Mortgage Choice with Renewable Short-term Contracts*

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Abstract

In this paper, we consider the choice between fixed (FRM) and variable rate mortgages (VRM) in repeated originations, primarily arising from short contractual terms. We isolate the role of state dependence, after controlling for borrower heterogeneity (both observed and unobserved) and factors previously shown to affect mortgage decisions. Capitalizing on the prevalence of short-term mortgage contracts in its housing finance, we use data for Canada consisting of a panel of individual mortgage originations from a cross-section of lenders. We also hand-collect data for the five largest Canadian chartered banks on the shares of variable rate contracts in different components of their mortgage originations. Our borrower-level results provide evidence of the importance of state dependence, suggesting a role for search or switching costs, as well as mortgage specific learning. Supportive of state dependence is also a finding of strong positive correlation between VRM share in renewals and its lag in new originations in chartered-bank data.

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1 Introduction

Recent theoretical and empirical macro studies have linked the effectiveness of monetary policy transmission to the share of variable rate mortgages (VRM) in debt outstanding.[1] In the case of dominant long-term contracts, the evolution of this share is largely influenced by the take-out of new home purchase mortgages.[2] However, with short mortgage terms an important source of turnover in this share additionally arises from exogenously imposed renegotiation of outstanding mortgage contracts. Given that new originations constitute only a small fraction of the stock outstanding, borrowers' decisions regarding existing mortgages have a potential to greatly affect the dynamics of the variable rate mortgage share, and thus play an important role in monetary policy transmission.

The determinants of mortgage choice between fixed and variable rate mortgages have been studied extensively. The reduced-form empirical papers in this strand of literature have focused on mortgage choice in a static framework. In turn, a number of stuctural papers have considered a dynamic set-up of a mortgage choice problem, allowing for the possibility of refinancing an existing mortgage either into the same fixed rate contract or a fixed rate contract with a change in other non-interest-rate-related elements.[3] Like the latter studies, we focus on borrowers' mortgage choice with respect to the interest rate type primarily at renegotiation associated with a mortgage roll-over at the end of the term, but also at refinancing and repeated home purchases.

More specifically, in this paper we consider persistence in contract choice in repeated originations, controlling for borrower heterogeneity, both observed and unobserved, as well as other factors previously found to play a role in mortgage decisions such as interest rates. To do that, we use an institutional feature of several mortgage markets,

[1] The papers that have contributed to this discussion include Calza, Monacelli, and Stracca (2009), Garriga, Kydland, and Sustek (2015) and Auclert (2016), among others.

[2] This would be the case even in the case where long-term mortgages are effectively refinanced earlier, in particular, with the purpose of reducing their interest rates. At roughly ten years, an effective tenure of long-term mortgages is still about twice as long as a short mortgage term.

[3] Included in the latter subset of papers are Campbell and Cocco (2003), Chambers, Garriga, and Schlagenhauf (2007) and Koijen, Van Hemert, and Van Nieuwerburgh (2009).

characterized by short committment terms and a long period to amortization, which creates demand for multiple contract renegotiations. Given that the timing of renegotiation in many cases is pre-determined, these mortgage finance systems provide us with a greater flexibility of looking at repeated originations than for example, in the case of long-term mortgage refinancing, where the decision to refinance and its timing (as well as the choice of contract) would be determined endogenously. However, the results obtained in our analysis would undoubtedly be relevant for the latter environment, given that at refinancing their long-term FRMs borrowers have an opportunity to not only reduce their interest rate, but renegotiate all other terms of the mortgage.

Our empirical analysis focuses on Canada and is based on micro-data from the Canadian Financial Monitor, which consists of a set of repeated cross-sections between 1999 and 2014, and has a panel component, which allows us to track repeated mortgage originations. The set of mortgages available to Canadian borrowers, in addition to fixed rate contracts, includes two types of variable rate mortgages - standard and dual-rate VRMs. Thus, we first extend a discussion of mortgage choice determinants in the literature to take account of these additional choices, and provide a set of benchmark results from the static model.[4] We then formulate our empirical approach to analyzing the role of state dependence in a dynamic set-up.

Amongst the two alternative estimation approaches used in the literature for the model with state dependence - random effect probit models and linear probability models - we focus on the latter. As noted elsewhere, these models are robust to the form of unobserved heterogeneity and avoid the problem of initial conditions in the dynamic process. In particular, we consider a GMM estimator in the context of dynamic linear probability model which does not require auxiliary distributional assumptions on the borrower-specific effects.[5] The alternative OLS and fixed effects estimators are biased

[4]Following Badarinza, Campbell, and Ramadorai (2014), we can write the model in terms of both mortgage interest rate type and length of term decisions.

[5]Among other considerations, we note that a linear probabiliry model does not constrain the predicted probabilities to the unit interval, and to the extent that assumptions are correct, the identification would be stronger in nonliner models.

upward and downward, respectively, setting a bounded range for the true estimates.

The models are estimated using data from the CFM, where we have information about borrower and mortgage contract characteristics, including month of origination. Using origination dates, we can merge in values of interest rate variables shown earlier to be relevant for borrower decisions. In the estimation we use interest rates posted by chartered banks nationally, given that these represent the only source of data publicly available to all borrowers. However, this also means that for the most part we would be unable to use time fixed effects in the estimation. Thus, as in Bhutta and Keys (2016), in addition to the information discussed above we include a set of time-varying controls at the local and regional levels, such as growth rates of house prices, wages and employment as well as unemployment rate.[6] For borrower-level variables, we rely on the formulation of a mortgage choice problem in Chambers, Garriga, and Schlagenhauf (2007), where the vector of state variables includes mortgage balances outstanding or the number of payments on the mortgage remaining, the stock of financial assets, and age.[7]

Estimating the dynamic linear probability model, we find a positive and significant coefficient on the previous mortgage contract choice. For mortgage determinants suggested previously in the literature and augmented to account for dual-rate VRMs in mortgage choice set, only the current spread is positive and significant, while long-term mortgage spread and house price growth estimates are not. We also find economically and statistically significant coefficients on local employment growth rate and wage growth over the previous three years, and rate of unemployment over the previous year, with positive and negative signs respectively. Amongst individual-level variables we find significance of the mortgage and financial asset positions, which are treated in

[6]While we do not address this explicitly, other authors have shown that there is no causation running from use of particular types of mortgage contracts to house prices. On the contrary, as shown in Barlevy and Fisher (2011) the use of some types of mortgages was pre-empted by house price appreciation.

[7]In Chambers, Garriga, and Schlagenhauf (2007) the value function for a borrower is described by the state vector which depends on the entering asset position, the prior period housing position, the number of periods remaining on an existing mortgage, mortgage contract type, the value of the current period idiosyncratic shock and age.

the estimation as endogenous variables, together with the previous mortgage contract choice. Coefficients on other variables such as age and income are positive, but not significant.

In search of suggestions regarding economic explanations for the structural state dependence, we consider whether borrowers change their mortgage provider between renegotiations, and whether there are any differences between home purchase vs. mortgage refinancing and renewal originations.[8] Finally, given our relatively small borrower-level sample, we also explore a relationship between new and renewal mortgages using hand-collected data from the five largest Canadian chartered banks on their shares of variable rate mortgages in different types of originations. We take the regression set-up proposed in Badarinza, Campbell, and Ramadorai (2014) with the VRM share in renewal originations as dependent variable and add a lag of VRM share in new originations. In addition to strong persistence in dependent variable at a one-month lag, previously reported in Badarinza, Campbell, and Ramadorai (2014) and attributed to slow adjustment in borrowers' expectations of interest rates and possibly peer borrower or mortgage supply effects, we also find a positive and significant coefficient for the lag of VRM share in new originations, between 28 and 36 months, which roughly corresponds to an average effective term of a mortgage.

This paper proceeds as follows. Section 2 provides an overview of the related literature. Section 3 characterizes dual-rate VRMs, prevalent in Canada, and discusses their risk profile relative to other contracts. Section 4 discusses the determinants in the choice between VRM and FRM contracts suggested in the existing literature, accounting for the presence of dual-rate VRM in the mortgage set. Section 5 formulates a household level model of mortgage choice, and its aggregated version with a VRM share as a dependent variable. Section 6 provides an overview of the Canadian Finan-

[8] In the panel data, we have information about a financial institution that originated each mortgage contracts, which we can use directly to determine whether or not there was a change in mortgage provider. We also have postal code information for each observation, which we can use to infer whether an origination represents contract renewal/refinancing or corresponds to a repeated home purchase. While this rule is not entirely conclusive, we proxy home purchase originations with a change in postal code between contracts.

cial Monitor survey that includes detailed information on household mortgage holdings, as well as data on shares of variable rate mortgages in originations of the five largest Canadian chartered banks. Section 7 provides estimation results from household level data, while Section 8 summarizes results for VRM share in total mortgage originations and their components in our bank-level data. Section 9 concludes.

2 Literature

Relative to the existing literature on mortgage choice, we consider the features of the dual-rate VRM as an alternative form of the variable rate mortgage, comparing its costs and risks relative to the standard fixed and variable rate contracts. We target this discussion to provide an input regarding mortgage determinants included in our empirical specifications, while keeping it fairly informal, given that we are able to distinguish between two types of variable rate mortgages only in a subset of all originations. Nevertheless, we add to the previous literature that has characterized different types of fixed rate mortgages varying in the slope of their repayment schedule (e.g. Chambers, Garriga, and Schlagenhauf (2007)), as well as adjustable rate (ARM) and complex mortgages, such as option ARMs, allowing for a delay in principal repayment (such as Barlevy and Fisher (2011) and Amromin, Huang, Sialm, and Zhong (2011)).

From the point of view of analyzing mortgage renegotiations, the closest to the analysis in this paper is Chambers, Garriga, and Schlagenhauf (2007), who consider a broader concept of refinancing that would involve any changes in mortgage terms, including but not limited to the commonly studied interest rate and cash-out refinancing of the fixed rate mortgages. In their model, refinancing borrowers are allowed to change their mortgage to any of the contracts available in the mortgage set and possibly adjust their housing equity position or amount of debt outstanding, for example, as a means of insuring income risks. The evolution of mortgage debt itself amongst other factors depends on the type of contract and associated amortization schedule, as well as the time in the life of the mortgage. The amount of debt outstanding, in turn, is the only

factor that determines refinancing costs, which do not have a fixed component and are uniformly proportionate across all contract types. In their analysis of mortgage transitions, the authors only report mortgage transitions with respect to the loan-to-value ratio and show a non-trivial degree of persistence.

As mentioned earlier, most focus in the literature, however, has been on refinancing of long-term fixed rate mortgages to a lower interest rate, in particular in the context of the US.[9] In particular, Campbell and Cocco (2003) present a decision-theoretic framework for the choice between ARM and FRM, where borrowers are also allowed to refinance their mortgages to another FRM under certain conditions, and they do so optimally. In turn, to reflect the the prevalence of refinancing mistakes (errors of omission and commision) in the data, Campbell and Cocco (2011) include in their model mortgage refinancing with a possibility of inertia.[10] Borrowers continue to be rational in the model, but the authors introduce a probability of inertia that can prevent a borrower from refinancing their mortgage to a lower interest rate. They can still can refinance in the next period if it continues to be optimal to do so. Both borrowers and lenders know that mortgage holders can fall into inertia state and incorporate this information into their decisions. In particular, mortgage premia set by lenders decrease with probability of inertia.[11]

In the case of short mortgage terms, Miles (2004) brings up the issue of remortgaging in the UK, in particular, in the context of the end to discounts usually offered with the initial contract, when borrowers can take their mortgage to a different lender or change

[9] Bhutta and Keys (2016) also consider the interaction between interest rate and house price refinancing incentives.

[10] In addition to refinancing of long-term FRM mortgages, Campbell and Cocco (2003) also provide a welfare evaluation of an option to take out an adjustable rate mortgage, which can be converted to a fixed rate mortgage. This conversion represents a discretionary decision by a borrower, e.g. when faced with large increases in interest rates on variable rate mortgages. The benefits to the borrowers accrue in this situation from a lower level of mortgage payments on the fixed rate mortgage compared to an ARM. In particular, this would apply to consumers who are more borrowing constrained (with low income and/or liquid assets), as they find it optimal to pay the higher average premium on the FRM in exchange for the lower current mortgage payments.

