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The Impact of Macroprudential Housing Finance Tools in Canada*

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Abstract

This paper combines loan-level administrative data with household-level survey data to analyze the impact of recent macroprudential policy changes in Canada using a microsimulation model of mortgage demand of first-time homebuyers. Policies targeting the loan-to-value ratio are found to have a larger impact on demand than policies targeting the debt-service ratio, such as amortization. In addition, we show that loan-to-value policies have a larger role to play in reducing default than income-based policies.

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*This version: March 27, 2017. This paper was produced as part of the BIS Consultative Council of the Americas (CCA) research project on "The Impact of macroeconomic policies: an empirical analysis using credit registry data" developed by the CCA Consultative Group of Directors of Financial Stability (CGDFS). Correspondence: Jason Allen: jallen@bankofcanada.ca. Timothy Grieder: tgrieder@bankofcanada.ca. Brian Peterson: petb@bankofcanada.ca. Tom Roberts: robm@bankofcanada.ca. The views in this paper are those of the authors and do not necessarily reflect those of the Bank of Canada. All errors are our own. We have benefited from comments provided by Gabriel Bruneau, Gino Cateau, Ricardo Correa, Leonardo Gambacorta, Lu Han (discussant), Seung Jung Lee, Chris Mitchell, Miguel Molico, Yasuo Terajima, Alexander Ueberfeldt, as well as members of the BIS CGDFS working group.

1 Introduction

Since the global financial crisis, macroprudential housing-finance tools have been increasingly utilized to reduce financial system vulnerabilities related to housing market imbalances (Galati and Moessner (2012) and Claessens (2015)). For instance, many countries in Europe, Asia, and the Americas responded to imbalances in their domestic housing markets, in part by tightening credit limits. Despite broad-based implementation, the effectiveness of such policies are not well understood. This paper attempts to fill this gap by analyzing loan-level data on first-time homebuyer (FTHB) mortgage choices in Canada over a period of changing macroprudential regulation. To quantify the aggregate impacts of macroprudential policy on borrower behavior and the dynamic responses of total credit, we propose, calibrate, and implement a microsimulation model of mortgage demand.

Macroprudential policy can directly affect household borrowing through wealth and income constraints by limiting or expanding access to the mortgage market. The macroprudential tools we analyze include changes to the maximum allowable amortization and the maximum allowable loan-to-value (LTV) ratio. Changes to amortization affect how much of a household's income is directed to its monthly mortgage payment. Between 2006 and 2007, we observed that the maximum allowable amortization period increased from 25 to 40 years. This is followed by a similarly-sized tightening in 2008. The second macroprudential change was to the LTV ratio, which is closely related to wealth. A relaxation of the LTV requirement allows individuals to enter the housing market with less financial wealth, while a tightening has the reverse effect. In 2006, regulatory changes were made to allow for 100% LTV loans, up from 95%. The LTV was tightened back to 95% in 2008.[1]

The first contribution of this paper is to present descriptive evidence of the impact of changes in Canadian macroprudential housing-finance policy on household demand for mortgage credit using detailed data on FTHB mortgage contracts. Our data cover the period 2005 to 2010, during which macroprudential tools were both loosened and tightened and when the housing market experienced a prolonged boom followed by a short bust and a long rebound. Institutional features of the Canadian mortgage environment—the fact that by law, mortgage insurance is required on all high LTV mortgages, and that this insurance is backed by the federal government—allows us to focus on the effectiveness of macroprudential tools without modeling the endogenous supply of credit, which hampers most empirical work in this literature. Given that mortgages are fully insured by the government, lending is free

[1] According to the IMF (2013), LTV constraints appear to be the most popular macroprudential tool used by authorities to manage demand for household credit.

of default risk allowing us to assume credit is supplied elastically and that any impact from macroprudential policies is driven by demand and the effect of the policies on households' borrowing constraints.

There are two main results from our analysis of the loan-level data, which are easiest to interpret if we assume that households target a fixed mortgage payment. That is, households budget a fixed percentage of their income towards housing in the same way that they budget for consumption, savings, etc.[2] First, we find that on average, households are more constrained by savings (wealth) than monthly cash flow (income). A key observation is that only a small fraction of households take advantage of the longer allowable amortization to lower their monthly payments. Most choose larger mortgage payments. This suggests that the majority of FTHBs were not constrained by income.

We do observe, on the other hand, a substantial increase in the fraction of households with no more than 5% equity at origination as the LTV constraint is loosened. Given that most households have sufficiently high income to make their mortgage payments, their demand for credit increased as the LTV constrained was loosened. Once the LTV constraint is loosened, most households are able to increase leverage and make the larger monthly mortgage payments they desired. The results we obtain during the tightening period are similar: as the government lowers the maximum allowable amortization length and LTV there is a greater fraction of borrowers at the maximum allowable LTV. FTHBs make larger down payments as a fraction of their income as house prices continue to rise, but more households are at the LTV constraint. We also observe a decrease in average monthly payments, driven by accommodating monetary policy. However, the total debt-service ratio remains flat, indicating that non-mortgage debt is higher. If households could borrow more they would, further highlighting the role of the LTV constraint.

Although our descriptive analysis of the observed choices of consumers provides valuable insight, it is difficult to quantify the impact of a change in an income constraint or wealth constraint on consumer choice. It is also difficult to conduct scenario-analysis – experiments we might be interested in include the impact of monetary policy shocks or a house price correction on demand. Individuals are sorting themselves along several dimensions, for example, housing choice, in addition to the different mortgage contract options. Furthermore, the macroeconomic environment, including monetary policy, is changing throughout our

[2]Although not strictly necessary, it is helpful to think of households choosing to budget in fixed proportions. Gorman (1964) shows when this is optimal (utility is additively separable) and Davis and Heathcote (2005) provide evidence that this was at least true in the U.S. over the period that they study (1984–2001), justifying Cobb-Douglas utility over housing, consumption, and leisure.

sample. Our second contribution, therefore, is to use a microsimulation model of mortgage demand to summarize the quantitative impacts of the changes in macroprudential policies on FTHB mortgage demand. We label this model HRAM, which stands for Household Risk Assessment Model. This model imposes some structure on how we interpret the data while still being highly flexible in capturing nonlinear responses that more traditional, rational forward-looking dynamic general equilibrium models generally have difficulty capturing.

The model imposes the following structure: there is a set of heterogeneous renters and homeowners. Every period a renter can qualify to become a homeowner if they have enough income and wealth to afford a house. This depends on the renter's characteristics as well an exogenous process for their income, financial assets, regional house prices, and the macroeconomic environment. The model, therefore, is not one with optimizing households. The probability that a renter in the survey data qualifies for and purchases a house, however, is chosen to match the loan-level data based on the joint distribution of income and mortgage-payment-to-income (PTI) and LTV ratios. When the government changes access to mortgage insurance it affects the probability of renters qualifying to become homeowners and whether or not they purchase a house. Using the model, therefore, we can map the impact of a policy change on the percentage of FTHBs who have sufficient wealth to enter the market, whether they purchase a house, and their demand for credit.

The results of our microsimulation model suggest that the wealth constraint has the largest impact on the number of FTHBs who enter the housing market. However, for FTHBs who have accumulated wealth, changes to the income constraint can also be substantial. This is because, conditional on income, high-wealth individuals are much more likely to own homes than low-income individuals. For example, we find that the tightening of the LTV constraint from 100% to 95% led to a 51% decrease in loan qualifications, a 7.9% decrease in FTHBs, and an 8.1% decrease in mortgage debt. We observe a 4.8% decrease in loan qualifications, a 3.6% decrease in FTHBs, and a 7.2% decrease in mortgage debt following a tightening in the amortization from 35 to 30 years. The impact of tightening the LTV is more than 10 times larger on qualifying to purchase a starter home, and the change in the number of FTHBs is larger following a change in LTV; however, the average mortgage size falls by about the same amount following changes in LTV and amortization. We also conduct several interest rate experiments that allow us to test the vulnerability of households to rate changes. We examine the impact of an unexpected 200 basis point increase in interest rates under different macro-prudential scenarios. The goal is to measure the relative importance of LTV versus PTI policies at mitigating household risk. We find that household arrears are lower in an environment with tight LTV but loose PTI policies compared to an environment with loose LTV but tight PTI policies. This further suggests that LTV policies are the most relevant for Canadian households.

This paper is related to the nascent but growing literature on the impacts of macroprudential tools on households, financial institutions, firms, and the aggregate economy. Using Korean data, Igan and Kang (2011) find house prices and transactions respond to changes in LTV, although not leverage. Han et al. (2016) study the Canadian market and the one million dollar cap on mortgage insurance implemented in 2012. They conclude that for macroprudential policy to be effective it must be targeted at liquidity-constrained borrowers, and that policy-makers need to take into account how agents (lenders, buyers, sellers) will respond to the regulation. Godoy de Araujo et al. (2015) use Brazilian credit registry data and find that tightening of the LTV leads to a change in the composition of borrowers. Work at the International Monetary Fund (IMF) and Bank for International Settlements (BIS) has focused more on the impact of macroprudential tools on bank lending. See for example Cerutti et al. (2016) and Kuttner and Shim (2013).[3]

Our paper is also related to the small set of papers that have used microsimulation models to study vulnerabilities in the household sector. This includes papers on Finland (Herrala and Kauko (2007)), Sweden (Johansson and Persson (2006)), Chile (Fuenzalida and Ruiz-Tagle (2011)) and Italy (Michelangeli and Pietrunti (2016)). Microsimulation models provide an advantage in that they can summarize large amounts of micro-level information and inference can be made about what changes might be expected regarding hypothetical policy changes (Harding (1996) and Gupta and Kapur (2000)). Compared with these papers, we focus on modeling mortgage demand with the explicit goal of understanding how consumers respond to changes in macroprudential policy.

