HOUSEHOLD RESPONSES TO MACROPRUDENTIAL POLICY

Iris Yao*

Abstract

I analyze how household leverage responds to debt-to-income (DTI) limits by considering a DTI tightening in Canada. I show that the policy effectively reduced household leverage through its effects on mortgage lending, along the extensive margin (fewer mortgages) and intensive margin (smaller mortgages). I present evidence that adjustment of non-mortgage debt is an important policy consideration and households exhibit window-dressing behavior around the time of origination by adjusting their non-mortgage debt. Prospective homebuyers who are above the DTI limit before origination reduce non-mortgage debt in order to satisfy DTI limits at origination but subsequently re-accumulate debt after origination. I show that this behavior is driven by the regulatory DTI cutoff and not unobserved shocks which may correlate with the home purchase decision and similar debt dynamics around origination. I also show that household adjustments of non-mortgage debt can affect the impact of DTI limits on macroeconomic variables such as house price growth.

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1 Introduction

Excessive household leverage can lead to financial crises, deep recessions, and slow recoveries (Jordá, Schularick, and Taylor, 2016; Mian and Sufi, 2009, 2011; Mian, Sufi, and Verner, 2017). To lower the probability of future crises and mitigate its negative impacts, many countries[1] have turned to macroprudential tools to curb the build-up of household debt. The theoretical motivation behind leverage restrictions is that atomistic agents overborrow in good times because they do not internalize the general equilibrium effect of asset sales on prices during bad times (Lorenzoni, 2008; Bianchi, 2011). This inefficiency creates a role for policies which restrict leverage ex-ante.

How does household debt respond to leverage restrictions in practice? Our understanding of the empirical policy impact remains limited, because implementation of these policies in the real world can be complicated. Policymakers must decide which type of debt to target (i.e., housing or total consumer debt), the appropriate limits to enforce, (i.e., collateral-based limits such as loan-to-value (LTV) or income-based such as debt-to-income (DTI)), and who to impose the limits upon (i.e., borrowers or lenders). Whether these policies can effectively improve financial stability depends on the choice of policy tools, institutions features, and how households respond. Indeed, existing empirical work has found disparate impacts of macroprudential tightening on mortgage credit, ranging from no change in aggregate issuance, to reductions in mortgage credit along both intensive and extensive margins[2].

Little is known about how households respond to macroprudential policies which restrict leverage by regulating mortgage lending. This paper examines how households adjust their leverage in response to these policies, and how these adjustments change over time. Studying the policy impact on total household leverage is important, because while macroprudential policies often target mortgage lending, they ultimately aim to curtail total household debt. This makes non-mortgage debt, which accounts for one-third of household debt payments, an important outcome to consider when evaluating policy

[1] Alam, Alter, Eiseman, Gelos, Kang, Narita, Nier, and Wang (2019) show that loan-to-value (LTV) and loan-to-income (LTI) limits have been used in 60 and 42 countries respectively, between 1990 and 2016.

[2] For example, Acharya, Bergant, Crosignani, Eisert, and McCann (2021) find that aggregate mortgage issuance is unchanged following a macroprudential tightening in Ireland, while Defusco, Johnson, and Mondragon (2020) find that in the U.S., 15% of the affected mortgages are no longer issued, and another 20% are reduced in size. Other studies have found intermediate cases in which the partial substitution from lenders constrained by a new LTI limit to unconstrained lenders lead to a dampening of the macroprudential policy, but still results in a net credit contraction (Peydró, Rodriguez-Tous, Tripathy, and Uluc, 2020)

impact. Understanding how households adjust leverage over time is also important, because this affects the permanence with which leverage restrictions can lower households' debt-service burden.

I attempt to make progress on this question by studying a policy change which tightened DTI limits for mortgage borrowers in Canada. This policy affected one-third of mortgage originations, and reduced the maximum allowable mortgage size by 16% for the average affected borrower. I analyze total household debt by combining two datasets; the first is credit bureau data which contains all sources of debt for the universe of Canadians with a credit report. This allows me to observe all sources of debt for each individual at a monthly frequency; by observing which individuals share joint accounts, I can then consolidate debt balances and payments at the household level. I augment this data with mortgage origination data from the Canadian banking regulator, which gives me necessary mortgage variables (i.e., interest rate, term length, LTV) and borrower characteristics (i.e., income) to compute DTI at the household level and track the DTI over time. This allows me to observe how households adjust their leverage over time, rather than focusing on a snapshot at origination, or on mortgage debt alone.

To identify the causal impact of this DTI tightening, I use a difference-in-differences research design which compares changes in outcomes over time for high-LTV mortgages (treated group) to low-LTV mortgages (control group). The identifying assumption is that outcomes for high and low-LTV mortgages would have evolved in parallel in absence of the DTI tightening. In order to argue that this identifying assumption is valid, I show that outcomes for both types of mortgages evolved in parallel during the four quarters prior to the policy change. I also provide evidence to that there is minimal switching between high and low-LTV loans as a result of the policy change.

First, I show that the stricter DTI requirements introduced by the policy were binding and had an aggregate impact on mortgage credit. I document that the policy reduced mortgage credit demand along both extensive and intensive margins. Specifically, 42% fewer high-LTV mortgages were issued relative to low-LTV mortgages, and of the mortgages issued, loan size declined by 3.4%. This extensive and intensive margin response ultimately results in a 45% relative decline the volume of mortgages issued.

Having established an aggregate affect, I turn to outcomes at the household level for households who are able to originate a mortgage after the policy. I begin by documenting a novel fact—households exhibit window dressing behavior around the time of origination in response to a DTI limit imposed at origination. I show that households which are above the DTI limit one year before origination lower their DTI by reducing non-mortgage debt payments. Importantly, the same households which see the largest reduction in DTI before origination also see the largest increase in DTI during the year after origination. I show that this behavior is driven by the regulatory limit and not other unobserved shocks which may drive similar de-leveraging and re-leveraging behavior around the time of a home purchase. I then study how household leverage responds when the existing DTI limits are tightened. I find that this tightening reduces DTI at origination by 3.7% for high-LTV households relative to low-LTV households, 10% of the mean DTI at origination prior to the policy. Four-fifths of the decline in DTI is attributable to lower mortgage debt payments and the remaining fifth is attributable to lower non-mortgage debt payments. Half of the policy impact on non-mortgage debt is eroded away as households re-accumulate debt after they satisfy the limit. However, the policy effectively reduces households' debt servicing burdens through the reduction in mortgage debt, which is a permanent reduction[3].

Having established that households exhibit some window-dressing behavior in order to satisfy the DTI limit, I explore how these adjustments affect the policy impact on delinquencies and house prices. I show a positive correlational relationship between DTI at origination and the likelihood that a household is delinquent on at least one debt payment within 18 months of origination. I further show that after controlling for DTI at origination, along with other household characteristics like income and credit score, households which were above the DTI limit prior to origination are still more likely to be delinquent. The increase in the probability of delinquency for a household which was above the DTI limit before origination is 0.004 percentage points, which represents 8% of the mean probability of being delinquent. This magnitude is larger than the increase in probability of deliquency associated with a one standard deviation increase in DTI at origination. Though higher DTI at origination is associated with a greater probability of default and DTI at origination is reduced under the new policy, delinquency rates do not differentially improve for high-LTV households after the policy. However, this may be explained by the backdrop of robust house price growth and strong economic fundamentals over my sample period, during which the average mortgage delinquency rate was 0.3% (relative to 4.4% in the U.S.) and average consumer loan delinquency rate was 1.05%

[3]Households could increase mortgage debt payments by extracting home equity; however, this is only permitted when home equity reaches a minimum of 20%. It is extremely rare for this to occur within the first 18 months of origination, which is the period I focus on. The modal high-LTV household begins with 5% home equity.

(relative to 2.28% in the U.S.).

Finally, I assess the policy impact on house prices and consider how the policy impact is mediated by whether households reduce mortgage or non-mortgage debt. I construct a regional-level treatment variable which corresponds to the share of mortgages issued in each region which would have failed to qualify under the new policy. I compare the change in house prices across different regions, and find that regions with a higher exposure to the policy see lower house price growth after the policy was implemented. Specifically, a one-standard deviation increase in the treatment variable leads to a relative decline of 1.0% in regional house prices over the course of a year. However, the policy impact on house prices depends on the extent to which stricter DTI limits force households to reduce the size of their mortgage, which reduces the house price that they can afford. If households can satisfy the DTI limit by adjusting along the non-mortgage debt margin and take on the same quantity of mortgage credit that they would have chosen in absence of the policy, the impact on house prices may be muted. I exploit the design of this DTI tightening in order to explore whether adjustment of non-mortgage debt mutes the policy impact on house prices. The policy is designed so that prospective homeowners must satisfy two separate limits—a mortgage payment-to-income limit (PTI) and a total debt-to-income limit (DTI). Households which are constrained by the PTI limit must lower the size of their mortgage; that is, no reduction of non-mortgage debt will allow them to satisfy the new policy and originate a mortgage. Hence, exposure to the PTI limit should reduce the house price that households can afford, which may then lead to a reduction in the average regional house prices. However, households who are constrained by the DTI limit, but not the PTI limit could feasibly afford the same house that they would choose in absence of the policy, provided they can reduce their non-mortgage debt to satisfy the new policy. I find that the house prices are more sensitive to the PTI limit—specifically, a one standard deviation increase in exposure to the PTI limit leads to a relative decline of 1.6% in house prices, whereas a one standard deviation increase in exposure to the DTI limit leads to a relative decline of 0.7%. This suggests that the macroeconomic implications of a DTI limit are affected by the type of debt (mortgage vs. non-mortgage) that households reduce.

My paper contributes to a large literature on the impact of macroprudential policies on household leverage. Firstly, it relates to a policy literature which empirically measures the impact of leverage restrictions on credit and house prices. Cross-country studies have shown a large degree of variation in the impact of these policies depending on how narrowly policies target specific markets (e.g., housing) (Akinci and Olmstead-Rumsey, 2018), whether these policies target borrowers or lenders (Cerutti, Claessens, and Laeven, 2017), and whether the policy is implemented in an emerging or developed economy (Alam, Alter, Eiseman, Gelos, Kang, Narita, Nier, and Wang, 2019). Recent evidence has relied on micro-level data to abstract from differences in institutional and market structures. Aastveit, Juelsrud, and Wold (2021) and van Bekkum, Gabarro, Irani, and Peydró (2019) show that higher LTV requirements lead to fewer mortgages issued, but conditional on home purchase, a higher vulnerability to negative shocks as households are less liquid after meeting the higher upfront costs of buying a home. The authors find divergent results on household default—whereas Aastveit, Juelsrud, and Wold (2021) find that households are more prone to default after job loss, van Bekkum, Gabarro, Irani, and Peydró (2019) find that households with negative income shocks have a lower likelihood of default.

This paper is closest to Defusco, Johnson, and Mondragon (2020); Peydró, Rodriguez-Tous, Tripathy, and Uluc (2020), and Acharya, Bergant, Crosignani, Eisert, and McCann (2021), who study income-based limits. Defusco, Johnson, and Mondragon (2020) study the Ability-to-Repay provision of the Dodd-Frank act, which increased the cost of lending to borrowers above a DTI threshold. The policy led to a 15% reduction in credit supply along the extensive margin and further reductions along the intensive margin, with an additional 20% of affected loans reduced in size. By contrast, Acharya, Bergant, Crosignani, Eisert, and McCann (2021) show that the quantity of mortgage remained largely unchanged after LTI and LTV restrictions were introduced in Ireland. Instead, lenders reallocated credit from low to high-income borrowers.Peydró, Rodriguez-Tous, Tripathy, and Uluc (2020) shows that a LTI limit imposed on lenders in the UK led to a net decline in mortgage credit, and borrowers were unable to fully substitute from constrained lenders to unconstrained lenders. I build on this work by focusing on how macroprudential tightening impacts demand for mortgage credit, and documenting how household adjustments along the non-mortgage debt margin can impact whether policy goals are achieved.

Secondly, this paper contributes to the discussion on macroprudential policy design. Among the 134 countries who have implemented some form of leverage restriction (Cerutti, Claessens, and Laeven, 2017), many have used a collateral-based limit such as loan-to-value (LTV) in conjunction with an income based limit such as loan-to-income (LTI) or debt-to-income (DTI)[4], consistent with the 'double trigger' model of mortgage default. While LTV limits are generally straight-forward in their formulation, income-based limits can take many forms. This has generated discussion among policymakers (Bank of England, 2021; Central Bank of Ireland, 2021) as to the tradeoffs between aligning closely with a household's repayment capacity (pointing to a DTI limit) and the additional regulatory burdens of a more complex instrument (a DTI limit requires monitoring non-mortgage debt and introducing maturity limits). My analysis suggests that the more simplistic LTI limit, which is immune to borrower manipulation may be preferable the more complicated DTI limit. This speaks broadly to the role of quantity regulations in lieu of complex regulations when strategic behavior is feasible and costly to detect (Glaeser and Shleifer, 2001; Behn, Haselmann, and Vig, 2022).

Thirdly, the motivation behind the DTI tightening is to ensure borrowers could continue to make debt repayments if subject to a negative shock such as job loss or large expense shocks. The consumer protection motives behind this policy is related to the literature on the broader regulation of consumer financial products (Campbell, Jackson, Madrian, and Tufano, 2011; Posner and Weyl, 2013; Jambulapati and Stavins, 2014; Agarwal, Chomsisengphet, Mahoney, and Stroebel, 2015). DTI ratios have been used in the US and abroad to help insulate borrowers against negative shocks, but have seen limited success in lowering default risk empirically (Foote, Gerardi, Goette, and Willen, 2010; Defusco, Johnson, and Mondragon, 2020; Hu, 2022), despite strong theoretical links between debt service and default (Campbell and ao Cocco, 2015; Corbae and Quintin, 2015). I provide evidence that the weak relationship between DTI and default may be attributable to households' adjustment of non-mortgage debt in response to DTI limits, which imply that limits imposed at a single point in time may not be fully representative of a household's debt-sevice burden. However, I caveat that my analysis is a partial equilibrium estimate, and does not consider the general equilibrium effect of DTI on default through house prices as outlined in quantitative general equilibrium models such as Greenwald (2018).

The rest of this paper proceeds as follows. Section 2 describes the Canadian residential mortgage market and policy details. Section 3 describes my data and sample construction, section 4 covers results on aggregate mortgage credit, section 5 covers results on debt-to-income, section 6 covers results on delinquenceies, 7 cover results on house prices, and section 8 concludes.

[4]LTI refers to the ratio of the total mortgage balance at origination to gross annual income. DTI refers to the flow of debt service payments (including non-mortgage debt) as a fraction of income.

2 Institutional Background

2.1 Household Indebtedness and Residential Mortgage Credit in Canada

Since the early 2000s, rising house prices and a sustained period of low interest rates have contributed to rising indebtedness among Canadian households. Between 2000-2018, Canada saw the largest increase in debt-to-income and had the highest DTI levels among all G7 nations (Bank of International Settlements, 2022). When households must dedicate a significant portion of income to servicing debt, they are more likely to be delinquent on their debt payments in the face of a negative shock. Hence, higher debt-to-income ratios render households more vulnerable to negative shocks and pose a threat to financial stability. The rising indebtedness among Canadian households prompted concerns from both policymakers at the Canadian Central Bank and international agencies such as the Bank of International Settlements[5].

To address the risk to financial stability, policymakers turned to regulating residential mortgages. Specifically, the banking regulator, OSFI (Office of the Superintendent of Financial Institutions), mandated a stricter mortgage qualification requirements which ”require institutions to examine carefully whether borrowers are able to repay their loans for the life of the mortgage” through ”test[ing] a borrower's ability to continue to make their mortgage payments in the event of difficult economic circumstances including a rise in interest rates, fluctuating house prices, or a reduction of income such as an on the job inquiry or job loss”.[6]

Residential mortgages are an important tool for managing financial stability for several reasons. First, mortgage debt payments account for two-thirds of total debt payments for the average homeowner, and one-fifth of bank assets for chartered banks (OSFI, 2016). Second, both new and existing homeowners are exposed to higher mortgage debt payments through interest rate increases. Unlike the standard 30-year fixed-rate mortgage contract in the U.S., the standard Canadian mortgage contract only holds the interest rate fixed for a five-year term, meaning that the contract rate is renewed every 5 years at the prevailing market rate. Positive economic performance through mid-2016 led policymak-

[5]Lawrence Schembri, the Deputy Governor of the Bank of Canada, noted that increasing household debt has ”increased the vulnerability of the economy and the financial system to adverse shocks to incomes and interest rates.” in his 2016 remarks entitled *Elevated Household Debt and the Risk to Financial Stability*. In 2018, BIS reported that ”aggregate credit indicators point to vulnerabilities in several jurisdictions. Canada, China, and Hong Kong SAR stand out, with both the credit-to-GDP gap and the debt service ratio flashing red.”

[6]See OSFI (2021) for OSFI's guideline on stress-testing residential mortgage borrowers.

ers to expect a rising path of interest rates, and hence rising mortgage debt service burdens. Thirdly, policymakers were concerned with the feedback loop between mortgage credit and house prices, noting that increasing household debt and strong house price growth have continued to reinforce each other (Bank of Canada, 2016). By mandating a stricter mortgage qualification process, regulators hoped to prevent households from exceeding their debt-servicing capacity and slow the pace of home price increases.

2.2 Policy Implementation

Before the policy change, prospective homebuyers needed to meet the following two conditions in order to originate a mortgage:

1. **Mortgage Payment to Income (PTI) Requirement:** the mortgage payment cannot exceed 39% of borrower income. The mortgage payment is calculated using the loan size, contract rate, and amortization length.

2. **Total Debt Payments to Income (DTI) Requirement:** the sum of mortgage payments and all other debt payments (e.g. outstanding car loans, credit card payments) cannot exceed 44% of borrower income.