[11] The modelling of inertia is in this case similar to Calvo sticky-pricing, where opportunities to change prices arrive only to a fraction of producers in each period, and these producers take this probability into account when setting their current prices.

the product held with the existing lender.[12] Thus, the primary reason for remortgaging in this case is to lower the ongoing cost of the mortgage, but other reasons could include a desire to change other features of the mortgage contract. Miles (2004) associate low observed remortgaging rates in the UK with switching costs between lenders, and within the same lender to a different product; as well as learning and search costs. In particular, if information is difficult to process, as borrowers acquire a good - mortgage contract, in this case, - infrequently, they may adopt simple rules on which to base decisions. In turn, if search costs are high, borrowers would expect to receive large gains to continue searching.

The question of persistence in financial decisions has been studied not only on the liability, but also asset side. In particular, Alessie, Hochguertel, and van Soest (2004) consider persistence in household ownership of stocks and mutual funds that could be attributed to stuctural state dependence and unobserved heterogeneity, using a bivariate dynamic probit model with random effects. They find that unobserved heterogeneity and state dependence play a large role for both types of assets. In particular, they attibute a large proportion of the positive correlation between holding stocks and mutual funds in the data to positive correlation in unoserved heterogeneity. Positive coefficients on the lagged dependent variables concerning ownership of the same asset type are related to the costs of acquiring each asset and asset-specific learning: once an investor gets into one asset class, they become more familiar with it, in particular, with respect to its risk and return characteristics. In turn, a negative state dependence effect of lagged ownership of stocks on ownership of mutual funds is explained by the costs of shifting funds across the two forms of stockholding.

Going back to mortgage choice, this study is related to a large empirical literature which considers home purchase financing decisions with different binomial or multinomial sets of mortgages contracts, that differ not only in their interest rate, but also the period of interest rate fixation and the period to amortization. Most of these studies

[12]This contract is different from an ARM with teaser rates in the US, for example, where a rate increase takes place with the same lender.

combine loan and aggregate level variables, suggested in the introduction and discussed in detail below as determinants of mortgage choice.[13] Their setting in a static environment can be explained by limited availability of panel data. However, an alternative approach to overcome this limitation and study mortgage choice behaviour over time is to use aggregate data sources where the variable of interest is an aggregate measure of borrowers' mortgage decisions expressed by a share of variable rate mortgages in total originations. The papers in this strand of literature include Koijen, Van Hemert, and Van Nieuwerburgh (2009) and Badarinza, Campbell, and Ramadorai (2014), as well as Nothaft and Wang (1992). In particular, a panel considered in Badarinza, Campbell, and Ramadorai (2014) includes a number of countries where mortgage terms are relatively short, similar to this paper, but these mortgage originations are represented by one data series for their total, without the components of new and repeated originations, as well as the subcomponents of the latter. In our analysis, we also use data for VRM shares amongst the five largest Canadian chartered banks to obtain additional evidence of persistence in mortgage choice by considering a relationship between current VRM share in renewal originations and the lagged VRM share in new originations. The length of the lag is expected to correspond to an average effective term of mortgage contracts and is determined empirically.

Finally, we note the links to the literature on the prevalence of behavioural biases in the population, such as Andersen, Campbell, Nielsen, and Ramadorai (2015) and Deng, Quigley, and Van Order (2000). The former estimates a mixture model of borrower refinancing types in which their characteristics affect both inattention (a low proportion of rational refinancers who respond to changes in interest rate incentives) and residual inertia (a low constant probability that fully inattentive borrowers refinance). With a rich dataset on borrower characteristics, they are able to estimate cross-sectional correlation between these two attributes and present some evidence of persistent unobserved heterogeneity in attention, which can in turn contribute to explaining the incidence of

[13]The following list of papers is far from complete and includes Koijen, Van Hemert, and Van Nieuwerburgh (2009), Coulibaly and Li (2009), Breslaw and Irvine (1996), Ehrmann and Ziegelmeyer (2014), etc.

observed refinancing mistakes (errors of omission and commission) in Denmark.

3 Introduction to Dual-Rate VRMs and Their Comparison with Other Mortgage Types

3.1 Main Characteristics of Dual-rate VRM contracts

Unlike a standard VRM, dual-rate variable rate mortgages are characterized by two interest rates: an interest rate used to set a constant level of regular installments over the length of the term until next renegotiation, and a series of periodic (debiting) rates determining current mortgage costs.[14] Common anchors for the former include a variable mortgage rate at origination, a fixed mortgage rate at origination or any other long-term rate.[15]

Regardless of the interest rate used to set the level of regular mortgage payments, under a dual-rate VRM the principal portion of each payment would contractually depend on the size of this rate relative to the debiting one. Principal payments would be most sensitive to interest rate changes when the latter constitute a dominant part of the mortgage payment, as in the case of new mortgages, with the sensitivity declining over time. This is unlike the case of a single-rate VRM, where variations in interest rates affect only the interest portion of mortgage payments, and the amortization schedule of the principal is not affected, set at the mortgage origination.[16]

In what follows we consider the case where an interest rate used for setting a constant level of mortgage payments is an initial variable rate. When interest rates ex-post exceed initial variable rate, a borrower can increase their payments to match interest increases

[14]For the purposes of this paper, terms such as single-rate VRM, standard VRM, and VRM with variable payments all refer to the same mortgage contract design.

[15]Lessard and Modigliani (1975) provide more details regarding different features of the design of dual variable-rate mortgages. Appendix A provides some additional background about how dual-rate VRMs were introduced in Canada.

[16]Without payment reset at renewal, the dual-rate VRM becomes a mortgage instrument with variable maturity.

or keep their payments unchanged. With large interest rate increases relative to the initial rate, a situation of negative amortization can arise, allowing lenders to promptly raise the level of regular mortgage payments to the level at least sufficient to cover the interest.

In most cases, however, dual-rate VRM regular installments would remain sufficient to cover interest rate payments associated with a mortgage, but with a constant payment would result in an implicit extension by lender of a within-period term loan, equal to the amount of delayed principal amortization. The approval for this type of within-mortgage-term loan would be implicitly granted with the mortgage loan origination, and its costs are assessed using the variable rates charged on a mortgage itself.

If future interest rates were expected to decline relative to an initial interest rate, the implications for a dual-rate VRM borrower would be different. In this case, a borrower would be paying down their mortgage balances outstanding at a faster pace that originally scheduled, but may be able to reborrow some of these prepayments in the absence of borrowing constraints, in particular, by accessing housing equity. This could allow dual-rate VRM borrowers to achieve an outcome largely similar to that under a standard VRM, where mortgage payments would decline automatically with lower interest rates.[17]

In either cases of future interest rate decreases or increases, a borrower who decides to remain in their house and continue with their initial contract terms, including term to amortization, would have their payments reset to a new level at renewal. Alternative options at term expiration, depending on the expected housing tenure, would also include mortgage refinancing to extend the period of amortization to smooth mortgage payment increases, and repayment of balances outstanding using the proceeds of a home sale.

[17]In the case of a dual-rate VRM, when a long-term rate is used to set the level of mortgage payments, expected principal repayment would be proportional to the difference between the expected average short-term rate and the long-term rate, and the implications of interest rate changes would be the opposite to the ones described above.

3.2 Comparison of Risks Associated with Different Types of Mortgages

Given the introduction in the previous section, one can now compare different mortgage types in terms of their risk characteristics from the point of view of the borrower.

We start with the re-cap of the risks associated with standard VRM and long-term FRM mortgages. As discussed in Koijen, Van Hemert, and Van Nieuwerburgh (2009) and Campbell and Cocco (2003), expected inflation represents the main source of risk of a FRM, as it translates into uncertain real capital value of the mortgage and poses a wealth risk for a borrower. In turn, Koijen, Van Hemert, and Van Nieuwerburgh (2009) show that the main risk of a standard VRM can be approximated with a real rate risk, given that expected inflation risk is nearly offset by the positive covariance between expected inflation and nominal interest rates: with an increase in expected inflation, real value of balances outstanding will be declining faster, but nominal interest rates would be higher as well, offsetting some of the relief.[18]

Thus, in terms of the comparison of risks associated with a standard VRM and FRM, the attractiveness of VRM would be increasing with higher variability of expected inflation and decreasing with higher variability of real rate. Campbell and Cocco (2003), however, suggest that beyond the real rate risk, an income risk of the short-term variability of real payments may play a role in the choice of VRM. This variability, in particular, arises due to the fact that with higher expected inflation, interest rates increase, while the current price level remains unchanged, leading to higher real payments. An increase in real mortgage payments would not matter for a mortgage holder who is able to smooth out these fluctuations by borrowing, but may pose problems for those facing binding borrowing constraints. Higher interest payments and an inability to borrow in this situation could result in negative consumption effects.

Extending the latter point of discussion to the case of a dual-rate VRM, we note that increases in expected inflation and nominal interest rates do not have an imme-

[18]This is equivalent to saying that the real value of VRM is almost unaffected by inflation.

diate impact on the real value of a regular mortgage payment, given that the levels of both prices and payments remain unchanged: the real value of interest payments increases with a higher nominal interest rate, and therefore, the real value of the principal repayment must fall one-for-one. Thus, relative to a standard VRM, the income risk associated with the variability of real payments would be lower under a dual-rate VRM, making it more attractive to those facing binding borrowing constraints.

On the other hand, relative to a standard VRM, one would expect a different net effect associated with dual-rate VRM coming from short-term variability of nominal interest rates, expected inflation risk and the covariance term of expected inflation and nominal interest rates. As in the case of standard VRM, higher expected inflation would mean higher interest rates and higher pace of erosion in balances outstanding, however, the real relief obtained would be smaller, given higher balances outstanding associated with constant mortgage payments under the dual-rate VRM. Thus, by comparison, the quantity of risk under a dual-rate VRM would fall between the levels associated with a standard VRM and FRM, combining real rate risk of VRM and some wealth risk of FRM.

Assuming that risks associated with different mortgage contracts are relatively constant over time, we next provide a formal discussion of the other factors considered to influence mortgage decisions.[19]

4 The Role of Interest Cost Differentials in Household Mortgage Choice

Koijen, Van Hemert, and Van Nieuwerburgh (2009) show that optimizing borrowers would choose to finance their home purchase with either fixed or standard variable rate

[19]Note that Koijen, Van Hemert, and Van Nieuwerburgh (2009) consider a model with heteroskedastic innovations, where time variation in the volatility of expected inflation and expected real rates delivers additional channels for variation in mortgage choice. The conditional volatilities of expected inflation and real interest rates enter with the predicted sign in the regression, but are not statistically significant, and add little explanatory power to the interest cost differential measures used as the main predictors.

mortgage based on the long-term differential between a fixed rate and an average of expected future variable mortgage rates.[20] Demand for VRMs would be higher when this cost differential is high. Koijen, Van Hemert, and Van Nieuwerburgh (2009) also argue that the long-term cost differential is not well approximated by the initial spread between fixed and variable mortgage rates as argued by other authors, due to deviations of future short-term rates from the initial variable rate.

Badarinza, Campbell, and Ramadorai (2014), however, suggest that initial spread may also be important in the choice between a FRM and a standard VRM, if borrowers care about their initial costs because of borrowing constraints or because they are trying to qualify for a larger mortgage.[21] They confirm an independent role of the current spread using an instrumental variables approach where it is also used to forecast a long-term mortgage cost differential.

In the case when a mortgage set also includes dual-rate VRM contracts with a sequence of debiting rates representing their interest costs, an unconstrained borrower would still rank it against a fixed rate mortgage contract using a long-term cost differential, based on a sequence of expected future rates. Similarly, borrowing constrained households would continue using current spread to make their choice between fixed and variable rate mortgages to minimize their initial mortgage costs. However, they could also be forward-looking with respect to the future mortgage costs, and choose a dual-rate VRM expecting a low long-term cost differential if a current spread is high. When this is the case, the payment differential between the two mortgages would remain the same over the length of the term despite increases in future rates relative to the initial rate.

