Macro-Prudential Policy and Canadian Housing Market:

Analysis of Five Major Provinces in Canada

by

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Abstract

The high level of household indebtedness and stretched valuations in some segments of the Canadian housing market poses a potential risk to financial stability in the country. To protect and strengthen the Canadian housing market, the government has taken prudential measures during 2008 to 2012 to reduce the risks associated with the housing market. This paper conducts an empirical analysis regarding the effectiveness of Canadian macro-prudential policies based on the user cost model. This paper found that the four rounds of policy changes were effective in reining in housing price and reducing housing credit growth in the five provinces including Ontario, British Columbia, Alberta, Quebec and Manitoba to varying degrees based on their diverse provincial economic backgrounds.

Keywords: housing market, macro-prudential policy, financial stability, user cost model

Table of Contents

List of Figures

List of Tables

1. Introduction

In Canada, the most important domestic risk to financial stability is the elevated level of household indebtedness and stretched valuations in some segments of the housing market[1]. The household debt to disposable income ratio in Canada has been rising for more than 20 years, from approximately 110 percent in 2000 to 165 percent in 2013 (Figure 1). As a major part of household debt, residential mortgage credit has risen significantly since 1990, however the growth rate of residential mortgage credit has been relatively stable from 2012 to 2013 (Figure 2). Housing prices have continued to rise in Canada since the recent 2008 financial crisis. Although, recently the growth rate of housing prices has moderated, it is still growing faster than disposable income (Figure 3). All of these facts suggest that there is still a large potential risk in Canadian housing market, which may amplify the adverse effects of other shocks on the financial system.

The Government of Canada has taken prudent measures to strengthen the minimum standards for government-backed insured mortgages to reduce the risk associated with high levels of household debt, housing market imbalances, and to support the long-term stability of the housing market[2]. Table 1 summarizes the key changes made to the rules for government-backed insured mortgages. These changes include reducing loan-to-value limits for new mortgages and mortgage refinancing, as well as reducing maximum amortization periods. The four rounds of policy changes announced by Department of Finance are typical macro-prudential tools to strengthen Canada's financial foundation. With the implementation of mortgage loan insurance rules changes from 2008, there has been a noticeable moderation in the growth of housing prices and housing credit. However, it is interesting to examine whether a soft landing in the Canadian housing market is due to changes in the mortgage loan insurance rules.

The aim of this paper is to assess the effectiveness of the macro-prudential policies taken by the Canadian government to address the housing boom. Instead of generally assessing the effectiveness of macro-prudential policy, I will analyze the four rounds of policy changes separately to determine which round of policy changes is more effective. Moreover, with the

[1] Source: Financial System Review - June 2014 – Bank of Canada
[2] Source: Financial System Review – December 2012 – Bank of Canada

imbalances in the Canadian housing market different segments may react differently to the policy changes. This paper also investigates whether the mortgage insurance policy changes in Canada have different effects on the provinces in terms of reining in housing prices and reducing housing credit growth. The purpose of this paper to analyze the different effects that policy changes have on different provinces contributes to the existing literature, since there has been no studies examining how distinct housing markets respond differently to general macro-prudential policies.

In making use of provincial monthly time series data, I analyze the policies effects on housing prices and housing credit growth in five major provinces. The model controls for factors that can affect the housing market such as housing rent, provincial economic growth, as well as monetary policy. The main findings of this paper suggest that the four rounds of policy changes have had an effect on reining in housing prices and reducing housing credit growth in all five provinces to various degrees based on their diverse provincial economic backgrounds. The measures taken in 2008 and 2012 are found to be more effective than other policy changes. Moreover, the five major provinces in Canada responded to the policy changes differently. In terms of housing prices, the policy changes worked most effectively in British Columbia, while for housing credit, Alberta responses to the policy changes most significantly.

The paper is organized as follows. Section 2 provides a brief description of housing finance in Canada. Section 3 discusses the linkage between household debt and housing prices and its importance in affecting financial stability. In this section, I also summarize the existing studies of macro-prudential policies in dealing with housing market instability. Section 4 investigates the theoretical frameworks that can help better understand the driving factors behind housing prices. In Section 5, empirical evidence is provided regarding the impact of macro-prudential policy based on the theoretical model discussed in section 4. Finally, I present the results derived from the regression analysis and discuss policy implications, as well as suggestions for future policy implementations in Section 6.

2. Background

In this section, a definition of macro-prudential policies is given and a description involving how they have been developed in Canada is discussed. An examination of the institutions that are involved in announcing and implementing macro-prudential policy is also addressed. In general, this section provides a comprehensive view regarding the role of macro-prudential policy in Canada.

