over the long-term bond increases by 1.48 p.p., which is almost double the premium of the baseline economy. This large increase in premium makes households worse off in equilibrium. In particular, a mortgage system close to the U.S. system leads to a decrease in welfare of around 4%, compared to the Canadian system.

7 Conclusion

We use quantitative dynamic model of borrower behavior in the presence of multiple mortgage contract types. In our model households face income, interest rate risk, and term premia risk and endogenously choose between three types of mortgages: a fixed-rate fixed-payment contract, a variable-rate fixed-payment contract and a variable-rate variable-payment contract. We find that endogenously all contracts can coexist in equilibrium and their existence improves household welfare. We show that both macroeconomic factors, such as interest rates and term premiums, and individual characteristics, such as wealth, leverage, and income, play crucial roles in driving mortgage choices.

When all three mortgage options are available, households can optimize their contract selection. Our analysis reveals that economies that restrict households to a single type of mortgage experience notable welfare losses, ranging from 1% to 6%, depending on the prevailing economic conditions. Fixed-rate mortgages, while offering payment certainty, tend to impose higher long-term costs, especially in environments with high term premiums. Conversely, variable-rate mortgages provide better consumption smoothing and allow faster deleveraging, though at the expense of higher payment volatility.

Our results have important implications for monetary policy transmission. Economies dominated by variable-rate mortgages experience stronger and faster pass-through of interest rate changes, while economies with a larger share of fixed-rate mortgages are more sensitive to forward guidance. This highlights the need for policymakers to consider the composition of mortgage contracts when designing monetary policies aimed at influencing household consumption and debt dynamics.

Overall, the availability of diverse mortgage contract options enhances household welfare by allowing more efficient consumption smoothing and debt management. Limiting these options not only leads to higher consumption volatility, but also results in slower debt reduction. Our findings underscore the importance of maintaining flexibility in mortgage contract offerings, particularly in the face of changing economic conditions.

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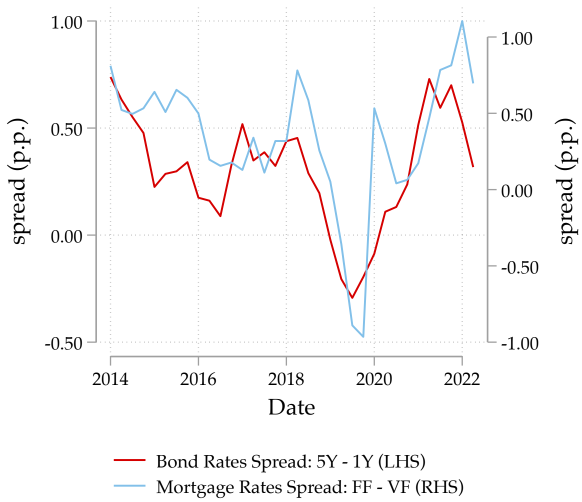
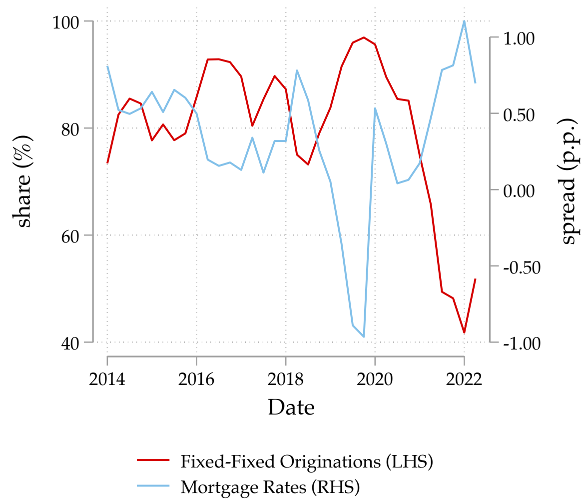
Figure 1: Bond and Mortgage Rates

This figure plots the relation between bond rates, mortgage rates, and mortgage originations. In panel (a), the spread between 5- and 1-year government bonds is very strongly positively correlated with the spread between FF and VF mortgage rates. In panel (b), the spread between FF and VF mortgage rates is negatively correlated with the fraction of new mortgage originations into FF contracts. These figures justify our choices for calibrating mortgage interest rates as fixed premiums over corresponding bond rates. See Section 3.2.1 for more details.



(a) Bond and Mortgage Rate Spreads



(b) Mortgage Spreads and FF Originations

Figure 2: Data vs Model

This figure plots the fraction of households choosing to originate Fixed-Fixed, Variable-Fixed, and Variable-Variable mortgages between 2014 and 2022. In each year, we use the observed mortgage rates and simulate the model for all other variables.