As with other mortgages with an increasing amortization schedule implied in this case, a delay in principal payments and an extension of a within-term loan would benefit borrowers expecting either a higher future income or house price growth.[22] The for-

[20] Koijen, Van Hemert, and Van Nieuwerburgh (2009) assume that mortgages are priced as derivatives contracts on the Treasury yield curve. Hence, the same sources that drive time variation in the Treasury yield curve will govern time variation in mortgage rates.

[21] We discuss the issue of mortgage qualification in greater detail below.

[22] From the point of view of a financial institution, the rationale for extending this within-term loan

mer would allow borrowers to compensate for higher total mortgage payments resulting from their reset at renewal. With the latter, a borrower would be able to accumulate additional housing equity and keep their LTV ratio low, thus relaxing borrowing constraints during the term of the mortgage. Furthermore, it would facilitate refinancing to extend amortization period with the purpose of lowering future mortgage payments and repayment of any delayed principal from the proceeds of the sale at mortgage term expiration.

The determinants discussed above don't only refer to a one-shot mortgage choice problem. They are also relevant for repeated originations, associated with home purchase, refinancing and renewal, but as shown in Koijen, Van Hemert, and Van Nieuwerburgh (2009), these determinants may have different strength or significance of effects across different types of originations, a possibility we consider explicitly in our empirical approach. Badarinza, Campbell, and Ramadorai (2014) also test the role of these interest rate variables in determining time variation in the term of fixed interest rate mortgages, in addition to the VRM share itself. We take this into account when formulating our empirical approach in Section 5.

5 Empirical Approach

We start with the borrower-level model, before proceeding to a formulation with an aggregate measure of mortgage choice given by a VRM share in originations.

5.1 Borrower-level Mortgage Choice

5.1.1 Model

We start with the most general specification of the problem of mortgage choice in period t with respect to the type of interest rate and mortgage term, both defined as binary

would be similar. In particular, the fact that interest rate increases would likely accompany a period of higher house price growth would help lower the loan-to-value ratio on the mortgage and provide additional room for carrying higher mortgage balances by the borrower. This would in turn reduce financial risk of the lender associated with this particular contract.

variables. We regress an indicator variable for a type of mortgage contract chosen on the previous contract, while controlling for interest rate differentials at the time of current contract origination, house price, employment and income trends at the regional level, and borrower-specific characteristics. In the specification below, $y_1 = 1$ for a choice of VRM, while $y_2 = 1$ for a choice of a longer term mortgage in excess of three years.

$$y^*_{1,irt} = X'_{it}\beta_{1X} + y'_{1,irt-1}\gamma_1 + y_{2,irt-1}\gamma_{12} + Z'_{rt}\beta_{1Z} + Y'_t\beta_{1Y} + \delta_r + \epsilon_{1,irt},\ y_{1,irt} = 1(y^*_{1,irt} > 0) \quad (1)$$

and

$$y^*_{2,irt} = X'_{it}\beta_{2X} + y'_{2,irt-1}\gamma_2 + y_{1,irt-1}\gamma_{21} + Z'_{rt}\beta_{2Z} + Y'_t\beta_{2Y} + \delta_r + \epsilon_{2,irt},\ y_{2,irt} = 1(y^*_{2,irt} > 0) \quad (2)$$

with the unobserved term assumed to have the following form:

$$\epsilon_{j,irt} = \mu_{j,i} + \nu_{j,irt} \quad (3)$$

for borrower i, in region r during period t, where $\mu_{j,i}$ is a borrower-specific component, which captures time invariant unobserved preferences and other factors; $\nu_{j,irt}$ is a possibly correlated error term, which captures transitory shocks.[23]

We focus on different motivations in mortgage choice that are associated with the following variables measured at time t of mortgage origination and included in vector Y: (i) the expected long-term mortgage cost spread $FRM_t - \hat{E}_t[V\bar{R}M_{t,t+T}] = (FRM_t - VRM_t) - (\hat{E}_t[V\bar{R}M_{t,t+T}] - VRM_t)$, where T refers to the length of the horizon over which expectations are formed; and (ii) the current mortgage cost spread $FRM_t - VRM_t$. Vector Z includes the average annual house price growth rate over the past one to three

[23]Subscript t associated with variables y_1 and y_2 (as well as X, Y, and Z) applies to a period in which a new mortgage contract was chosen; while $t-1$ could refer either to the previous period (when a previous mortgage contract was in effect) or to the previous mortgage itself, numbered sequentially.

years; average employment growth over the past three years; average wage per worker over the past three years; and average unemployment rate during the past year. We also include geographic fixed effects, to account for constant geographic differences. The vector X it includes a number of borrower-level including age at the time of origination, income reported in the year preceding renegotiation, loan amount at origination and stock of financial assets of the borrower.

5.1.2 Household Expectations of Future Average Short-term Rates

The interest rate differentials previously identified as determinants of mortgage choice and included in vector Z are given by current and long-term mortgage spreads.

For the construction of the latter, as in Koijen, Van Hemert, and Van Nieuwerburgh (2009), we assume that expectations follow an adaptive process, such that the forecasted future expected average variable mortgage rate is given by a simple rule based on the past values of short-ter interest rates, i.e. $\hat{E}_t[V\bar{R}M_{t,t+T}] = V\bar{R}M_{t-K,t}$. Here, expectations are assumed to be homogeneous across borrowers, as a function of observed aggregate variables.

As an alternative, we also follow Badarinza, Campbell, and Ramadorai (2014), who use a rational expectations model replacing future expected short-term rate $\hat{E}_t[V\bar{R}M_{t,t+T}]$ with realized future rates over horizon T, and then instrument these future rates with current and lagged interest rates with different horizons K of between 1 and 3 years. The choice of T and K for interest rate variables is determined by data availability, as well as additional considerations of specific features of variable rate mortgage contracts, such as their convertibility into FRM contracts with a certain minimum length of remaining term.

5.2 Model of VRM Share in Total Originations and their Components

We note that individual mortgage decisions modeled in 1 can be aggregated in each time period into VRM share using either a simple count of all VRM originations in their total or constructing a value-weighted share with mortgage amounts [and survey weights].[24] These aggregated shares for each period t could be constructed for total activity originations, or their components associated with renewal, home purchases and mortgage refinancing.

With short-term mortgage contracts and state dependence ($\gamma_1 > 0$ in 1) at renewal we would mechanically get a positive correlation between current VRM share in renewal originations and VRM share in past new originations, or lag of VRM share in new originations. We would expect the correlation between the two to be the highest at the lag corresponding to an effective mortgage term, at which borrowers renew their mortgages. Depending on the volume of renewal originations or their share in total originations, the relationship with the lag of VRM share in new originations would also apply to total originations.[25]

More specifically, we rely on the model for aggregate VRM share in Badarinza, Campbell, and Ramadorai (2014) and modify it accordingly to include different lags of VRM share series:

$$VRMshare_t = \mu + \rho VRMshare_{t-1} + \beta_C(FRM_t - VRM_t) + \beta_L(FRM_t -$$

[24]The same can be done using 2 to create a weighted average series for the term of interest rate fixation for fixed rate mortgages or a weighted term for all originations of fixed and variable rate mortgages.

[25]Thus, the dependence of VRM share on longer-term lags of new originations would complement the findings in Badarinza, Campbell, and Ramadorai (2014), who show significant persistence at 1-month lag in VRM share in total originations. The authors attribute the high estimated coefficient on the lag variable to inertia possibly associated with slow adjustment in expectations of interest rates and borrower peer effects, as well as mortgage lender effects.

$$-\hat{E}_t[VR\bar{M}_{t,t+T}]) + \beta_{hp}\hat{E}_t[\bar{g}^{hp}_{t,t+T}] + \epsilon_t \quad (4)$$

where expected house price growth and short-term interest rates are defined as in the earlier discussion (using behavioural and rational approaches).

6 Data Description

In our analysis, we use several data sources, which largely span the period between 1999 and 2014 and combine household survey data with chartered bank data.

6.1 Borrower-level Data: Canadian Financial Monitor

For our borrower-level analysis, we use micro data from the Canadian Financial Monitor survey conducted each year since 1999 by Ipsos Reid Canada with an average of 1,000 respondents each month and 12,000 per year. The sample is designed to be representative of the Canadian population in terms of such metrics as: (i) household ownership by region; (ii) work status by region; (iii) household size by region; (iv) city size by region; (v) household head age by region; and (vi) income by region; with weights supplied with each observation. Although the CFM is a repeated cross-sectional survey and is not designed as a panel, some households complete the survey more than once, and are reweighted in the new survey to keep representativeness of the sample.[26]

The survey has detailed information about different types of household liabilities and current assets; it also provides information about respondents' homeownership status, value of housing assets, income, employment status/type, main demographic characteristics, such as education, age, family composition and a geographic identifier represented by a 6-character postal code.

The main information module used in the paper is the mortgage module. It contains

[26] Damar, Gropp, and Mordel (2014) also use the panel component of CFM for their study of real effects on Canadian households of dealing with domestic lenders with different degrees of exposure to the US over the period of the 2007-2009 financial crisis.

self-reported information about the method of acquisition of a mortgage (directly from a financial institution or from a broker); name of the financial institution holding the mortgage; length of the relationship with a financial institution; type of mortgage rate - fixed vs. variable - and the rate itself; the length of the mortgage term for a variable rate mortgage and a period of interest rate fixation for fixed rate mortgages; the size of mortgage payments; their frequency; and mortgage balances outstanding at the time of the survey.[27]

Up until mid-2000s, the CFM collected information on up to eight different mortgages in four categories, such as principal residence, second or vacation home, and investment real estate. This mortgage information was matched to properties used as security, with information on their current market values. In the period that followed, however, the survey questionnaire was simplified with an option of listing up to four different mortgages, but without a clear labeling of the purpose of the mortgage or its relation to collateral. Our analysis across these different subperiods suggests that an overwhelming number of borrowers have been reporting on a single mortgage, and that mortgage characteristics across the first mortgages in the two sub-periods of the 2000s are roughly consistent. Thus, for the purposes of this paper we use across the board information on the first reported mortgage.

In the cross-sectional CFM data, we are unable to identify mortgage originations directly and thus turn to an inference procedure instead. This procedure would determine the month of mortgage origination by subtracting from the survey period the length in months of the mortgage relationship with a financial institution. We use the data we generate in such a way for two purposes. First, given the coverage of the CFM, we would like to construct for each month a share of variable rate mortgages in total originations and compare our findings from the CFM with the chartered bank data discussed below. Second, we would also like to analyze the determinants of mortgage

[27]Other information that does not consistently repeat across years includes the size of the downpayment, its percent relative to the value of the home, amortization period, etc. Given its ad-hoc nature, we are unable to utilize this information over the whole sample period, but we do make occasional references to it in our robustness checks.

choice at the borrower level. In both instances we would like to make sure that our data regarding the period of origination are reliable and that we have information on borrower demographic and financial characteristics at the time of mortgage originations.[28]

For these reasons and following other papers in the literature, like Ehrmann and Ziegelmeyer (2014), we use a 24-month cut-off for the length of the relationship with a financial institution in each cross-section and compare the results obtained using this criterion with the weighted average VRM share from chartered bank data.[29] Amongst different types of originations identified in this manner, renewals usually involve the most limited changes in their characteristics, which can create a perception on the part of a borrower that renewal is part of the same contract, even though from the perspective of the financial institution it is a new contract. As a result some borrowers may fail to re-start the count of the length of relationship, and as a result may be omitted from the set of originations. However, we do not find this to be a serious constraint.

Starting with originations defined in each cross-section we then construct a panel of borrowers with mortgage contracts and identify repeated mortgage originations using the same cut-off. The CFM provides weights associated with its panel component formed using the adjacent pairs of years, however, our sample includes additional observations, which may be separated by in time by more than 1 year and thus the weights provided may not be approapriate. Consequently, we are unable to provide results that would be respesentative of the population of repeated mortgage borrowers, and what we present here in terms of individual borrower outcomes can be considered as sample outcomes. However, when we consider their implications for the aggregate level

[28] In particular, one of the concerns we have regarding the use of a maximum number of observations available for the purposes of constructing monthly values of VRM shares in total originations is the situation where households who respond to the survey in adjacent years may not consistently report the length of their relationship with a financial institution after the first appearance. More specifically, we refer to the difference in the number of months between the two adjacent interviews and the reported change in the length of the relationship with the financial institution.