2.1 What is Macro-prudential Policy and Why is it Important?

The 2008 global financial crisis has indicated that monetary policy and micro-prudential banking regulations are not sufficient to prevent the potential risk in financial sector. Macro-prudential policy is regarded as complementary tool to existing policy frameworks to address systemic risk and maintain financial stability and has been widely examined and applied. Asia-pacific regions such as Hong Kong and South Korea are the most active users of prudential policies. According to Kenneth et al. (2012), from the first quarter of 1980 to the first quarter of 2012, there were 46 changes to loan-to-value ratios and 19 debt-to-service ratio changes across 13 regions in Asia[3]. Since macro-prudential policy is effective at targeting the risks associated with serious household indebtedness and overheated housing prices in financial markets, its implementation may be more practical, cost-effective, and have less spillover effects when compared with monetary policy. As a result, the proper implementation of macro-prudential tools is an important factor in its success.

2.2 Macro-prudential Policy in Canada[4]

In Canada, banks dominate the residential mortgage market and hold approximately 75 percent of outstanding mortgages. However, under the policy framework the Office of the Superintendent of Financial Institutions (OSFI), federally regulates mortgage originators including all banks and some non-banks. The function of OSFI is to apply principle-based

[3] Loan to value ratio is mortgage amount divided by appraised value of the property. Debt to service ratio includes gross debt to service ratio and total debt to service ratio. According to Allan, Cesaire and Jie (2010), the gross debt to service ratio is the ratio of the carrying costs of the home (mortgage payments, property taxes and heating costs) to the borrower's income. The total debt service ratio includes not only housing-related expenses but also all other debt obligations.

[4] See Allan, Cesaire and Jie (2010) for more discussions of Canadian residential mortgage market.

supervision focused on the institution's risk. In June 2012, OSFI issued "Guideline B-20", which is to be followed by all federally regulated lenders. Federally regulated lenders such as banks are not only under the OSFI's supervision, but are also required to insure high ratio mortgages if the LTV ratio is greater than 80 percent. The Department of Finance is responsible for designating mortgage insurers after consulting with the OSFI. Canada Mortgage and Housing Corporation (CMHC) is the largest mortgage insurer in Canada and is under the management of the federal government. Mortgage insurance changes are announced by Department of Finance, implemented by CMHC, and supervised by the OSFI. More importantly, mortgage insurance changes acts as an effective macro-prudential policy tool in controlling systemic risk and is reviewed in the Bank of Canada's Semi-annual Financial Systems Review.

Between 2008 and 2012, the qualifying rules for government-backed insured mortgages have been tightened four times reflecting the rising housing market in Canada. The commonly used tools of macro-prudential policy by the Canadian government include loan-to-value (LTV) ratios and amortization periods. More specifically, during the four rounds of policy tightening the LTV limit for new mortgages was reduced from 100% to 95%, while the LTV limit for mortgage refinancing was lowered from 95% to 80%. In addition, the amortization period was shortened from 40 to 25 years. The decreased LTV limit for new mortgage means that the maximum Canadians can borrow when buying their first home falls to 95% of the home's value. As well, the decreased LTV limit for mortgage refinancing means that borrowers are restricted to borrowing only up to 80% of the home's value when refinancing their home. The large decreases in the LTV refinancing limit during the past four years reveal that government restricts borrowers shifting consumer debt into mortgages by "using homes like ATM machines". The decreasing LTV limit for both new mortgages and mortgage refinancing can act as a preventive tool against excessive borrowing, while reducing systemic risk related to household indebtedness. As well, shortening amortization periods will require borrowers to pay down their mortgages at a faster pace. With shortening amortization period, consumers will qualify for fewer mortgages because of a large monthly payment, but save thousands in interests[5]. These changes are an

[5] See the news posted on Financial Post written by Garry Marr for more details, http://business.financialpost.com/2012/06/21/you-still-dont-need-a-lot-of-cash-to-buy-a-house/

effective method for the government to ensure that households do not become overextended, while also acting to support and strengthen the housing market.

In the following section, an empirical analysis is conducted to determine whether the policy changes have achieved the government's goal of stabilizing the housing market. The analysis will also help to determine whether the policies have had a different impact on various housing market segments in Canada.

3. Literature Review

The global economic crisis triggered by the US subprime mortgage crisis in 2008 has demonstrated the vulnerability of housing markets, as well as the importance of housing market stability. The boom and bust of housing markets can cause widespread problems for financial systems and could potentially result in the collapse of these systems. The ramifications can have a significant impact on the development of national and international economies, which was seen in the financial crisis of 2008. The central role of housing markets in the recent crisis has attracted broad attention involving how to reduce the boom and bust cycles to achieve stability in the housing market. The key point of achieving this goal is to understand the linkage between housing prices and household debt, which is considered as one of the most important reasons associated with financial system vulnerabilities.