In October 2016, OSFI tightened both PTI and DTI requirements for high-LTV mortgages (LTV $>$ 80%), which are guaranteed against borrower default by the government and account for 46% of total mortgage credit issued by volume[7]. Instead of lowering the DTI cap, the policy change calculates the mortgage payment using a 'qualifying interest rate', which is strictly higher than the contract interest rate (Figure 2a):

$$\text{Qualifying Rate} = \max\{\text{Contract Rate} + 0.02, \text{Bank of Canada Benchmark Rate}\} \tag{1}$$

Since the qualifying rate is strictly higher than the contract rate, the resulting mortgage payment will be strictly higher than the payment implied by the contract rate (holding loan terms and income fixed). This reduces the maximum allowable loan size by pushing a borrower closer to the maximum allowable PTI and DTI thresholds (Figure 2b). Note that the mortgage payment ultimately paid by the borrower is still determined by the

[7]High-LTV mortgages (5% down payment) are roughly analogous to Federal Housing Administration (FHA) mortgages, which feature low down payments (3.5%) and strict DTI requirements. Low-LTV mortgages can be compared to Fannie/Freddie mortgages, which feature higher down payments (20%) and no formal DTI caps (See Allen and Greenwald (2022) for more details on the correspondence between the Canadian and U.S. mortgage markets).

contract rate; a higher qualifying rate is used only for mortgage approval purposes. The spirit behind the policy design is to ensure that a household has a sufficient income buffer to afford their mortgage payments if subjected to a negative shock such as an expense shock or reduction in income. For the average high-LTV borrower in the year prior to the policy, this tightening reduces the maximum loan size by 16%.[8]

3 Data

This paper uses regulatory and credit bureau data to construct a comprehensive picture of each household's liabilities over time. An important contribution of this paper is to collect both mortgage and non-mortgage debt for each household at regular intervals before and after mortgage origination. First, the inclusion of non-mortgage debt is important because non-mortgage payments constitute one-third of the average household's total debt-service obligations (Table 1). While macroprudential policies often target mortgage debt, they generally aim to lower the total debt service burden; focusing exclusively on mortgage debt would ignore a significant fraction of households' debt service burdens. Second, usage of regulatory data avoids the data coverage issues frequently faced by researchers who rely on mortgage servicing data for the DTI variable. For example, U.S. mortgage servicers do not report DTI ratios for approximately 50% of the sample, and the missing coverage varies over time as different servicers enter or exit the dataset (Foote, Gerardi, Goette, and Willen, 2010; Defusco, Johnson, and Mondragon, 2020). To the extent that mortgages with missing DTI ratios are systematically different, or that data coverage covaries with the incidence of DTI-related policies, biases could be introduced when studying the impact of these policies.

3.1 Data Sources

Mortgage Debt. Data on mortgage originations are from the federal banking regulator, the Office of the Superintendent of Financial Institutions (OSFI). This includes all new mortgage originations from all chartered banks in Canada, which represent 75% of all

[8] The average high-LTV borrower has an income of $84.7K and has a maximum allowable loan size of $507K before the policy change (using the average pre-period interest rate of 2.06%, LTV of 95%, and amortization term of 25 years). Post-policy, the maximum allowable loan size for the same borrower is $424K, a reduction of 16%. This calculation assumes that the borrower carries no non-mortgage debt, and that the lender would be willing to lend up to the 39% mortgage payment-to-income limit; violation of either assumption will further reduce the maximum allowable mortgage loan size.

new mortgage originations by volume. The data contain loan characteristics (outstanding balance, interest rate, loan-to-value, origination month) and borrower characteristics (income at origination, age, credit score, county).

Non-Mortgage Debt. Data non-mortgage debt is obtained from TransUnion. This data contains debt balances and payments at the account level for each consumer in Canada with a credit report, at a monthly frequency. TransUnion also contains data on mortgage debt, which I use to merge with the mortgage debt from OSFI. The mortgage origination data from OSFI contains missing variables from TransUnion (mortgage rate, loan-to-value, borrower income at origination).

House Prices. House price indices is from Teranet, the standard house price index used by the federal banking regulator when assessing housing market conditions. It is a repeat-sales index constructed by computing the change in price between sales of the same property across different time periods. This price index is unaffected by changes in the characteristics or quality of properties transacted, but excludes new properties and properties which were only bought once.

3.2 Sample Construction and Summary Statistics

To construct a comprehensive picture of each household's liabilities, I merge the mortgage originations data and TransUnion data using using four fields common to both datasets: the outstanding mortgage balance at origination, origination month, lender, and borrower county. Outstanding mortgage balances are reported with a high level of precision (down to the exact dollar amount), which allows for precise matching between the OSFI and TransUnion datasets. I consolidate debt balances and payments at the household level by combining loan balances for individuals who share the same mortgage account number. The resulting dataset allows me to track debt balances and payments at the household level at a monthly frequency.

The sample period runs from 2015Q3 - 2017Q4 to include four quarters before and after the policy was announced. The end point is set to 2017Q4, since OSFI introduced new leverage restrictions in the beginning of 2018 targeting low-LTV mortgages, which I use as a control group in this paper. Within the sample period, I include all 25-year amortization, fixed-rate purchase mortgages. I drop observations which with missing income, LTV, PTI, DTI, or geographic identifiers, which represent 7% of the available data. The final sample consists of approximately 530,000 loans, of which approximately 460,000 are matched to TransUnion data.

Summary statistics are presented in Table 1. The average high-LTV (treated) mortgage has a larger outstanding balance than a low-LTV (control) mortgage (\$353K vs. \$307K), goes to a household with lower gross income (\$115K vs. \$93K), but similar DTI ratios (40%).

4 Policy Impact on Aggregate Mortgage Credit

In this section, I assess the policy impact on the aggregate issuance of mortgage credit. The existing empirical literature has not reached a consensus on the effect of leverage constraints on mortgage origination volume. In the U.S., Defusco, Johnson, and Mondragon (2020) find that a policy which lowered the DTI limit lowered the quantity of mortgage credit: 20% of affected households lowered the size of their mortgage and 15% of affected households were prevented from borrowing altogether. By contrast, Acharya, Bergant, Crosignani, Eisert, and McCann (2021) find that while loan-to-income (LTI) and LTV restrictions in Ireland affected one-third of households, residential mortgage originations were affected by these limits as lenders shifted originations from households constrained by the policy to households which were unconstrained. Similarly, Peydró, Rodriguez-Tous, Tripathy, and Uluc (2020) find that LTI restrictions in the U.K. led to a decline in the number of mortgages issued to low-income borrowers, but this was offset by increased lending to high-income households.

4.1 Empirical Strategy

To estimate the policy impact, it is important to note that this policy was enacted during a period of strong house price growth. Therefore, I will need to separate the policy impact from the macroeconomic trends which drove strong demand for mortgage credit during this period of time. I use a difference-in-differences framework to assess the change in issuance of high-LTV mortgages (treated group) relative to the change in issuance of low-LTV mortgages (control group). The identifying assumption is that issuance of both types of mortgages would have evolved in parallel in absence of the policy.

Prospective homeowners who are constrained by the policy can choose to remain in the rental market (extensive margin response) or originate a smaller mortgage (intensive margin response). To assess the extensive margin response, I aggregate the number of mortgages for each market segment (LTV > 80, LTV ≤ 80), up to the county-quarter level and run the following specification:

$$\log(\text{No. of Mortgages})_{sct} = \alpha + \beta_0 \cdot \mathbb{1}(\text{High-LTV})_s + \beta_1 \cdot \mathbb{1}(\text{High-LTV})_s \times Post_t + \gamma_{pt} + \epsilon_{sct} \tag{2}$$

where log (No. of Mortgages)$_{sct}$ is the logarithm of the number of mortgages in segment $s \in \{\text{LTV} > 80, \text{LTV} \leq 80\}$, issued in county c, in quarter t. $Post_t$ is an indicator equal to 1 for all time periods strictly after 2016Q3, and γ_{pt} is a state-quarter fixed-effect to capture time-varying differences between different states (e.g. different housing dynamics or economic conditions in coastal states vs. interior states). To assess the intensive margin response, I replace the dependent variable in equation 2 with $\log(\text{Mortgage Volume})_{sct}$.

One concern with this empirical approach is the possibility that households switch from high to low-LTV mortgages as a direct result of the policy. This is possible if households cannot satisfy the stricter DTI requirement for a high-LTV mortgage, but have enough savings to increase their downpayment and take on a low-LTV mortgage, which is not subject to the new policy. I address this concern in two ways. In Appendix A, I provide evidence for limited substitution between high and low-LTV mortgages during my sample period. I also construct an alternative treatment variable called the Disqualified Share which measures how intensely treated each county is by calculating the percentage of mortgages issued in a county which would have failed to qualify under the new policy:

$$\text{Disqualified Share}_c = \frac{\text{\# Pre-Period Mortgages Which Would Fail to Qualify Under New Policy}_c}{\text{\# Pre-Period Mortgages}_c}$$

I designate a county as treated if the Disqualified Share is above the median across all counties, and compare mortgage issuance across treated and control counties by estimating the specification below:

$$\begin{aligned} \log(\text{No. of Mortgages})_{ct} = \alpha &+ \beta_0 \cdot \mathbb{1}(\text{Above Median Disqualified Share})_c \\ &+ \beta_1 \cdot \mathbb{1}(\text{Above Median Disqualified Share})_c \times Post_t + X_c'\rho + \gamma_{pt} + \epsilon_{ct} \end{aligned} \tag{3}$$

Where X_c is a vector of county-level controls including the average household income, unemployment rate, and sales-to-listings ratio[9], measured as of 2016Q3 in each county.

[9]The sales-to-listings ratio is a standard measure used to gauge the demand for homes relative to the supply. A high sales-to-listings ratio is an indicator that demand for homes is high relative to supply. By standard industry definitions, a sales-to-listings ratio between 0.4-0.6 indicates a balanced market. Higher values indicate a seller's market.

If there is substantial substitution from high-LTV mortgages to low-LTV mortgages as a result of the policy, aggregate mortgage issuance will not differ between treated and control counties after the policy change.

4.2 Results on Aggregate Mortgage Credit

I begin by providing evidence that the stricter DTI requirements introduced by the policy was a binding constraint for new mortgage originators. Figure 1a shows the distribution of DTI for high-LTV mortgages before and after the policy. In particular, it shows that the tightened DTI requirement was a binding constraint for a significant proportion of high-LTV mortgages. One-third of high-LTV mortgages issued before the policy would fail to qualify under the new policy. Figure 1b confirms that the elimination of high-LTV mortgages with DTI above 44% occurs precisely during the quarter when the policy was introduced, and is therefore caused by the policy change.

Panel A of Table 2 reports estimates from equation 2. Column (1) of Table 2 reports a 42% relative decline in the number of high-LTV originations, which shows that the stricter DTI requirements prevented or delayed home purchases for a substantial fraction of prospective high-LTV households. Column (3) shows that of the households who were able to successfully originate a mortgage after the policy, the average loan size was 3.4% smaller, or a reduction of approximately \$10K relative to the pre-policy loan size. The reduction in the number of mortgages issued along with a reduction of average mortgage size leads to a relative decline of 44% in mortgage issuance volume shown in Column (2). To show that the reduction in loan issuance was a direct result of the policy change, Figure 3 plots coefficient estimates from a more flexible difference-in-difference specification which allows the effect of the policy to vary by quarter, replacing the $Post_t$ indicator with an indicator for each quarter in the sample period (omitting 2016Q3, the quarter before the policy was announced). These figures show that the decline in the number of mortgages issued, total volume of mortgage issuance, and reduction in average mortgage size coincides with the introduction of the policy.

Panel B of Table 2 reports estimates from equation 3. Since the treatment variable is defined differently, the magnitudes from Panel B are not directly comparable to those in Panel A. Instead, Column (1) verifies that counties with a greater share of pre-policy mortgages subject to disqualification by the policy did indeed see a larger decline in the number of total mortgages issued after the policy. This provides evidence that households were not able to fully substitute from low-LTV to high-LTV loans in response to the policy.

I provide further detailed evidence on limited switching in Appendix A.

5 Policy Impact on Debt-to-Income

I begin by documenting a novel fact about how household leverage behaves in response to the pre-existing DTI limits. In particular, that households exhibit window dressing behavior around the time of origination. Prospective homebuyers who are close to or above the DTI limit reduce their debt payments in order to meet the limit at the time of origination, but subsequently re-accumulate debt so that their DTI is above the limit within a year after origination. Given this fact, I then turn to measuring the policy impact on DTI and assessing how the policy impact is affected by households' window dressing behavior.

5.1 Debt-to-Income Response Before and After Origination

In this section, I document that households exhibit window dressing behavior around the time of origination in response to the existing DTI limit, before the policy change. I begin with aggregate evidence in Figure 5, which shows the DTI distribution for households who originate high-LTV mortgages at three points in time—one year before origination, at origination, and one year after origination. The DTI at each point in time is calculated by taking the sum of the household's mortgage payment and adding the non-mortgage debt payments at the given point in time. This figure shows that a DTI limit at origination effectively forces households who were above the limit one year before origination to reduce their DTI, which shifts the DTI distribution to the left. For policymakers who are concerned about households' capacity to service debt, this is a desirable outcome because it limits the maximum debt-service burden for mortgage originators. However, the DTI distribution shifts right within one year after origination, which suggests that the reduction in DTI is temporary.

Next, I show that the households who reduce DTI in order to satisfy the limit at origination are the same households who increase their DTI above the 44% limit after origination. I begin by sorting households into different groups based on their DTI before origination, calculated as follows:

$$\text{Pre-Origination DTI}_i = \frac{\text{Mortgage Payment}_i}{\text{Income}_i} + \frac{\text{Non-Mortage Debt Payments 18 Months Before Origination}_i}{\text{Income}_i} \tag{4}$$

I focus on households who are close to or above the DTI limit, since these households must reduce their DTI in order to successfully originate a mortgage. I restrict attention to households with a pre-origination DTI between 36%-52%, a symmetric window around the DTI limit of 44%; this subsample represents 40% of the total sample. I sort households into four different groups based on their pre-origination DTI, and calculate the average DTI for each group at a monthly frequency. In Figure 6, I show that the households who were in the DTI bin furthest above the limit see the largest reduction in their DTI. Importantly, these households also see the largest increase in their DTI after origination. This suggests that the shifts in the DTI distribution shown in Figure 5 are attributable to the same set of households.

This reduction and subsequent in DTI can occur through changes in either mortgage or non-mortgage debt. Mortgage payments are fixed by the terms of the mortgage contract, and no refinancing is possible until home equity reaches a minimum of 20%, which is rare within the first 18 months after originating a high-LTV mortgage. Therefore, the changes in DTI that I document occur through lowering and accumulating non-mortgage debt before and after origination.

Table 3 quantifies the visual patterns in Figures 5 and 6. In Panel A, I confirm that households with a pre-origination DTI which is further above the 44% limit see a greater decline in DTI prior to origination by estimating the following specification:

$$\begin{aligned}\Delta(\text{DTI Before Orig.})_{it} = {} & \beta_0 \mathbb{1}(\text{Pre-Origination DTI} > 44\%)_i + \beta_1 (\text{Distance Above DTI Limit})_i \\ & + \beta_2 \mathbb{1}(\text{Pre-Origination DTI} > 44\%)_i \times (\text{Distance Above DTI Limit})_i + \\ & + X_i' \rho + \gamma_{ct} + \epsilon_i\end{aligned} \tag{5}$$

The dependent variable is the difference between a household's pre-origination DTI and the DTI at origination for mortgage i, Pre-Origination DTI is as defined in equation 4; Distance Above DTI Limit is the difference between a household's pre-origination DTI and the limit of 44%; $\mathbb{1}(\text{Pre-Orig. DTI} > 44\%)_i$ is an indicator set to one if the household's pre-origination DTI is above the 44% limit; X_i is a vector of controls which include income, age, credit score, and an indicator if the household is a first-time home-buyer.

Column (1) of Table 3 confirms that households with a pre-origination DTI further above the limit see a greater decline in DTI prior to origination. Column (2) shows that for households above the 44% limit, the decline in DTI moves almost one-for-one with the household's distance above the limit. This magnitude remains stable after controlling for borrower characteristics and using variation within borrowers who originated within the same county, during the same month to account for variation in local economic conditions which may drive de-leveraging behavior.

Panel A establishes that households who were furthest above the DTI limit saw the greatest reduction in DTI prior to origination. In Panel B, I show that households which see larger reductions in DTI before origination also see a larger increase in DTI during the 18 months after origination. I estimate the following specification and restrict to the sample of households with $\Delta(\text{DTI Before Orig.}) \geq 0$:

$$\begin{aligned}\Delta\text{DTI After Origination}_i = {} & \beta_0 \mathbb{1}(\text{Post-Origination DTI} > 44\%)_i + \beta_1(\Delta \text{ DTI Before Orig.})_i \\ & + \beta_2 \mathbb{1}(\text{Post-Origination DTI} > 44\%)_i \times (\Delta \text{ DTI Before Orig.})_i \\ & + X_i'\rho + \gamma_{ct} + \epsilon_i \end{aligned} \tag{6}$$

Column (1) confirms that households who saw a greater reduction in DTI before origination also see a greater increase in DTI after origination. Column (2) shows that households who were above the 44% limit increase their DTI at a faster rate relative to those who were below the limit. However, the decline in DTI is not fully recovered—for every 1% reduction in DTI before origination, 0.85% is recovered by 18 months after origination. This magnitude also remains stable after controlling for borrower characteristics and county-quarter fixed effects.

The evidence above is consistent with window-dressing behavior around the time of origination. The DTI for households who are above the regulatory limit decline before origination and rebound afterwards; those who see a larger reduction in DTI also see a larger subsequent increase in DTI. This behavior is also consistent with alternative explanations. First, since home purchase is not randomly assigned, it is possible that unobserved shocks (e.g. family formation, promotion) coincide, (or lead to) both the decision to purchase a home and the decision to repay outstanding debt and take on additional debt after the home purchase (for example, to furnish the home[10]). Second, prospective homeowners may be lowering their debt burden in order to achieve targets unrelated to the regulatory DTI threshold. For example, a lower debt burden is generally correlated with a higher credit score, which in turn can lead to improved contract terms such as a lower mortgage rate.

To provide evidence that the behavior outlined in this section is driven by the regulatory DTI limit rather than unobserved shocks, I argue that these unobserved shocks should be independent of the DTI limit. This implies that households which have a DTI slightly above the limit should be equally likely to engage in this behavior as households with a DTI slightly below the limit. In Figure 7, I plot the average DTI at origination against the DTI 12 months before origination. It shows that DTI at origination moves in tandem with the DTI before origination, but only for households whose DTI before origination is below the limit of 44%. For households with a DTI above the limit prior to origination, DTI at origination hovers around 44%, the maximum allowable DTI. This suggests that only households above the DTI limit before origination reduce their DTI, behavior consistent with the intent to meet the regulatory threshold rather than deleveraging due to unobserved shocks. This behavior also inconsistent with prospective homeowners who reduce DTI solely to improve the terms of their loan contract.