[29] We use a strictly less than 24-month cut-off, which takes into account the considerations of the sample size and recall accuracy on the part of borrowers. In particular, for the construction of the aggregate VRM shares, we smooth the raw data series using a three-month rolling window. These results are discussed in Section C.2.

originations, we obtain consistent results.

For the benchmark results we do not differentiate between different types of repeated originations. However, as alluded to earlier, we can use a number of proxies to identify repeated mortgage originations associated with home purchases, renewals and refinancing. Our data are rich enough to include the 6-digit postal code with each observation, so a change in a postal code between repeated originations will be associated with a move, such as following a repeated home purchase. In turn, no change in a postal code between two mortgage contracts would be associated with either refinancing an amount of mortgage or the term to amortization, or with a roll-over renewal.

In the next subsection we discuss the alternative data on the VRM shares in the total of all originations and their components from the five largest Canadian chartered banks. More specifically, with this data we get an additional breakdown of VRM share for purchase/refinancing and renewal originations. More details on these data are also provided in Appendix B.

6.2 Bank-level Data on Quantities

Four banks in our data are identified as originating predominantly dual-rate VRMs, and one - standard VRMs. Mortgage series available for each bank refer to VRM shares in the total of their originations and two components classified as "mortgage renewals with the same financial institution" and "all other". The majority of the other category is comprised by home purchase and refinancing originations, with the balance accounted for by mortgage switches at renewal or mortgage renewals with a financial institution different then the original lender.[30] The data for each institution are available at a monthly frequency, spanning a number of different periods, with the longest series going as far back as November 1999.

[30]For one of the banks we have information about all of the individual categories of other originations for the post-2009 period. Seventy percent of these originations are constituted by home purchase (40%) and mortgage refinancing (30%) originations. Unlike in the mid-to-late 1990s, there were no significant changes in the level of bank competition over the period under consideration that would have resulted in dramatic increases or decreases in this share.

While the coverage in our bank-level data may appear limited by comparison to economy-wide shares available in the data for other countries, in particular, the United States, it does cover a substantial part of mortgage originations in the economy. This is the case due to very high concentration of the banking sector in Canada and its importance relative to other financial institutions that originate mortgages: in the post-1999 period, chartered banks have held on average 73 percent of mortgage balances outstanding, with the largest six banks responsible, respectively, for an average of 92 percent of mortgage cash disbursements and balances outstanding over the same period.

6.3 Data on Prices

We can also use CFM to construct average prices of fixed vs. variable mortgages over the period under consideration. However, given our inference procedure to originations, we suggest to use a more accurate source of data on mortgage prices from the same five chartered banks, whose data were used to construct average VRM shares.

A peculiar feature of the Canadian system, which goes back to the wave of financial institution mergers in the mid-to-late 1990s, is the co-existence of posted and discounted rates. Posted rates represent "generic" rates quoted by banks on their mortgage products and constitute public information. A mode average of posted rates on the 5-year fixed rate mortgages across the major six Canadian banks is also used as a qualification rate for variable rate mortgages. In turn, as suggested by their name, discounted rates are usually quoted as a discount from a posted rate and represent a tool of price discrimination, with several levels of discounts available. The discounted rate is usually determined as the outcome of the mortgage application and can represent renumeration for a client-bank relationship, often measured by a number of products booked with the bank, or potential for such a relationship, if a borrower is new. Discounts are usually very competitive for home purchase mortgage originations, and can all but disappear at renewal if a borrower does not exert pressure on its financial institution by searching. As a usual practice, at renewal a bank holding maturing mortgage would set their

offered rate to reach a certain mortgage profitability level that takes into account the heavily discounted initial mortgage rate.

Our interest rate data consist of average posted fixed and variable mortgage rates collected across a number of financial institutions. Most of the derivative interest rate variables used in our analysis are constructed using a difference in interest rates, so that whether we use posted or discounted interest rates would matter less for the analysis as long as discounts on fixed and variable mortgage rate comove over time.

6.4 Other Data

Finally, in addition to interest rate data series, we also use house price data at different levels of disaggregation. We have data from Teranet which provides repeated sales house price indices at city level. To keep our sample as large as possible, given available data, we assign city indices to respective provinces and then use these provincial indices in our analysis. In particular, for the cases where one province has multiple city assignments, we construct a population-weighted index across the cities.

While city-level indices provide some degree of variation, we would like to get more heterogeneity in the cross-section of geographical locations. For this reason we turn to house price indices for new construction, including land, collected by Statistics Canada.[31] These are available for the main census metropolitan areas, for which we also have an identifier in the data. The correlation between new and repeated-sale house price indices is quite high, which suggests a similar behavior of house prices in both markets. Given that our data on mortgages are associated with both new housing and repeated sales, the use of this index would also be appropriate for our analysis.

[31] In the new future the authors would be able to obtain access to FSA-level area house price growth data from Teranet, at which point we will redo the analysis using FSA level house price growth variable.

7 Borrower-level Analysis of Mortgage Choice

7.1 Static model of household mortgage choice

In this section, consistent with existing literature we present estimation results for the static model in 1-2 where we pool together all observations, treating our data as a series of cross-sections and implicitly assuming no omitted variables or fixed effects. In turn, in the next section we move to a dynamic panel data model, which explicitly accounts for unobserved heterogeneity and previous household mortgage contract choice, as a shifter in the conditional probability of choosing a variable rate mortgage repeatedly.

Table 1 reports estimates from the linear probability model for the choice of contract with respect to interest rate type and the length of mortgage term, separately. In the case of the mortgage interest rate type, the choice variable is binary, set to 1 for the variable rate mortgage and zero otherwise. The mortgage term has several values in the data, which we reduce to two categories: shorter-term and longer-term mortgages with the cutoff of 3 years.[32]

With respect to the choice of mortgage interest rate type, we find a positive and significant coefficient on the current spread variable, and positive but not significant coefficient on house price growth with a one period look-back period. The long-term mortgage spread is essentially zero in the case of a 1-year look-back period. With respect to demographic characteristics, older, higher-income households as well as those with more financial assets are also expected to have a higher probability of choosing a variable rate mortgage.

Compared to the choice of mortgage interest rate type, the sign is reversed on the current mortgage spread when the dependent variable is the length of the mortgage term

[32]While we group all mortgages with a term of more than three years together, it may also be possible to consider them separately. The analysis of the average term of interest rate fixation and VRM share in the aggregate data using the same framework has been suggested in Badarinza, Campbell, and Ramadorai (2014). We note, however, that in our context the concept of mortgage term applies not only to the fixed rate mortgages, where it is synonimous with the length of the period of interest rate fixation, but also to variable rate mortgages, where it represents the length of the lender's commitment to advanced loan funds and the period to full contract renegotiation. The mortgage terms are more limited for variable rate mortgages, often varying between 3 and 5 years only.

Table 1: Estimated marginal effects from cross-sectional data

Variables	Interest type	Mortgage term
β_C	0.06*	-0.02*
β_L	-0.00	0.00
β_{HP}	0.08	0.03
Age	0.07*	-0.03**
log income	0.04*	-0.00
log mortgage	0.01	0.05*
log financial assets	0.02*	-0.01**
empgrowth	-0.01* *	-0.01
urate	-0.01*	0.01***
wagegrowth	0.01	0.02*
No. of observations	8,624	8,624

presented as binary variable, with the higher spread reducing the term of the mortgage. The signs of coefficients on the house price growth and long-term mortgage spread are positive, and the size of the latter increases and becomes statistically significant when the length of the look-back period increases from 1 year to 3 years. The signs of the coefficients are thus similar to those reported in Badarinza, Campbell, and Ramadorai (2014) and estimated on a panel of countries over different subperiods of the late 1990s and 2010s. Relative to the specification for mortgage interest rate type, we also find reversion in signs associated with coefficients on age variable and the log of household financial assets.

7.2 Dynamic household mortgage choice

7.2.1 Mortgage contract transitions

Before estimating a dynamic model of household mortgage choice in 1 we provide a brief characterization of household transitions between two subsequent mortgage contracts, unconditionally as well as a function of the type of mortgage contract originated – home purchase or refinancing/renewal – and the lender-borrower relationship – whether a household has changed their mortgage institution between the two mortgage contracts or not.

We use a panel of observations discussed earlier, where we only distinguish between fixed and all variable rate mortgage contracts. We could go one more step forward and also use institutional affiliation information to distinguish between dual-rate and standard variable rate mortgages. However, the sample of observations is dramatically decreased in this case.[33] Based on the panel of all total activity mortgage originations, Table 2 presents results on transitions between different types of mortgages. We find a significant degree of persistence in household mortgage choice. The absorption rate is somewhat higher for fixed rate mortgages, where 86 percent of households stay with the same type of mortgage contract, compared to 65% for all variable rate mortgages, but the implied probabilities in both cases are significantly higher than their counterparts in originations not conditioned on previous mortgage choice.

Conditioning on the type of origination - renewal vs. other (purchase and refinancing) originations - we find that households are more likely to stay with variable rate mortgage at renewal if this is what they chose as their initial mortgage contract. Some of the persistence in household mortgage choice is also associated with an on-going relationship with a financial institution. Households who remain with their financial institution are also more likely to stay with the same mortgage contract.

We next formally estimate a dynamic model of household mortgage choice, introducing a number of control variables discussed earlier.

7.2.2 Dynamic Panel Model Estimation

Amongst the two alternative estimation approaches used in the literature - random effect probit models and linear probability models - we focus on the latter. These models control for the arbitrary correlation between unobserbed heterogeneity (μ_i) and the regressors and can be used to elimitate the incidental parameters associated with the unobserved heterogeneity. As noted elsewhere, the linear models are robust to the form of unobserved heterogeneity and avoid the problem of initial conditions in the dynamic process. However, they do not constrain the predicted probabilities to the unit

[33] Some of the results for this 5-instution household level sample are presented in Appendix D.

Table 2: Transitions between fixed and variable rate mortgages in the panel of all financial institutions in the CFM, across all types of originations, %

Previous contract	Current contract	
	Fixed	Variable
	Total mortgage originations	
Fixed	86	14
Variable	35	65
	Home purchase originations	
Fixed	82	18
Variable	45	55
	Refinancing/renewal originations	
Fixed	87	13
Variable	33	67
	Same institution	
Fixed	90	10
Variable	28	72
	Different institution	
Fixed	80	20
Variable	48	52

Notes: The transition matrices are computed using the maximum number of observations with available mortgage contract information (in particular, exceeding the counts reported for regression specifications below, where additional limitations on the data are introduced by the requirement of non-missing values for all observations in different specifications). However, the results do not change qualitatively when we consider the smaller sample of observations, on which the dynamic model is estimated. Home purchase originations are defined as those where the 6-character postal code does not change between two mortgage originations. In turn, refinancing/renewal originations refer to all other originations associated with no change in the postal code. Same institution indicator is associated with equality in financial institution codes between two mortgages.

interval, and to the extent that assumptions are correct, the identification is stronger in nonliner models.

Starting with the linear probability model specification of 1:

$$y_{1,irt} = X_{it}^{'}\beta_{1X} + y_{1,irt-1}\gamma_1 + y_{2,irt-1}\gamma_{12} + Z_{rt}^{'}\beta_{1Z} + Y_t^{'}\beta_{1Y} + \delta_r + \mu_{j,i} + \nu_{1,irt}, \text{ for } i = 1, ..., N, t = 2, ..., T \quad (5)$$

and supposing that ν_{irt} is serially uncorrelated, the standard fixed-effects approach is to first difference 5 to eliminate $\mu_{j,i}$:

$$\delta y_{1,irt} = \Delta X_{it}^{'}\beta_1 + \Delta y_{1,irt-1}\gamma_1 + \Delta y_{2,irt-1}\gamma_{12} + \Delta Z_{rt}^{'}\beta_{1Z} + \Delta Y_{t}^{'}\beta_{1Y} + \Delta\nu_{1,irt}. \quad (6)$$

We apply the standard system GMM estimation, separately for mortgage interest rate type and mortgage term equations. This estimator allows for any type of heteroskedasticity, including that implied by the binary nature of the dependent variable; endogeneity of some of the regressors used as controls as well as pre-determined nature of other regressions, such as the lagged dependent variable.

7.2.3 Results

In Table 3, we report the results of estimation using the pooled GLS, the within-group estimator and the first-difference GMM estimator.