The paper is organized as follows. Section 2 presents institutional details of the Canadian mortgage market. Section 3 highlights the key macroprudential rule changes implemented in Canada between 2005 and 2010. Section 4 presents the data. Section 5 presents the microsimulation model and policy experiments. Section 6 concludes.

[3]The impacts of macroprudential tools have also been studied in dynamic stochastic general equilibrium (DSGE) models. Lambertini et al. (2013) and Angelini et al. (2012) are just two examples.

2 Institutional Background

Canada's *Bank Act* (section 418) requires mortgage insurance on all high-ratio mortgages, where high-ratio is defined as less than 20% equity at origination. With insurance, financial institutions are willing to lend to borrowers otherwise excluded from the mortgage market. Since high-ratio mortgages are insured, financial institutions do not face default risk.[4] Furthermore, there are steep prepayment penalties, limiting lender's exposure to prepayment risk.

Conditioning mortgage access on mortgage insurance also allows the government to change access through insurance guidelines/rules.[5] In response to the 1991 recession mortgage insurance underwriting guidelines were loosened to spur housing investment. This continued throughout the mid-1990s and early and mid-2000s. However, following the onset of the global financial crisis and growing imbalances in Canada's housing markets, the government tightened mortgage insurance access between 2008 and 2016 by lowering the maximum allowable amortization length and LTV and debt-service ratios, and reintroduced house price caps for mortgage insurance. We discuss some of these changes in Section 3. See Schembri (2014) and Crawford (2015) for a discussion of Canada's policy framework and how it functioned during the crisis.

Mortgages in Canada are typically 5-year fixed-rate contracts (term) with a 25-year amortization, and insurance is in place during the entire life of the mortgage. The insurance premium is a one-time fee that depends on the LTV ratio. Access is conditional on being below a maximum debt-service ratio and, more recently, a minimum credit score.[6] Borrowers have the option to roll-in the insurance premium into the loan, which is almost always done. The qualifying rules and premiums are common across insurers and lenders.

Finally, there is one public insurer, Canada Mortgage and Housing Corporation (CMHC), and now two private insurers (Genworth Financial and Canada Guaranty). In the case of borrower default, lenders are protected by the insurer. In the case of borrower and insurer default, lenders have a government guarantee that pays 100% if the mortgage is insured by

[4]About half of total mortgage credit is uninsured. Banks do face default risk on these mortgages. In addition to being high-equity, most provinces, however, have full recourse mortgages, meaning that most Canadians who forfeit on their homes would owe the difference between the recovered value of the house and the face value of the mortgage.

[5]The government also has authority over mortgage securitization since CMHC is in charge of securitizing insured mortgages. We abstract from changes to securitization, which is almost entirely public (Mordel and Stephens (2015)), that could affect bank funding.

[6] The government introduced LTV-based pricing in 1982. Premiums are a determined by CMHC and are set to meet certain capital requirements. The private insurers follow CMHC's pricing.

CMHC and 90% if it was insured by a private insurer. The government therefore establishes mortgage insurance regulations and guidelines to manage its contingent liabilities stemming from vulnerabilities related to housing markets and household indebtedness.

3 Mortgage Access Constraints and Rule Changes

In this section we highlight some key changes to mortgage insurance guidelines over the period 2005 to 2010. We analyze the impact of most of these changes on household mortgage demand in what follows. The main rule changes were to the LTV constraint and the amortization length, the latter of which operates through the TDS constraint.

3.1 Mortgage insurance constraints

Access to mortgage credit is controlled through mortgage insurance guidelines, especially those related to LTV and TDS constraints. The LTV constraint states that the ratio of loan size to house value has to be less than $\overline{LTV}$,where historically in Canada $\overline{LTV}$ has fluctuated between 90 and 100 and is currently at 95. The TDS constraint is defined as follows:

$$\left(\frac{\text{mortgage payment + other housing costs + other debt payments}}{\text{household income}}\right) \times 100 \leq \overline{TDS},$$

where $\overline{TDS}$ in Canada is currently 44. A borrower's PTI is their mortgage payment as a fraction of household income.

The impact of changes to the income and wealth constraints can be best understood by considering a borrower's housing and mortgage choice problem. An increase in $\overline{LTV}$ allows the household to borrow more for the same housing choice. If $\overline{LTV}$ equals 100, the household can borrow the full value of the house, subject to the TDS constraint. For the TDS constraint, given a fixed level of non-mortgage debt, an increase in amortization loosens the payment constraint. Households that are income-constrained therefore benefit from longer amortization periods.

3.2 Rule changes

The specific rule changes we study are as follows. First, on February 25, 2006 CMHC increased its maximum amortization from 25 to 30 years in what was supposed to be a four-month pilot program.[7] Soon after, on March 16, 2006, Genworth Financial (Genworth) increased its maximum amortization from 25 to 35 years. On June 28, 2006, CMHC allowed contracts to amortize over 35 years and matched Genworth's insurance premiums. Following these increases in amortization, on October 2, 2006 Genworth increased the maximum allowable LTV from 95 to 100. This was followed closely on October 10, 2006 when Genworth increased its maximum amortization from 35 years to 40 years. On November 19, 2006 CMHC increased its maximum allowable LTV from 95 to 100, and also increased its maximum amortization from 35 to 40 years. We label the period February 25, 2006 to November 14, 2008 as the "loose" period in the data.

The "tightening period" begins October 15, 2008. The tightening concerned changing amortization lengths for high-ratio mortgages from 40 to 35 years and LTV ratios from 100 to 95, and imposing a new TDS constraint of 45. The government also established a minimum credit score and loan documentation standards.

4 Data

In this section we introduce the main variables used in our analysis for the individual-level data at mortgage origination. These data form the basis of our descriptive analysis of the impact of the changes in macroprudential regulation on mortgage contracts. We also use these data to discipline the household-level survey data, which in turn, is used to calibrate the microsimulation model presented in Section 5.

4.1 Mortgage insurance data

Information on the mortgage contract, borrower, and lender is collected by CMHC at the time of origination for all insured mortgages. This information includes the interest rate, loan amount, house price, debt-service ratio, term, amortization, household income, credit score, and lender name. On average, 60% of contracts are new originations and 40% are refinancing. We drop all refinancing and focus on the more homogenous set of new orginations. Since our focus is on FTHBs, we also drop all repeat buyers. Approximately 20% of new

[7] The insurance premium for this product was an additional 25 basis points. We do not believe that small changes in insurance premiums affect demand. Premiums are amortized over the full amortization period, and therefore represent only a small fraction of the cost of borrowing. In our analysis of premium changes we do not find any impact on borrower demand.

originations are repeat buyers.[8] Table 1 presents summary statistics of the key variables for three subperiods using the population of CMHC-insured FTHB residential purchases. Dollar values are in nominal CAD except where noted. The subperiods broadly coincide with a "pre" period, a "loosening" period, and a "tightening" period. The pre-period is from February 24, 2005 to February 24, 2006, and occurs before the rapid loosening of insurance guidelines for fixed-rate mortgages. The loosening period corresponds to February 25, 2006 to October 14, 2008, during which mortgage insurance guidelines for amortization length and LTV were relaxed multiple times. We focus our discussion on the cumulative impact of the loosening on mortgage contract characteristics such as amortization, LTV, TDS, and interest rates. We also examine the impact of rule changes on average borrower income. Finally, the tightening period corresponds to October 15, 2008 to April 18, 2010.[9] Over this period, the government tightened amortization, LTV, and TDS constraints. These periods form the basis for measuring the impact of macroprudential changes on mortgage demand.[10]

From Table 1, we observe a noticeable increase in loan size over time, which is not surprising given the increases in house prices. Incomes have also increased over time. LTV ratios appear relatively flat in Table 1; however, the amortization length and TDS ratios are increasing. The average age of a FTHB is 35. From Table 1 we see that the fraction of contracts that are fixed-rate mortgages is high, nearly 90%. The percentage of variable-rate mortgages, however, increases at the end of 2008 as the central bank cut interest rates and offered forward guidance that set expectations that rates would be low for some time (Mendes and Murchinson (2014)). Finally, we also present an indicator for whether the source of the

[8] Anenberg and Bayer (2013) point out that the internal movement of repeat buyers is especially volatile—20% of U.S. originations in down years and 40% in peak years. Allen et al. (2014) document that repeat buyers take out larger loans to purchase larger homes than FTHBs. However, on average, they have lower LTV ratios and similar TDS ratios as FTHBs. Where repeat buying is likely more volatile is in the uninsured mortgage space, where we do not have data, and outside the scope of macroprudential policy.

[9] On April 19, 2010 the government changed the TDS formula for variable-rate mortgages (VRMs) and for mortgages of terms longer than five years, which substantially affects loan qualifying. Our data ends in December 2010 therefore we do not study this particular rule change and cut the sample just prior to its enactment. We therefore also miss some of the further tightening that occurred between 2011 and 2016. See Crawford (2015) for a complete discussion of rules changes in Canada over the last two decades.

[10] There is one technical complication when forming the sub-periods. On average the time between application and closing is 45 days. For tightening episodes, both the application and closing dates are important since lenders typically provide a 90-day rate guarantee. The mortgage tightening therefore applies immediately on the announcement day to borrowers without pre-approval and applies approximately 90 days later (implementation date) for those pre-approved under the old rules. Therefore, individuals with a closing date after the implementation date are considered affected by the change, and individuals with closing dates before the announcement are considered unaffected. Individuals who closed during the phase-in time are not considered affected if they applied before the announcement. For loosening, the announcement and implementation dates coincide.