During the boom in the housing market, rising house prices increased the value of household collateral. As a result, households are able to borrow more money for further consumption in both the housing and non-housing market. The increased demand for housing drove house prices even higher. The pro-cyclicality of the housing market can exacerbate instability in the financial sector, expand the extent of cyclical fluctuations in the economy, and have severe implications for the housing market and possibly lead to a bust.

Many countries have made a large effort to reduce the pro-cyclicality of the housing market. Conventional monetary policy is regarded as a "blunt tool" for stabilizing housing markets (Ben Bernanke 2010), since interest large rate hikes can dampen the growth of house

prices and run the risk of causing a recession (Kuttner and Shim 2013). As a result, alternative policies that can complement monetary policies or independently stabilize housing markets are of great interest.

The purpose of this section is to review the theoretical and empirical frameworks in the existing literature to study macro-prudential policies and their effectiveness in stabilizing housing markets. The theoretical approach that captures the links between housing finance and the real economy is the Dynamic Stochastic General Equilibrium (DSGE) model. In capturing the differences between household borrowing and lending behavior over the life cycle, Iacoviello (2005) modeled monetary business cycles with nominal loans and collateral constraints tied to housing values. With the collateral constraints, the model revealed that higher house prices increases the value of household collateral, which increases the capacity of households to borrow, causing higher demand and leading to higher expenditures in both consumption and housing. This collateral effect dramatically improves the response of aggregate demand to housing price shocks. Christensen et al. (2009) constructed a similar DSGE model for Canada, which showed that the presence of borrowing constraints improves the performance of the model in accounting for real data in house prices and consumption in the country.

Based on the above model, economists began modeling macro-prudential policies into DSGE model to study the effectiveness of the policies in stabilizing housing market booms and busts. Christensen and Meh (2011) added a countercyclical regulatory loan-to-value (LTV) to a DSGE model with housing and borrowing secured by housing collateral. The study found that financial shocks can revalue collateral and increase the borrowing capacity of households suggesting that a countercyclical LTV is a more effective tool for stabilization the market. This has been shown to more effective at dampening the increases in debt and the expansion in housing prices and residential investment, when compared to monetary policy since it targets the source of the vulnerability. Alpanda, Cateau, and Meh (2014) incorporated broader macro-prudential instruments into a DSGE model to analyze the effects of financial shocks and macro-prudential policies on the Canadian economy. The findings reveal that in terms of reducing household debt, more targeted tools such as LTV regulations are the most effective and least

costly, followed by bank capital regulations and monetary policy. The above findings reveal that the examination of cross-province performance in stabilizing the housing market with the use of loan-to-value ratio regulations in Canada has not been conducted in the past.

The DSGE model successfully captures the pro-cyclicality of the housing market during the boom cycle driven by house prices and household debt accumulation; however, there are limitations to the model. As Christensen (2011) discussed, the lack of financial intermediaries and the decision of households to default makes the model inadequate at capturing how loan losses can lead to banking sector stress and tighter lending standards, which can be further amplified during a housing bust cycle.

The literature involving empirical frameworks to study macro-prudential policies and housing market blooms has increased recently, especially in the economies of emerging countries. Wong et al. (2011) assessed the effectiveness and drawbacks of maximum LTV ratios as a macro-prudential tool based on Hong Kong's experience and applied an econometrical analysis of data from 13 economies. In terms of banking stability, they found that the LTV policy can significantly reduce the responsiveness of mortgage default risk to changes in property prices and macroeconomic fluctuations. Using the GARCH model, they also analyzed the effects of LTV policies on property market activities. The evidence that tightening LTV caps will have a significant dampening effect on property market activities varies across different countries. However, the highlights of this paper show that the mortgage insurance programs have not reduced the effectiveness of the LTV policies in mitigating the liquidity constraints generated its implementation.

Applying both micro and macro level data, Igan and Kang (2011) studied Korean experiences with macro-prudential policies and found that loan-to-value and debt-to-income limits are associated with a decline in house price appreciation and transaction activities. In addition to applying OLS estimation approach to process with a regional dataset, they also utilized a matching estimator framework to deal with household level survey data and found that the LTV and DTI limits can alter expectations, which can play a key role in bubble dynamics.

Using the similar OLS estimation method, Krznar and Morsink (2014) found that macro-prudential policies implemented by Canadian regulators were associated with lower mortgage credit growth and housing price growth.