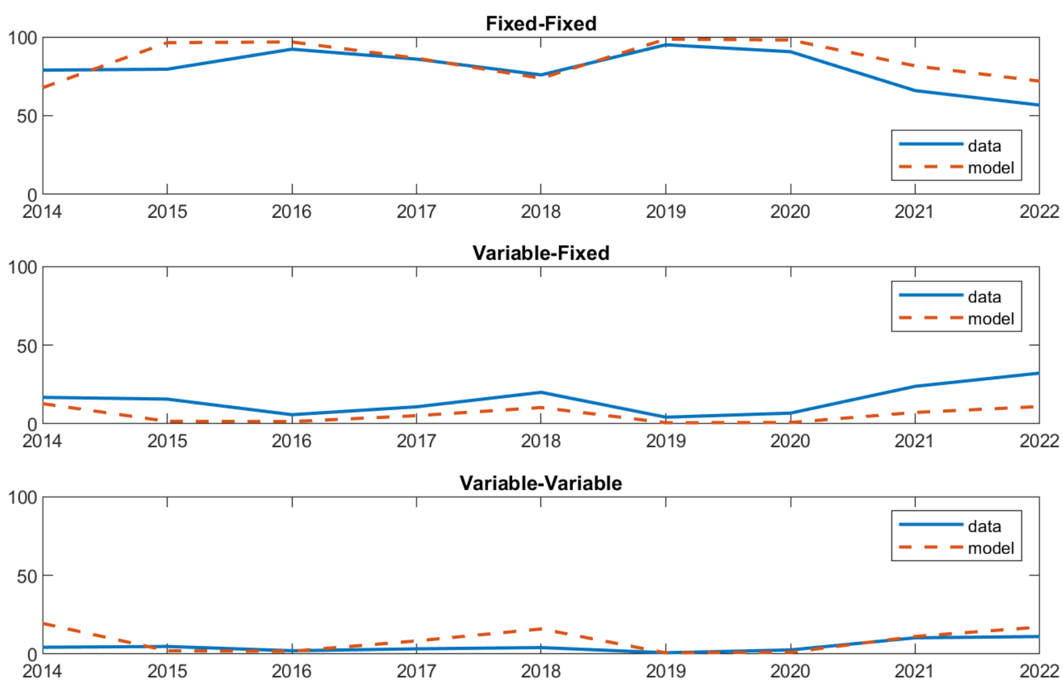


Figure 3: Illustration of Mortgage Choice Policy Functions over Aggregate Factors

This figure shows the policy functions for mortgage type choice as continuous function of the aggregate factors, term premium and 1-year bond rate, for four combinations of household leverage and cash-on-hand. The top two panels show the policy functions when cash-on-hand is low and leverage is low or high. The bottom two panels show the policy functions when leverage is high and cash-on-hand is low or high. The green color shows when agents leave the housing market and become renters, the blue color shows when households opt for a fixed-rate fixed-payment (FF) mortgage, the red color shows when households opt for a variable-rate fixed-payment (VF) mortgage and the yellow color when households opt for a variable-rate variable-payment (VV) mortgage.

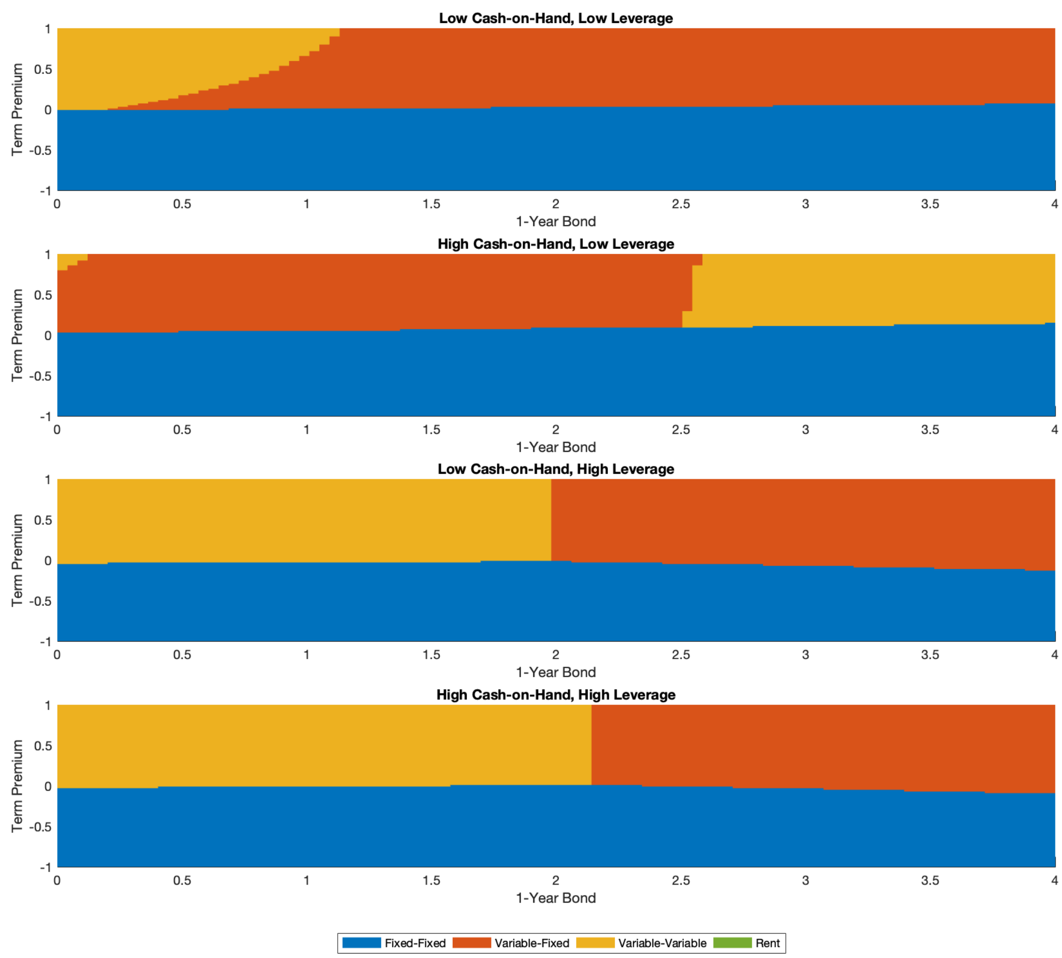


Figure 4: Illustration of Mortgage Choice Policy Functions over Household Factors