Focusing on the coefficient on the lagged mortgage contract first, columns (1) and (2), respectively, represent the upper and lower bounds on its estimates. The coefficients on the lagged mortgage choice in (4) and (5) fall within the range, but the former coefficient is still biased downward. The set-up of the bivariate probit model in (3)-(4) treats the lagged mortgage contract choice as an endogenous variable, and applies the same set of dependent variables as in the equation for the current choice. However, this approach does not go full length to examine the initial conditions problem, which would lead to the bias relative to the results obtained in column (5).

Looking at the estimates from the bivariate model, we find positive and statistically significant coefficients on the current mortgage spread both for the current and preceding mortgage, however, the coefficient in (3) is larger and significantly different from the coefficient in (4), suggesting that current spread is more important in the "initial" mortgage choice, such as that associated with home purchase. In column (5) we find positive and significant coefficients on the current mortgage spread, commensurate with that in column (4). Estimated coefficients on other controls for local conditions are of expected sign, in particular, positive for the wage and employment growth over the

Table 3: System GMM of Household mortgage choice

	Pooled GLS	Within-group estimator	Bivariate probit		System GMM (FD)
			y_{t-1}	y_t	
	(1)	(2)	(3)	(4)	(5)
y_{t-1}	0.36*	-0.30		0.05	0.24*
current mortgage spead	0.03	0.04	0.09*	0.05**	0.04***
long-term spread	-0.01	0.15**	-0.01	-0.01	-0.00
house price growth	0.17	-0.37	0.41	0.23	0.02
age	0.02	-0.47	0.07	0.08	0.05
log income	0.02	-0.11	0.07**	0.05	0.03
log mortgage	-0.05*	-0.05	0.03	-0.04**	-0.04***
log financial assets	0.01	-0.01	0.01	0.01	0.00
empgrowth	0.04**	-0.02	-0.03	0.03	0.03**
urate	-0.00	-0.15**	-0.02***	-0.01	-0.00
wagegrowth	0.01	0.11*	0.01	0.00	0.02
lagged term	0.00	-0.01		-0.00	0.02
AR(1) test					-1.92**
Sargan test					11.34
Hansen test					12.84
Sample size	953	953	881	881	953

Both *long spread* and *house price growth* are constructed as backward-looking averages over horizons of between 1 and 3 year, the results in the table are reported for a 1-year horizon. *empgrowth* and *wagegrowth* refer to regional average employment and wage growth rates over the past three years, *urate* refers to average unemployment rate over the past 12 months. *lagged term* is a dummy for the longer than three-year term of previous mortgage contract. *, **, and *** refer to 1-, 5- and 10% significance levels.

preceding three years and negative for the rate of unemployment in the previous year. Focusing on column (5) results using the GMM estimator, where mortgage amount, financial assets and the length of the previous mortgage term are treated as endogenous, we find positive but not statistically significant coefficients on income and age (measured by the age of the head of household) variables. The coefficient on mortgage size is negative and statistically significant, while coefficient on financial assets is positive, but just outside of the threshold for significance. These is also no evidence either from the serial correlation tests or from the Sargan test that the simple AR(1) model is mis-specified.

To provide some suggestion behind the economics of state dependence we also consider if there are differences between home purchase vs. renewal and refinancing originations, and whether results differ depending on whether households change their relationship with their financial institution in the process of renegotiation. State dependence appears to be of greater importance for renewal originations and is related to the borrower's relationship with their lending institution.

Given that we are unable to use weights provided in the CFM for its panel component, we test the results obtained in our micro-data using an alternative data source on VRM shares in total activity originations and their components from the five largest Canadian chartered banks. As discussed earlier, we would like to see if household "inertia" may lead to dependence in VRM share in renewal originations on the lagged VRM share in new home purchase and refinancing originations, as well as whether mortgage determinants may have different importance across these components of total activity originations.[34] The last exercise mirrors somewhat the bivariate probit model used to obtain estimates reported in columns (3) and (4) with respect to the differential importance of mortgage determinants for the original and subsequent contract choices.

[34]There is a difference between our borrower and bank-level data in that we observe joint renewal and refinancing originations in the former, and joint home purchase and refinancing originations in the latter. This is an artifact of data limitations in both of our datasets.

8 VRM Shares in Components of Total Originations

Our results using a small panel of repeated originations suggest inertia in borrowers' contract choices. To test their representativeness, we are interested in the relationship between aggregate counterparts of individual choices, such as VRM share in aggregate renewal originations and its lag in new originations, largely associated with home purchases (but also containing mortgage refinancing). By comparison to renewal originations in the chartered-bank data, the set of repeated originations on which the borrower-level analysis was carried out includes not only renewals, but also repeated home purchases and refinancings. The two sets are thus comparable, but not exactly equivalent.

Before we assess this relationship directly, following Badarinza, Campbell, and Ramadorai (2014), we consider specifications with only an own lag of dependent variable for specifications with VRM shares in total originations, as well as in new and renewal originations separately.[35] In the results reported in Table 4, a coefficient on own lag of dependent variable is at least 0.9 in all types of originations. Current and long-term cost minimization motives are important for VRM share in renewal originations (in the case of $T = 3$ horizon), while current spread is important for new originations across all horizons. We keep the house price growth variable in line with the discussion of the effects of including dual-rate VRMs into the set of mortgage choices.[36]

Continuing with the analysis of the components of total activity originations, in Table 5 we report estimation results where we introduce a lag of VRM share in new originations into the renewals specification. As in the results of the borrower-level analysis reported earlier, we find a positive and significant coefficients on the lags of

[35] Badarinza, Campbell, and Ramadorai (2014) find a high degree of autocorrrelation in total originations' VRM share using monthly data. They associate such high persistence in VRM share with slow adjustment in household expectations of interest rates, borrower peer effects as well as slow adjustment in lender mortgage offerings.

[36] The results are similar when we omit house price growth variable.

Table 4: Regression results for the model of VRM share in total originations and their components

	ρ	β_C	β_L	β_{HP}
	Backward-looking household rules			
	Total mortgage originations			
K=1, T=1	.93*	.02*	-0.00	.21***
K=2, T=2	.89*	.02*	.01	.21*
K=3, T=3	.90*	.02*	.01	.1***
	Total purchase and refinancing originations			
K=1, T=1	.92*	.02*	-.01	.25**
K=2, T=2	.88*	.03*	.00	.26*
K=3, T=3	.90*	.02*	.01	.11***
	Total renewal originations			
K=1, T=1	.95*	.01	.00	.16
K=2, T=2	.93*	.01	.01	.13
K=3, T=3	.92*	.01***	.01**	.06

Note: The dependent variable and interest rate differentials in all specifications are constructed as weighted averages across the five largest chartered banks in Canada over the period between November 1999 and June 2014 at monthly frequency. Prior to 2005, our data include only two banks, and data for all five banks are available post-2007. ρ is the coefficient on the 1-month lagged mortgage share; β_C, β_L and β_{HP} refer to current and long-term mortgage spreads coefficients, and house price growth, respectively.

new VRM share between 24 and 36 months, which generally correspond to an effective average length of the mortgage term.[37]

[37]This effective term is a function of the initial distribution of mortgage contract terms, as well as borrowers' effective prepayment of their mortgages leading to an early contract termination.

Table 5: Regression results for VRM share in renewal originations

	ρ^{renew}	ρ_L^{renew}	ρ_L^{new}	β_C	β_L	β_{HP}
	Backward-looking specification					
K=1, T=1	.95*			.01	.00	.16
K=1, T=1, L=36	.82*	.01	.13***	.04**	-.01	.46*
K=1, T=1, L=32	.82*	-.01	.16**	.05*	-.02	.43*
K=1, T=1, L=28	.87*	-.08	.17*	.04*	-.01	.18
K=1, T=1, L=24	.92*	-.10	.14**	.03***	-.01	.02

Note: The dependent variable and interest rate differentials in all specifications are constructed as weighted averages across the five largest chartered banks in Canada over the period between November 1999 and June 2014 at monthly frequency. Prior to 2005, our data include only two banks, and data for all five banks are available post-2007. ρ refers to the coefficient on 1-month lag of VRM share in renewal originations (dependent variable), ρ_L^{new} and ρ_L^{renew} are coefficients on lags of lengths L in months for VRM shares in new and renewal originations, respectively. T and K refer to the lengths of forward- and backward-looking horizons in years for the purpose of constructing long-term interest cost differentials. β_C, β_L and β_{HP} refer to current and long-term mortgage spreads coefficients, and house price growth, respectively.

9 Conclusions

In this paper, we have presented some evidence of the effects of state dependence on individual household mortgage choice in repeated originations, accounting for unobserved heterogeneity. We have also provided an informal discussion regarding the economic sources of this state dependence, potentially associated with costs of searching and switching to a different interest rate type product, as well as learning costs. A necessary limitation of our analysis is that we cannot properly control for supply factors associated with lenders' changes in the mix of products or non-price related incentives offered to borrowers, given that we only use price variables.

We include in the set of repeated originations mortgage renewals and refinancings, as well repeated home purchases. The former two types of originations arise from the short-term nature of mortgages relative to the period to amortization, and provide borrowers with an opportunity to renegotiate their existing contracts without changing the quantity of housing assets. While renegotiation allows borrowers to change their interest rate type and other terms, the timing of a large fraction of renewals and refinancings

is largely pre-determined by the initial borrower's decision regarding the length of their mortgage term. While early refinancing can happen from time to time, its incidence is usually limited. This is in contrast to many previous analyses of interest rate refinancing with long-term fixed rate mortgages and no prepayment penalties, which have focused on its optimal timing.

In the economy-wide context, persistence in household mortgage choice has been invoked by Badarinza, Campbell, and Ramadorai (2014) who find very high first-order correlation over short horizons in VRM share in total mortgage originations, which they suggest can be attributed to slow adjustment in household expectations of interest rates as well as lender inertia in terms of their product offerings (the period of observation in their analysis is a calendar month). However, our results both in the borrower and aggregate-level data suggest a mechanism for the longer-term persistence in VRM share. This mechanism is not specific to short-term mortgage contracts, as even in the case of refinancing long-term mortgages to a lower interest rate borrowers can choose any type of mortgage, not only a fixed rate mortgage with a lower rate, similar to the earlier discussion based on Chambers, Garriga, and Schlagenhauf (2007).[38]

From the point of view of aggregate implications, inertia or switching and searching costs at renewal can be costly for households who remain with their mortgage contract. These factors can also affect the effectiveness of the monetary policy transmission, even when mortgage terms are relatively short, and worsen it futher when mortgage terms are as lengthy as the period to amortization, amplifying the effects of errors of omission.

[38] Koijen, Van Hemert, and Van Nieuwerburgh (2009) also consider the role of their backward-looking rule for refinancing originations, primarily associated with extracting home equity and lowering an interest rate in effect. However, they do not consider additional aspects of these mortgage decisions, as they group together ARM-to-FRM, FRM-to-ARM and FRM-to-FRM refinancing.

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Appendix

A History of Variable Rate Mortgages in Canada

In Canada, a variable rate mortgage contract was first introduced in the early 1980s, with the purpose of alleviating problems with the supply of housing finance through shifting at least some of the risks faced by financial institutions to borrowers.

Two main options for the management of risks associated with variable rate mortgages were considered: (i) an interest rate capper mortgage, limiting within-the-term interest rate increases passed on to the borrower and priced accordingly relative to the fully variable rate mortgage; and (ii) a dual-rate mortgage, fixing regular mortgage payments for the length of the term, as with FRM, but with an interest cost component varying with a benchmark rate, such as prime lending rate.[39] In practice, both solutions co-existed over part of the period since the VRM introduction, but during the 2000s interest rate caps on variable rates have been mostly replaced with an option delegated to a household to lock in a fixed mortgage rate for the remainder of the term, allowing protection from any future interest rate increases.