5.2 Policy Impact on Debt-to-Income

The results thus far have focused on how households respond to the pre-existing DTI limit before the policy change. I now turn to identifying the policy impact of tightening the DTI requirement at origination. To identify the causal impact of the policy on average DTI, I use a difference-in-differences design to compare the change in average DTI for high-LTV mortgage originators (treatment group) relative to change in DTI for low-LTV mortgage originators (control group). The role of the control group is to establish a counterfactual of how DTI would have evolved in absence of the policy. I estimate the policy impact on the average DTI by running the following difference-in-differences specification:

$$\mathrm{DTI}_i = \beta_0 \mathbb{1}(\text{High-LTV})_i + \beta_1 \mathbb{1}(\text{High-LTV})_i \times \mathbb{1}(\text{Post})_t + X_i' \rho + \gamma_{ct} + \epsilon_{ict} \tag{7}$$

DTI_{ict} is the DTI for the household which originated mortgage i in county c, in quarter

[10] Benmelech, Guren, and Melzer (2021) find that households spend on average $8,000 more on home-related durables and home improvements in the two years following a home purchase.

t; the vector X_i represent a set of household controls which include age, credit score, income and an indicator of the household is a first-time homebuyer. Finally, I include county-quarter fixed effects, γ_{ct}, to control for time-varying differences across different counties. I cluster standard errors at the county level to account for correlated model errors within a county.

Panel A of Table 4 reports the estimation results. Column (1) shows that DTI is reduced by 3.7 percentage points at origination, which is 10% of the mean DTI at origination before the policy change. Using the average income for a high-LTV mortgage originator before the policy, this represents a reduction of $3,500 in annual debt payments, or 5.6% of the average household's annual consumption (Statistics Canada, 2016). Figure 4 confirms that the decline in DTI is driven by the policy rather than by showing that the decline in DTI occurs precisely in the quarter during which the policy was first implemented. Columns (2) and (3) decompose the decline in DTI at origination into the decline in mortgage and non-mortgage payments as a fraction of income. Mortgage payment-to-income is reduced by 3.1 percentage points and accounts for four-fifths of the total DTI decline.

Results in section 5.1 show that households can adjust their non-mortgage debt before and after origination in order to temporarily satisfy the DTI limit. This dynamic adjustment means it is insufficient to assess the policy impact by estimating the reduction in DTI at origination. To assess the policy impact at different points in time, I focus on non-mortgage debt-to-income, since this is the margin along which households can adjust. Then, I estimate the policy impact on non-mortgage debt-to-income at month τ after origination at three points in time—12 months before origination, at origination, and 12 months after origination:

$$\begin{aligned}\text{Non-Mort. DTI } \tau \text{ Months After Origination}_{it} &= \beta_0 \mathbb{1}(\text{High-LTV})_i \\ &+ \beta_1 \mathbb{1}(\text{High-LTV})_i \times \mathbb{1}(\text{Post})_t + X_i'\rho + \gamma_{ct} + \epsilon_{it}\end{aligned} \tag{8}$$

If households can engage in the window-dressing behavior described in section 5 in response to the DTI tightening, I expect β_1 to be zero at 12 after origination. In other words, the non-mortgage debt burden one year after origination is not different for high-LTV households who obtain a mortgage before or after the policy. Note that this alone would not render the policy tightening ineffective for two reasons. First, the policy could still exclude the riskiest households from the mortgage market altogether if these households cannot meet the stricter DTI limit and therefore cannot originate a mortgage at all. Second, the policy led to lower mortgage payments relative to income, which are permanent reductions until the household can extract home equity. However, households are prevented from extracting equity before their home equity reaches at least 20%. Since the modal household with a high-LTV mortgage begins with 5% home equity, this is highly unlikely within the first year.

Panel B of Table 4 reports the estimation results. Column (1) shows that policy impact reduced non-mortgage debt payments modestly by 0.22% for high-LTV households 12 months before origination. Equivalently, households who were ultimately able to originate a high-LTV mortgage after the policy had modestly lower non-mortgage debt-to-income 1 year before origination. Column (2) shows that the relative decline in non-mortgage debt for high-LTV households increases to 0.70% during the month of origination, which reflects a reduction in non-mortgage debt during the months prior to origination as borrowers respond to the tightened DTI limit. Column (3) shows that 12 months after origination, half of the decline in non-mortgage debt-to-income estimated at the time of origination is eroded away as households re-accumulate non-mortgage debt. This shows that the policy impact 12 months after origination is weaker than the estimates at origination in Panel A of Table 4 would suggest. Figure 8 plots estimates of β_1 from equation 8 at a quarterly frequency during the year before and after origination and confirms that households respond to the tighter DTI requirement by engaging in the same window dressing behavior outlined in the previous section. However, this behavior does not fully offset the policy impact on non-mortgage debt, since high-LTV households still see a relative decline in their non-mortgage debt-to-income 12 months after origination.

6 Policy Impact on Delinquencies

6.1 Empirical Strategy

I begin by establishing a correlational relationship between DTI and the probability of delinquency. Results from section 5 suggest that a household's DTI at origination may be a misrepresentative measure, since households can adjust their DTI during the months prior to origination. Therefore, I also investigate how a household's DTI one year before origination impacts their probability of default by including an indicator set to one if the household was above the regulatory DTI limit before origination. More specifically, I run the following specification on the subsample of high-LTV households:

$$\mathbb{1}(\text{Delinquent})_{it} = \beta_0 \text{DTI}_i + \beta_1 \mathbb{1}(\text{Pre-Origination DTI} > 44\%)_i + X_i' \rho + \gamma_{ct} + \epsilon_{it} \qquad (9)$$

The outcome variable is an indicator equal to 1 if a borrower misses at least one debt payment (mortgage or non-mortgage) within 18 months of origination, and DTI is the debt-to-income at origination. I include county by quarter fixed effects to account for differences in local economic conditions which may drive delinquencies (e.g. oil shocks) and cluster standard errors at the county level.

Having established the relationship between DTI and delinquency, I turn to assessing the policy impact on delinquency. One important policy goal was to reduce the probability of delinquency and default, through lowering the debt-service burden for prospective homeowners. I assess whether the policy successfully lowered the probability of delinquency by estimating the following difference-in-difference specification:

$$\mathbb{1}(\text{Delinquency})_{it} = \beta_0 \mathbb{1}(\text{High-LTV})_i + \beta_1 \mathbb{1}(\text{High-LTV})_i \times \mathbb{1}(\text{Post})_t + X_i' \rho + \gamma_{ct} + \epsilon_{it} \tag{10}$$

The outcome variable, county-quarter fixed effects, and clustering of standard errors are the same as above; X_i is a vector of borrower characteristics which include income, age, credit score, an indicator of the household is a first-time homebuyer, and the household's DTI 12 months before origination.

6.2 Results on Delinquencies

Panel A of Table 5 reports the results. Columns (1) and (2) confirms that households with a higher DTI at origination and households which had a DTI above the regulatory limit before origination have a higher probability of being delinquent on at least one credit account. One standard increase in the DTI at origination increases the probability of being delinquent by 0.003 percentage points, which is 6% of the mean probability across the sample of high-LTV borrowers. Column (3) shows that conditional on having the same DTI at origination, households with a high pre-origination DTI remain marginally more likely to be delinquent. In terms of magnitudes, they are 0.4% more likely to be delinquent, which represents 8% of the mean probability, a larger increase than a one standard deviation increase in DTI at origination. Columns (4)-(5) shows that the predictive power of $\mathbb{1}$(Pre-Origination DTI $>$ 44%) after including borrower controls (age, credit score, income) and including county-quarter fixed effects. Overall, these results show that conditional on observable characteristics at origination, a household with a DTI above 44% before origination will be more likely to be delinquent on at least one debt payment within 18 months of origination, though this positive association is not a causal relationship.

Panel B of Table 5 shows that high-LTV households are on average more likely to be delinquent on at least one payment, but the policy change has no discernable effect on delinquency. One possible reason for the null effect is the positive economic environment during the sample period, during which the baseline delinquency rate was extremely low. Additionally, all mortgages in Canada are full-recourse loans, which further reduces the delinquency rate. During my sample period, the average mortgage delinquency rate during the sample period was 0.3%, relative to 4.4% in the U.S. For non-mortgage consumer loans, the average delinquency rate was 1.05%, half the average delinquency rate of 2.28% in the U.S.

7 Policy Impact on House Prices

In this section, I measure the policy impact on house price levels. Tightening the debt-to-income (DTI) requirement reduces the maximum amount of debt a household can take on. If households respond by reducing their mortgage debt, they may not be able to pay as much for a house as they otherwise could in absence of the DTI tightening. Whether this leads to a change in average house price levels is a subject of debate and depends on the severity of the tightening, the share of households impacted by the policy, the elasticity of housing supply, and the degree of housing market segmentation between renters and buyers, among other factors.

I begin by showing that regions with a larger proportion of households affected by the policy see lower house price growth after the policy. Then, I decompose the proportion of households impacted by the policy into those who are constrained by the mortgage payment-to-income (PTI) limit and those constrained by the DTI limit. This is because results in section 5 show that some households can adjust their non-mortgage debt before origination in order to satisfy the DTI limit at origination. If these non-mortgage debt adjustments allow households to take on the same quantity of mortgage debt that they would have in absence of the policy change, the policy impact on house prices will be reduced.

7.1 Empirical Strategy

I estimate the policy impact on house prices by comparing the change in house prices across regions with differential exposure to the policy. I construct a policy exposure variable by calculating the fraction of borrowers in each region who obtained loans in the pre-period (2015Q3-2016Q3), but would have failed to qualify for a loan with the same terms (size, interest rate, amortization) under the new policy[11]. A region is the smallest geographic unit for which house price data is available. Out of all 1,450 counties, Teranet covers 1,267 counties, but only provides pricing data for 276 distinct regions. Counties are aggregated into a single region if there are very few repeat-transactions in a given quarter.

Columns (1)-(3) show summary statistics at the regional level, for the full sample and split by above and below median policy exposure. On average, 14% of pre-policy mortgages issued in a region would have failed to qualify under the new policy. Regions with above and below-median policy exposure are similar in terms of pre-policy, unemployment rates, and sales-to-listings ratios. However, regions with above-median policy exposure feature lower income mortgage borrowers with lower credit scores who tend to be located in less urban areas.

To estimate the impact of the policy on house prices, I run the following specification:

$$\Delta \log(\text{House Price Index}_r) = \gamma_s + \beta \text{Policy Exposure}_r + X_r' \rho + \epsilon_r \tag{11}$$

where $\Delta \log(\text{Price}_r)$ is the change in the log regional price index between 2016Q3 and 2017Q4. I take two steps to address the concern that policy exposure is correlated with other variables which drive differences in house prices. First, I include a set of regional controls, X_r, which include average household income, unemployment rate, and sales-to-listings ratio, all measured as of 2016Q3. I also add a set of state fixed-effects γ_s to account for time invariant level differences in house prices across different states and cluster standard errors at the state level. Second, I estimate the following specification to show that the timing of house price changes matches the timing of the policy:

$$\log(\text{Price}_{rt}) = \gamma_r + \delta_t + \sum_{t \neq \text{2016Q3}} \beta_t \cdot \text{Policy Exposure}_r \times \mathbb{1}(\text{Quarter})_t + \epsilon_{rt} \tag{12}$$

Where γ_r is a regional fixed-effect, and δ_t is a quarterly fixed-effect to control for macro trends. I cluster standard errors at the state level to account for correlated errors within each state.

The policy exposure variable captures the share of pre-period mortgages which would

[11] This exposure variable is very similar in spirit to the treatment variable used in equation 3, but is calculated at a broader geographic level.

have failed to qualify under the new policy, but does not distinguish between the two different reasons for which a loan would fail to qualify—exceeding the PTI limit of 39%, or the DTI limit of 44%. This distinction is important because the quantity of mortgage credit and hence affordable houses for a household can respond differently to these two limits. If a household is constrained by the PTI limit after the policy, the maximum possible mortgage that they can qualify for is smaller and they must choose a house at a lower price or delay their purchase. However, if households are constrained by the DTI limit, but not the PTI limit, the policy may not affect the quantity of mortgage credit a household can take on. If these households can lower their non-mortgage debt enough to satisfy the DTI limit at origination and purchase the house they would have chosen in absence of the policy, the policy impact on house prices will be reduced.

I construct two additional regional treatment variables to separately capture these two constraints. First, I generate the PTI exposure variable, defined as the share of pre-period mortgages which would have failed to qualify under the new policy because the PTI limit of 39% would be exceeded. To isolate the impact of the PTI limit, I include only mortgages which would have exceeded the PTI limit of 39%, but not DTI limit of 44% in this measure. Second, I create the DTI exposure variable, the share of pre-period mortgages which would exceed the DTI limit of 44%. To isolate the effect of the DTI limit, I set the mortgage payment-to-income to the maximum allowable PTI of 39% for households who would exceed the PTI limit under the new policy.[12]

Table 6 provides summary statistics of the PTI and DTI exposure variables. Columns (4)-(5) compare regions with above and below median exposure to the PTI limit; columns (6)-(7) repeats the exercise with the DTI limit. Regions with high exposure to the PTI limit are not the same as those with high exposure to the DTI limit. In fact, correlation between the two exposure measures is 0.08, because the two measures are capturing different regional characteristics. Regions with above-median exposure to the PTI limit are more urban, have experienced higher house price growth during the pre-period, and have higher sales-to-listings ratios (or where demand for housing is high relative to the supply of housing available for sale). Regions with above-median exposure to the DTI

[12]Consider the following numerical example: a mortgage of $300K with a contract rate of 2.60%, issued to a household with $50K in gross annual income and non-mortgage debt payments worth 2% of their income. Pre-policy, this translates to a PTI of 33% and DTI of 35%. After the policy, the mortgage payment is calculated at the qualifying rate, 4.80%, leading to a PTI of 41% and DTI of 43%. This mortgage would violate the PTI constraint, but not the DTI constraint. Suppose now the household has non-mortgage debt of 5%. I calculate the post-policy DTI as $\min\{0.39, \text{post-policy PTI}\}$ + non-mortgage debt, which yields 44% in this example. This mortgage would still only violate the PTI constraint, not the DTI constraint.

limit do not exhibit the same characteristics; they tend to be less urban, experience lower pre-period house price growth, are areas with lower sales-to-listings ratios.

To understand whether house prices respond differently to these two limits, I run two tests. First, I check whether house price changes are more responsive to the policy exposure variable when exposure is driven by exposure to the PTI limit rather than the DTI limit. I estimate the baseline house price specification in equation 11 and interact the policy exposure variable with an indicator if more than half of the pre-period mortgages which would be disqualified by the new policy are disqualified by the PTI limit (this occurs in 130 of the total 276 regions).

$$\begin{aligned}\Delta \log(\text{Price}_r) = \gamma_s + \beta_1 \text{Policy Exposure}_r + \beta_2 \text{Policy Exposure}_r \times \mathbb{1}(\text{PTI Driven})_r \\ + \beta_3 \mathbb{1}(\text{PTI Driven})_r + X_r' \rho + \epsilon_r\end{aligned} \tag{13}$$

The coeffcients of interest are β_1 and β_2; β_1 represents the policy impact on house prices when mortgages are disqualified by the DTI limit; β_2 represents the marginal impact the policy has on house prices when the constraint is driven by the PTI limit alone. Since the policy exposure variable includes mortgages which would be disqualified due to violating both the PTI and DTI limit under the new policy, I also run a second test which estimates the house price response to the PTI and DTI exposure variables, which captures the share of mortgages disqualified due to each limit in isolation:

$$\Delta \log(\text{Price}_r) = \gamma_s + \beta_1 \text{PTI Exposure}_r + \beta_2 \text{DTI Exposure}_r + X_r' \rho + \epsilon_r \tag{14}$$

The coefficients β_1 and β_2 are interpreted as the effect of a tighter PTI and DTI limit on house prices respectively.

7.2 Impact of Policy Exposure on House Prices

I begin by showing a negative relationship between the change in house prices and policy exposure in Figure 10. Table 7 summarizes the main estimation results, which quantify this negative relationship. Column (1) shows that a one-standard deviation increase in policy exposure leads to a relative decline of 2.4% in regional house prices. Column (2) and (3) show the effect is reduced to a relative decline of 1.0% after including regional controls and accounting for average differences in house price levels across states. This relative price decline is the cumulative decline over four quarters; the implied quarterly decline is 0.25%.

Figure 11 plots the quarter-by-quarter house price response from equation 12. It shows that house prices responded with a lag, and much of the decline in house prices occur six months after the policy was implemented. The modest short-term impact is consistent with existing empirical evidence of how house prices respond to tighter DTI ratios in the U.S. Johnson (2020) finds that the short-run (6-month) house price decline of 2% is much smaller than the long-run (4-year) effect of 7%. The direction of the house price response is consistent with the house price response to macroprudential tightening in other countries. Igan and Kang (2011) find that tightening DTI in Korea reduces monthly house price growth by 0.5%; in the U.K., Peydró, Rodriguez-Tous, Tripathy, and Uluc (2020) find that tightening loan-to-income lowers average house price growth from 6.8% to 5.3%; in Ireland, Acharya, Bergant, Crosignani, Eisert, and McCann (2021) find that annual house price growth is reduced from 15% to 7% after loan-to-income and loan-to-value are tightened.

7.3 Impact of PTI and DTI Exposure on House Prices

Columns (4)-(7) of Table 7 assesses the relative importance of PTI and DTI limits on house prices. Column (4) shows that the house prices do not respond differentially to PTI limit or DTI limit when using national variation in the policy exposure variable. Column (5) shows that using within-state variation, the house price response in regions where policy exposure is PTI driven is a relative decline of 1.0% as compared to regions where policy exposure is DTI driven. The difference between using national variation and within-state variation is due to different local economic conditions as a confounding variable. DTI limits are most binding in regions which have experienced lower employment growth[13], which is correlated with lower house price growth (Table 6).

Columns (6)-(7) of Table 7 shows the estimation results from equation 14. Column (6) shows that a one standard deviation increase in the PTI disqualified share leads to a relative decline of 1.6% in house prices, whereas a one standard deviation increase in DTI disqualified share leads to a relative decline of 0.7%. Consistent with the estimate in column (4), the two effects are not statistically different from each other, which suggests that both limits have a negative impact on house prices. When using within-state variation

[13] Annual labor statistics indicate that growth in payroll employment during the policy period was concentrated in British Columbia (+3.0%) and Ontario (+2.2%), while Alberta and Saskatchewan saw notable declines of -1.4% and -3.5% respectively (Labour Statistics Devision, 2017). Correspondingly, average quarterly house price growth was 8.8% in British Columbia and 8.6% in Ontario, but only 0.4% in Alberta and Saskatchewan.

in PTI and DTI limits, the impact of the PTI limit remains similar—a one standard deviation increase in the PTI limit leads to a relative decline of 1.2%. However, the impact of the DTI limit is reduced to a relative decline of 0.1%. This suggests that exposure to DTI limits have a much smaller impact on house prices after controlling for local economic conditions, which may reflect the fact that households can comply with a DTI limit by adjusting non-mortgage debt without reducing the size of their mortgage.