This figure shows the policy functions for mortgage type choice as continuous function of the household factors, leverage and cash-on-hand, for four combinations of the term premium and 1-year bond rate. The top two panels show the policy functions when term premium is low and interest rates are low or high. The bottom two panels show the policy functions when term premium is high and interest rates are low or high. The green color shows when agents leave the housing market and become renters, the blue color shows when households opt for a fixed-rate fixed-payment (FF) mortgage, the red color shows when households opt for a variable-rate fixed-payment (VF) mortgage and the yellow color when households opt for a variable-rate variable-payment (VV) mortgage.

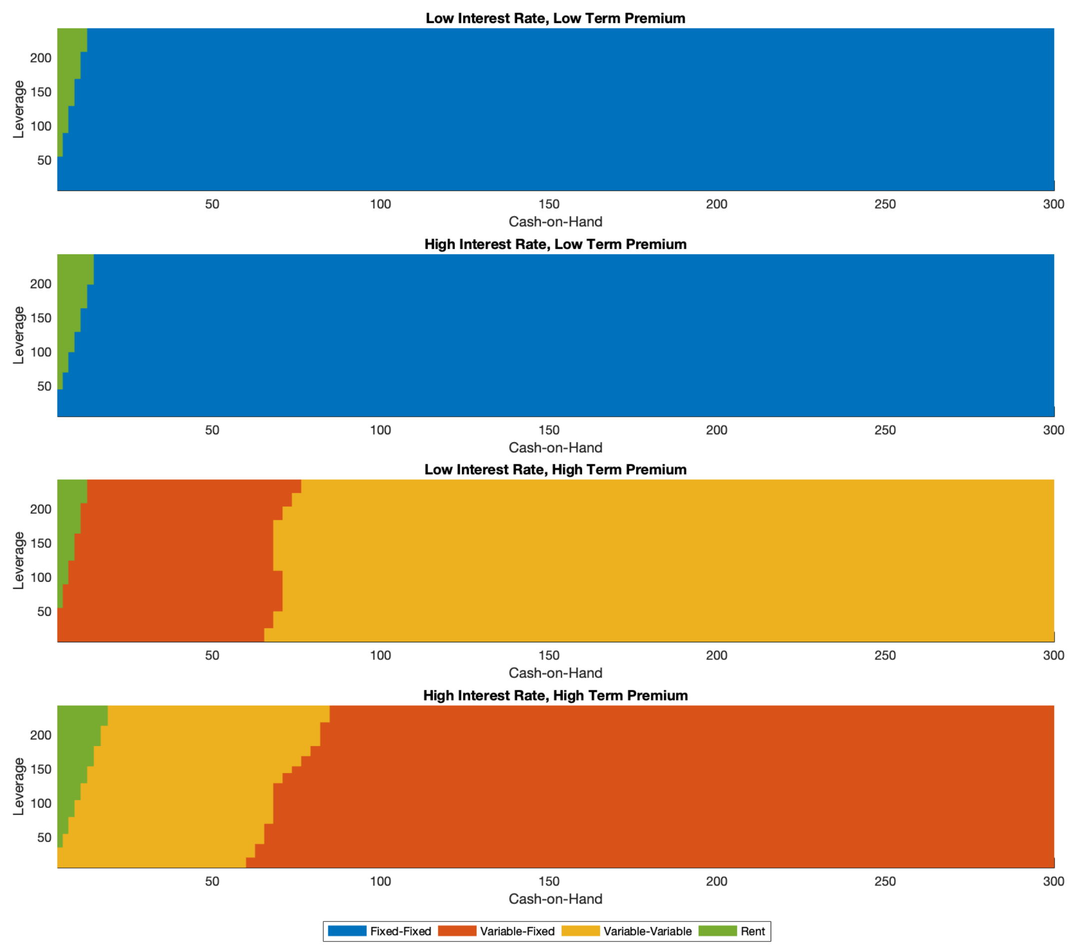


Figure 5: Mortgage payments composition and deleveraging

The left panel of this figure shows for a given level of interest rate and term premium the composition of payments for the three types of mortgage contracts under consideration (FF in blue, VF in red and VV in yellow) for a household that took a mortgage of a given type in period 0 (origination period). Each bar shows the total payments in each year of the 5-year term. The darker areas correspond to principal payments, the lighter ones show interest payments. The right panel shows mortgage balances outstanding at the end of the period for the three types of mortgage. The top two panels show these effects when term premium is low and interest rates are low/high. The bottom two panels show these effects when term premium is high and interest rates are low/high.