Table 1: Summary statistics of transaction-level data for new purchases

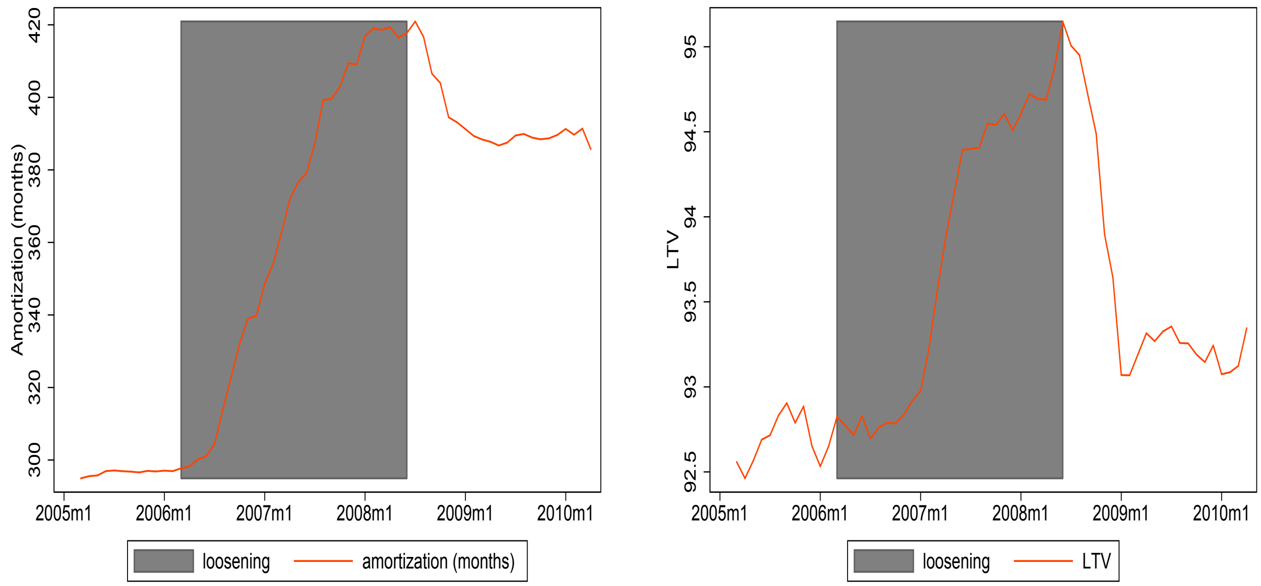
We present house prices both in nominal terms and deflated using a consumer-price index. All dollar figures are in CDN dollars. Mortgage is the loan size. The variable (rate-bond) represents an estimate of a lender's profit margin. It's the contract rate minus funding costs, approximated by the matched-term Government of Canada bond rate. *Income* captures total household income. I(FRM) is an indicator variable equal to 1 if the mortgage is fixed-rate and 0 if variable-rate. The mortgage term is the length of the contract in months. I(FICO≥680) is an indicator equal to 1 if the borrower's (best) credit score is at least 680. I(DP=unconventional) is an indicator equal to 1 if a borrower's down payment was non-traditional such as a gift and 0 otherwise.

	2005/02/24-2006/02/24		**2006/02/25-2008/10/14**		**2008/10/15-2010/04/18**	
	mean	std dev.	mean	std dev.	mean	std dev.
House price (nominal)	207,614	103,627	247,680	128,231	292,234	141,962
House price (real)	192,528	95,936	221,016	114,829	254,813	123,717
Mortgage (nominal)	190,646	93,024	228,783	117,140	267,405	129,158
Income (nominal)	78,523	38,817	87,389	46,108	91,105	49,244
rate-bond	1.05	0.63	1.29	0.74	1.99	0.85
I(FRM)	0.93	0.26	0.91	0.28	0.87	0.34
Term (months)	58.82	15.05	59.99	12.85	56.33	12.69
I(FICO≥680)	0.77	0.42	0.78	0.41	0.84	0.37
I(DP=unconventional)	0.27	0.44	0.25	0.43	0.24	0.43

down payment was unconventional; this includes sweat equity, second lien, gifts, or non-traditional sources. On average, these represent 25% of cases. Most conventional down payments are from either private or registered savings plans.

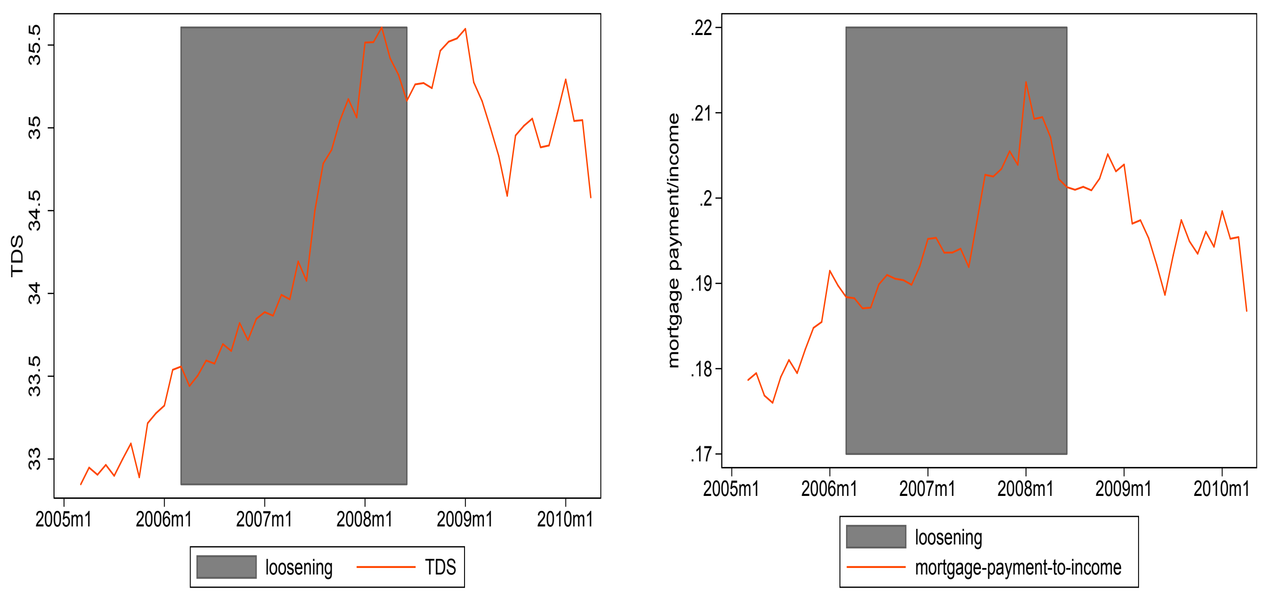
In Figure 1 and Figure 2 we present the main variables of interest over the full sample for FTHBs. All dates are based on closing and not application. The contract variables of interest are amortization, LTV, TDS and PTI. Broadly speaking, there are three periods: the shaded area denotes a period of loosening; the period immediately following is a period of tightening; and the first year represents a period with no change in mortgage insurance guidelines. From the figures we clearly observe an increase in amortization, LTV, and TDS during the loosening and a similar decrease during the tightening. Figure 2(b) captures only the monthly mortgage payment component of TDS. Mortgage payments between 2006 and 2008 are increasing even as amortization lengths are increasing, which loosens the income constraint. This is because monetary policy is tightening, making mortgages more expensive, and also because the wealth constraint is loosening and households are borrowing more.

Figure 1: Average amortization length and LTV for FTHBs



(a) Amortization (b) LTV

Figure 2: Average TDS and monthly PTI ratio for FTHBs



(a) TDS (b) PTI

4.2 Analysis

Our empirical analysis examines how both mortgage contract characteristics and borrower characteristics were affected by changes in mortgage insurance guidelines. We focus on FTHBs choosing five-year fixed-rate mortgages.

The main specification is equation (1) where y is our variables of interest: LTV, amortization, TDS, PTI, house prices, loan size, household income, and interest rates. D_j is an indicator variable equal to 1 for the period under which mortgage insurance rule j is in place and 0 otherwise. We estimate equation (1) for two samples. First, where D_1 equals 1 during the loosening period from February 25, 2006 to July 8, 2008 and 0 from February 24, 2005 to February 24, 2006. Second, where D_2 equals 1 during the tightening period from July 9, 2008 to April 18, 2010 and 0 during the loosening period. We also include month fixed effects interacted with location fixed effects (ν_m), where location is an FSA.[11] This allows us to control for location-specific seasonality (for example, housing demand might be different in Vancouver and Montreal across seasons due to weather) and unobservable differences in housing market conditions. Standard errors are clustered at the FSA level. For covariates we include borrower characteristics such as age and broker-use, as well as property characteristics such as dwelling type and age. We also include bank fixed effects (θ_b).

$$y_{it} = \alpha_0 + \beta X_{it} + \gamma_{j1} D_{jt} + \theta_b + \nu_m + \epsilon_{it}. \tag{1}$$

We present results for the loosening period (2006–2007) and the tightening period (2008–2010) in Table 2 and Table 3, respectively. Given that multiple tools were used in quick succession it is difficult to assign causation to any one particular tool or to present marginal effects. We therefore present the cumulative impacts and discuss the broad relationships between changes in macroprudential tools and household borrowing and explore specific mechanisms that are likely at play. We do allow the policy variable, D, to interact with log-income (demeaned) when looking at LTV and amortization. We do this to explore consumer heterogeneity in response to lending policies.[12]

Our results highlight that most contract, borrower, and market characteristics respond to changes in mortgage guidelines. In addition, there is heterogeneity in impacts depending on income. As a result in Section 5 we model income heterogeneity. The cumulative impact of loosening the LTV is correlated with a 1.1% increase in income. This is likely because the

[11] An FSA is a forward sortation area and is the first three letters of a Canadian postal code.