Estimates from equation 13 and 14 show that the policy has a negative impact on house prices, and that this impact is larger in regions which are constrained by the PTI limit, rather than the DTI limit. This is consistent with the idea that households' adjustment of non-mortgage debt may allow them to maintain the same level of mortgage leverage in spite of the DTI tightening, which dampens the impact of the DTI tightening on house prices.

8 Conclusion

This paper documents how households respond to a macroprudential policy which restricted borrowing. I show that the policy effectively reduces household leverage through an extensive margin effect—by excluding households who can no longer qualify for a mortgage under the stricter DTI requirement, and through an intensive margin effect—by reducing the size of mortgages issued to households who do qualify under the stricter requirement. I also document that households exhibit window dressing behavior in response to the DTI limit, and those households which undertake the largest reduction in DTI in order to satisfy the limit prior to origination are precisely those who see the largest subsequent increase in DTI. I show that this behavior erodes half of the reduction in non-mortgage debt induced by the policy, though reductions in mortgage debt remain permanent. Finally, household responses have important implications for the macroeconomic impact of DTI limits. Specifically, house price responses to DTI limits depend crucially upon the extent to which households can still take on the same quantity of mortgage credit that they would like in absence of the policy, by satisfying the DTI limit through adjustments along the non-mortgage debt margin. The findings in this paper have important implications for future policy design—in particular, it is important to consider the different margins along which households can respond to macroprudential leverage restrictions in order to achieve permanent reductions in household debt service burdens and lower house prices, both of which are important to maintaining financial stability.

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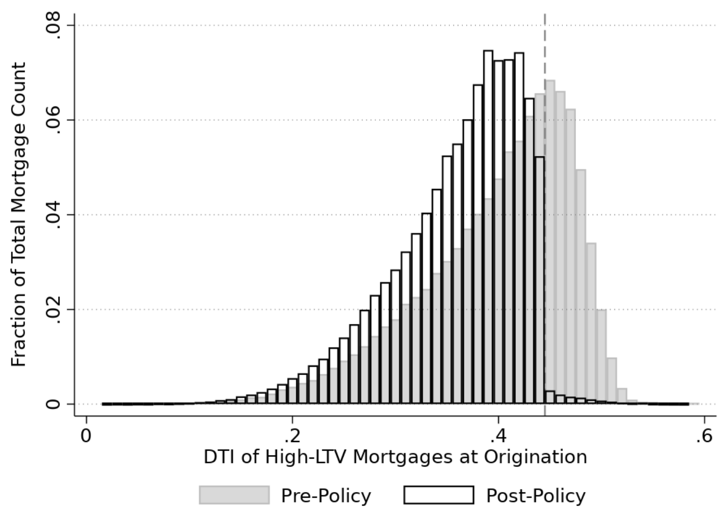
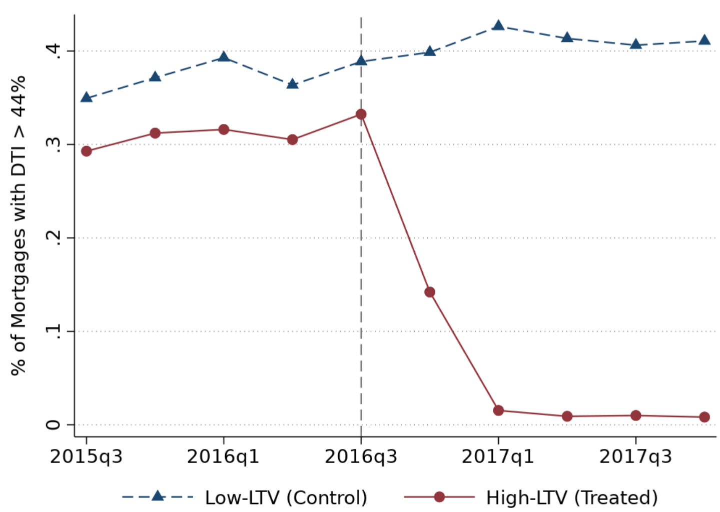
Figure 1: Policy Impact on Debt-to-Income

This figure plots the change in DTI distribution after the DTI requirements are tightened for high-LTV mortgages (LTV > 80%). The top panel shows the distribution of DTI during the year before and after the policy, for treated mortgages. The bottom panel plots the proportion of low-LTV (control group) and high-LTV (treated group) mortgages with a DTI above 44% in each quarter. DTI is calculated as total debt payments (mortgage + non-mortgage) as a proportion of gross income. All mortgage payments in this figure are calculated using the qualifying rate (see Figure 2).



(a) *DTI Distribution for High-LTV (Treated) Mortgages*



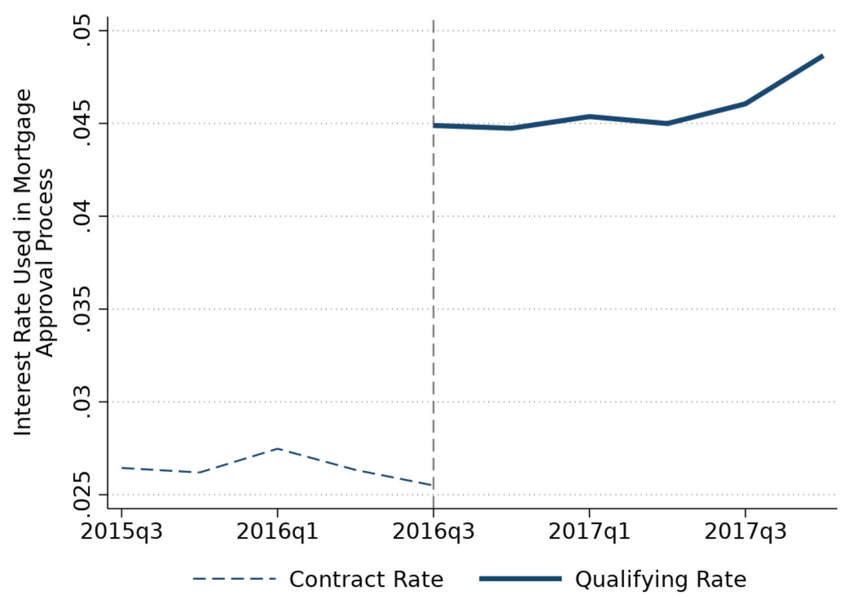
(b) *Proportion of Mortgages with DTI > 44%*

Figure 2: Policy Implementation

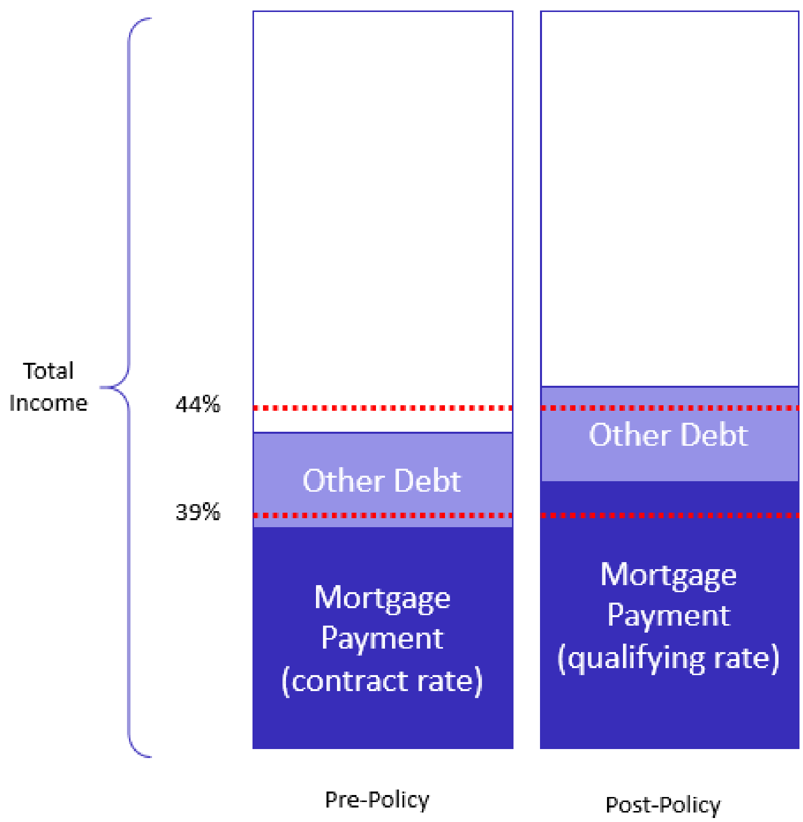
This figure shows how the policy tightened debt-to-income for high-LTV (LTV $>$ 80%) mortgage originators, which comprise 48% of all mortgage borrowers. The top panel shows the average interest rate used in the mortgage approval process before and after the policy change. Before the policy, each borrower's mortgage payment was calculated using the interest rate on their mortgage contract (contract rate). After the policy, a qualifying rate (defined below) was used for high-LTV (treated) mortgage borrowers. For two-thirds of treated borrowers, the Bank of Canada Benchmark Rate was the effective qualifying rate.

$$\text{Qualifying Rate} = \max\{\text{Contract Rate} + 200bps, \text{Bank of Canada Benchmark Rate}\}$$

The bottom panel shows how using a higher interest rate in the approval process tightens DTI requirements. All else equal (mortgage size, amortization, borrower income), the monthly mortgage payment calculated using the qualifying rate will be higher than the monthly payment implied by the contract rate. This may disqualify borrowers who exceed the maximum mortgage payment-to-income (PTI) limit of 39% or the total debt payment-to-income (DTI) limit of 44%. Note that the mortgage payment calculated using the qualifying rate is used for the approval process only; the actual mortgage payments made to the lender are still calculated using the contract rate. The PTI limit of 39% and DTI limit of 44% exist both pre and post-policy, and remain unchanged throughout the sample period.



(a) *Interest Rate Used in the Mortgage Approval Process*



(b) *Impact of Using the Qualifying Rate on Mortgage Approval*

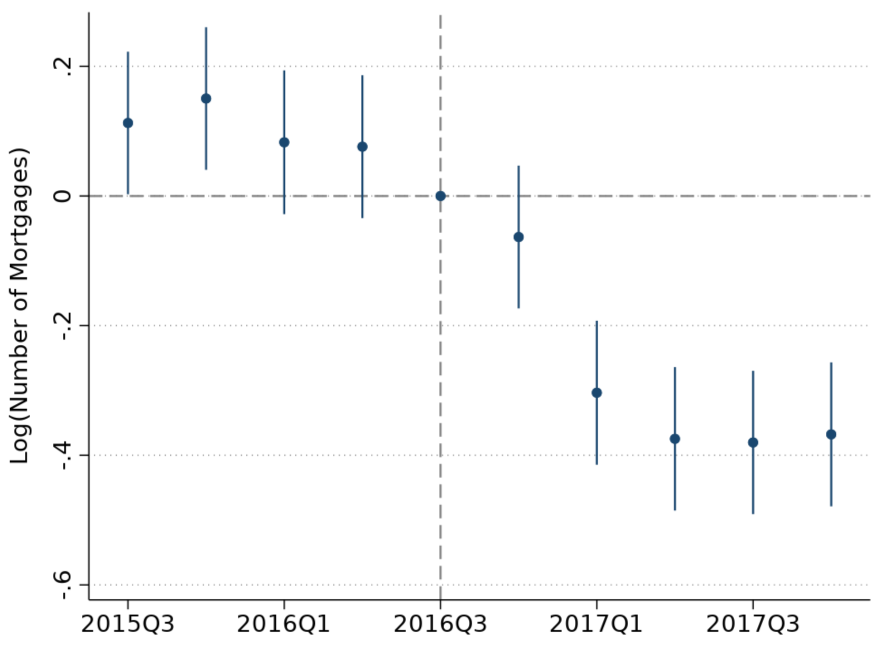
Figure 3: Policy Impact on Aggregate Mortgage Issuance

This figure shows how aggregate mortgage issuance responds to the policy. To verify that the timing of changes in mortgage issuance line up with the policy change, changes in mortgage issuance are estimated quarterly and the coefficients β_t from the specification below are plotted in Panels (a) and (b). Each unit of observation is at the segment-county-quarter level, where segment $s \in \{\text{Low-LTV}, \text{High-LTV}\}$. Quarter$_t$ are a set of quarterly dummies; the omitted quarter is 2016Q3, the quarter before the policy was implemented. The coefficients β_t can be interpreted as the difference in the outcome variable in quarter t relative to 2016Q3. I include a set of state-quarter fixed-effects to absorb time-varying differences across states.

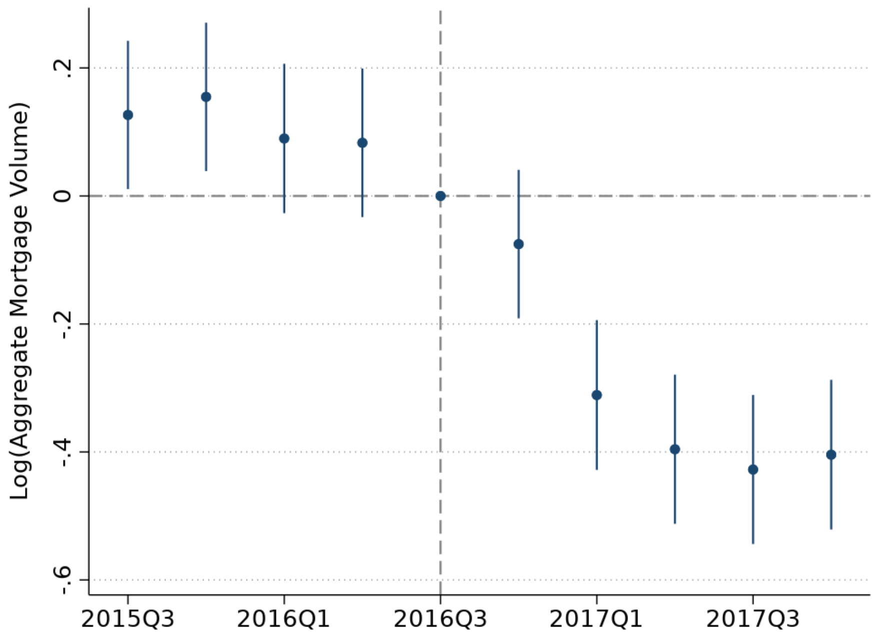
$$y_{sct} = \beta_0 \mathbb{1}(\text{High-LTV})_s + \sum_{t \neq 2016Q3} \beta_t \mathbb{1}(\text{High-LTV})_s \times \mathbb{1}(\text{Quarter})_t + \gamma_{pt} + \epsilon_{sct}$$

The independent variable is $\log(\text{Number of Mortgages})_{sct}$ in Panel (a) and $\log(\text{Aggregate Mortgage Volume})_{sct}$ in Panel (b). Panel (c) plots the β_t coefficents from the following specification. Each unit of observation is a mortgage; X_i is a vector of borrower controls which include income, age, credit score, and an indicator if the household is a first-time homebuyer; γ_{ct} is a set of county-quarter fixed effects. Standard errors are clustered at the county level.

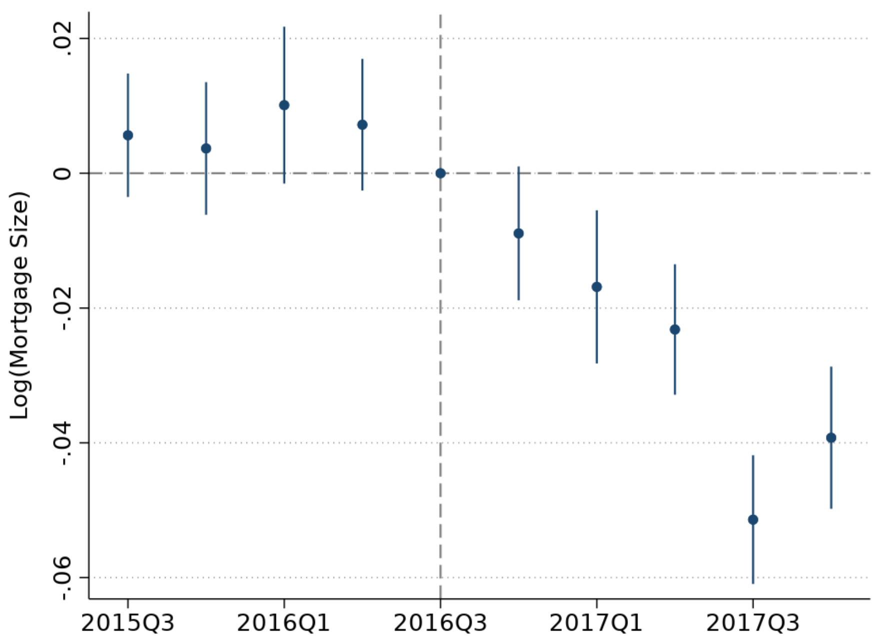
$$y_{it} = \beta_0 \mathbb{1}(\text{High-LTV})_i + \sum_{t \neq 2016Q3} \beta_t \mathbb{1}(\text{High-LTV})_i \times \mathbb{1}(\text{Quarter})_t + X_i' \rho + \gamma_{ct} + \epsilon_{it}$$



(a) *Policy Impact on Number of Mortgages Issued*



(b) *Policy Impact on Total Mortgage Volume*



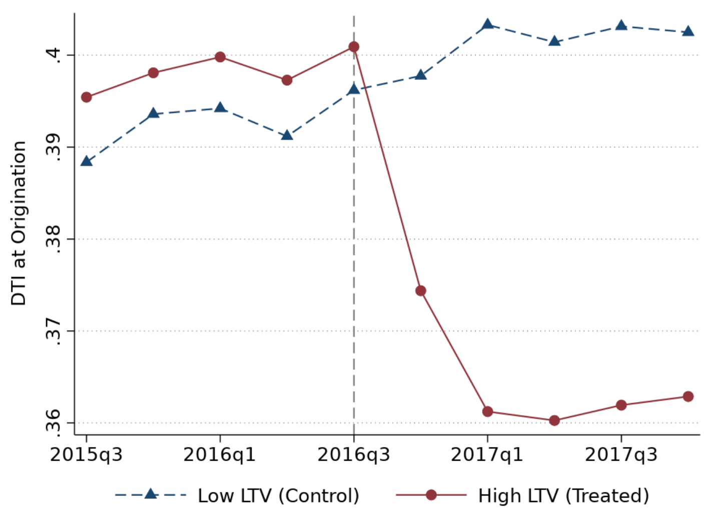
(c) *Policy Impact on Average Mortgage Size*

Figure 4: Policy Impact on Debt-to-Income at Origination

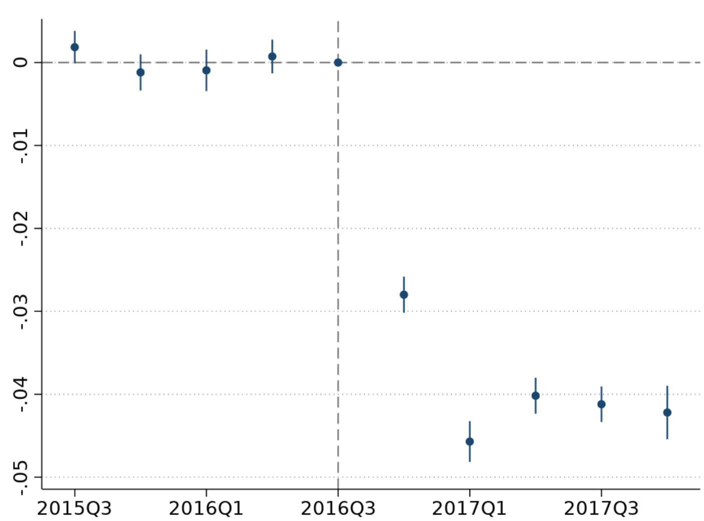
This figure shows the policy impact on the DTI at origination. DTI is equal to the sum of monthly mortgage and non-mortgage debt payments as a percentage of income. Panel (a) shows the average DTI for mortgage originations, by low and high-LTV segments. Panel (b) plots estimates of β_t from the specification below.

$$\text{DTI}_{it} = \beta_0 \mathbb{1}(\text{High-LTV})_i + \sum_{t \neq 2016Q3} \beta_t \mathbb{1}(\text{High-LTV})_i \times \mathbb{1}(\text{Quarter})_t + X_i'\rho + \gamma_{ct} + \epsilon_{it}$$

Each unit of observation is a mortgage; the vector X_i are a set of borrower controls, including income, age, credit score, and an indicator if the household is a first-time homebuyer; γ_{ct} are county-quarter fixed-effects. Standard errors are clustered at the county level.