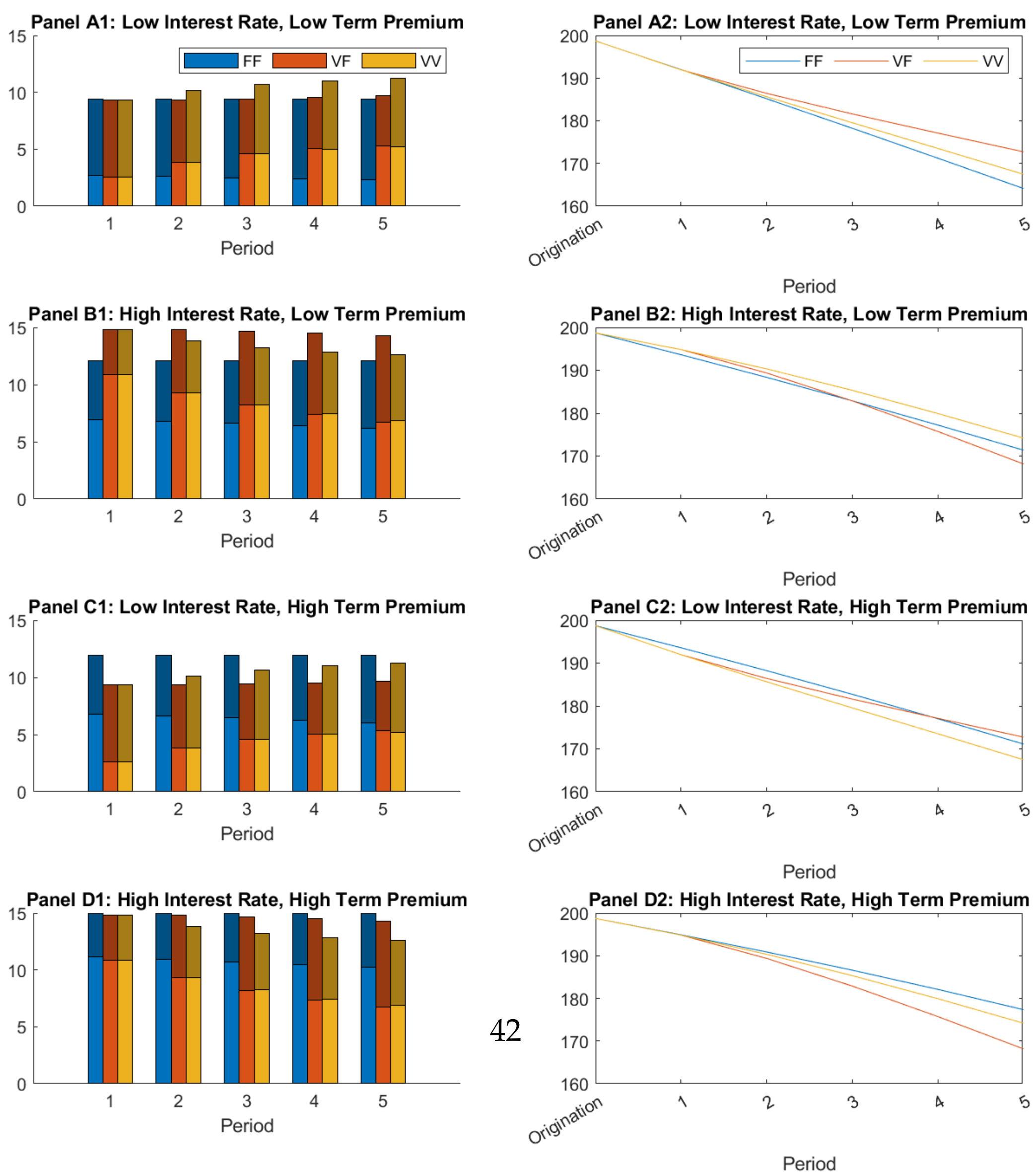


Figure 6: Impulse response functions to monetary policy shocks

This figure shows local projections à la Jordà (2005) within our model. The left panel shows cumulative impulse response functions of consumption for a 1 p.p. increase in the risk-free rate. The right panel shows cumulative impulse response functions to a 1 p.p. increase in term premia. The blue line shows the effects on an economy where all contracts are available. The dashed lines show the effects when only one contract is available.