The conversion may take place at different points in time, determined by household tolerance of the pace of rate increases, although there are certain requirements on the remaining minimum length of the term and some differences between switches taking place prior to and after the end of the first three years with the lender. Unlike at renewal, conversion to FRM can only take place with the original lender, thus a new fixed mortgage rate offered to a household (such as a posted fixed rate) would likely transfer all of the surplus from conversion to a lender. The difference between conversion and a constant level of regular payments under a dual-rate VRM, is that the former

[39] In the case of an interest rate capper mortgage, the lender would absorb any losses associated with increases in mortgage rates beyond the level of the cap, thus still sharing some of the associated risk of interest rate fluctuations.

puts a cap on any future interest rate increases, while under the latter only regular mortgage payments are capped and accumulated unpaid principal resulting from any further interest rate increases would have to be repaid later.

B Bank-level Data

For five out of the six largest chartered banks in Canada we have monthly data on the composition of originations between fixed and variable rate mortgage contracts, as well as monthly averages of posted fixed and variable interest rates.

B.1 Data on Quantities

Four banks in our data are identified as originating predominantly dual-rate VRMs, and one - standard VRMs. Several of the banks also offered other variable rate mortgage products throughout 2000s; however, these were largely legacy products carried over from the period of high inflation, and did not receive significant take-up due to a lack of competitive pricing. Amongst these products are rate capper mortgages, as well as open variable rate mortgages, which allow unlimited prepayment of a mortgage within a term.

Mortgage series available for each bank refer to the total of their originations and two components classified as mortgage renewals with the same financial institution and all other. The majority of the other category is comprised by home purchase and refinancing originations, with the balance accounted for by mortgages switches from other financial institutions at renewal. Given that there is no contractual requirement to continue a relationship with the same bank at the expiration of the first or any consequent term, a household can choose to switch their lender.[40]

[40] Allen, Clark, and Houde (2014) provide a detailed characterization of the negotiation and renegotiation process in Canada and its effect on mortgage pricing.

The latter decision balances the benefits of lower interest rates with costs of searching for a new lender, including the time invested into the process and the costs of re-applying associated with mortgage application, title search, home appraisal, legal and other fees. All of these are not required for a mortgage rollover with the same financial institution, which happens largely automatically, conditional on good payment history over the term. In particular, mortgage rollover is not affected by changes in home value, which could be a main impediment for approval if a household were to re-apply for a mortgage with a different financial institution following an episode of a house price decline that raises substantially the property's LTV ratio.[41]

B.2 Data on Prices

Our interest rate data consist of posted fixed and variable mortgage rates for each financial institution in the sample. One bank also provided a series on effective mortgage rates, which represent a weighted average of posted and discounted rates applied to total activity originations. An alternative source of data on both fixed and variable mortgage rates is from the internet-based ING Bank for the period preceding its takeover by the Scotiabank.[42] Unlike other large chartered banks, ING did not use a two-tier system as its quoted rates represented actual borrowing rates charged to households who qualified for a mortgage. As a result, they would be equivalent to some measure of discounted rates offered by other institutions. In the absence of information on the proportions of mortgages originated at different interest rates, our benchmark analysis uses posted

[41] If a household, whose renewal LTV jumped above 80%, also had to take out mortgage insurance, despite having had a pre-renewal LTV ratio of less than 80%, this would most likely outweigh any benefits of a transfer. If a household found themselves under water, they would not be able to get an approval at a different financial institution at all. Over the period studied, Canada, however only experienced short episode of small house price decline during the recession of 2008-2009.

[42] After the take-over there appears to be a structural break in the ING series, as the bank's pricing strategy may have changed, potentially to differentiate between products offered by the two institutions.

mortgage rates. But for robustness purposes we also consider alternative rate series based on different assumptions regarding shares of posted vs. discounted originations, and ING effective interest rate series.

B.3 Weighted Data Series

While we have information for five individual chartered banks, for confidentiality reasons and given the different time periods for which these data are available, we create three weighted series of VRM shares in "total activity", "new" (purchase/refinancing) and renewal originations, and two interest rate series. The data on VRM shares used in this paper are unique in that they constitute the longest time series for Canada for total activity originations, and their components in new (purchase and refinancing) and renewals originations. The shares are constructed relative to the universe of all fixed rate mortgages, which have generally been offered at terms between 1 and 5 years. Amongst these mortgages five-year terms have remained the most popular over the period under consideration. The interest rate data series are for the five-year fixed and variable mortgage rates, both posted.

C Behaviour of VRM Share: Descriptive Analysis

In this section, we provide support for the use of mortgage choice determinants as controls in the main borrower-level analysis as well as in specifications with VRM shares in components of different types of mortgage originations.

C.1 VRM Shares Comparison with the CFM

In Figure 1 we plot VRM share in total activity originations, using weighted average of the data from the five largest chartered banks until 2014, spliced with OSFI data

corresponding to the same set of lenders after that.[43]

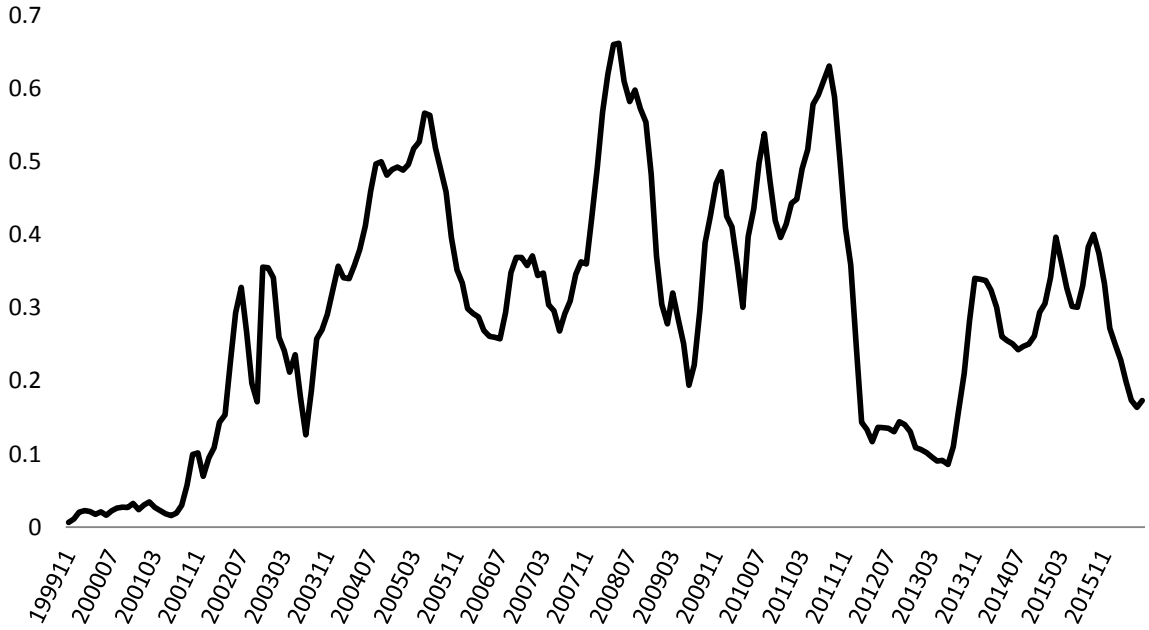

Figure 1: Weighted average VRM share in total mortgage activity originations of five largest Canadian chartered banks spliced with OSFI VRM shares, 1999-2016

The correlation between the chartered bank series and those for all financial institutions constructed using CFM using the above mentioned approach are about 70 percent. Both sources display substantial degree of variation in VRM share, ranging between 1 and 70 percent over the period studied. There are several relatively large movements in VRM share, including during 2011, which we analyze when looking at the comovement of the VRM share with interest rate differentials and house price growth discussed in Subsection C.3.

Figure 2 shows the relationship between weighted VRM share for the five largest Canadian chartered banks and weighted VRM share in total mortgage originations constructed using CFM data for the these institutions for the period ending in 2014.

[43]Official statistics collected by the Office of the Superintendent of Financial Institutions for the share of fixed versus variable rate mortgages in total activity originations include all federally regulated banks, including the largest five, but go back only to 2010.

The CFM series can be matched to the latter series using financial institution affiliations reported in the CFM. Over the period before 2011, the VRM share in CFM is stable under different definitions of mortgage originations. Past 2011, CFM implied share is somewhat sensitive to the cutoff for the length of the relationship with a financial institution. We also note a substantial increase in volatility of VRM share constructed using CFM, which is associated with some reduction in the size of CFM sample that can be used in our analysis.

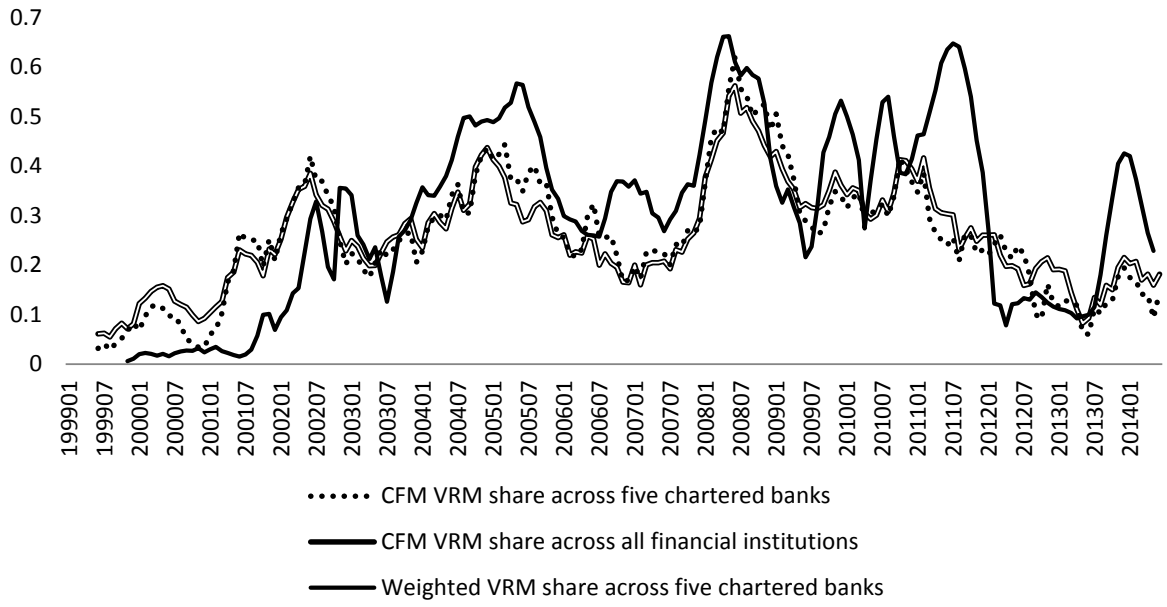

Figure 2: Comparison of VRM shares from CFM and the five largest Canadian chartered banks, 1999-2014

C.2 VRM Shares in Components of Total Originations using Chartered Bank Data

In Figure 3 using time series for the bank with the longest history of data, we find that VRM share in new originations exceeds its counterpart in renewals for most of the period under consideration, although the gap between the two series varies over time.

The picture is similar for the total of all originations, where we add one more financial institution in 2002 and the rest post-2005. In terms of the co-movement of components of aggregate VRM share, the contemporaneous correlation between VRM shares in new and renewal originations is on average around 70 percent.

In addition to contemporaneous correlation, we also consider correlation pattern between current VRM share in renewal originations and VRM share in new originations at different lags. The idea here is that in the presence of inertia one would be able to forecast the future evolution of VRM share in renewal originations using the past share in new originations, with the discrepancy relative to the actual data explained by changes in interest rates and other variables, to which borrowers may still respond. We find the hump-based correlation structure between VRM share in renewals and new originations, with the peak at about 58% at 36 months, which would roughly correspond to an average effective mortgage term over the period under study.