(a) *DTI At Origination for Low-LTV and High-LTV Mortgage Borrowers*



(b) *Difference-in-Difference Coefficients*

Figure 5: Distribution of Debt-to-Income Before, At, and After Origination

This figure shows the distribution of DTI for high-LTV originations before the policy change. DTI is calculated at three different points in time: one year before origination, at origination, and one year after origination, as follows:

$$\text{DTI}_{i\tau} = \frac{\text{Mortgage Payment}_i + \text{Non-Mortgage Debt Payments}_{i\tau}}{\text{Income}_i}$$

where $\text{DTI}_{i,t}$ is the DTI reported for mortgage i in month τ relative to origination. The mortgage payment and borrower income for mortgage i are based on values reported at origination. Non-mortgage debt payments are equal to the sum of revolving debt payments (credit card, personal lines of credit) and installment payments, reported in month τ relative to origination.

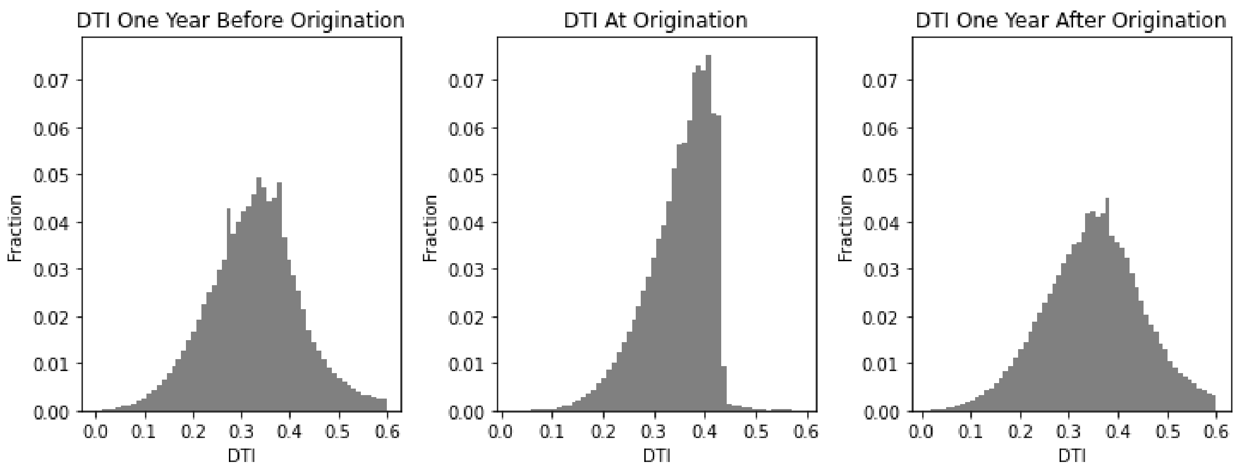


Figure 6: Change in Debt-to-Income Before and After Origination

This figure shows how DTI evolves before and after origination. The sample is restricted to high-LTV mortgages, originated before the policy change. Each mortgage is sorted into one of four groups based on the household's pre-origination DTI, calculated as below:

$$\text{Pre-Origination DTI}_i = \frac{\text{Mortgage Payment}_i}{\text{Income}_i} + \frac{\text{Non-Mortage Debt Payments 18 Months Before Origination}_i}{\text{Income}_i}$$

The average DTI is calculated at a monthly frequency for each group and indexed to zero 18 months before origination, so the figure plots changes in DTI relative to the DTI level 18 months before origination. Standard errors shown at the 95% confidence level.

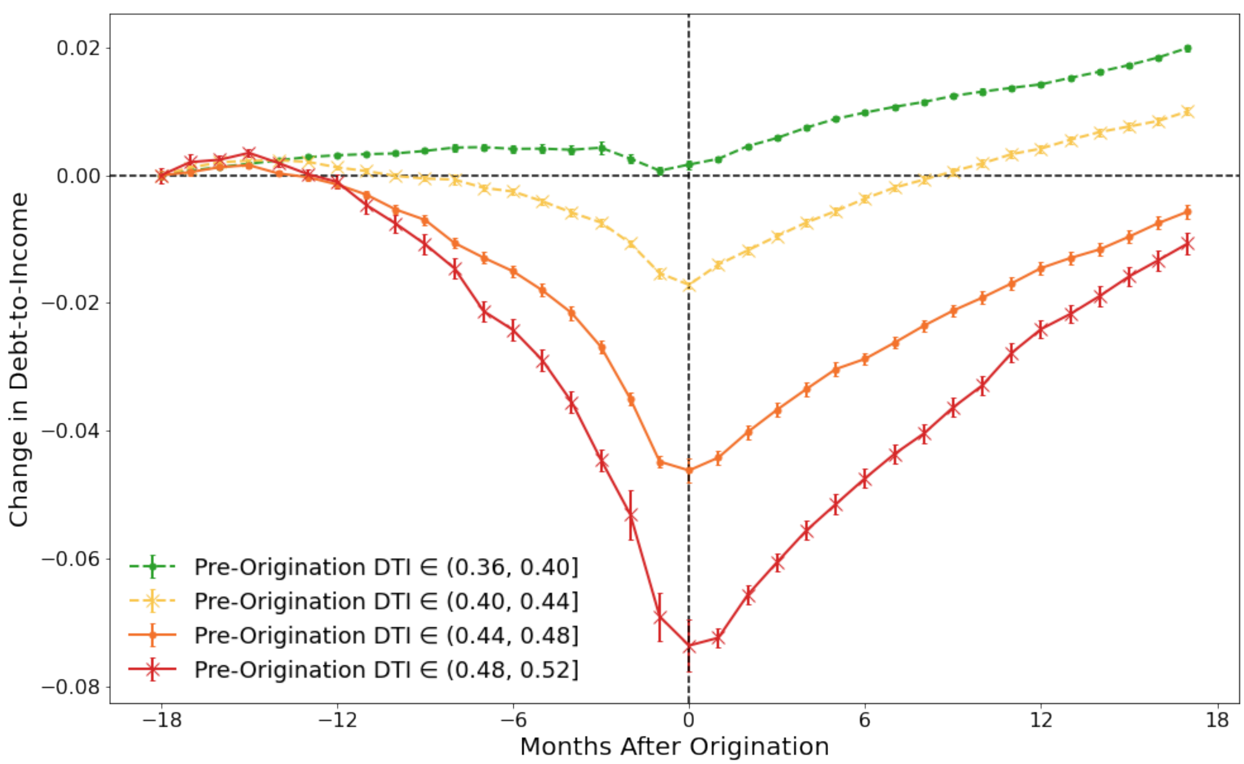


Figure 7: Debt-to-Income at Origination vs. Debt-to-Income Before Origination

This figure shows the relationship between DTI at origination and DTI levels 12 months before origination. DTI at each point in time is calculated as follows:

$$\text{DTI}_{i\tau} = \frac{\text{Mortgage Payment}_i + \text{Non-Mortgage Debt Payments}_{i\tau}}{\text{Income}_i}$$

The sample is restricted to high-LTV mortgages originated before the policy change (2015Q3-2016Q3). Each mortgage is sorted into a DTI bin based on the borrower's DTI 12 months before origination. For example, mortgages which are included in the leftmost DTI bin along the x-axis are those with DTI$\in$ $(0.28, 0.30]$ 12 months before origination. The y-axis shows the average DTI at origination, along with standard errors at the 95% confidence interval. The vertical and horizontal dotted lines delineate the regulatory DTI limit of 44%.

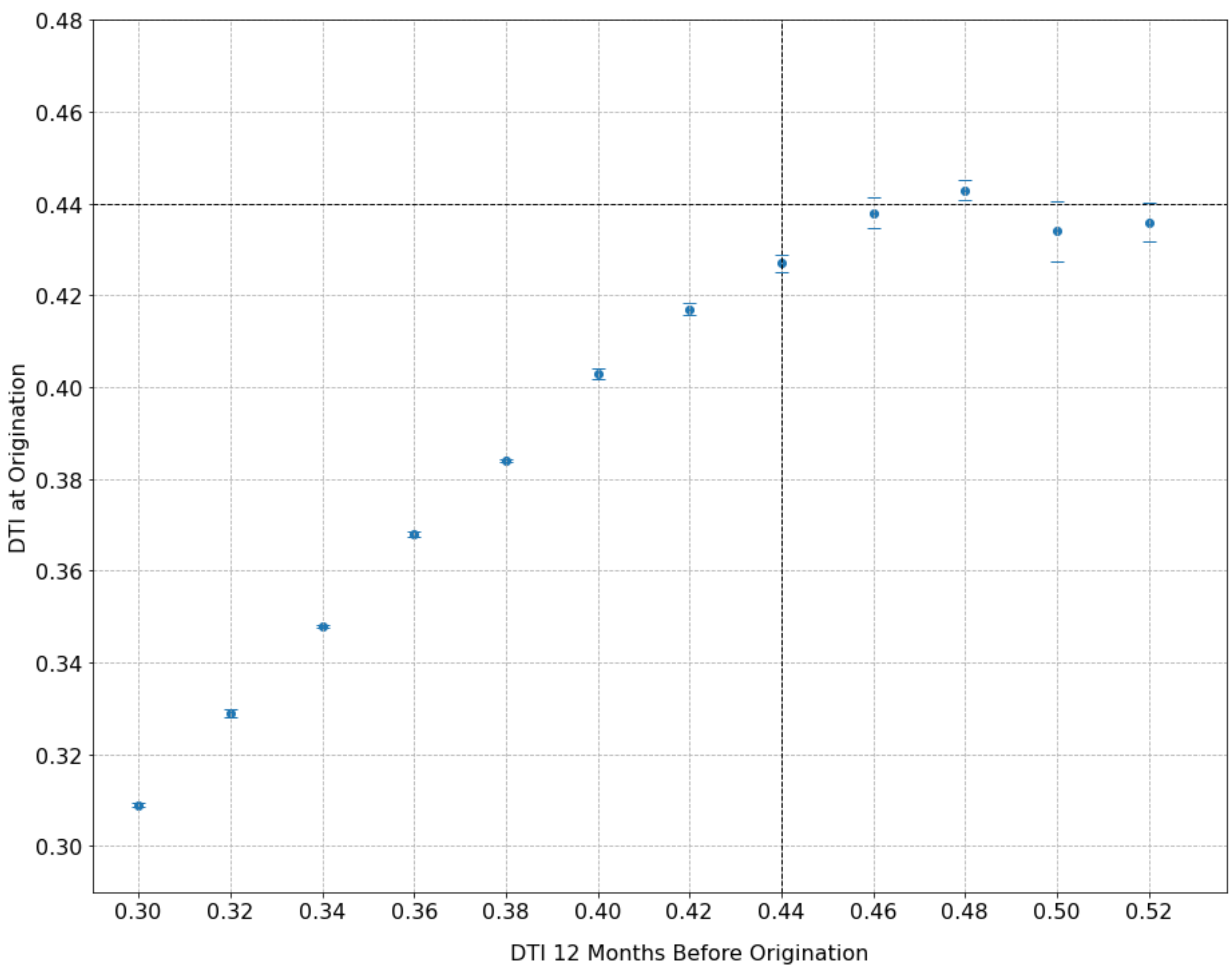


Figure 8: Policy Impact on Non-Mortgage Debt-to-Income

This figure shows the policy impact on non-mortgage debt-to-income at different points in time before and after origination. Specifically, it plots the β_1 coefficient from the specification below:

$$\begin{aligned}\text{Non-Mort. DTI } \tau \text{ Months After Origination}_{it} &= \beta_0 \mathbb{1}(\text{High-LTV})_i \\ &+ \beta_1 \mathbb{1}(\text{High-LTV})_i \times \mathbb{1}(\text{Post})_t + X_i' \rho + \gamma_{ct} + \epsilon_{it}\end{aligned}$$

where the outcome variable is the non-mortgage debt-to-income τ months after origination, for mortgage i, originated in county c, in quarter t. The vector X_i is a vector of borrower controls which include age, income, credit score, and an indicator of the household is a first-time home-buyer; γ_{ct} are a set of county-quarter fixed effects. Standard errors are clustered at the county level.

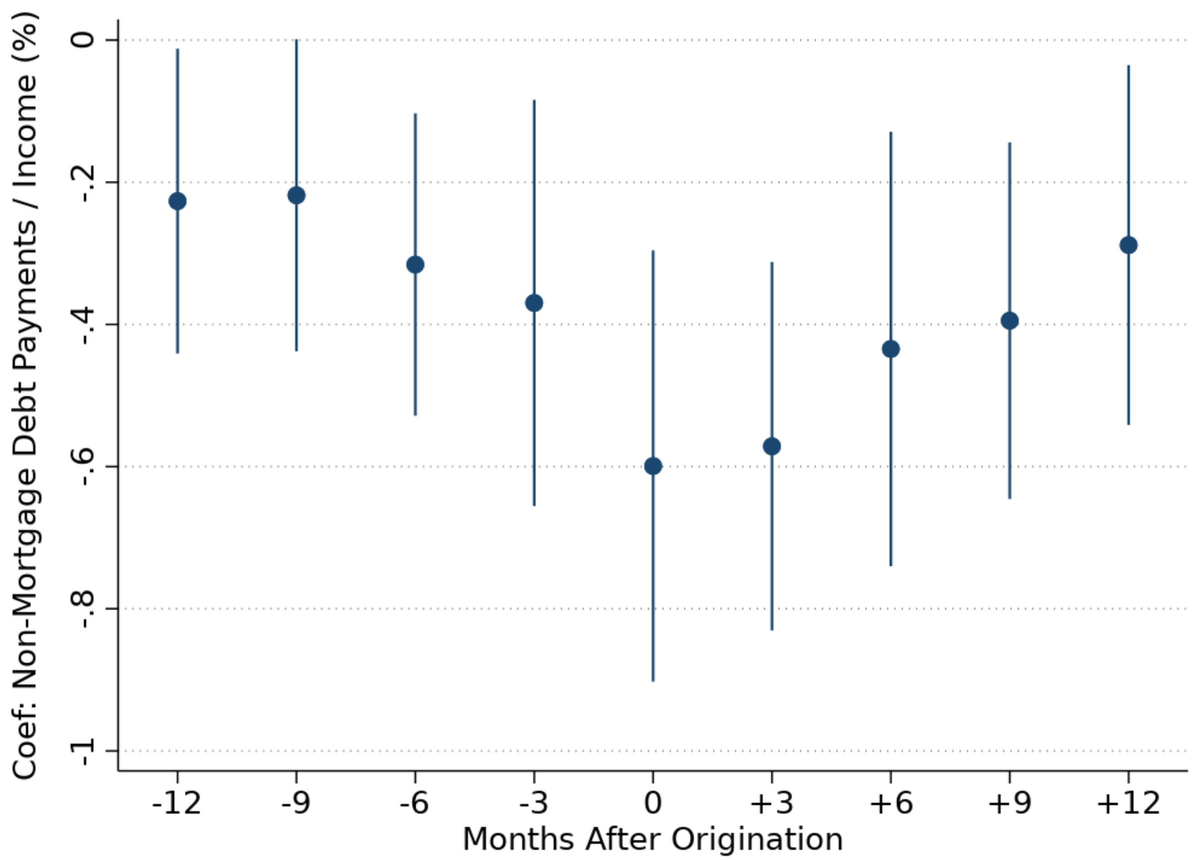
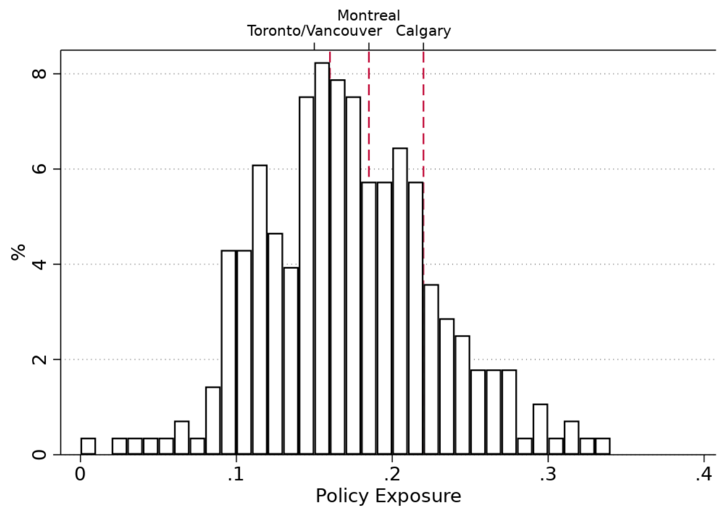


Figure 9: Distribution of the Policy Exposure Variable

This figure shows the distribution of the policy exposure variable. Policy exposure is defined as the percentage of loans issued in each region which would have failed to be issued with the same terms (size, interest rate, amortization) under the new policy. Regions are defined by a geographic unit with a distinct Teranet house price index, and may contain multiple counties.