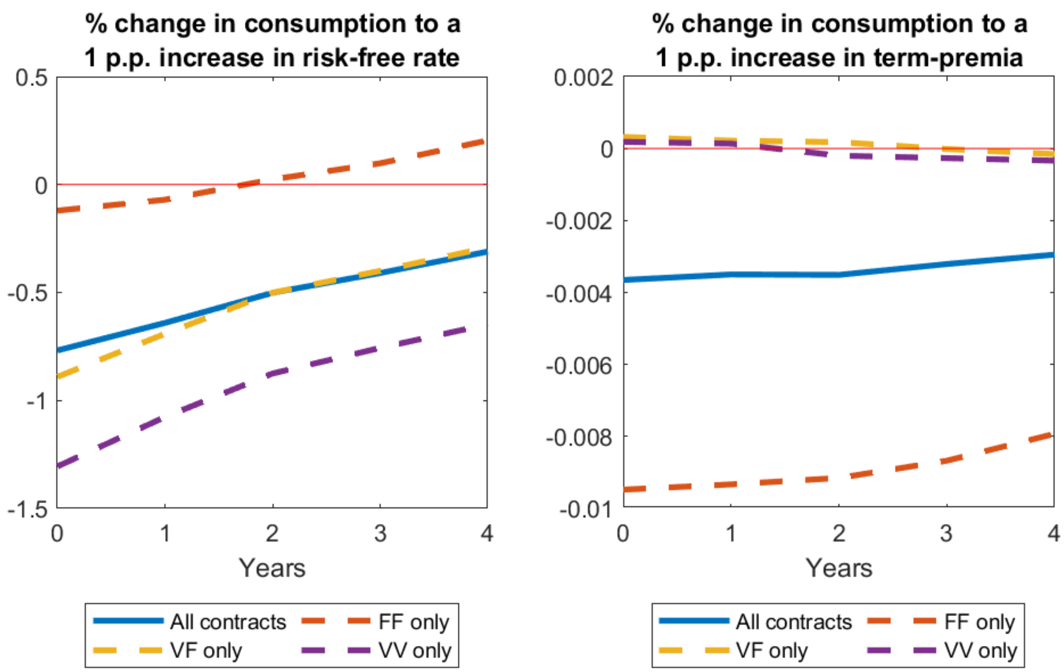


Figure 7: Distribution of mortgage spreads: model and data

This figure plots in dashed lines the distribution of the mortgage spreads using the self-reported mortgage rates from 2019 and 2023 American Housing Surveys relative to the currently prevailing FHLMC rates in the respective survey years. This is an update of figure 5 from Campbell (2006). The solid lines plot the counterparts in our model. We feed the time-series of long-term government bond yields and term-premiums into our model and simulate an overlapping generation set of agents. At the 2019, 2023 simulated dates we plot the data counterparts of the model.

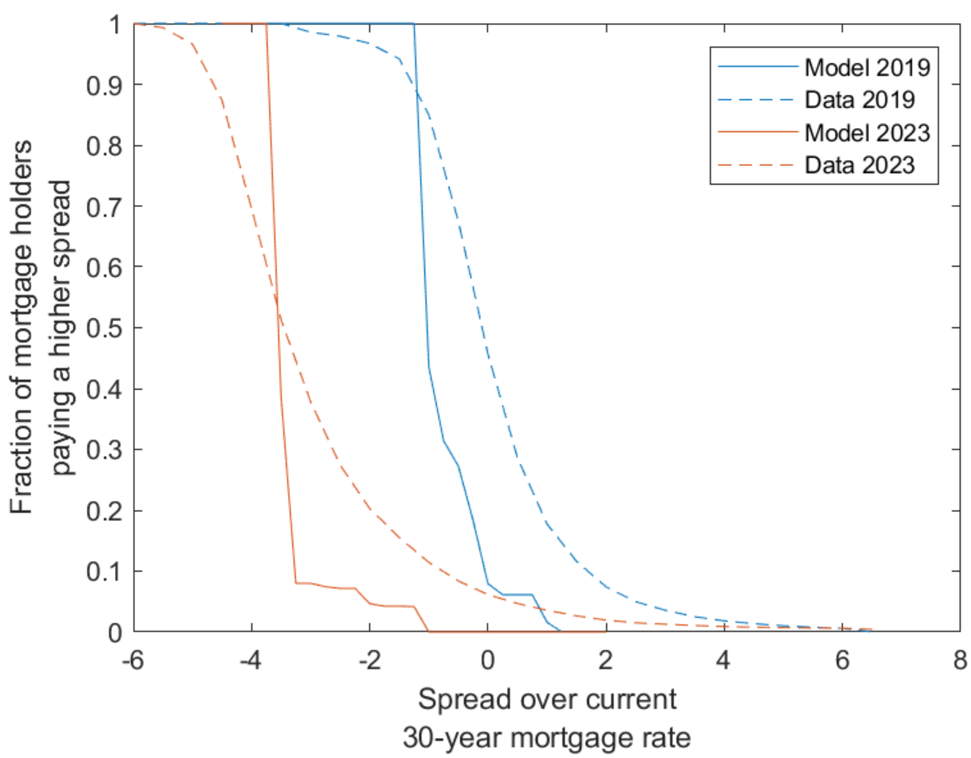


Table 1: Summary of Mortgage Types and Interest Rates

Mortgage	Interest Payment R_I	Total Payment R_{TP}
Fixed-Fixed	Contract Rate	Contract Rate
Variable-Fixed	Market Rate	Contract Rate
Variable-Variable	Market Rate	Market Rate

Table 2: Interest Rates

This table shows parameters governing the interest rates detailed in Sections 2.1 and 2.2. Panel (a) contains parameters for the one period bond. Panel (b) contains parameters for the term premium. Panel (c) contains parameters for mortgage premia.

(a) One-Period Bond

Parameter	Value
$\bar{r}$	0.0298
ρ_r	0.8965
σ_r	0.0121

(b) Term Premium

Parameter	Value
$\bar{\omega}$	0.0042
ρ_ω	0.741
σ_ω	0.0052

(c) Mortgage Terms and Premia

Parameter	Value
N_M	5
ϕ_{FF}	0.015
ϕ_{VF}	0.015
ϕ_{VV}	0.015

Table 3: Income Process Parameters

This table shows parameters governing the income process detailed in Section 2.3.4. Panel (a) contains parameters for the deterministic components of income: the household fixed effect, the lifecycle age profile, and the retirement replacement rate. Panel (b) contains parameters for the unemployment shock, such as the replacement rate. Panels (c) and (d) contain parameters for the persistent and transitory shocks, respectively. The income process and parameters follow closely Guvenen et al. (2021) for the working life and Cocco et al. (2005) during retirement. Over the working life, the variance of the persistent income process is scaled down to match that in Cocco et al. (2005).