[12] Ideally, if data were available, we would also want to interact D with financial wealth.

relaxation of the wealth constraint allows high-income-low-wealth individuals to enter the housing market with smaller down payments, since they easily meet the income constraint. In contrast, we observe the probability of low-income individuals at the maximum LTV falling. Even though zero-down-payment mortgages are allowed during this period, households must still meet the income constraint, which is not always feasible. In addition, not everyone has a preference for the largest feasible mortgage (e.g., Brueckner (1994)). Only 17% of households took advantage of the zero-down product.

In column (3) of Table 2 we see that cumulative loosening is correlated with a 22.7% increase in the average amortization length and no heterogeneity by income. From column (4) we observe that as the maximum allowable amortization was incrementally increased from 25 to 40 years, the percentage of borrowers at the constraint fell. This is because nearly all borrowers were at the constraint pre-loosening and not all new borrowers choose the maximum following the relaxation of the constraint. Given that amortization plays an important role in the income constraint (and not the wealth constraint), this suggests that for at least some FTHBs, the income constraint was not binding. Column (5) presents the relationship between the cumulative impact of loosening and average TDS while column (6) presents the relationship for PTI. Both are large and significant. Why? House prices were rising substantially over the period, by 19.2% during the loosening period, and from column (10) we also see that interest rates were rising. From column (9) we also see that incomes increased by 11.8% during the loosening period. The result that mortgage payments increased, therefore, despite longer amortization and larger incomes, is driven in large part by higher interest rates on larger loans. This suggests that borrowers were not income-constrained, but instead constrained by wealth. If households were constrained by income, mortgage payments should have remained flat as they took on longer amortizing mortgages.

Now consider the period of tightening guidelines and the results in Table 3. This period affected the types of borrowers who could become FTHBs. House prices are continuing to rise but now monetary policy is accommodating due to the global financial crisis. Lower interest rates allows for larger loans for the same TDS constraint, even though the amortization constraint is being tightened by the government. We observe the average TDS is unchanged from the loosening period and the mortgage-to-income ratio falls. This is because the new inflow of FTHBs have more non-mortgage debt than the previous cohort. They are constrained by their non-mortgage debt. They are also constrained by their savings. We observe a continued increase in the fraction of FTHBs at the maximum allowable LTV constraint even as households' down-payment-to-income ratio increases. This is especially true for high-income households. For income, the picture is more complicated. There are more households at the maximum allowable amortization, suggesting FTHBs are constrained. The average monthly-payment-to-income ratio, however, falls. This is driven by two facts. First, interest rates are falling. However, because of households' existing non-mortgage debt (tightening TDS) and because of the LTV constraint, they cannot borrow their desired amount.

Table 2: Impact of loosening macroprudential policy changes

This table shows the relationship between changes in macroprudential tools and mortgage contract characteristics for all new purchases. The coefficient *loose* is an indicator equal to 1 for the period February 25, 2006 to November 14, 2008 and 0 otherwise. The estimation sample is February 24, 2005 to November 14, 2008. The variables of interest are loan-to-value (LTV), $I(LTV \geq 95)$, log-amortization (AM), $I(AM = max)$ (equal to 1 if the chosen amortization is equal to the maximum allowable at the date of the contract and 0 otherwise), the log of the total debt-service ratio (TDS), and the log of the monthly PTI ratio ($\log(PTI)$), log-house prices ($\log(HP)$), log-loan size ($\log(loan)$), demeaned log-income ($\log(inc)$) and contract rate (rate). Included are bank, FSA × month of the year fixed effects as well as controls for dwelling structure (type and age) and mortgage term. There are 150,459 observations. Robust standard errors clustered at the FSA level are in parentheses. Significance level is *** p<0.01, ** p<0.05, and * p<0.1.

	(1) LTV	(2) I(LTV≥95)	(3) AM	(4) I(AM=max)	(5) log(TDS)	(6) log(PTI)	(7) log(HP)	(7) log(loan)	(9) log(income)	(10) rate
loose	1.096***	0.041***	0.227***	-0.362***	0.044***	0.105***	0.192***	0.240***	0.118***	0.677***
	(0.030)	(0.004)	(0.002)	(0.005)	(0.001)	(0.003)	(0.007)	(0.007)	(0.004)	(0.004)
log(inc)	0.536***	0.025***	-0.023***	-0.062***						
	(0.052)	(0.007)	(0.002)	(0.005)						
loose	0.104*	0.029***	0.005	-0.049***						
×log(inc)	(0.058)	(0.007)	(0.003)	(0.006)						
Constant	95.61***	0.84***	5.67***	0.90***	3.52***	-1.85***	11.773***	11.803***	-0.247***	4.792***
	(0.171)	(0.020)	(0.009)	(0.017)	(0.008)	(0.017)	(0.020)	(0.020)	(0.018)	(0.025)
R^2	0.088	0.076	0.267	0.215	0.057	0.241	0.639	0.629	0.286	0.334

Table 3: Impact of tightening macroprudential policy changes

This table shows the relationship between changes in macroprudential tools and mortgage contract characteristics for all new purchases. The coefficient *tight* is an indicator equal to 1 for the period July 9, 2008 to April 18, 2010 and 0 otherwise. The estimation sample is February 25, 2006 to April 18, 2010. The variables of interest are loan-to-value (LTV), $I(LTV \geq 95)$, log-amortization (AM), $I(AM = max)$ (equal to 1 if the chosen amortization is equal to the maximum allowable at the date of the contract and 0 otherwise), the log of the total debt-service ratio (TDS), and the log of the monthly PTI ratio ($\log(PTI)$), log-house prices ($\log(HP)$), log-loan size ($\log(loan)$), demeaned log-income ($\log(inc)$) and contract rate (rate). Included are bank, FSA × month of the year fixed effects as well as controls for dwelling structure (type and age) and mortgage term. There are 170,167 observations. Robust standard errors clustered at the FSA level are in parentheses. Significance level is *** p<0.01, ** p<0.05, and * p<0.1.

	(1) LTV	(2) I(LTV≥95)	(3) AM	(4) I(AM=max)	(5) log(TDS)	(6) log(PTI)	(7) log(HP)	(8) log(loan)	(9) log(income)	(10) rate
tight	-0.761***	0.008***	0.027***	0.108***	0.002*	-0.044***	0.099***	0.116***	-0.004	-1.261***
	(0.023)	(0.003)	(0.001)	(0.003)	(0.001)	(0.002)	(0.003)	(0.003)	(0.003)	(0.005)
log(inc)	0.529***	0.047***	-0.029***	-0.141***						
	(0.040)	(0.004)	(0.003)	(0.005)						
tight	0.248***	0.018***	-0.015***	-0.007						
×log(inc)	(0.049)	(0.006)	(0.003)	(0.006)						
Constant	96.943***	0.896***	5.903***	0.509***	3.565***	-1.737***	11.960***	12.039***	-0.149***	5.443***
	(0.150)	(0.019)	(0.009)	(0.018)	(0.008)	(0.015)	(0.017)	(0.018)	(0.017)	(0.025)
R^2	0.075	0.071	0.138	0.135	0.049	0.228	0.656	0.643	0.274	0.563

5 Microsimulation Model

Although our descriptive analysis provides some suggestive evidence on the effect of macroprudential policy on household borrowing, it is lacking in several dimensions. Most importantly, it does not offer a succinct answer to the question: What is the impact of macroprudential policies on mortgage demand? In this section, we present a general overview of our microsimulation model, HRAM.

Time is discrete, with a finite horizon given by T. A household $i \in \mathcal{I} = \{1, 2, 3, \ldots, I-1, I\}$ is defined as

$$i = \left(\Omega_i, \{X_{i,t}\}_{t=0}^{t=T}\right),$$

where Ω_i is a $J \times 1$ vector of fixed household characteristics, such as age, education, employment status, and geographic region, and $X_{i,t}$ is a $K \times 1$ vector of time-varying household variables, such as labor income and financial assets. Refer to an element in $X_{i,t}$ as $x_{i,t}^k$.

The nominal labor income of household i in period t is denoted by $x_{i,t}^Y$. Financial assets are denoted by $x_{i,t}^{FA}$, and housing assets by $x_{i,t}^{HA}$. The total financial resources available to household i at time t, is the sum of labor income (minus tax payments) and financial assets (with the return) less debt:

$$\underbrace{x_{i,t}^{FA} - x_{i,t}^{D} + x_{i,t}^{C}}_{\text{Asset, debt, consumption}} = \underbrace{x_{i,t}^{Y}(1-\tau) + x_{i,t-1}^{FA}\left(1 + R_t^{FA}\right) - x_{i,t-1}^{D}}_{\text{Available financial resources}} - \underbrace{x_{i,t}^{DP}}_{\text{Required debt payments}}$$

where τ is the tax rate on income, and R_t^{FA} is the return on financial assets, which is assumed to be exogenous.

5.1 First-Time Homebuyers

A three-stage approach is used to determine if a household, i, will be a FTHB in period t:

1. Determine whether a household is a potential FTHB, $p_{i,t} = 1$. Denote the complete set of potential FTHBs as $\mathcal{I}_t^P$.