(a) *Policy Exposure*

(b) *House Price Changes*

Figure 10: Policy Exposure and House Price Growth

This figure shows the relationship between policy exposure and the change in log(House Price) from the quarter before the policy was implemented to the end of the sample period, 2016Q3-2017Q4. Policy exposure is measured as the fraction of mortgages issued during the pre-period (2015Q3-2016Q3) which would have failed to qualify under the new policy rules.

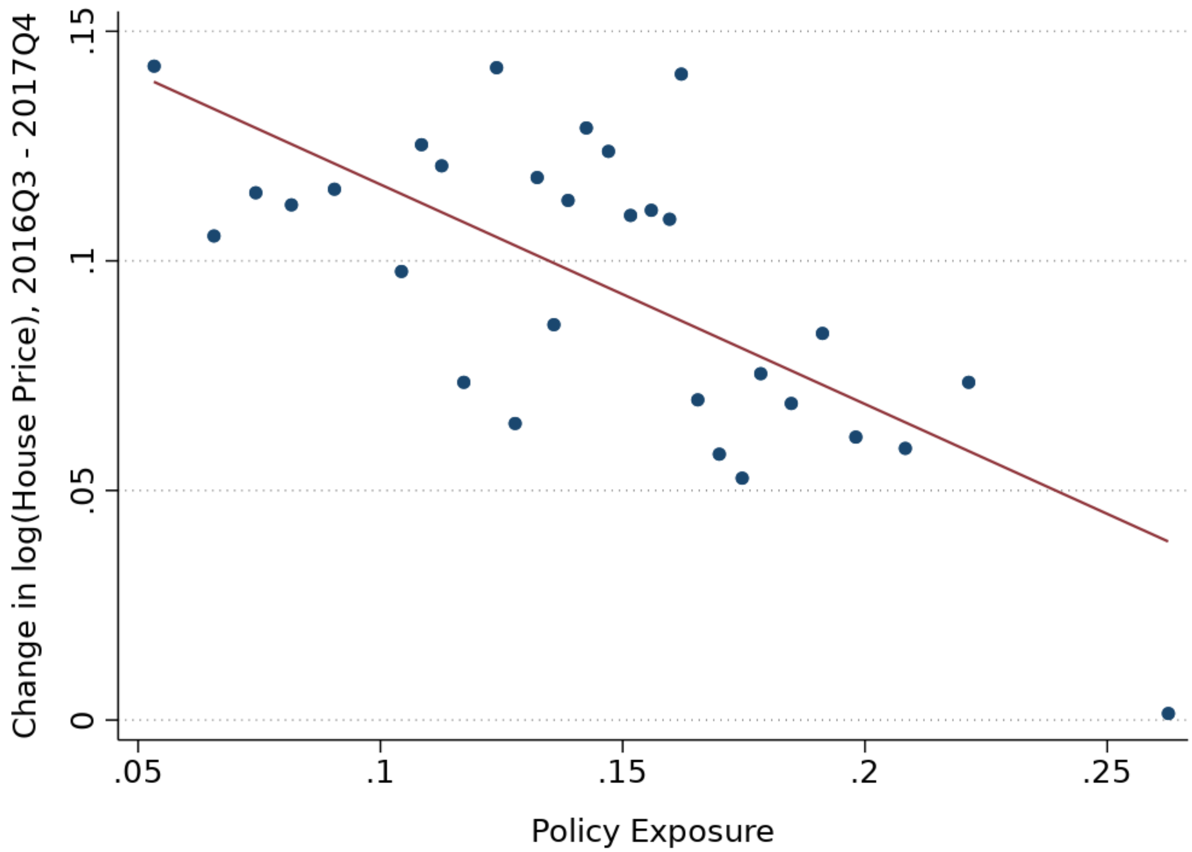


Figure 11: Policy Impact on House Prices

This figure shows the policy impact on house prices. Specifically, the figure plots the coefficients β_t from the specification below:

$$\log(\text{Price}_{rt}) = \gamma_r + \delta_t + \sum_{t \neq 2016\text{Q3}} \beta_t \cdot \text{Policy Exposure}_r \times \mathbb{1}(\text{Quarter})_t + \epsilon_{rt}$$

Where $\log(\text{Price}_r t)$ is the log house price index for region r in quarter t. Policy exposure is defined as the fraction of mortgages issued pre-policy (2015Q3-2016Q3) which would have failed to qualify under the new policy rules. Each unit of observation is a region-quarter; γ_r and δ_t are a set of regional and quarterly fixed-effects, and standard errors are clustered at the state level.

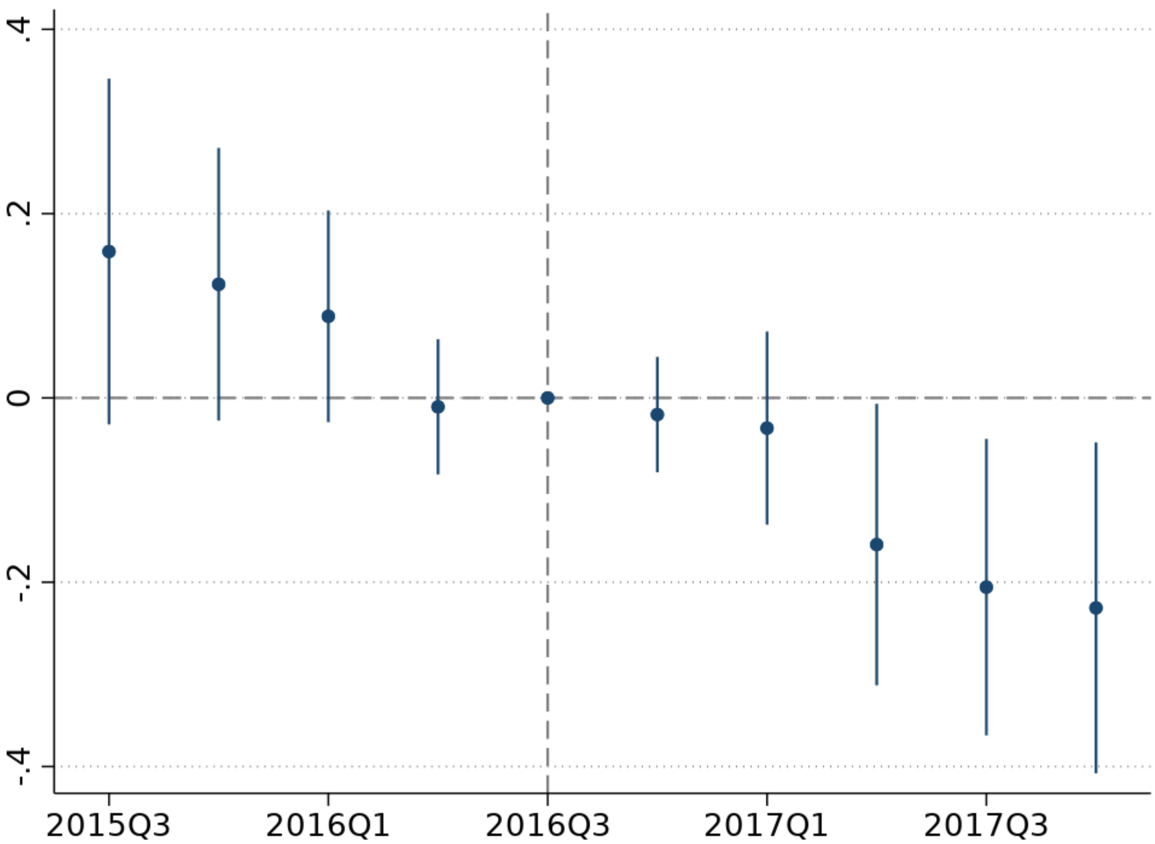


Table 1: Summary Statistics for Low-LTV (Control) and High-LTV (Treated) Borrowers

This table reports borrower and loan characteristics during the year before and after the policy. All variables are reported at origination. Mortgages with LTV $>$ 80% were subject to the DTI tightening outlined in Figure 2. Mortgages with LTV $\leq$ 80% were not subject to the policy change. Source: Canadian federal banking regulator, Office of the Superintendant of Financial Institutions (OSFI).

	Pre-Policy (2015Q3-2016Q3)			Post-Policy (2016Q4-2017Q4)		
	(1) Full Sample	(2) LTV $\leq$ 80%	(3) LTV $>$ 80%	(4) Full Sample	(5) LTV $\leq$ 80%	(6) LTV $>$ 80%
Panel A: Borrower Characteristics						
Income (thousands)	103.23	114.60	93.27	108.34	116.13	97.64
	(58.38)	(68.13)	(46.01)	(60.91)	(68.21)	(47.08)
Credit Score	760.57	775.16	747.83	766.19	776.69	751.81
	(60.20)	(59.11)	(58.21)	(59.73)	(58.70)	(58.10)
Age	39.509	42.381	36.964	39.653	41.524	37.065
	(11.675)	(11.974)	(10.782)	(11.684)	(11.895)	(10.868)
First-Time Homebuyer (%)	52.23	39.17	63.94	52.58	42.55	66.40
	(49.95)	(48.81)	(48.02)	(49.93)	(49.44)	(47.24)
Panel B: Mortgage Characteristics						
Mortgage Payment / Income (%)	28.09	27.28	28.81	25.83	28.64	21.97
	(10.69)	(11.83)	(9.52)	(10.98)	(12.13)	(7.65)
Non-Mortgage Debt Payments / Income (%)	11.77	12.68	10.98	11.67	12.34	10.76
	(10.19)	(12.17)	(7.99)	(10.85)	(12.53)	(7.90)
Mortgage Size / Income	3.215	3.069	3.342	3.243	3.298	3.166
	(1.419)	(1.587)	(1.241)	(1.454)	(1.647)	(1.131)
House Value (thousands)	349.82	398.96	306.81	379.15	431.65	307.12
	(172.59)	(187.62)	(145.21)	(189.39)	(199.13)	(147.34)
Interest Rate (%)	2.62	2.56	2.67	2.71	2.70	2.72
	(0.34)	(0.33)	(0.35)	(0.39)	(0.36)	(0.42)
Loan-to-Value	86.78	78.21	94.27	84.98	78.19	94.29
	(8.76)	(3.65)	(3.46)	(8.73)	(3.67)	(3.49)
N	221,837	103,533	118,304	209,909	121,425	88,484

Table 2: Policy Impact on Aggregate Mortgage Issuance

This table reports the policy impact on mortgage issuance. Columns (1)-(2) of Panel A estimates the policy impact on aggregate mortgage issuance; specifically, it reports estimates of β_1 from the following specification. Each unit of observation is at the segment-county-quarter level, where segment $s \in \{\text{Low-LTV}, \text{High-LTV}\}$. Post is an indicator set to 1 if the quarter of issuance is during or after 2016Q4. Standard errors are clustered at the state level.

$$y_{sct} = \beta_0 \mathbb{1}(\text{High-LTV})_s + \beta_1 \mathbb{1}(\text{High-LTV})_s \times \mathbb{1}(\text{Post})_t + \gamma_{pt} + \epsilon_{sct}$$

Column (3) of Panel A estimates the policy impact on the average mortgage size and reports the estimate of β_1 from the following specification. The unit of observation is a mortgage; borrower controls include income, age, and credit score, all reported at origination. Standard errors are clustered at the county level.

$$y_{it} = \beta_0 \mathbb{1}(\text{High-LTV})_i + \beta_1 \mathbb{1}(\text{High-LTV})_i \times \mathbb{1}(\text{Post})_t + X_i' \rho + \gamma_{pt} + \epsilon_{it}$$

Panel B repeats the exercise in Panel A, using a treatment variable which is defined at the county level rather than the loan level. A county is treated if the Disqualified Share (defined below) is above the median across all counties. This specification compares aggregate mortgage issuance across different regions with differential exposure to the policy.

$$\text{Disqualified Share}_c = \frac{\text{\# Pre-Period Mortgages Which Would Fail to Qualify Under New Policy}_c}{\text{\# Pre-Period Mortgages}_c}$$

	(1) Number of Mortgages	(2) Aggregate Volume	(3) Mortgage Size
Panel A: Loan-Level Treatment			
Post × High-LTV	-0.418***	-0.447***	-0.034***
	(0.026)	(0.027)	(0.002)
High-LTV	-0.062***	-0.003	0.057***
	(0.016)	(0.017)	(0.002)
Borrower Controls			✓
State × Quarter FEs	✓	✓	✓
N	22,213	22,213	517,121
R-Squared	0.25	0.37	0.41
Panel B: Regional-Level Treatment			
Post × High Disqualified Share	-0.082**	-0.091**	-0.022**
	(0.034)	(0.036)	(0.009)
High Disqualified Share	0.368***	0.454***	0.179***
	(0.025)	(0.026)	(0.007)
County Controls			✓
State × Quarter FEs	✓	✓	✓
N	11,253	11,253	11,253
R-Squared	0.32	0.48	0.76

Table 3: Change in Debt-to-Income Before and After Origination

This table reports how debt-to-income changes before and after origination. The sample consists of all high-LTV mortgages, originated before the policy change. Each unit of observation is a mortgage. Panel A reports estimates of β_1 and β_2 from the following specification:

$$\begin{aligned}\Delta(\text{DTI Before Orig.})_{it} = &\beta_0 \mathbb{1}(\text{Pre-Origination DTI} > 44\%)_i + \beta_1(\text{Distance Above DTI Limit})_i \\ &+ \beta_2 \mathbb{1}(\text{Pre-Origination DTI} > 44\%)_i \times (\text{Distance Above DTI Limit})_i + \\ &+ X_i'\rho + \gamma_{ct} + \epsilon_i\end{aligned}$$

where $\Delta(\text{DTI Before Orig.})_{it}$ is defined as the difference between a borrower's pre-origination DTI and DTI at origination for mortgage i issued in quarter t. When the outcome variable is positive, it indicates a reduction in DTI; Pre-Origination DTI is calculated as the sum of a household's mortgage payment and their non-mortgage debt payments 12 months before origination, as a fraction of gross income. (Distance Above DTI Limit) is defined as the difference between the pre-origination DTI and the DTI limit of 44%. The vector X_i is a set of borrower controls which consist of income, age, credit score, and an indicator for whether the household is a first-time homebuyer, all reported at origination. Standard errors are clustered at the county level.

Panel B reports estimates of β_1 and β_2 from the specification below, restricted to the sample of high-LTV mortgages originated before the policy change with $\Delta(\text{DTI Before Orig.} \geq 0)$:

$$\begin{aligned}\Delta(\text{DTI After Orig.})_{it} = &\beta_0 \mathbb{1}(\text{Post-Origination DTI} > 44\%)_i + \beta_1(\Delta\text{ DTI Before Orig.})_i \\ &+ \beta_2 \mathbb{1}(\text{Post-Origination DTI} > 44\%)_i \times (\Delta\text{ DTI Before Orig.})_i + X_i'\rho + \gamma_{ct} + \epsilon_{it}\end{aligned}$$

Post-origination DTI is defined in the same way as pre-origination DTI, but using average non-mortgage payments 18 months *after* origination.

	Δ DTI			
	(1)	(2)	(3)	(4)
Panel A: Before Origination				
Distance Above DTI Limit	0.479***	0.274***	0.284***	0.301***
	(0.001)	(0.002)	(0.002)	(0.002)
Distance Above DTI Limit × Pre-Origination DTI > 0.44		0.762***	0.761***	0.742***
		(0.006)	(0.006)	(0.006)
Borrower Controls			✓	✓
County × Quarter FEs				✓
N	110,708	110,708	110,708	110,708
R-Squared	0.42	0.51	0.52	0.56
Panel B: After Origination				
Δ DTI Before Origination	0.771***	0.667***	0.678***	0.682***
	(0.004)	(0.007)	(0.007)	(0.008)
Δ DTI Before Origination × Pre-Origination DTI > 0.44		0.193***	0.188***	0.182***
		(0.010)	(0.010)	(0.011)
Borrower Controls			✓	✓
County × Quarter FEs				✓
N	31,167	31,167	31,167	31,167
R-Squared	0.04	0.04	0.07	0.14

Table 4: Policy Impact on Debt-to-Income

This table reports the policy impact on debt-to-income (DTI) of new originators. DTI is reported at origination, and is defined as the sum of mortgage payments and non-mortgage debt payments, as a percentage of gross income. Each unit of observation is a mortgage. Panel A of this table reports estimates of β_1 from the specification below:

$$y_{it} = \beta_0 \mathbb{1}(\text{High-LTV})_i + \beta_1 \mathbb{1}(\text{High-LTV})_i \times \mathbb{1}(\text{Post})_t + X_i'\rho + \gamma_{ct} + \epsilon_{it}$$

where the dependent variable is DTI in column (1), mortgage payment-to-income in column (2), and non-mortgage debt-to-income in column (3). All outcome variables are in %. The vector X_i' is a vector of borrower controls including income, age, credit score, and an indicator if the household is a first-time homebuyer; γ_{ct} are a set of county-quarter fixed effects. Standard errors are clustered at the county level.

Panel B reports estimates of β_1 of the regression above, where the outcome variable is non-mortgage debt-to-income at 12 months before origination, the month of origination, and 12 months after origination.