(a) Deterministic Type & Lifecycle Components

Parameter	Value
α_i	0.99
a_0	-2.0317
a_1	0.3194
a_2	$-0.0577/10$
a_3	$-0.0033/100$
ω	0.94

(b) Unemployment Shock

Parameter	Value
λ	0.52
a_ν	-2.495
b_ν	-1.037
c_ν	-5.051
d_ν	-1.087

(c) Persistent Process

Parameter	Value
ρ	0.991
p_z	0.176
$\mu_{\eta,1}$	-0.524
$\sigma_{\eta,1}$	0.113
$\sigma_{\eta,2}$	0.046
κ_η	0.470

(d) Transitory Shock

Parameter	Value
p_ϵ	0.044
$\mu_{\epsilon,1}$	0.134
$\sigma_{\epsilon,1}$	0.762
$\sigma_{\epsilon,2}$	0.055

Table 4: Welfare Gains

This table shows the ex-ante welfare gains (losses) in consumption equivalent units for economies with only FF mortgages available (first row), only VF mortgages available (second row) or only VV mortgages available (third row) compared to an economy where all three types of mortgages are available. The first column shows the gains (losses) unconditionally and the remaining columns shows them conditional on the term-premium and the level of interest rates.

Panel A: Welfare (equilibrium loan premium)

		High Rf		Low Rf	
	Unconditional	High TP	Low TP	High TP	Low TP
FF only	-3.18%	-6.11%	-1.93%	-3.43%	-1.48%
VF only	-1.82%	-0.26%	-3.74%	-0.50%	-2.76%
VV only	-2.79%	-1.51%	-4.95%	-1.23%	-3.52%

Panel B: Welfare (baseline loan premium)

		High Rf		Low Rf	
	Unconditional	High TP	Low TP	High TP	Low TP
FF only	-3.77%	-6.88%	-2.60%	-3.92%	-1.90%
VF only	-2.71%	-1.36%	-4.78%	-1.23%	-3.47%
VV only	-3.58%	-2.49%	-5.88%	-1.86%	-4.14%

Table 5: Income, Consumption, Wealth and Leverage over the Life-Cycle

This table reports average income, consumption, financial wealth, and leverage over the life-cycle, for the four scenarios under consideration. In scenario "All" households can choose any of the 3 mortgage types available (and switch among them), in "FF" households can only choose a fixed-rate fixed-payment mortgage, in "VF" households can only choose a variable-rate fixed-payment mortgage and in "VV" households can only choose a variable-rate variable-payment mortgage.

	Income	Consumption				Financial wealth				Leverage			
Age group		All	FF	VF	VV	All	FF	VF	VV	All	FF	VF	VV
26 - 30	100.91	41.82	40.907	41.512	41.33	191.55	191.86	193.13	194.11	249.06	249.86	249.05	249.09
31 - 35	119.38	71.263	70.428	71.466	71.502	271.21	272.6	272.81	273.56	212.71	215.39	213.1	213.05
36 - 40	134.73	89.119	88.37	89.187	89.156	300.4	302.02	300.75	301.68	168.55	172.41	169.29	169.22
41 - 45	145.35	98.139	97.475	98.087	98.149	307.69	308.73	307.7	308.5	114.46	118.19	115.17	115.1
46 - 50	150.38	105.52	104.96	105.45	105.55	305.87	306.18	305.68	306.17	47.342	49.25	47.65	47.624
51 - 55	148.98	114.29	114.16	114.19	114.28	297.37	297.35	297.14	297.34	0.000	0.000	0.000	0.000
56 - 60	141.75	109.96	109.92	109.95	109.96	304.15	304.37	304.12	304.11	0.000	0.000	0.000	0.000
61 - 65	129.31	103.12	103.09	103.12	103.12	313.92	314.13	313.92	313.89	0.000	0.000	0.000	0.000

Table 6: Mean and volatility of consumption and mortgage payments

This table reports averages and standard deviations of consumption growth, as well as levels of interest and total mortgage payments (in thousands) for the four scenarios under consideration. The statistics reported are conditional on households having a mortgage outstanding.

	All	FF only	VF only	VV only
Av. consumption growth	0.060	0.062	0.063	0.067
Std. consumption growth	0.262	0.257	0.276	0.269
Av. interest payments	7.335	8.129	7.438	7.389
Std. interest payments	6.203	6.135	6.537	6.434
Av. total payments	17.827	18.611	17.931	17.873
Std. total payments	5.427	5.200	5.838	5.493

Table 7: Drivers of mortgage type choice

This table reports income, income growth, consumption, standard deviation of consumption, average financial savings and the proportion of mortgages outstanding by type of mortgage conditional on the aggregate state of the world (levels of interest rates and term premia).

	High interest rates		Low interest rates	
	High TP	Low TP	High TP	Low TP
Income	130.08	130.21	130.23	130.19
Income growth	0.014	0.014	0.014	0.014
Av. consumption growth	0.071	0.070	0.052	0.048
Std. consumption growth	0.296	0.281	0.234	0.227
Savings	183.71	183.18	169.84	168.14
Mtg. type proportion:				
Fixed-fixed	0.145	0.425	0.165	0.446
Variable-fixed	0.471	0.310	0.387	0.251
Variable-variable	0.384	0.265	0.448	0.303

Table 8: Mortgage type choice - additional statistics

This table reports average income, savings, leverage, debt-to-income, standard deviation of mortgage payments and average levels of risk-free rate and term premium conditional on the mortgage type the household has outstanding in an economy where all mortgage types are available to choose from. The first column shows these statistics conditional on the household having a FF mortgage outstanding, the second column shows the statistics conditional on a VF mortgage outstanding, and the last column shows them conditional on a VV mortgage outstanding.