2. Determine whether a potential FTHB qualifies for a mortgage, $q_{i,t} = 1$. Denote the complete set of qualified FTHBs as $\mathcal{I}_t^Q$.

3. Determine a households down payment, and whether a qualified FTHB actually purchases a house, $b_{i,t} = 1$. Denote the final set of buying FTHBs as $\mathcal{I}_t^B$.

We now present each step in the process.

5.1.1 Potential FTHB

For a household to be a potential FTHB, three conditions must be met: (i) a household must not currently own housing assets, $x_{i,t}^{HA} = 0$, (ii) a household must be under 50 years old, and (iii) a household must be employed.[13] If these conditions are met, $p_{i,t} = 1$.

5.1.2 Qualified FTHB

We next turn to which households qualify for a mortgage. The home ownership process is driven by a mortgage debt-service shock, which is a function of household income. At time t = 0, all households that do not yet own a house draw a one-time idiosyncratic shock for their PTI, ω_i^{PTI}, which is a function of household income:

$$\omega_i^{PTI} \sim N\left(\mu\left(x_{i,0}^{Y}\right), \sigma\right). \tag{2}$$

We calibrate the shock process for ω_i^{PTI} using the mortgage origination data, and allow for dispersion at the household level. This formulation assumes that a household has a deep underlying preference for the amount that it is willing to spend per month on its owner-occupied housing, akin to assuming that household i would like to allocate a constant fraction of its gross income to meet mortgage payments.

Given a household's PTI preference shock, the mortgage chosen by household i is given by

$$x_{i,t}^{MORT} = \omega_i^{PTI}\left[\frac{x_{i,t}^{Y}}{12}\right]\left[\frac{\left(1+r_t^5/2\right)^{2T}-1}{\left(\left(1+r_t^5/2\right)^{1/6}-1\right)\left(1+r_t^5/2\right)^{2T}}\right], \tag{3}$$

where T is the amortization of the mortgage (measured in years) and r_t^5 is the nominal five-year fixed mortgage rate. Therefore, our assumption on debt servicing essentially determines the household's mortgage choice. For a given PTI shock, lower rates and longer amortization allow a household to take on a larger mortgage.

Modeling the down payment decision is more challenging. Given total household financial assets, the most valuable house that household i can purchase is

$$x_{i,t}^{HPMAX} = x_{i,t}^{MORT} + x_{i,t}^{FA}, \tag{4}$$

[13] The age restriction allows us to capture heterogeneity in preferences for renting.

with the associated maximum down payment:

$$x_{i,t}^{DPMAX} = \frac{x_{i,t}^{FA}}{x_{i,t}^{MORT} + x_{i,t}^{FA}}. \tag{5}$$

Given these calculations, household i faces three qualifying constraints:

1. (*TDS: Income Constraint*) Total household debt-servicing must be below the TDS threshold:

$$\omega_i^{PTI} + \frac{x_{i,t}^{CDPAY}}{x_{i,t}^{Y}} \leq \overline{TDS}, \tag{6}$$

   where $x_{i,t}^{CDPAY}$ is payments by households due to consumer debt (i.e., non-mortgage debt), and $\overline{TDS}$ is the regulatory cap on insured mortgage highlighted in Section 3.

2. (*Down Payment Constraint*) The down payment by household i must be above the regulatory minimum:

$$x_{i,t}^{DPMAX} \geq DP^{MIN}. \tag{7}$$

3. (*Affordability*) Through a combination of down payment and mortgage servicing, a household must be able to afford an entry-level house:

$$x_{i,t}^{HPMAX} \geq HP_{Reg_i,t}^{STARTER}, \tag{8}$$

   where $HP_{Reg_i,t}^{STARTER}$ denotes the price of a starter home at time t in the region in which household i lives. The affordability constraint also limits the choice of down payment for some households, since some households will need to make a large enough down payment in order to afford a starter house.

If equations (6) to (8) are satisfied, then we say that household i qualifies for a mortgage of size $x_{i,t}^{MORT}$ and $q_{i,t} = 1$. We denote the set of households that qualify for a mortgage as $\mathcal{I}_t^Q$.

5.1.3 Buying FTHBs and Down Payment Decision

Given the set of households that qualify for a mortgage, $\mathcal{I}_t^Q$, we next determine which households purchase a house in period t, as well as the down payment used to purchase the house. This is a complex problem, since there are many factors behind a homebuying decision, such as those related to family planning or employment opportunities. Furthermore, the down payment decision is complicated by the fact that some households may choose to not use all of their financial assets for the down payment. To simplify this decision, we partition the set of possible down payments into four categories:

$$\mathcal{DP} = \{0\%, 5\%, 10\%, 20\%\}.$$

Using similar data, Allen et al. (2014) show that the nonlinearity of mortgage insurance pricing leads to bunching at these levels and this is therefore a reasonable assumption.

To simplify the homebuying decision, we make the homebuying and down payment decision a function of income and the minimum affordable down payment. Formally, we assume that for each period t, every household i in $\mathcal{I}_t^Q$ receives a shock from the uniform distribution, $\varepsilon_{i,t}^{dp_k} \sim U[0,1]$, for each down payment dp_k in $\mathcal{DP}$ that is below $x_{i,t}^{DPMAX}$. For example, if $x_{i,t}^{DPMAX} = 8\%$, then household i would receive two shocks: $\varepsilon_{i,t}^0$ and $\varepsilon_{i,t}^5$. A household then purchases a house with down payment dp_k if

$$\varepsilon_{i,t}^{dp_k} \geq Z_t \overline{\theta}\left(dp_k, x_{i,t}^Y\right). \tag{9}$$

If equation (9) holds for more than one dp_k, then the household makes the larger down payment. The variable Z_t is an aggregate shock that captures movements in housing demand that are not due to changes in mortgage qualification.

The calibration of $\overline{\theta}$ is the central part of the model where the structure speaks to the data. While the details are discussed in Section 5.2, the idea is that we discretize household income and perform a one-step generalized method of moments (GMM) calibration to match the joint distribution of income and down payments from the mortgage originations data shown in Table 6 and Table 7.

Due to the limited size of the household-level survey data, we limit the homebuying decision to only income and wealth (via the down payment). While this does not capture all of the potential factors influencing housing demand, such as age, eduction, etc., income and wealth are quite effective in capturing these factors. For instance, we have found in our calibration that higher-income and higher-wealth renters are more likely to become owners, which partially captures the effects of age.

Last, macro factors that might influence housing demand from unconstrained households can shift demand via the aggregate factor Z_t. The path of aggregate variables, such as house prices, interest rates, unemployment and income is presented in Section 5.2 to be consistent with the actual path of these variables.

5.2 Calibration

The calibration uses loan-level transaction data from CMHC to identify those households most likely to become FTHBs in the household-level survey data. Table 4 summarizes the exercise. We start by identifying a set of potential FTHBs (Section 5.1.1). Second, there is a PTI preference shock that determines the amount of housing that would be assigned, which must be at least the minimum regional housing price to qualify (Section 5.1.2). Finally, there is the probability of purchasing a house (Section 5.1.3). The set of potential FTHBs is taken from a household survey, discussed below. This provides information on financial assets as well as detailed information about the characteristics of potential borrowers, including income, which is required to match the loan-level data. The PTI shock is used to find qualifying households among the set of renters identified in the first step, and to determine an amount of housing that would be assigned. These are chosen to match the joint distribution of income and PTI ratio of FTHBs in the loan-level data. The PTI draw must give an amount of housing that is greater than the minimum for that region. Finally, the probability that a qualifying individual purchases a house is determined by the joint distribution of that individual's income and down payment. We discuss each step in more detail.

Table 4: Use of microdata in the calibration strategy

Data set	Uses	PTI shocks and Pr(purchasing)
Loan-level mortgage insurance data (CMHC)	Benchmark to help describe FTHBs	Determine moments for joint distributions
Household survey data	Used in HRAM	Match moments in the mortgage insurance data
	Determines financial assets & income of FTHBs	Joint distributions of PTI/income and down payment/income

5.2.1 Household survey data and the set of potential FTHBs

In the first step, households are identified as potential FTHBs if they have sufficient financial wealth and income, and meet the criteria described in Section 5.1.1: that they do not currently own housing assets, are under 50 years old, and are employed.

The set of potential FTHBs is constructed using the household-level data summarized in Table 5 and taken from the *Canadian Financial Monitor* (CFM) survey, conducted quarterly by Ipsos-Reid, a survey and marketing firm, since 1999. The survey is of approximately 12,000 households per year and includes detailed information on assets and liabilities as well as socio-demographic information. Crucially, the survey includes homeowners and renters. The household-level data initialize the households in the model, so that the distribution of home ownership, income, and financial assets matches the distribution observed in the data.[14] Home ownership is around 68%. Whether a household that is currently renting can qualify for a mortgage will depend upon the household's income (whether the household can afford the monthly payment) and financial wealth (whether the household can afford the minimum down payment).

We provide summary statistics for two data sets, the first for 2005 and the second an average over 2007–2008. In our policy experiments we use the first data set for the loosening scenarios, with FTHBs calibrated to the CMHC loan-level data from the pre-loosening period of 2005. We then measure the impact of loosening relative to a counterfactual benchmark case where macroprudential rules are not changed. Similarly, we use the second data set as the data for the tightening scenarios, with FTHBs calibrated to the CMHC loan-level data from the pre-tightening period of 2007–2008, to measure the impact of tightening. The impact of the tightening is also measured relative to a counterfactual benchmark case where macroprudential rules are not changed.