	Panel A: Policy Impact At Origination		
	(1) Total	(2) Mortgage	(3) Non-Mortgage
Post × High-LTV	-3.749***	-3.085***	-0.599***
	(0.062)	(0.033)	(0.134)
Borrower Controls	✓	✓	✓
County × Quarter FEs	✓	✓	✓
N	458,195	458,195	458,195
R-Squared	0.57	0.89	0.22

	Panel B: Non-Mortgage Debt / Income		
	(1) Before Orig.	(2) At Orig.	(3) After Orig.
Post × High-LTV	-0.227**	-0.599***	-0.288**
	(0.095)	(0.134)	(0.112)
Borrower Controls	✓	✓	✓
County × Quarter FEs	✓	✓	✓
N	458,195	458,195	458,195
R-Squared	0.15	0.22	0.18

Table 5: Delinquency

A loan is considered delinquent if a scheduled payment is more than 90 days late. Panel A shows the relationship between whether a household is delinquent on at least one scheduled payment to their DTI at origination and whether their DTI one year before origination was above the regulatory limit of 44%. The sample is restricted to high-LTV mortgages, across both pre and post-policy periods. Each unit of observation is a mortgage. It reports estimates from the following regression:

$$\mathbb{1}(\text{Delinquent})_{it} = \beta_0 \text{DTI}_i + \beta_1 \mathbb{1}(\text{Pre-Origination DTI} > 44\%)_i + X_i'\rho + \gamma_{ct} + \epsilon_{it}$$

The outcome is an indicator if a loan is delinquent within 18 months of a household's mortgage origination. Pre-Origination DTI is the household's DTI 12 months before origination. The vector X_i is a set of borrower controls which include income, credit score, age, and an indicator if the household is a first-time homebuyer, γ_{ct} are a set of county-quarter fixed effects. Panel B reports the policy impact on the probability of delinquency. It reports estimates of β_0 and β_1 from the following specification:

$$\mathbb{1}(\text{Delinquent})_{it} = \beta_0 \mathbb{1}(\text{High-LTV})_i + \beta_1 \mathbb{1}(\text{High-LTV})_i \times \mathbb{1}(\text{Post})_t + X_i'\rho + \gamma_{ct} + \epsilon_{it}$$

	Panel A: $\mathbb{1}$(Delinquency, Any Credit Account)				
	(1)	(2)	(3)	(4)	(5)
DTI at Origination	0.048***		0.042***	0.046***	0.083***
	(0.010)		(0.011)	(0.011)	(0.012)
$\mathbb{1}$(Pre-Origination DTI > 44%)		0.006***	0.004**	0.003*	0.003*
		(0.002)	(0.002)	(0.002)	(0.002)
Borrower Controls				✓	✓
State × Quarter FEs					✓
N	193,853	193,853	193,853	193,853	193,853
R-Squared	0.00	0.00	0.00	0.00	0.09

	Panel B: $\mathbb{1}$(Delinquency)	
	(1) Mortgage Account	(2) Any Credit Account
Post × High-LTV	0.000	-0.001
	(0.0003)	(0.0013)
High-LTV	0.001***	0.011***
	(0.0002)	(0.0009)
Borrower Controls	✓	✓
State × Quarter FEs	✓	✓
N	458,195	458,195
R-Squared	0.04	0.05

Table 6: Region Summary Statistics

This table provides summary statistics at the regional level. For each mortgage issued during the pre-period, I compute a post-policy mortgage payment-to-income (PTI) according to the new policy rules. I also compute post-policy DTI as $\min\{0.39, \text{post-policy PTI}\}$ + non-mortgage payment-to-income. Policy exposure is defined as the share of mortgages issued during the pre-period which have a post-policy PTI above the PTI limit of 39% or a post-policy DTI above the limit of 44%. PTI exposure is the share of pre-period mortgages with a post-policy PTI $>$ 39%, but post-policy DTI $\leq$ 44%. DTI exposure is the share of pre-period mortgages with post-policy DTI $>$ 44%. High-LTV share is the fraction of mortgages issued pre-policy with LTV $>$ 80%. Urban is an indicator equal to 1 if the region overlaps with the Toronto, Vancouver, or Montreal metropolitan areas. The sales-to-listings ratio is the number of sales within each region as a proportion of total listings; a value above 0.6 indicates a short supply of homes relative to demand. All values are measured during the year prior to the policy, 2015Q3-2016Q3.

		Policy Exposure		PTI Exposure		DTI Exposure	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	All Regions	Above Median	Below Median	Above Median	Below Median	Above Median	Below Median
Policy Exposure	0.14	0.18	0.11	0.17	0.12	0.17	0.12
	(0.05)	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)	(0.04)
PTI Exposure	0.05	0.06	0.03	0.07	0.03	0.05	0.05
	(0.03)	(0.03)	(0.02)	(0.02)	(0.01)	(0.03)	(0.03)
DTI Exposure	0.08	0.10	0.06	0.09	0.08	0.11	0.06
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)
High-LTV Share	0.41	0.48	0.34	0.41	0.41	0.52	0.31
	(0.16)	(0.14)	(0.16)	(0.14)	(0.18)	(0.12)	(0.13)
Urban	0.45	0.38	0.51	0.54	0.35	0.20	0.70
	(0.50)	(0.49)	(0.50)	(0.50)	(0.48)	(0.40)	(0.46)
$\Delta \log(\text{HP})$	0.08	0.07	0.10	0.10	0.07	0.05	0.12
	(0.09)	(0.10)	(0.09)	(0.10)	(0.09)	(0.08)	(0.09)
Sales-to-Listings Ratio	0.61	0.60	0.61	0.63	0.58	0.58	0.63
	(0.10)	(0.11)	(0.09)	(0.09)	(0.10)	(0.11)	(0.08)
Unemployment Rate (%)	6.39	6.49	6.28	6.47	6.31	6.45	6.33
	(0.78)	(0.79)	(0.77)	(0.77)	(0.79)	(0.80)	(0.77)
Average Income ('000)	114.62	108.31	120.94	112.20	117.05	107.12	122.13
	(20.02)	(15.73)	(21.83)	(16.23)	(23.00)	(16.45)	(20.50)
Average Credit Score	765.95	761.92	769.97	765.84	766.05	761.03	770.86
	(8.80)	(7.59)	(8.07)	(7.41)	(10.02)	(7.74)	(6.84)
N	276	138	138	138	138	138	138

Table 7: Policy Impact on House Price Change Between 2016Q3-2017Q4 (%)

This table reports estimates of the house price response to the policy change. The unit of observation is a region. The dependent variable is the change in log house price index for each region between 2016Q3 and 2017Q4. The house price index is a repeat-sales index, which reports the change in prices for properties which have been sold at least twice. Columns (1)-(3) reports estimates of β from the following specification:

$$\Delta \log(\text{Price}_r) = \gamma_s + \beta \text{Policy Exposure}_r + X_r'\rho + \epsilon_r$$

where Policy Exposure$_r$ is the share of mortgages issued in region r during the pre-period (2015Q3-2016Q3) which would have failed to qualify under the new policy; X_r is a vector of regional controls which include average household income, unemployment rate, and sales-to-listings ratio, all measured as of 2016Q3. Column (4)-(5) report estimates of β_1, β_2, and β_3 from the following specification:

$$\begin{aligned}\Delta \log(\text{Price}_r) = \gamma_s &+ \beta_1 \text{Policy Exposure}_r + \beta_2 \text{Policy Exposure}_r \times \mathbb{1}(\text{PTI Driven})_r \\ &+ \beta_3 \mathbb{1}(\text{PTI Driven})_r + X_r'\rho + \epsilon_r\end{aligned}$$

where $\mathbb{1}(\text{PTI Driven})_r$ is an indicator if more than half of the pre-period mortgages which would be disqualified by the new policy are disqualified by the PTI limit. Column (6)-(7) report estimates of β_1 and β_2 from the following specification:

$$\Delta \log(\text{Price}_r) = \gamma_s + \beta_1 \text{PTI Exposure}_r + \beta_2 \text{DTI Exposure}_r + X_r'\rho + \epsilon_r$$

where PTI Exposure$_r$ is the share of mortgages issued in region r during the pre-period which would have failed to qualify because they exceed the mortgage payment-to-income (PTI) limit of 39%, but not the debt-to-income (DTI) limit of 44%. Similarly, DTI Exposure$_r$ is the share of pre-period mortgages in region r which would have exceeded the DTI limit under the new policy. Each unit of observation is a region, and standard errors are clustered at the state level.

	Δ log(Price) Between 2016Q3 and 2017Q4						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Policy Exposure	-0.478***	-0.366***	-0.182***	-0.376***	-0.032		
	(0.086)	(0.071)	(0.069)	(0.107)	(0.102)		
Policy Exposure × $\mathbb{1}$(PTI Driven)				0.009	-0.197*		
				(0.125)	(0.107)		
PTI Exposure						-0.528***	-0.418**
						(0.182)	(0.166)
DTI Exposure						-0.233*	-0.043
						(0.119)	(0.145)
Controls		✓	✓	✓	✓	✓	✓
State FEs			✓		✓		✓
N	276	276	276	276	276	276	276
R-Squared	0.40	0.73	0.81	0.73	0.82	0.72	0.82

A Substitution Between High and Low Loan-to-Value Mortgages

In Section 4, I estimate the policy impact on the quantity of mortgage credit issued by comparing the change in the number and volume of high-LTV mortgages relative to the change in low-LTV mortgages. One concern with this approach is the extent to which a household who would have chosen a high-LTV mortgage in absence of the policy chooses to take out a low-LTV mortgage instead in order to circumvent the tighter DTI requirement. If there is substantial substitution from high to low-LTV mortgages during the sample period, low-LTV mortgages would not be an appropriate control group.

To evaluate the extent of substitution between the two mortgage products, I propose an auxiliary control group, mortgages with LTV strictly below 80.

Note that among loans with LTV $\leq$ 80%, there is no formally enforced cap on PTI or DTI, and 12% of mortgages with LTV $\leq$ 80% have a DTI above the 44% cutoff during the pre-policy and post-policy period. Therefore, a borrower does not gain any additional slack in their PTI or DTI constraint by decreasing their LTV to a level strictly below 80%. If borrowers are liquidity constrained, product substitutions prompted by the policy change should not affect mortgages with a LTV strictly below 80%. In the section below, I designate the group of LTV$<$ 80% mortgages as the auxiliary control group, LTV$=$ 80% as the low-LTV group and LTV $>$ 80% as the high-LTV group. Figure A.1a summarizes how the DTI tightening applies to the three LTV segments.

I begin by comparing the number of mortgages issued across the three LTV groups before and after the policy. If borrowers switch between the high-LTV and low-LTV mortgages, I expect the number of high-LTV mortgages to fall and the number of low-LTV mortgages to increase, relative to the number of mortgages in the auxiliary control group. First, I provide visual evidence that substitution between high-LTV and low-LTV mortgages is limited. Figure A.1b the seasonally adjusted log(Number of Mortgages) in each LTV segment, and shows that issuance of low-LTV and auxiliary mortgages move in tandem. To quantify the degree of substitution between high and low-LTV mortgages, I aggregate the number of loans up to the segment (LTV$<$ 80, LTV$=$ 80, LTV$>$ 80), county, quarter level and run the following specification:

$$\begin{aligned}\log\left(\text{No. of Mortgages}\right)_{sct} = \alpha + \beta_1 Post_t \times \mathbb{1}(\text{low-LTV})_{sc} + \beta_2 Post_t \times \mathbb{1}(\text{high-LTV})_{sc} + \\ \beta_3 Post_t + \beta_4 \mathbb{1}(\text{low-LTV})_{sc} + \beta_5 \mathbb{1}(\text{high-LTV})_{sc} + \delta_{ct} + \epsilon_{sct}\end{aligned} \tag{15}$$

The coefficients of interest are β_1 and β_2, which reflect how the number of high-LTV and low-LTV mortgages changed relative to LTV $<$ 80% mortgages after the policy. Column (1) of Table A.1 shows that the number of high-LTV loans declined by 46%. This decline in high-LTV loans is not offset by an increase in low-LTV loans—in fact, there was no statistically significant increase in the low-LTV mortgage segment relative to mortgages in the auxiliary group, which suggests substitution between high-LTV and low-LTV mortgages was not substantial during the sample period.

Next, I test whether the composition of households for high and low-LTV groups changed relative to the auxiliary control group. Consider a low income household who fails to qualify for a high-LTV mortgage after the policy change and decides to originate a low-LTV mortgage; this would be reflected in an increase in the average income of high-LTV households a decrease in the average income of low-LTV borrowers, relative to the auxiliary control group. I estimate the following specification:

$$\begin{aligned} y_{ict} = \alpha + \beta_1 Post_t \times \mathbb{1}(\text{Low-LTV})_{ic} + \beta_2 Post_t \times \mathbb{1}(\text{High-LTV})_{ic} + \\ \beta_3 Post_t + \beta_4 \mathbb{1}(\text{Low-LTV})_{ic} + \beta_5 \mathbb{1}(\text{High-LTV})_{ic} + \delta_{ct} + \epsilon_{ict} \end{aligned} \tag{16}$$

where y_{ict} is a household characteristic (e.g. income) for mortgage i, issued in county c, quarter t. The coefficients of interest are β_1 and β_2, which reflect how the average value of a characteristic changes for high-LTV and low-LTV mortgage originators, relative to originators of mortgages in the auxiliary control group. Columns (2) - (4) show that high-LTV borrowers earn higher income, are older, and have a higher credit score after the policy relative to the auxiliary control group. The average income, age, and credit score of low-LTV borrowers are not economically or statistically changed, which suggests that borrowers who leave the high-LTV mortgage segment do not substitute to low-LTV loans.

From an aggregate perspective, product substitution from high-LTV to low-LTV loans during the sample period appears muted. However, if the number of borrowers who substitute are sufficiently small, it is possible for substitution to occur without affecting aggregate loan counts or average borrower characteristics. To address this concern, I focus only on the group of households who are most likely to substitute to low-LTV mortgages and examine the degree of substitution within this group.

All else equal, households taking on a high-LTV mortgage to purchase a house that is more expensive relative to their income, i.e., a higher value to income (VTI) purchase, are more likely to be disqualified under the new policy. If a household carried zero non-mortgage debt, they would fail to qualify for their mortgage at VTI ratios above 5.8. Empirically, the VTI distribution shows that the share of loans issued at higher VTIs is lower during the post-period (Figure A.2a).

Since high VTI loans are more likely to be infeasible under the new policy, substitution from high to low-LTV loans are also more likely at higher VTIs. This substitution would be seen in a shift towards lower VTIs for high-LTV loans, and a shift towards higher VTIs for low-LTV loans. To isolate changes in the distribution of loans caused by the policy change, I normalize the VTI distribution for loans with $LTV = 80$ (Figure A.2c) and $LTV > 80$ (Figure A.2a) by the VTI distribution for loans with $LTV < 80$ (Figure A.2b), the control group. This normalization procedure will allow me to isolate changes to the distribution caused by the policy, and is valid under the following two assumptions:

1. The VTI distribution of the control group (LTV $<$ 80) is not affected by the policy.
2. In absence of the policy, a change in a given VTI bin in the control group ($LTV < 80$) would have been the same as the corresponding change in the VTI bin for both the low-LTV ($LTV = 80$) loans and of the high-LTV loans ($LTV > 80$).

Figure A.3 shows the normalized distributions, with standard errors calculated using a bootstrap procedure. Figure A.3b shows that the VTI distribution of high-LTV loans shifts towards the left relative to the control group, as high VTI borrowers either exit the market or purchase smaller homes. By contrast, there is no statistically significant change in the VTI distribution for loans with $LTV = 80$ (Figure A.3a).

To understand why substitution is limited, consider a back-of-the envelope calculation of the trade-offs facing the typical high-LTV borrower shown in Figure A.2. Column (1) shows the purchase price, LTV, and income for the average high-LTV borrower during the pre-period who would have failed to qualify under the new policy. Column (2) shows that this same borrower fails to qualify for their loan under the new policy because their total debt payments is 46% of their income, higher than the 44% threshold. Column (3) shows that this borrower could move to a low-LTV mortgage, but this would require them to increase their down payment four-fold, and this adjustment is much larger than necessary, since their PTI and DTI ratios would be 26% and 37%, well under both the 39% and 44% thresholds. Columns (4) and (5) show alternative scenarios where the borrower could qualify by purchasing a house which is 4% cheaper, or reduce their LTV from 95% to 90% (rather than from 95% to 80%). Existing evidence shows that down payments are a binding constraint for households in Canada and many other developed nations[14];

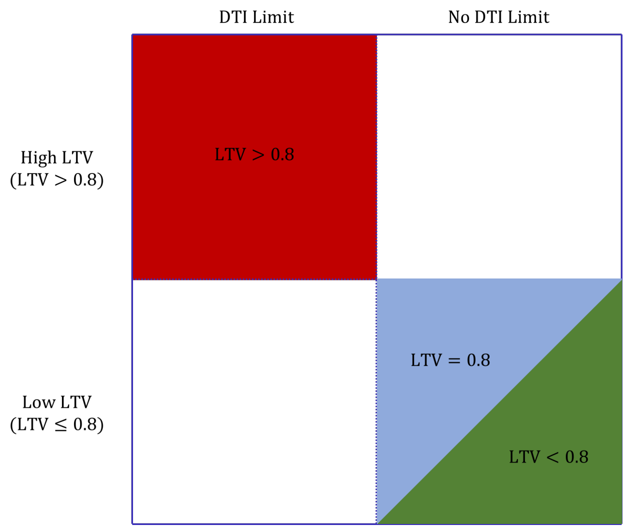
[14]See Allen, Grieder, Peterson, and Roberts (2020); van Bekkum, Gabarro, Irani, and Peydró (2019); Berger, Turner, and Zwick (2020); Tracey and van Horan (2021); Tzur-Ilan (2022).

empirically, bunching in the distribution of LTV ratios also suggests that households are liquidity constrained[15]. Figure A.2 suggests that for the average borrower constrained by the policy, smaller adjustments to the LTV or house price are sufficient to qualify. These alternative scenarios also ignores adjustments the borrower could make to non-mortgage debt without any changes to the house price or down payment.