	FF	VF	VV
Av. income	122.400	131.420	135.510
Av. savings	163.480	177.070	186.320
Av. leverage	175.350	152.300	150.660
Debt-to-income	1.967	1.641	1.545
Std. total mortgage payments	0.192	0.210	0.212
Std. total interest payments	0.022	0.028	0.028
Risk-free rate	0.029	0.034	0.028
Term-premia	-0.000	0.006	0.006

Table 9: Preference Heterogeneity

This table shows average consumption growth, standard deviation of consumption growth, average savings and proportion of mortgages outstanding by type of contract for different preference parameters. Panel A shows the results for subjective discount factor, panel B for risk aversion and panel C for the elasticity of intertemporal subsitution. The middle column in all the panels is our baseline specification.

Panel A: Different subjective discount factors

	$\beta = 0.93$	$\beta = 0.95$	$\beta = 0.97$
Av. consumption growth	0.059	0.060	0.060
Std. consumption growth	0.255	0.262	0.266
Savings	169.320	176.330	186.340
Mtg. type proportion:			
Fixed-fixed	0.308	0.294	0.274
Variable-fixed	0.355	0.356	0.356
Variable-variable	0.336	0.350	0.370

Panel B: Different degrees of risk aversion

	$\gamma = 5$	$\gamma = 10$	$\gamma = 15$
Av. consumption growth	0.037	0.060	0.091
Std. consumption growth	0.249	0.262	0.353
Savings	131.380	176.330	199.210
Mtg. type proportion:			
Fixed-fixed	0.298	0.294	0.286
Variable-fixed	0.333	0.356	0.370
Variable-variable	0.368	0.350	0.343

Panel C: Different degrees of intertemporal substitution

	$\psi = 0.6$	$\psi = 0.75$	$\psi = 0.9$
Av. consumption growth	0.062	0.060	0.059
Std. consumption growth	0.253	0.262	0.271
Savings	187.030	176.330	168.350
Mtg. type proportion:			
Fixed-fixed	0.307	0.294	0.298
Variable-fixed	0.359	0.356	0.339
Variable-variable	0.333	0.350	0.363

Table 10: Welfare comparison between Canadian and U.S. systems

This table shows the ex-ante difference in welfare between the Canadian and U.S. mortgage systems. The benchmark model is the Canadian system where all three types of contracts are available. The first row is the welfare change and the second row is the difference in loan premia for each scenario.

	FF only	FF only (equilibrium rate)	U.S. FRM	U.S. FRM (equilibrium rate)
Welfare (vs baseline)	-3.77%	-3.19%	7.04%	-4.08%
Δ Loan Premium	0.00%	-0.07%	0.00%	1.48%

A Detailed Institutional Background on the Canadian Mortgage Market

The Canadian mortgage market is relatively concentrated in the traditional banking sector, with the dominant Big 6 banks responsible for the largest share of mortgage originations and balances outstanding. In this section, we describe the Canadian market in great detail, but the most pertinent details may be summarized as follows. The standard mortgage contract has a 5-year term and structures to amortize the total balance over 25 years. Households can choose between a rich menu of mortgage contracts, and we observe significant heterogeneity both across time and in the cross-section. Prepayment and home equity extraction are virtually nonexistent due to a fee structure that strongly disincentivizes mortgage adjustment within the contract term. As such, we argue that the Canadian system is an ideal laboratory to study the drivers of different mortgage types.

A.1 Contract Term and Amortization

Unlike the U.S. mortgage market, where long-term fixed rate mortgages (FRMs) are dominant, the Canadian mortgage market is characterized by contracts with short terms (2-5 years, with the 5-year term being the most prevalent) and long amortization period (25-30 years). Term is the length of time over which a financial institution commits to extending a loan to a borrower under certain conditions. The amortization period is the length of time it takes to pay off a mortgage. Thus, with a mortgage term that is shorter than the amortization period the contract is amortized only partially.

At the end of the term, a borrower is faced with a number of options. The most common option for the borrower is to renew mortgage with their current lender, by rolling over at most their balance outstanding and having their mortgage rate reset to the current level of market interest rates. Typically, by the end of the amortization period, a mortgage contract would have been renewed several times. Alternatively, if the mortgage is not renewed with the current lender, the balance outstanding needs to be repaid in full, either with the proceeds of a home sale or with another lender taking over the mortgage at renewal.[4] Unlike in

[4] About 90% of borrowers renew with their original lender (Allen and Li, 2024). These are borrowers who either prefer the convenience of renewing with their lender and don't shop for a more competitive rate at renewal, or those that do shop around, but stay with their original lender as it price matches an outside offer. These outside offers do need to be generated through a qualification process, while only the history of past

the US where households are faced with non-trivial refinancing decisions and the resulting inertia, this issue is not present in Canada since all borrowers have to renew their mortgages at the end of the term.