In the household-level survey data, the average potential FTHB had an average income of $65,779 in 2005 and $67,614 between 2007 and 2008. Financial assets are heterogeneous, and determine how binding the wealth constraint is for those buying a house. The average potential FTHB in 2005 had $55,193 in 2005, which is more than the 75th percentile, due to positive skewness. Between 2007 and 2008, potential FTHBs had, on average, financial assets of $29,225, and again, this is more than the 75th percentile.[15]

5.2.2 Matching loan-level and household-level data

The second step is to use the joint distribution of mortgage payments and income in the loan-level data to find matching potential homeowners in the household-level survey data. Table

[14]Specifically, we populate the households in the model with households from the survey data. We then replicate households according to their survey sample weights (replicated households will receive different idiosyncratic PTI shocks). Thus, we have a set of potential FTHBs rich enough to match the heterogeneity in the data. Importantly, we use the data on financial assets and household income from the survey to determine if a household can make a sufficiently large enough down payment and afford an entry-level home in order to qualify for a mortgage. In contrast, the loan-level data do not include household financial assets.

[15]The average assets are substantially lower in the second period because during this period, the down payment required to purchase a house went from 5% to 0%. While the financial crisis may have reduced household financial assets, this only became more pronounced in 2008Q4, and would not explain the drop in the 2007–2008 period relative to 2005. The fact that the mean of financial assets is more than the 75th percentile highlights the positive skewness in financial assets and that there are some affluent households who could easily afford a house but instead choose to rent.

Table 5: Household variables used in HRAM from CFM household survey data

This table provides summary statistics on the main variables in HRAM. The variables are for those households that qualify to purchase a house, not all potential households. $x_{i,t}^{Y}$ is gross household income; ω_i^{age} is the head-of-household age; $x_{i,t}^{FA}$ is total financial assets; and $x_{i,t}^{CDPAY}$ is the consumer debt-to-income ratio. Outside of the survey data, we calibrate the mean interest rate to the five-year average discounted fixed-rate mortgage (R^5) and house prices to the average resale price by region based on Canadian Real Estate Association data (HP). Finally, unemployment (UR) is the average of total weeks unemployed divided by total weeks in the labor force observed over the sample period.

Variables	2005				2007-2008			
	mean	sd	p25	p75	mean	sd	p25	p75
$x_{i,t}^{Y}$ $)	65,779	31,555	40,000	82,500	67,614	29,545	47,500	85,000
ω_i^{age}	37.2	7.9	28	42	35	7.9	28	42
$x_{i,t}^{FA}$ ($)	55,193	95,746	14,150	48,250	29,224	58,254	1,500	27,550
$x_{i,t}^{CDPAY}$ (%)	0.97	8.91	0	6.34	4.32	6.5	0	8.54
HP ($)	172,633	79,865	113,634	214,317	203,421	85,062	141,532	247,175
R^5 (%)	4.93	0.45	4.63	5.31	5.50	0.30	5.39	5.63
UR	6.6	9.4	0	9.2	7.9	10.8	0	11.4

6 and Table 7 show the breakdown of parameters that are determined from the CMHC loan-level data, to be used in the calibration for their respective exercises. As with the household-level data, there are two periods: the pre-loosening period of 2005 (Table 6), and the pre-tightening period of 2007–2008 (Table 7). We determine the relative frequency distribution of FTHBs for 11 income classes, as well as for each income class, average PTI ratios, and the distribution of these FTHBs across key down payment categories.[16] Each of these income classes in the set of potential FTHBs in the survey data, therefore, receives an average PTI ratio corresponding to what is presented in the table. The average PTI ratio with respect to income is somewhat hump-shaped; however, borrowers in the highest income category have lower ratios than the low-income borrowers, on average. In addition to matching the within-income-category average PTI ratio, we also match the between-dispersion in PTI ratios for each of our two periods. That is, the σ in equation (2). For 2005 we calibrate σ to 5.3 and for 2007–2008, we calibrate σ to 5.5.

The third and final step is to use the joint distribution of income and down payment for FTHBs in the loan-level data to determine the probability of a potential match in the household-level survey data of buying a house. Table 6 and Table 7 provide this information as well. We calibrate the LTV choices to three options in the pre-period and to four options in the loosening period. The fourth option is a 100% LTV choice available only during this

[16]The empirical distribution of down payment ratios is highly clustered around key ratios that define the laddered increases in mortgage insurance premium rates.

Table 6: Loan-level data calibration: 2005

Calibration variables for HRAM. Potential FTHBs are drawn from CFM based on whether their income, PTI ratio, and LTV ratio characteristics match those in the loan-level data. Income is gross nominal household income. The distribution of LTV by income is based on the loan-level data. The fraction of FTHBs with an LTV of less than 80, i.e., outside of the insurance space, is based on CFM. The cross-sectional dispersion in mp/inc (σ in equation (2)) is 5.3.

Income category	Frequency	PTI		LTV	
($)	(%)	mean	95%	90%	80%
0-24,999	0.8	17.8	58	26	16
25,000-34,999	4.5	17.9	53	29	19
35,000-44,999	9.8	18.2	50	31	19
45,000-54,999	14.5	18.0	49	32	19
55,000-59,999	8.0	17.8	48	32	19
60,000-69,999	14.9	17.6	46	34	19
70,000-84,999	18.9	17.2	49	35	17
85,000-99,999	12.2	16.4	43	34	22
100,000-119,999	8.7	15.2	40	37	23
120,000-149,999	4.8	14.0	36	38	25
150,000+	2.9	10.9	33	36	31

period. The majority of borrowers have a 95% LTV. On average, 13.4% of borrowers in the population have 0% down. This is because 16.8% of borrowers in the insured space have 100% LTV mortgages and here we are adding FTHBs in the uninsured space to the calibration. We know very little about these borrowers, except that on average during the sample period they represent about 20% of FTHBs.

Potential FTHBs can usually qualify in more than one LTV category. Because there is a strong tendency for a household's LTV qualifying range to be constrained mainly at the lower end, the assignment of FTHBs to LTV categories proceeds iteratively, from low to high levels of LTV. The result of this iterative procedure is a pool of potential FTHBs in the household-level survey data that is representative of the FTHBs found in the CMHC loan-level data.

Note that while matching the joint distribution of income and down payment, we also match the unconditional income distribution. That is, we ensure that the fraction of FTHBs in each of the 11 income categories matches what we observe in the mortgage origination data. The frequencies are given in column (2) of Table 6 for the 2005 calibration and column (2) of Table 7 for the 2007–2008 calibration.

Table 7: Loan-level data calibration: 2007 to 2008

Calibration variables for HRAM. Potential FTHBs are drawn from CFM based on whether their income, PTI, and LTV ratio characteristics match those in the loan-level data. Income is gross nominal household income. The distribution of LTV by income is based on the loan-level data. The fraction of FTHBs with an LTV of less than 80, i.e., outside of the insurance space, is based on CFM. The cross-sectional dispersion in mp/inc (σ in equation (2)) is 5.5.

Income category	Frequency	PTI	LTV			
($)	(%)	mean	100%	95%	90%	80%
0-24,999	0.5	18.1	9.9	49	25.1	16
25,000-34,999	2.8	18.2	12	45.7	23.4	19
35,000-44,999	7.3	18.9	14.5	41.4	25.1	19
45,000-54,999	11.7	18.9	14.5	39.3	27.2	19
55,000-59,999	6.8	18.7	14.7	39.8	26.4	19
60,000-69,999	14.5	18.6	14.9	39.1	27	19
70,000-84,999	19.0	18.1	14.4	40.2	28.4	17
85,000-99,999	14.2	17.6	13	37.6	27.5	22
100,000-119,999	11.3	16.6	12.2	36.7	28.0	23
120,000-149,999	7.2	15.3	10.7	34.9	29.4	25
150,000+	4.7	12.7	8.3	30.6	30	31

5.3 Housing Market

So far we have discussed the demand for mortgage credit, with little discussion of the housing or rental markets. This is because once renters have sufficient income and wealth to purchase a starter home in their neighborhood, they will do so, subject to an idiosyncratic shock. The decision to rent is implicitly the complement of the decision to enter the housing market (abstracting from the household formation decision). Renters who qualify to enter the market but do not receive the idiosyncratic shock continue to rent. In this respect, an explicit modeling of the rental decision is not essential for addressing the issues at hand. The price of housing, however, which is determined exogenously from the model, plays an integral role, since it is an input in deciding which households can enter the market.

We calibrate the minimum house price for market entry using a combination of census metropolitan area (CMA) and population-weighted provincial house price data. Specifically, we use the average resale price based on the Canadian Real Estate Association housing data at the CMA level for those living in one of the 25 CMAs and provincial prices for those living outside those areas. Between the two periods, national house prices increase from just under \$173,000 to just over \$203,000 with substantial variation across cities. The average house price in Vancouver and Toronto, for example, is more than twice that of other

Canadian cities. Also outside of the household data are interest rates. Over the sample period, the average typical interest rate on a five-year fixed-rate mortgage increased from 4.93% to 5.50%.

5.4 Results

We perform two sets of experiments. First, we calibrate HRAM to a base case using data from 2005. This captures the period prior to the sequence of macroprudential loosenings highlighted in Section 3. We then quantify the impacts of macroprudential loosening for insured mortgages on FTHBs. In the second set of experiments we calibrate HRAM to data from the loose period (2007–2008). This second set of experiments allows us to quantify the implications of macroprudential tightening on the set of FTHBs who were able to take advantage of the most generous mortgage terms in our sample. For the experiments, we assume that, for potential FTHBs in a given down payment and income category, the PTI shock that each household receives and the probability of buying a house are both unchanged from the relevant baseline scenario (no rule change) to the rule-change scenario. However, because the pool of potential FTHBs itself changes in size as the rule change alters the extent of household qualification, across all down payment and income categories, the number of FTHBs will change.