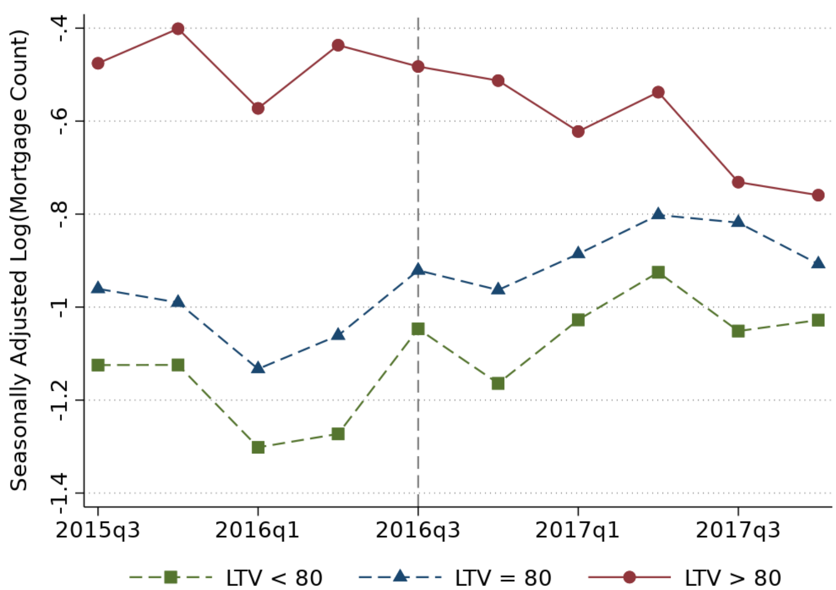
[15]Mortgages with LTV ratios above 80% are mandated to carry government insurance. The cost of government insurance are typically passed on to the household. The non-linearity of mortgage insurance pricing schedules lead to bunching at 80% (for households who have sufficient savings to avoid mortgage insurance altogether), 90%, and 95%. See Allen, Clark, and Houde (2014) for details

Figure A.1: Policy Impact on Mortgage Issuance by LTV Segment

This figure shows how mortgage issuance evolves over time, by different LTV segments. Panel (a) shows that debt-to-income (DTI) requirements are tightened only for high-LTV (LTV $>$ 80%) mortgages, not low-LTV (LTV $\leq$ 80%) mortgages. For borrowers who consider switching from a high to low-LTV mortgage due to the policy change, it is sufficient to lower LTV to exactly 80%, and lowering LTV to a level strictly below 80% does not provide additional slack in the DTI requirements. This implies that the number of mortgages with LTV $<$ 80% should not be impacted by the policy. Panel (b) shows log(mortgage count) evolves over time for the three LTV segments, LTV $<$ 80%, LTV $=$ 80%, and LTV $>$ 80%. Mortgage counts within each segment are seasonally adjusted by subtracting the average number of mortgages issued each quarter.



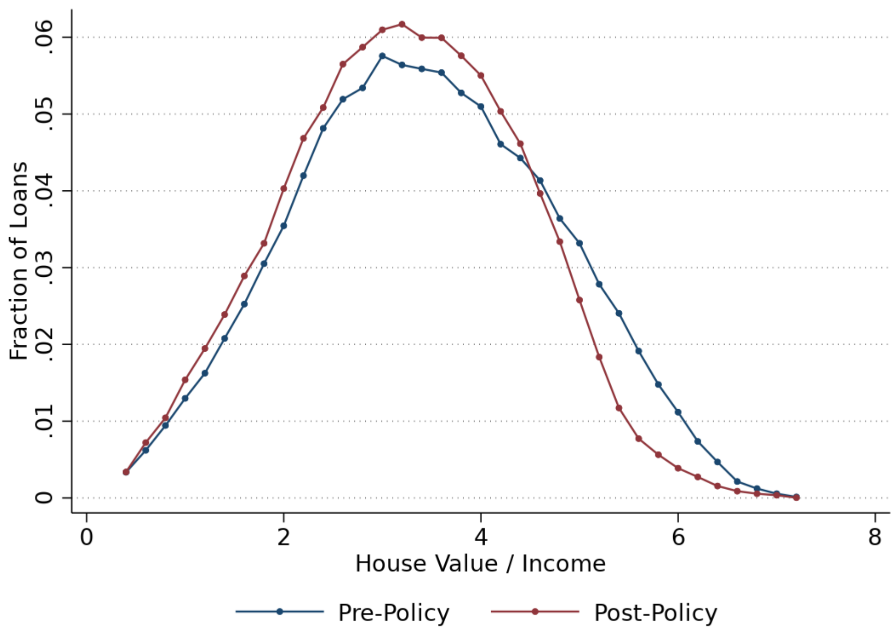
(a)



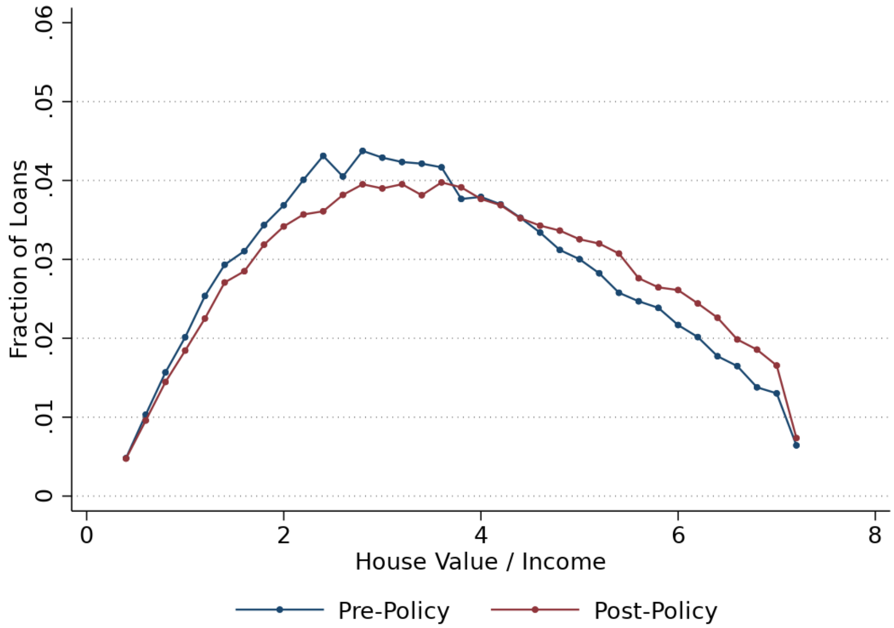
(b)

Figure A.2: VTI Distributions by LTV Group

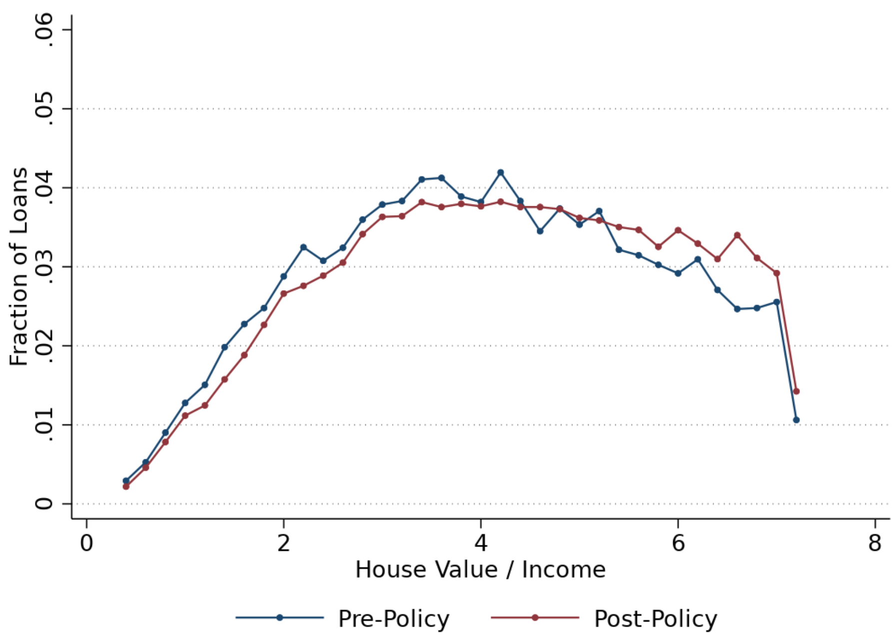
This figure shows the distribution of home value to income (VTI) for all loans issued during the pre-period (navy) and post-period (maroon) for each LTV group. In a given LTV group, loans are divided into VTI bins. Bins range from 0.4 to 7.2, in increments of 0.2; all bins contain at least 0.5% of all loans. Loans are sorted into bins by rounding down the VTI to the closest fifth, so the VTI bin of 6 includes all loans less than or equal to 6, but strictly greater than 5.8.



(a) *LTV* $>$ *80%*



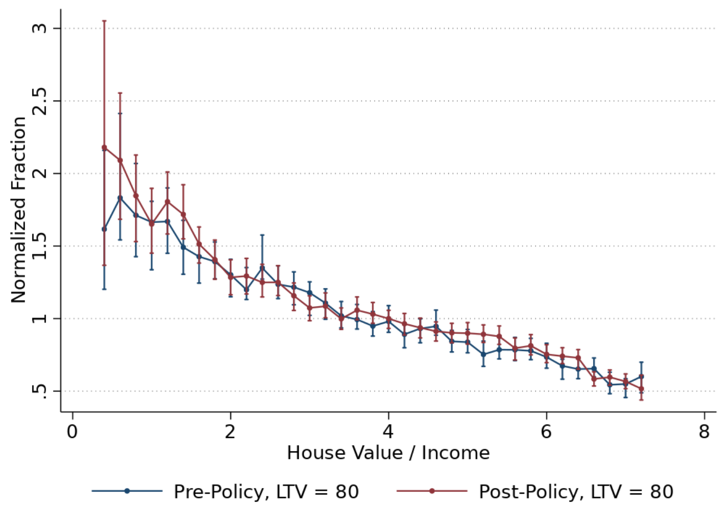
(b) *LTV = 80%*



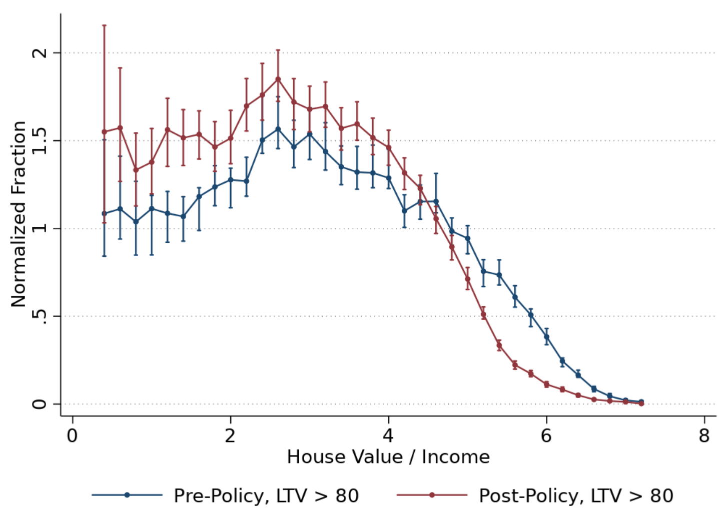
(c) *LTV < 80%*

Figure A.3: Normalized Value-to-Income Distributions for Low and High-LTV loans

This figure shows the distribution of home value to income (VTI) for loans with LTV $= 80\%$ and $LTV > 80\%$. Each distribution is normalized by dividing the fraction of loans in each VTI bin by the fraction of loans in the same VTI bin for loans with LTV $< 80\%$. Standard errors are shown at the 95% confidence interval, and are estimated using 50 bootstrapped samples from the observed sample of mortgages.



(a) $LTV = 80$



(b) $LTV > 80$

Figure A.4: Distribution of Loan-to-Value

This figure shows the distribution of loan-to-value (LTV) for all mortgages issued during before the policy change (2015Q3-2016Q3) and after the policy change (2016Q4-2017Q4). LTV is calculated as the outstanding mortgage balance at origination as a fraction of the sale price of the property.

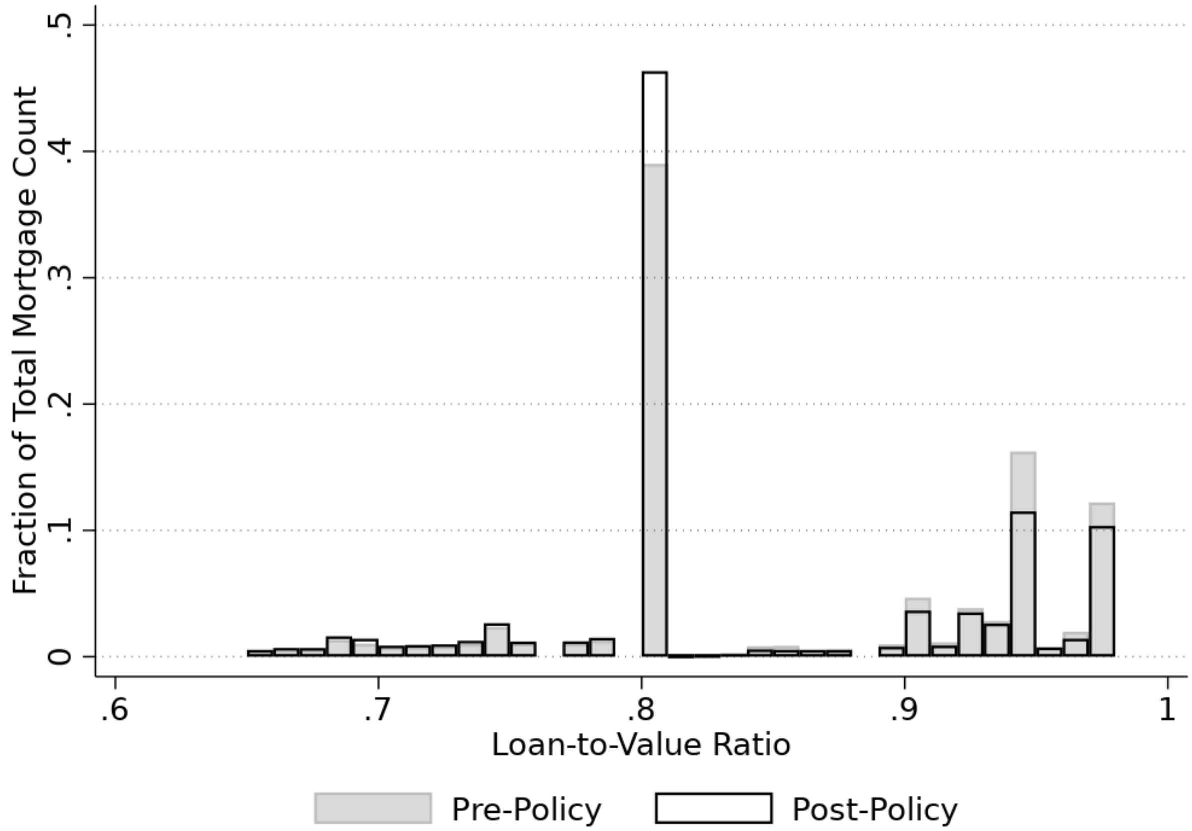


Table A.1: Policy Impact on Product Substitution From High-LTV to Low-LTV Loans

This table reports estimates of the policy impact on substitution from high-LTV (LTV $>$ 80%) mortgages to low-LTV (LTV $=$ 80%) mortgages. Column (1) estimates how the policy impact on the number of high-LTV mortgages and low-LTV mortgages issued relative to the number of mortgages issued with LTV $<$ 80%:

$$\log\left(\text{No. of Mortgages}\right)_{sct} = \alpha + \beta_1 Post_t \times \mathbb{1}(\text{low-LTV})_{sc} + \beta_2 Post_t \times \mathbb{1}(\text{high-LTV})_{sc} + \beta_3 Post_t + \beta_4 \mathbb{1}(\text{low-LTV})_{sc} + \beta_5 \mathbb{1}(\text{high-LTV})_{sc} + \gamma_{ct} + \epsilon_{sct}$$

$\log\left(\text{No. of Mortgages}\right)_{sct}$ is the number of mortgages in segment s, where $s \in \{\text{LTV} < 80\%, \text{LTV} = 80\%, \text{LTV} > 80\%\}$; γ_{ct} is a county-quarter fixed effect; standard errors are clustered at the county level. Each unit of observation in Column (1) is a segment-county-quarter.

Columns (2)-(4) estimates the the policy impact on the composition of the borrowers for $LTV =$ 80% and $LTV >$ 80% loans, relative to the control group of $LTV <$ 80% loans. Specifically, estimates are shown for the following regression:

$$y_{it} = \alpha + \beta_1 Post_t \times \mathbb{1}(\text{Low-LTV})_i + \beta_2 Post_t \times \mathbb{1}(\text{High-LTV})_i + \beta_3 Post_t + \beta_4 \mathbb{1}(\text{Low-LTV})_i + \beta_5 \mathbb{1}(\text{High-LTV})_i + \delta_{ct} + \epsilon_{it}$$

where the dependent variable is borrower income in Column (2), borrower age in Column (3), and borrrower credit score in Column (4). Each unit of observation in Columns (2)-(4) is a mortgage.

	(1) Log(Loan Count)	(2) Income	(3) Age	(4) Credit Score
Post×High LTV	-0.456***	5305.271***	0.694***	2.392***
	(0.019)	(634.2243)	(0.1279)	(0.6562)
Post×Low LTV	-0.017	742.802	0.075	1.009
	(0.017)	(638.7128)	(0.1288)	(0.6608)
N	31,752	378,500	378,500	378,500
R-Squared	0.81	0.16	0.10	0.10
County × Quarter FEs	✓	✓	✓	✓

Table A.2: Scenario Analysis for a High-LTV Household Constrained by DTI Tightening

This figure shows back-of-the-envelope calculations for a high-LTV (LTV $>$ 80%) household who fails to qualify under the new policy. The first column of this table shows the average house price, LTV, and income for the average high-LTV loan which would be infeasible under the new policy. The second column shows that the mortgage would not qualify under the new policy because the debt-to-income (DTI) would exceed 44%. Columns (3)-(5) show possible adjustments a household could make in order to qualify for a mortgage. Column 3 shows calculations for a household who switches products to a LTV = 80 mortgage, which are not covered by the policy; column (4) shows a high-LTV mortgage for a cheaper house, and column (5) shows a high-LTV mortgage with an increased down payment.

	(1)	(2)	(3)	(4)	(5)
	Pre-Policy	**Post-Policy**	**Low LTV**	**High LTV, Smaller House**	**High LTV, Higher Down Payment**
Purchase Price	380000	380000	380000	365000	380000
LTV	0.95	0.95	0.8	0.95	0.9
Down Payment	19000	19000	76000	18250	38000
Loan Size	361000	361000	304000	346750	342000
Income	83210	83210	83210	83210	83210
Rate Used to Calculate Mortgage Payment	0.0269	0.0464	0.0269	0.0464	0.0464
Monthly Mortgage Payment	1654	2035	1393	1955	1928
Monthly Mortgage Payment / Income (PTI)	**0.29**	**0.35**	**0.26**	**0.33**	**0.33**
Monthly Non-Mortgage Debt Payments	763	763	763	763	763
Monthly Non-Mortgage Debt Payments / Income	**0.11**	**0.11**	**0.11**	**0.11**	**0.11**
Total Debt Payments / Income	**0.40**	**0.46**	**0.37**	**0.44**	**0.44**