A.2 Mortgage Types

Households in Canada can choose between 3 types of contract: (i) a fixed rate fixed payment mortgage (Fixed-Fixed mortgage), akin to an FRM mortgage in the United States, (ii) a variable rate variable payment mortgage (Variable-Variable mortgage), akin to an ARM mortgage in the United States and a (iii) variable rate fixed payment mortgage. Fixed rate (Fixed-Fixed) mortgages have both their rate and payment fixed over the length of the term. Variable rate mortgages have their interest payments determined by the current level of short-term rates. However, the total payment depends on whether a mortgage is a variable payment (Variable-Variable) mortgage or a fixed payment (Variable-Fixed) mortgage. With Variable-Variable mortgages, the total payment changes as often as the interest rate used to calculate interest payments.

With Variable-Fixed mortgages, the level of total mortgage payments does not change with the current interest rate and the most popular rate used to set the level of payments is the short-term interest rate at origination.[5] With two different interest rates used for setting a level of interest and a level of payments, whenever the two differ from each other, the principal portion of the total payment absorbs the differences.

In particular, if interest rates increase over the length of the term relative to the initial interest rates, the interest portion of the payment would increase, and the principal portion decrease, resulting in a slower repayment of principal. The opposite is true when interest rates fall below the level of initial interest rate.[6] Absent any other adjustments, a change

payments matters for renewal with the original lender.

[5]Other interest rates, such as a 5-year mortgage rate can also be used to set the level of total payments. However, since March 2018 all lenders offering this type of contract in Canada use the short-term rate at origination. It is possible for borrowers to request their payments to be set at a level exceeding that implied by the current interest rate, but this is not very common. In particular, until May 2018 one Big 6 bank offered its variable rate borrowers a choice between variable payments and fixed payments with the level of the former set using the 5-year fixed mortgage rate. The variable rate mortgages with fixed payments, however, had almost no take-up at this lender.

[6]Borrowers have the option to increase the level of regular installments or make lump-sum payments within allowed limits. This can offset the decreased principal payments when interest rates rise. Most borrowers

in the interest rate immediately changes the effective amortization of the loan. At renewal, given market interest rates, payments are calculated to maintain the original 25-year amortization period. As a result, unexpectedly higher interest rates over the current mortgage contract, which lead to lower principal payments, imply larger payments in the next contract. In contrast, Black (1998) envisioned a contract with fully variable amortization periods, where interest rate increases resulted in longer amortizations and interest decreases in shorter amortizations, with no changes in monthly payments. To be clear, this is not the contract offered in Canada, although in 2024, the Canadian government offered some relief to renewers by allowing them to increase amortizations due to the large interest rate increases in 2022 and 2023.

A.3 Prepayment and Equity Extraction

Prepayment of mortgages in full and refinancing (outside of renewal periods) is rare in Canada. Partial prepayments through lump-sum payments, are limited to between 10 and 20% of the initial balance of the mortgage per year. However, unlike in the U.S., where full prepayment is often penalty-free, in Canada full prepayment of a mortgage within a term involves a penalty, whose size depends on the type of the mortgage and the direction of the change in interest rates. For variable rate mortgages of both types, the penalty is three months of interest payments on the balance outstanding at the time of prepayment. The same penalty applies to fixed rate mortgages when interest rates at the time of prepayment exceed the contract rate in effect, but the incentives to prepay in the rising rate environment may be limited.

On the contrary, when interest rates decrease relative to the contractual rate, the penalty is calculated using the interest rate differential between the contractual and current rates and is applied over the remainder of the term.[7] From the borrower's perspective this eliminates

rarely exercise these options. In extreme cases, interest rates may rise to the point where the lender forces the household to adjust regular payments and/or make a lump-sum payment to maintain regulatory constraints such as maximum loan-to-value ratios. When rates fall, however, borrowers cannot adjust payments to make smaller principal payments. Only prepayments in excess of the regular installments can be reborrowed under certain conditions.

[7] More precisely, for all of the Big 6 banks the penalty is calculated using the posted interest rate at the time of origination and the current posted rate on the term closest to the remaining term to renewal. Contractual interest rates for most borrowers feature a discount relative to posted rates. Some smaller lenders keep the penalty at 3 months of interest regardless of the direction of changes in interest rates.

any gains from ending the term early to take advantage of lower interest rates.[8] Thus, early renewal is not at all common in Canada in either periods of low or high interest rates.

The existence of prepayment penalties also reduces the incentive of Canadian consumers to extract their home equity through cash-out refinancing that involves paying off the current balance and originating a new loan secured by the same property with a higher balance.[9] Cash-out refinancing is most likely to happen when a consumer approaches her scheduled renewal date and when prepayment penalties do not apply. However, taking out equity through home equity lines of credit (HELOCs) does avoid prepayment penalties and is more flexible in the amount that consumers can borrow. Hence, it is more prevalent in Canada compared to cash-out mortgage refinancing (Ho et al., 2019), which is much more widely used in the United States.

[8]There may still be a benefit of terminating a contract early and renewing a mortgage with a lower interest rate outside of the traditional banking system.

[9]Borrowers may be able to avoid prepayment penalty when increasing the size of the mortgage with their current lender (porting in place to increase the mortgage amount), but there is still a cost associated with doing so. While the existing portion of the loan may conserve the current interest rate, the amount of the increase is assessed a rate of interest equal to the current posted rate that is about 200 basis points higher than the average contractual interest rate.