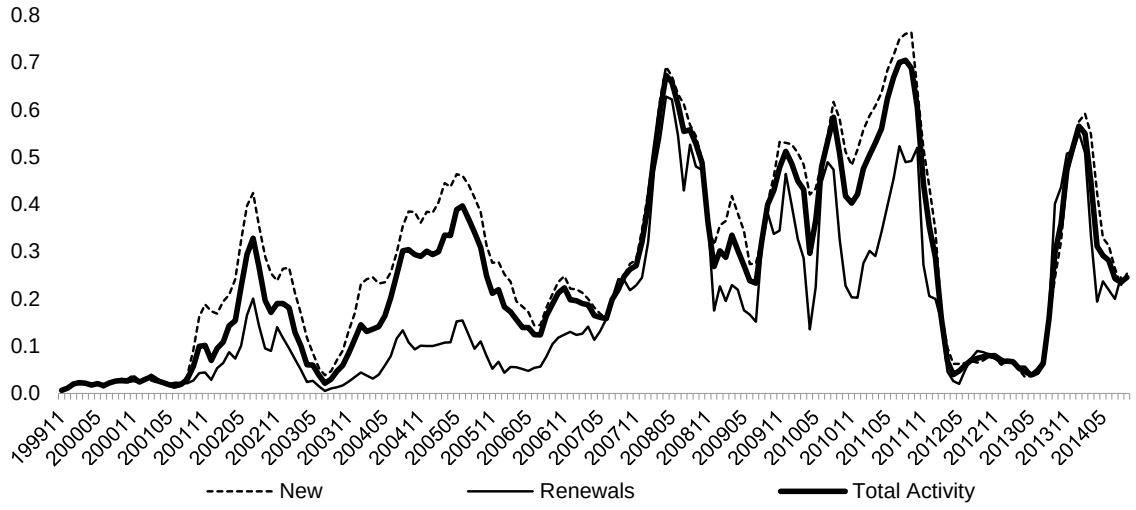

Figure 3: Time series of VRM share in total activity mortgage originations and their components for a chartered bank with the longest time series, 1999-2014

We formalize this analysis in the main body of the text.

C.3 Mortgage Choice and Interest Rate Differentials

We next overlay on the plots of the chartered-bank weighted average VRM share in total activity originations several measures of interest cost differentials analyzed previously in the literature and discussed earlier in Section 4.

In Figure 4 we focus on backward-looking rule for expected interest rate differential evaluated using posted mortgage rates and bond market data; and on the current mortgage rate spread in Figure 5. Relative to the 5-year fixed (long) mortgage rate, we use 1 to 3-year variable rate averages chosen to account for limited data availability and short-term nature of Canadian mortgage contracts.[44] We use data on posted rates for our benchmark results, and a number of alternative series for robustness checks.

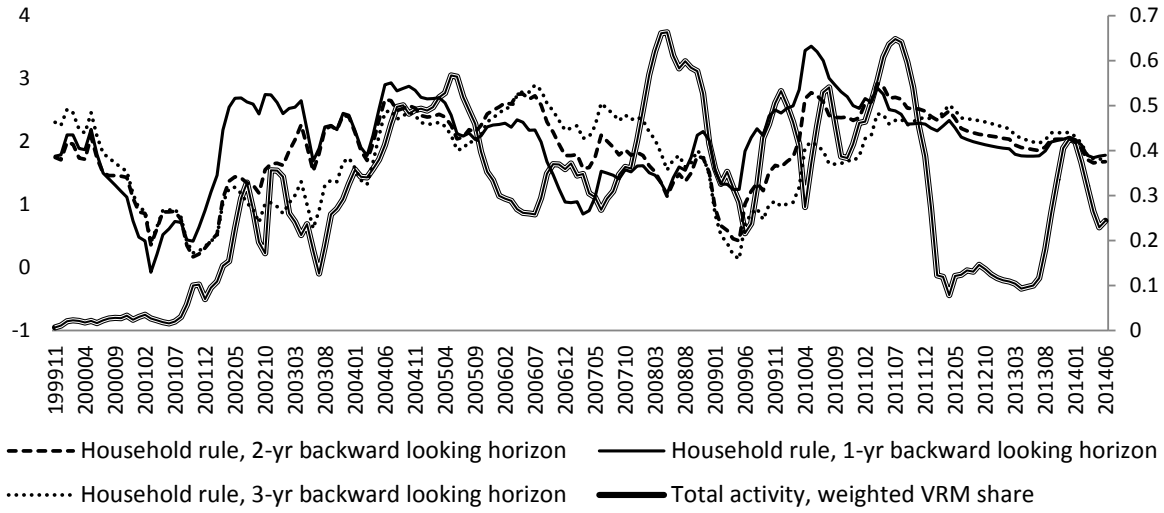

Figure 4: Weighted average VRM share in total activity and different measures of interest cost differentials, 1999-2014

The correlation of the weighted average VRM share in total activity originations is the highest with the 1-year backward-looking rule and the current spread. Corre-

[44]The three-year maximum horizon for a short-term interest rate average can also be explained by convertibility feature available with variable rate mortgage. This feature allows borrowers to change their mortgage type from variable to fixed rate, with the new term equal to the remaining period on the term - above a set minimum - and the new level of fixed rate determined by interest rate conditions at the time of mortgage conversion.

lations for two and three year horizons are both lower, and together correlations with backward-looking rules are significantly lower than those previously reported in Koijen, Van Hemert, and Van Nieuwerburgh (2009) for the US. Given that our total activity originations include not only home purchase originations, but also renewas and refinancing, we look at the components separately. When VRM share is considered only in new (home purchase/refinancing) originations, correlations increase by about 10 percentage points to 60%, and fall respectively for renewal originations.

Using data for one of the banks, where data on offered mortgage rates are available, we find correlation between weighted VRM share and backward-looking proxies of expected mortgage cost differentials of about 60 per cent, compared to two-thirds of this magnitude for posted rates. However, as mentioned earlier, the data for offered rates is difficult to obtain and is not available for all financial institutions. Their knowledge by a borrower would be a matter of obtaining quotes from individual institutions, or dealing with a mortgage broker who has access to mortgage rate offers from different lenders.

On the one hand, these lower correlations could reflect the fit of backward looking rules as previously discussed in Koijen, Van Hemert, and Van Nieuwerburgh (2009), but they could also be attributed to a series of regulatory changes aimed at tightening mortgage rules in Canada that started in mid-2008. These changes would have been most relevant for home purchase and refinancing originations and we discuss them in greater detail below.

Starting with the fit and the interest rate behaviour, we note that over the period between the late 2004 and 2006, as interest rates in Canada were normalizing, the backward-looking rule would have been too high, overstating the attractiveness of VRM mortgages, as their share in total originations was coming down. The opposite is true over the period between mid-2007 and mid-2008, when the backward-looking

spread does not match a substantial increase in VRM share. It is too low, given that it is based on previously higher level of interest rates and thus underestimates the attractiveness of VRM mortgage. In turn, forward-looking long-term spread would correctly incorporate an extended period of future low short-term rates, raising its level to match a simultaneous increase in VRM share.[45]

Post mid-2008 we find that movements in VRM share appear to be somewhat bigger than would be suggested by the movement in all spreads, likely contributed to by a series of regulatory changes. In mid-2008 and early 2011 these changes involved lowering the maximum amortization period for insured mortgages. These changes would have indirectly tightened qualification rules for borrowers interested in VRMs and possibly reduced their pick-up, however, the magnitude of the effect would have crucially depended on the prevalence of mortgages with these longer amortization periods.[46]

A more direct effect on qualification constraints could have resulted in mid-2010 from a change in the qualification rate itself. This rate was changed from a 3- to a 5-year benchmark fixed interest rate.[47] These changes would have been expected to have an immediate effect on the borrowers who were not able to adjust their purchase date or the amount of downpayment to avoid facing qualification requirements altogether. However, over time borrowers would have been expected to adjust to these changes.[48]

[45]The forward-looking spread is constructed using predicted value of future short-term interest rates as in Badarinza, Campbell, and Ramadorai (2014).

[46]Qualification rules in Canada apply to insured mortgages with loan-to-value ratios of over 80%. These rules set an interest rate used in evaluating the burden of debt service for the mortgage borrower. Prior to 2010, the qualifying rate on insured mortgages was a three-year posted fixed mortgage rate, meaning that VRM borrowers had to meet total debt-service-ratio (DSR) requirement at that rate as opposed to a variable rate itself. The regulatory changes of 2008 indirectly affected eligibility by requiring in each period larger regular installments due to principal payments relative to income.

[47]Note that the level of the qualification rate is set as a function of posted 5-year fixed rates set by the 5 largest chartered banks in Canada. The rates usually adjust with movements in the government 5-year rates as well as bank funding costs more directly. However, it is also possible that outside of these events banks could collectively adjust their posted rates to effect the benchmark rate and thus affect the tightness of qualification requirements. This would be a supply channel effect, whereby lenders can affect borrower incentives to take on variable rate mortgages and as a result VRM share in the aggregate.

[48]In Appendix E, we provide a informal assessment of the effect of qualification requirements by

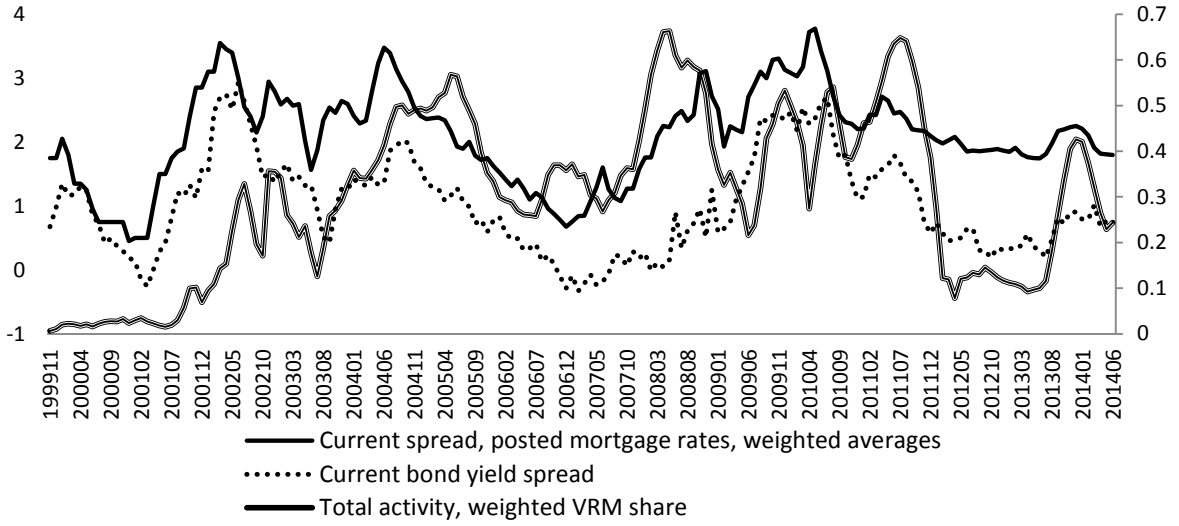

Figure 5: Weighted VRM share in total activity and different measures of current spread (1999-2014)
Note: Measures of the current spread are given by the difference between long- and short-term interest rates, and are constructed using mortgage and bond returns. We use posted returns only.

D Pooled Probit Results for a Multunomial Model of Household Mortgage Choice

We rerun the static pooled probit specification proposed in the main text with two types of variable-rate mortgages with fixed vs. variable installments (single- vs. dual-rate VRMs). Table 6 summarizes the results of the model with adaptive household expectations of future short-term interest rates.

We find that an increase in the current spread increases the probability of selecting a dual-rate VRM across all three specifications (using 1 to 3 year horizons on long-term and house price growth variables). Similarly, higher house price growth increases the probability of selecting either of the variable rate mortgages, but more so for the dual-rate VRM, across the longer-horizon specifications.

looking at the distribution of debt-service ratios of borrowers with new mortgages.

Table 6: Marginal effects from the multinomial probit model (using adaptive expectations approach)

	3-year	2-year	1-year
	Fixed-rate mortgage		
Mortgage type at $t-1$	-.15*	-.14*	-.15*
Current spread	-.03*	-.04*	-.03*
Long-term spread	.02	.02	-.01
House price growth	-1.11*	-1.06*	-.44***
	Single-rate VRM		
Mortgage type at $t-1$	.02*	.02*	.02*
Current spread	.01	.01**	.00
Long-term spread	.00	.01	.01
House price growth	.36***	.48*	.25**
	Dual-rate VRM		
Mortgage type at $t-1$	.13*	.12*	.13*
Current spread	.02**	.03**	.03*
Long-term spread	-.03**	-.02	-.01
House price growth	.76**	.59**	.19

E Household Mortgage Transitions with Two Types of Variable Rate Mortgages

Relative to the main text, here we draw a distinction between two types of variable rate mortgages - single and dual-rate VRMs - using a sample of repeated home purchase, refinancing and renewal mortgages held with either of the five largest chartered banks. Table 7 shows that absorption rates for dual and single-rate VRMs are generally similar to each other, and to the absorption rate for variable rate mortgages in the sample of all financial institutions in Table 2. Transition probabilities between single and dual-rate VRMs themselves are relatively small and correspond directly to a change in the financial institution-lender. However, these numbers do not reflect the full extent of household transitions between lenders and thus the set of mortgages considered by a household at mortgage origination.