Thus, the impacts can occur on both the extensive and intensive margins. The extensive margin encompasses households that are newly included or excluded from the set of FTHBs as a result of a change in macroprudential rules; the intensive margin can be affected because with the PTI shock held constant, the mortgage size increases as the amortization period increases, and vice versa. In either case, the results can be interpreted as responses to how income and wealth constraints have changed with the new rule(s).

We first experiment with the impact of loosening on mortgage demand. For this case, we first calibrate the baseline FTHBs to the 2005 loan-level data. For the relaxation of the down payment to 0%, we assume that the probability of buying at 0% is the same for potential FTHBs who qualify at 0% as for those who qualify at a 5% down payment, with the latter probability determined in the baseline calibration. When we do this experiment, we assume that households that qualified under the tighter policy still qualify under the looser policy.[17]

[17] Note that otherwise, due to our assumption that households have a fixed PTI (meaning that a loosening of the amortization implies that a household purchases a larger house), it arises that some households would not be able to afford the down payment for the larger house. Since this is not an intended effect in the exercise, we essentially relax the fixed-PTI assumption for some baseline FTHBs, where necessary. Note

For the loosening experiments, we consider four different amortization changes. The variables in the first three rows in Table 8 were implemented in 2006, whereas the fourth row combines these into a hypothetical one-time policy move. We report three outcomes of the model: (i) the change in the percentage of qualified households, (ii) the change in the percentage of FTHBs, and (iii) the change in FTHB mortgage debt. The difference between the changes in the number of households that qualify and the households that purchase is a function of our calibration. If we did not calibrate the model to the loan-level data, a greater number of households in lower income categories would be assigned as FTHBs in the model. These potential FTHBs, however, would in reality have a lower propensity to purchase a house, which may reflect preferences that the calibration helps to reflect. Recall the probability of buying a house is given by condition (9). The first result is that a relaxation in the amortization from 25 to 30 years leads to a 4.5% increase in FTHBs and an 11.3% increase in mortgage demand. The second relaxation was amortization from 30 to 35 years, conditional on the first change in amortization having already happened. The increase in demand is smaller in this case, with an increase in entry of 2.7% and an increase in demand of 7.5%. The smaller impact is because of the smaller percentage increase in amortization and because of the nonlinear effects of amortization on mortgage payments. The third row shows that further loosening had an even smaller effect—a 2% increase in entry and an increase in demand of 5.4%. The fourth row measures the impact of changing the amortization from 25 to 40 years in one step rather than sequentially. The impacts on entry and demand are nearly identical to the sequential changes.

The fifth row in Table 8 considers the impact of keeping the amortization fixed at 40 years and changing the LTV from 95 to 100. This change was made in November 2006 by the government, and as we saw in Section 4.2, there was a 17% uptake in zero-down-payment insured mortgages. We observe a 129.7% increase in FTHBs and a 137.4% increase in mortgage demand. Clearly this is an overestimation of what we observe in the data. When we examine the impact of tightening from 100 to 95, we see that the impact is not symmetric. When we allow FTHBs to enter with zero savings, the only constraint is the income constraint. Many individuals therefore qualify to enter. Not everyone, however, enters the market. This is because we are not capturing behavioral features, such as aversion to having zero equity, preferences for renting, or aversion to debt by some households, which these results clearly imply are important given the large pure-qualification effect.

that this gives an extensive margin effect that is the same as it would be if the preference shock specified a fixed mortgage amount instead.

Table 8: Impacts of loosening policy from the structural model

Experiment		Δ in # of Qualified Households (%)	Δ in # of FTHBs (%)	Δ in FTHB Mortgage Debt (%)
Loosening: Calibrated to 2005 data				
LTV	Amortization			
95	25 to 30 yrs	6.5	4.5	11.3
95	30 to 35 yrs	4.4	2.7	7.5
95	35 to 40 yrs	3.1	2.0	5.4
95	25 to 40 yrs	12.9	9.0	24.7
95 to 100	40 yrs	166.9	129.7	137.4
HP ↑ 2005 to 2006	unchanged	-6.2	-4.1	-2.5
HP ↑ 2005 to 2008	unchanged	-9.7	-6.7	-4.2
Tightening: Calibrated to 2007–2008 data				
LTV	Amortization			
95	40 to 35 yrs	-3.5	-2.1	-5.3
95	35 to 30 yrs	-4.8	-3.6	-7.2
95	30 to 25 yrs	-7.3	-5.1	-10.4
100 to 95	40 yrs	-51.5	-7.9	-8.1

The last two rows in the loosening panel consider the impact of house prices on FTHBs. In the model, prices do not respond endogenously to macroprudential rule changes. This experiment shows that if we allow house prices to increase to match the actual price increase observed between 2005 and 2007–2008, this would offset approximately 75% of the increase in affordability allowed by loosening the amortization from 25 to 40 years. To fully capture the effects of the macroprudential policy on house prices, general equilibrium effects would need to be incorporated, where housing supply elasticities would play a crucial role (see section 5.5).

For the tightening, we calibrate the model to the 2007–2008 loan-level data. This was a period when rules had been substantially loosened, and a tightening from this period would likely have put restrictions on FTHBs who entered with 0% equity and 35- to 40-year amortization. We consider four experiments. The first three are a tightening of the maximum allowable amortization, while the last is a tightening of the maximum allowable LTV from 100 to 95. A tightening of amortization from 40 to 35 years leads to a small reduction in FTHBs and mortgage demand. A tightening from 35 to 30 years leads to a 3.6% reduction in FTHBs entering the market and a 7.2% reduction in the demand for credit. This change in amortization, like a change from 30 to 25 years, has similar impacts on mortgage demand to a change in LTV. The change in LTV from 100 to 95 has a 7.9% decrease in FTHBs and an 8.1% decrease in credit. Notice that the fraction of households that qualify falls more dramatically for a relatively smaller proportional change in the LTV—the impact also appears to be more on the extensive margin, through the change in qualification, rather than the intensive margin of average mortgage sizes. In Section 4.2 we argued that the wealth constraint was the most binding—this is where that constraint appears. Once the 100% LTV mortgages are removed, households can no longer qualify with zero equity. Given our calibration exercise in Table 7, and equation (9) that maps income and LTV into purchasing probabilities, only 13.4% of the population of baseline FTHBs had zero down (16.8% of the high-LTV FTHBs), and the impact on total credit from the LTV change is 8.1%.

In addition to measuring the responses of FTHBs to hypothetical changes to income and wealth constraints, one can assess the impact of the combined changes in constraints over time. In Figure 3, we present the full path of credit growth in Canada, starting with the 2006 loosening of amortization and including all the tightening between 2008 and 2010. Here, total credit is the sum of x_i^D, or the sum of mortgage credit and other household credit. The impact on total credit growth is immediate upon loosening and tightening. Loosening leads to an increase in total credit while tightening leads to a contraction.

A key assumption in the calculation of cumulative effects pertains to the persistence of the individual rule-change effects. Figure 3 reflects the assumption that extensive margin effects are transitory one-off effects, which should, on balance, have a net effect of roughly zero on mortgage credit growth over the long term. This is because the loosening of rules should largely create a pull-forward effect, as households that had an underlying intention/preference to enter the housing market, independent of prevailing macroprudential rules, are able to enter, subject to supply constraints, sooner in the loosened periods. The tightening period beginning in 2008 eventually returned both the maximum amortization and LTV levels to their original pre-2006 states, at 25 years and 100%. With the exception of some households that might never have been able to enter the housing market, had it not been for the loosened period, most of the extensive margin effects would amount to a shifting of FTHB entry from later periods into earlier periods. In other words, most of these FTHBs who entered would have eventually increased their financial assets or income sufficiently to enter the market, even without the looser period.

The intensive margin effects, in contrast, are more likely to have persisted for the entire period that they were in place.[18] That is, throughout the period that a 40-year amortization was allowed, some FTHBs would continue to take out 40-year amortizations. Rather than being a shift in demand from one period to another, the distribution of mortgage characteristics should experience a sustained shift, as long as the new rules are held in place. The combination of these transitory and sustained effects gives the cumulative impact in Figure 3, levelling out at a 6% increase in the level of mortgage credit by 2012. Although this level increase will diminish over time, as the stock of longer-amortization mortgages are paid off, one could argue that the household debt-to-income level is higher than it otherwise would have been without this period of looser rules. So while the impacts of macroprudential rule changes have been difficult to determine in many settings, our simulations suggest that these changes may have been important and lasting.

Finally, we can also use HRAM to provide insights as to how tighter macroprudential policies can help increase the resilience of FTHBs, and potentially the financial system, to shocks. To do so, we simulate the cohort of entering FTHBs for two years to examine to what extent they have sufficient financial assets to continue making their debt payments in the face of idiosyncratic unemployment shocks. More specifically, we examine the evolution of arrears for FTHBs, where a household is in arrears if a mortgage payment has been missed for 90 days. The simulation is performed under two scenarios: a baseline and an interest rate shock. For each scenario we quantify how different macroprudential policy can lower arrears for FTHBs. As in the loosening example above, we calibrate the baseline to the 2007–2008 loan-level data. The maximum LTV is therefore 100 and the maximum amortization period is 40 years. The national unemployment rate is set at 7.9% (See Table 5), which determines the probability individuals lose their jobs and, depending on their financial wealth, default.