To shed light on the question of institutional transitions, we look directly at the information on affiliations of the current and previous mortgage contracts in our panel

Table 7: Transitions between fixed and different types of variable rate mortgages in the panel of all financial institutions in the CFM, across all types of originations

	Fixed	Variable-single	Variable-dual
Fixed	85	4	12
Variable-single	37	58	5
Variable-dual	36	2	62

Table 8: Transitions across individual institutions in the sample of largest five chartered banks in the CFM

	Standard 1	Standard 2	Standard 3	Dual-rate	Standard 4	N obs.
Standard 1	82	3	5	7	3	150
Standard 2	3	79	10	5	2	178
Standard 3	3	8	82	5	2	209
Dual-rate	2	6	6	82	5	179
Standard 4	3	8	8	7	74	133

Table 9: Transitions between groups of financial institutions across different combinations of mortgage contracts

	Dual-rate VRM	Standard VRM
Panel A	All contracts	
Dual-rate VRM	0.94	0.06
Standard VRM	0.19	0.81
Panel B	FRM-to-FRM	
Dual-rate VRM	0.94	0.06
Standard VRM	0.17	0.83
Panel C	FRM-to-VRM	
Dual-rate VRM	0.88	0.12
Standard VRM	0.28	0.72
Panel D	VRM-to-FRM	
Dual-rate VRM	0.93	0.07
Standard VRM	0.31	0.69

sample of borrowers with the largest five lenders. We label them by their contract offering as standard or dual-rate. Unsurprisingly, at around 20%, the overall frequency of transitions measured directly across institutions reported in Table 8 is higher than that implied by 7.

We next break down overall transition statistics presented in Table 9 between different types of mortgage contracts – FRM-to-FRM, FRM-to-VRM and VRM-to-FRM.

Panel A reports overall transition rates. Panel B includes only households that do

not change their FRM contract. It suggests that 17 percent of households move their FRM mortgages from the standard VRM institution to the same contract in a dual-rate VRM lender, while 6 percent move their mortgage in the opposite direction. Thus, in either case, it would be likely that households who change lenders would be exposed to the full set of contracts available at the receiving end institution. Panel C summarizes FRM-to-VRM transitions. It suggests that 28 percent of households with an FRM from the standard-VRM institution convert their mortgage to a dual-rate VRM at one of the institutions offering this type of contract, and that 12 percent of households with FRM contract transition in the opposite direction. Lastly, Panel D reports transitions from any type of VRM to a FRM contract. 31 percent of households with a standard VRM take up a FRM contract at a financial institution offering dual-rate VRMs; while 7 percent of households with a standard VRM take up a FRM contract in the institution which offers dual-rate VRMs. Together these results suggest a non-negligible degree of mobility between institutions with standard and dual-rate VRMs either within the same type of contact - like FRM - or across different types of contracts - such as FRM and VRM.

Further, no change in a financial institution affiliation can also be an optimal outcome of the process involving search across lenders with an exposure to a complete set of mortgage contracts. Given our data we can only touch upon this question indirectly and in a very crude manner, by comparing average interest rates reported by borrowers who stay with the same financial institution with those reported by switchers. In this exercise, we only look at originations that maintain their contract type. Results presented in Table 10 suggest a reduction of 30 basis points on the interest rate charged on the subsequent mortgage contract for stayers, and 50 basis points for switchers, where the latter number needs to be measured against the background of switching costs, which include fees associated with home appraisal, mortgage application, title search,

Table 10: Relative fixed-rate mortgage cost reduction associated with a change in a financial institution

	$t0$	$t1$	$t1 - t0$
No change in financial institution	0.056	0.053	0.003
Change in financial institution	0.061	0.056	0.005

etc.

As a final step in the assessment of an effective set of mortgage contracts available to households, we also provide a simplified analysis of qualification constraints that may limit household choice to fixed rate mortgages, as discussed earlier. In particular, we compare levels of realized debt-service ratios on FRM contracts to their values implied by a qualification rate in effect in a given period. If the debt-service ratio at a chosen level of debt and an effective qualification rate exceeds the required cut-off, a household will be constrained to a 5-year FRM only.[49] The simplifying assumption in this exercise is that only the type of contract adjusts if the qualification requirement for a variable rate mortgage is not met. A more appropriate way of approaching this question would be to take into account joint determination of a value of a home purchased, amount borrowed and mortgage contract type, where a household could trade off the cost of borrowing at lower variable rates against the lower mortgage debt and possibly less expensive home or higher downpayment. That in turn would require solving a problem of joint determination of debt and savings. Given its complexity, we do not pursue this approach here.

The moments reported in Table 11 include the average and the median values of the DSR distribution for new fixed rate mortgage originations implied by qualification rates. The DSR distribution, as expected, is skewed to the right, with the mean value exceeding the median. The distance of the average and median values from the quali-

[49] We do not distinguish here between insured and uninsured mortgages, given that lenders can use discretion in applying these qualification rules to uninsured mortgages as well.

Table 11: Average and median values of the DSR ratio distribution for fixed rate mortgages implied by qualification requirements, %

	mean	$p50$
dual-rate VRM		
effective	0.09	0.07
posted	0.13	0.10
single-rate VRM		
effective	0.10	0.08
posted	0.15	0.12
any VRM		
effective	0.12	0.10
posted	0.15	0.12

fication rule cutoff for DSR (currently at 44 percent) provide an indirect indication of how important these may be.[50]

F Summary of Household Characteristics under Different Mortgage Contracts

Statistics reported in Table refer to a sample of pooled CFM cross-sections are constructed using observations for borrowers with a mortgage term with their financial institution of less than 12 months. In this case, a financial institution is identified as one of the largest five banks.

In turn, Table 13 reports household characteristics for the subsamples of fixed and all variable rate mortgages, with a further break-down by type of mortgage origination, including purchases, refinancing, remortgaging and renewal. The numbers of observations reported in the table do not coincide with those reported in the text, given that here we are using a finer classification of types of mortgage originations, adding

[50] A more direct approach would be to report a fraction of mortgages whose DSR ratio using a qualification rate exceeds the maximum allowed. Using this approach, we also confirm that qualification rules do not significantly constrain household mortgage choice. This also relates to the previous discussion of the role of qualification requirements in affecting the relationship between VRM shares and interest rate differentials, such as current and backward-looking long-term interest rate spreads.

Table 12: Summary of household characteristics for dual-rate VRM, standard VRM and VRM (pooled CFM cross-sections)

	m_t	LTV_t	DIR_t	inc_t	Age	Hhd. size	Educ.	Freq.
Panel A	Fixed-rate mortgage							
1999	90727	0.61	1.61	76218	39	2.92	3.76	560
2002	100082	0.64	1.75	77532	41	2.85	3.95	235
2005	132764	0.64	2.05	81365	40	2.93	3.94	185
2006	130558	0.62	2.30	78373	42.5	2.7	3.91	169
1999-2007	108866	0.63	1.91	76617	40	2.87	3.78	2,392
2008	160361	0.65	2.94	81660	39	2.49	4.32	130
2009	149236	0.63	2.21	88283	41	2.61	4.20	115
2010	157046	0.57	2.72	80295	45	2.44	3.58	178
2012	179628	0.69	2.67	89478	43	2.56	3.53	117
2010-2014	162673	0.66	2.63	84535	45	2.48	3.89	632
1999-2014	122737	0.64	2.10	78742	41	2.77	3.84	3,269
Panel B	Standard VRM							
1999	120833	0.77	2.36	61667	32	3.3	3.7	13
2002	83939	0.50	1.87	84999	49	2.8	4.2	13
2005	119091	0.58	1.82	89500	45	2.5	4.1	35
2006	159365	0.67	2.35	95781	44	2.9	4	16
1999-2007	107414	0.57	1.81	85551	46	2.75	4.03	118
2008	191750	0.60	2.34	108333	44.4	2.7	4.7	10
2009	188751	0.82	3.70	85313	44	2.4	4.28	25
2010	171719	0.61	2.6	87000	42	2.38	4.88	16
2012	140165	0.56	2.27	87333	43	2.56	3.53	117
2010-2014	160109	0.55	2.49	90446	44	2.72	2.74	57
1999-2014	135416	0.60	2.24	87838	45	2.7	3.74	210
Panel C	Dual-rate VRM							
1999	75563	0.60	1.52	80673	41	3.35	3.9	26
2002	109162	0.59	1.54	89660	41	2.95	4.3	104
2005	154153	0.58	2.37	88479	43	3	4.0	98
2006	117425	0.53	2.13	78367	47	2.82	3.96	50
1999-2007	118629	0.56	1.91	86557	44	2.98	4.10	551
2008	150911	0.58	2.64	79492	48	2.5	4.38	59
2009	158703	0.55	2.29	96270	46	2.70	4.39	61
2010	157403	0.578	2.63	83509	46	2.31	4.16	58
2012	182390	0.51	3.26	88707	46	2.34	4.54	29
2010-2014	168549	0.57	2.78	88483	46	2.31	4.43	176
1999-2014	134137	0.56	2.17	87163	45	2.79	4.21	847

Note: The sample includes all mortgage observation meeting the above mentioned criteria for the period between 1999 and 2014, without missing values for any of the variables of interest. m_t refers to amount of balances outstanding, LTV_t refers to loan-to-value ratio, DIR_t is the debt-to-income ration, inc_t refers to total before-tax household income, $Hhd.size$ refers to household size, and $Educ.$ refers to education with higher level of education associated with a higher numerical value.

Table 13: Summary of household characteristics by type of mortgage activity and type of interest rate (CFM panel sample, all financial institutions)

	Fixed-rate mortgages					All variable-rate mortgages				
	m_t	LTV_t	DIR_t	inc_t	Freq.	m_t	LTV_t	DIR_t	inc_t	Freq.
Panel A	1999-2007									
Purchase	125043	0.63	1.49	72960	369	131874	0.52	1.27	79632	103
Refinancing	127967	0.65	1.65	74253	255	137400	0.62	1.65	81454	99
Remortgaging	85913	0.48	0.55	72759	177	93989	0.49	0.44	82222	82
Renewal	92918	0.61	1.95	71720	500	94685	0.52	1.90	78601	172
Panel B	2008-2009									
Purchase	191458	0.57	1.41	84632	34	159292	0.46	1.51	78281	16
Refinancing	161415	0.58	2.11	77877	53	158950	0.62	1.57	96216	37
Remortgaging	152708	0.34	0.29	80882	17	178594	0.39	0.33	88750	17
Renewal	103311	0.43	2.22	75742	66	131308	0.46	1.96	91012	43
Panel C	2010-2014									
Purchase	171614	0.59	2.26	74938	40	181177	0.43	0.99	91176	17
Refinancing	176067	0.61	2.22	81803	65	196444	0.53	1.84	93750	32
Remortgaging	148279	0.56	0.48	71689	38	117024	0.33	1.16	60500	21
Renewal	129483	0.53	2.57	77933	129	139149	0.70	2.98	84455	57
Panel D	1999-2014									
Purchase	134346	0.62	1.55	74047	443	141262	0.50	1.26	80926	136
Refinancing	141102	0.63	1.82	76041	373	153393	0.60	1.67	87081	168
Remortgaging	101023	0.48	0.52	73191	232	110004	0.45	0.55	79402	120
Renewal	100692	0.58	2.09	73241	695	109793	0.55	2.14	81783	272

Note: This sample only includes mortgages from a panel component of CFM. Due to a small number of observations we only distinguish between all variable and fixed-rate mortgages. m_t refers to mortgage balances outstanding (proxying for the amount taken out according to the mortgage contract); LTV_t refers to the loan-to-value ratio on the mortgage; DIR_t is the debt-to-income ratio; and inc_t refers to household income.

remortgaging. The latter refers to households obtaining a mortgage where they had none in the previous period, such as reverse mortgages.