The alternative macroprudential policies we consider include the cases where the maximums are 95 for the LTV and 40 years for amortization as well as the case with 100 for LTV and 25 years for amortization. We also examine the combined effect of having the maximums at 95 for LTV and 25 years for amortization. The shock scenario involves a 2 percentage point increase in mortgages rates at the start of the second year, after our FTHBs have entered the market. The goal is to mimic interest rate risk at renewal. All else equal, the

[18] The intensive margin effect is approximately the difference between the total percentage effect on FTHB mortgage credit and the percentage effect on the number of FTHBs.

higher mortgage rates lead to an increase in arrears because the larger monthly mortgage payments more quickly reduce the savings of an unemployed household.[19]

Results from our simulations are shown in Table 9. Our outcome variable of interest is the average of the aggregate arrears rate over a two year horizon. The aggregate arrears rate is defined as the aggregate amount of mortgages in arrears over the entire amount of mortgages outstanding. We draw several conclusions from these simulations. First, the fall in arrears due to a tightening of the LTV constraint is much larger relative to a reduction in the amortization period under both the baseline and shock scenario. The reason for this result is that the tightening of the LTV constraint restricts the entry of FTHBs to those households with larger holdings of financial assets which can be drawn on to make mortgage payments, in the case of income loss. Second, the impact on arrears of a combination of tighter LTV and tighter amortization is only marginally higher than the sum of each change individually, suggesting that the impacts of these policies are largely orthogonal to one another.

Table 9: Impact of interest rate shock on arrears

This table presents the percentage change in household arrears under different macroprudential scenarios. The exercise is calibrated to 2007-2008 loan-level data where the maximum LTV is 100 and the maximum amortization is 40 years. The Baseline case is under a normal interest rate path and Shock is the 200 basis point increase in rates at renewal.

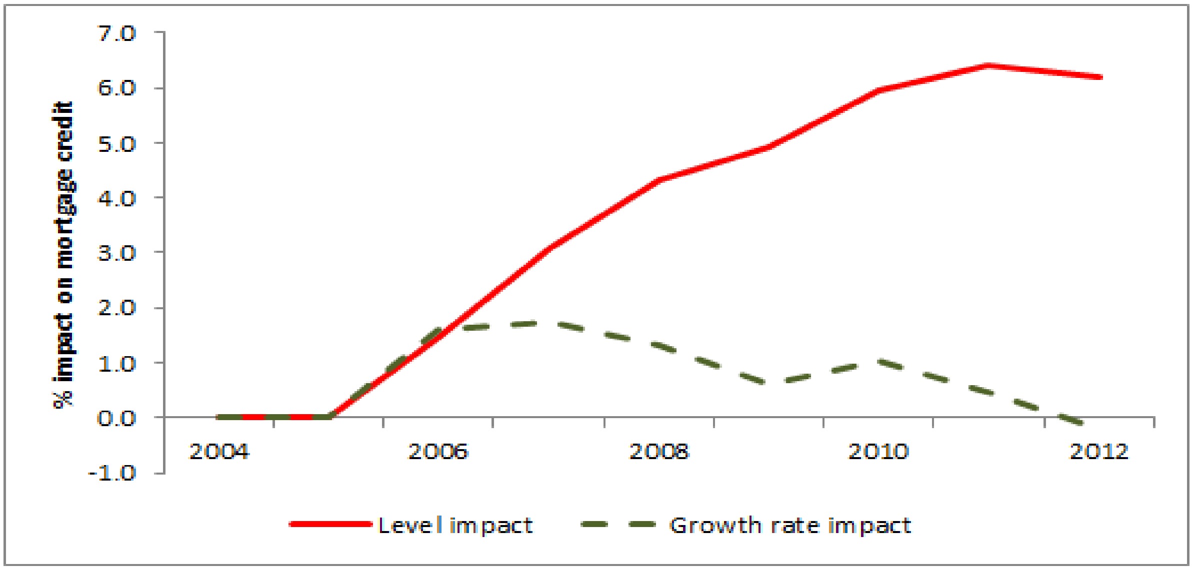
	LTV 95/AM 40	LTV 100AM 25	LTV 95/AM 25
Baseline	-17.5	-5.0	-24.1
Shock	-18.7	-6.2	-24.9

5.5 Discussion

The results of the experiments suggest that wealth constraints are more effective than income constraints at affecting mortgage demand, particularly on the extensive margin, for a given proportional change and the given starting points of policy parameters (95% maximum LTV and maximum 25-year amortization for insured mortgages). Income constraints, however, are just as effective as wealth constraints for high-wealth homebuyers. The focus of the empirical

[19]In reality, a 5-year fixed rate mortgage would not reflect rate changes until the mortgage is renewed. Instead, in these simulations we assign 1-year fixed-rate mortgages to our FTHBs, to accelerate the pass-through of interest rates and better illustrate their eventual impact. Note also that since macroprudential policies are only imposed at the time of origination, a substantial increase in the monthly mortgage payment does not imply households will violate the income constraint provided the monthly mortgage payments are being made.

Figure 3: Impact of macroprudential loosening and tightening on credit growth



analysis and the model, however, is on mortgage demand, and ignores some aspects of the general market for housing as well as potential supply effects. In this section we discuss how market participants other than buyers might react to macroprudential policy, affecting the interpretation of our results.

We are currently abstracting from the response of lenders in the model. As a response to tighter macroprudential regulation, for example, there are two potential responses that could lead to lower rates. First, tightening can reduce the borrowers' risk, which could lead lenders to reduce rates. Given that financial institutions do not face default risk in this market, this seems unlikely. Second, since tightening can lead some potential buyers to be disqualified from accessing mortgage insurance, financial institutions might respond by easing rates (moral hazard), subject to the mortgage still being profitable. This could be a response to a tightening of amortization, since amortization and rates are alternatives that could be adjusted in order for a household to meet the income constraint. Interest rates and LTV, however, are not substitutes, therefore we would not expect financial institutions to lower rates in response to a tightening of the LTV. In both instances, the macroprudential policy will be less effective. In the context of our results, the impact of tightening the income constraint will be smaller than what we estimate.

The model abstracts from other factors as well, including the possible effects from rule changes on expected housing returns. A loosening could prompt a pull-forward of demand not only because of easier conditions for qualification, but also in anticipation that demand, and thus house prices, will be stronger going forward. Conversely, a tightening could at least temporarily influence sellers to accept lower-than-otherwise prices in the belief that demand would weaken. While this could contribute to the impacts from the rule changes, it would likely amount to one-off effects that would roughly net-out to zero over time; any pull-forward would not indefinitely continue to accumulate, and would certainly not continue once the amortization and LTV rules had returned to their original pre-2006 states. Nevertheless, to the extent that such factors could obscure the estimation of the effects of interest, i.e., on wealth and income constraints, and on mortgage debt levels, they would still be important.

Another feature not captured in HRAM is the market response in terms of house prices. Although an endogenous explanation for house prices is beyond the scope of the model, the model irrespectively provides insight into the possible impacts of macroprudential rules. The potential benefits of a loosening on affordability could be at least partially lost through market overheating; however, this would be conditional on the elasticity of supply over a given time horizon, thus rule changes interact with the ability of housing supply to respond to increased demand. Rapid loosening could be more likely to induce house price increases if the expansion in demand outpaces supply, so as to not achieve the intended benefits for affordability, at least in the short term. Over a longer time horizon, of course, the elasticity of supply should increase.

In the opposite case of a rule-tightening, though, any endogenous effect on house prices would serve to mitigate the negative affordability impact. This should diminish the concern about negative side effects from measures implemented to counteract mushrooming household debt. In either case, the relative elasticities of short-term versus long-term supply are worthy of consideration.

6 Conclusion

This paper analyzes the impact of key macroprudential housing finance rule changes in Canada on household borrowing behavior and mortgage credit. From changes in consumer demand, we find that LTV constraints, which work through the wealth channel, are effective housing finance tools. Given that the average household is able to meet changes in cash flow, we conclude that, at least with the types of changes we observe to amortization, that changes directed at household repayment constraint are less effective. Households are attracted to these products, however, they are not binding.

An important contribution of this paper is the use of microsimulation modeling to capture the interactions of multiple policy tools and the non-linearities in consumer responses. This model imposes some structure on how we interpret the data while still being highly flexible in capturing nonlinear responses that more traditional, rational forward-looking dynamic stochastic general equilibrium models generally have difficulty capturing. The model allows us to map the impact of a policy change on the percentage of FTHBs who enter the market and their demand for credit. The results of our microsimulation model suggest that the wealth constraint has the largest impact on the number of FTHBs who enter the housing market and amount of debt that they hold. However, the impact of changes in amortization, which affect the income constraint, do affect high-wealth households. Finally, we show that LTV policies seem to reduce the impact of interest rate shocks on household vulnerabilities relative to income-based policies.

A caveat of our results is that we have taken as given that lenders are able to change the supply of credit exogenously in response to changes in macroprudential policy. This appears reasonable, given that banks do not face default risk in the Canadian (insured) mortgage market. However, if there is a tightening, banks might react strategically to price mortgages in a way that partially offsets changes in macroprudential policies. More importantly, we do not capture general equilibrium effects. A relaxation of mortgage insurance guidelines leads to entry of FTHBs, which can lead to house price appreciation, which leads to further entry and greater house price appreciation. This can affect both current and future mortgage demand in a way that is not captured in the model.

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