Kuttner and Shim (2012) translated the user cost model argued by Himmelberg, Mayer, and Sinai (2005) into a regression model to study the effects of a variety of macro-prudential measures including maximum LTV ratios, maximum DTI ratios, and three other distinct policy measures on housing prices and housing credit. Using a broad panel dataset including 57 economies and over 30 years of observations, Kutter and Shim (2012) found that certain types of macro-prudential policies could be effective tools for stabilizing the housing prices and credit cycles. However, it is hard to compare the effectiveness of different policy instruments. In their latest work in 2013, they added two different empirical methods in an effort to assess the robustness of the results including the mean group regression analysis and event study analysis. Evidence indicates that the maximum DTI ratio is more effective at slowing credit growth when compared with the LTV ratio limits.

The existing literature mainly focuses on the effectiveness of certain instruments such as the LTV ratio and DTI ratio in macro-prudential policy. Inspired by the previous work, this paper will analyze whether macro-prudential policies affect provincial housing markets differently based on the specific policy environment in Canada. This is a unique research direction since it analyzes the effectiveness of macro-prudential policies in a Canadian and provincial setting.

4. Empirical Framework

This section provides the empirical framework that will be used in this paper to assess the impacts of macro-prudential policies in Canada. I will first introduce the theoretical model that the regression analysis is partially based on. In applying the user cost model, a better understanding about what drives housing prices can be achieved. And I further include variables to model macro-prudential policy into the housing price regression. As for housing credit, there is no well-defined theoretical model to be based on, so the regression analysis of housing credit

is simply an analogy from housing price regression, which is more of a reduced form. Through the empirical analysis, I intend to examine several issues including: 1) whether the four rounds of macro-prudential policy changes implemented in Canada are generally effective, 2) whether the national level macro-prudential policy has a different impact among the five different provinces in Canada, and how the provinces have responded to the policies, and 3) among the four rounds of policy changes, which round is the most effective and the reasons for why it may be more effective.

4.1 Theoretical Model[6]

The user cost model proposed by Himmelberg, Mayer and Sinai (2005) provides a useful tool to learn about the economic fundamentals. Based on the proposition of Himmelberg et al. (2005), the cost of homeownership is composed of total six parts representing both cost and offsetting benefits. The components include the opportunity cost of capital, property taxes cost, the tax deductibility of mortgage interest and property taxes for filers who itemize on their federal income taxes, maintenance cost, expected capital gain (or loss) as well as additional risk premium for the risks associated with owing a home. Summing all the six components gives the cost of homeownership:

$$\text{Cost of Homeownership} = P_t r_t^{rf} + P_t w_t - P_t \tau_t (r_t^m + w_t) + P_t \delta_t - P_t g_{t+1} + P_t \gamma_t$$
$$= P_t u_t$$

where P_t is the housing price, r_t^{rf} is risk-free interest rate. w_t and τ_t are property tax rate and income tax rate respectively. δ_t represents depreciation rate. g_{t+1} is the expected appreciation rate of the house price. Finally, γ_t stands for risk premium on owning a house. The fraction u_t is known as the user cost of housing.

To achieve the equilibrium in the housing market, the cost of homeownership, $P_t u_t$ should be equal to the cost of renting, R_t.

$$R_t = P_t u_t$$

Rearrange this equation we can get user cost relationship.

[6] See Himmelberg, Mayer and Sinai (2005) paper, Assessing High House Prices: Bubbles, Fundamentals and Misperceptions for more details of user cost model construction.

$$\frac{P_t}{R_t} = \frac{1}{u_t}$$

4.2 Reduced Form Regression[7]

The purpose of this section is to transform the user cost model into a reduced form regression of housing price and housing credit.

4.2.1 Reduced Form Regression of Housing Price

Based on the user cost model, we have the following reduced form regression for housing price:

$$\Delta \ln P_{jt} = \alpha_j + \beta_1 \Delta \ln P_{jt-1} + \beta_2 \Delta \ln R_{jt-1} + \beta_3 \left(\ln R_{jt-1} - \ln P_{jt-1}\right) + \beta_4 i^m_{jt-1} + \beta_5 \pi_{jt-1} + \beta_6 i^s_{jt-1} + \beta_7 \Delta \ln Y_{jt-1} + \gamma X^i_t + \varepsilon_{jt}$$

where, $\Delta \ln P_{jt}$ is the first difference of log housing prices for each province and $\Delta \ln P_{jt-1}$ is $\Delta \ln P_{jt}$ lagged for one quarter. $\Delta \ln R_{jt-1}$ is the first difference of log housing rent for each province lagged for one quarter, while $(\ln R_{jt-1} - \ln P_{jt-1})$ is the one quarter lagged log difference of housing rent and housing price. $\Delta \ln Y_{jt-1}$ is the first difference of log GDP for each province. i^m_{jt-1}, i^s_{jt-1}, and π_{jt-1} are the lagged one-quarter mortgage interest rates, short-term interest rates, and inflation rates respectively.

There are some challenges of translating the user cost model into a regression equation. One of the most challenging aspects is related to data limitations. First, both property and income tax rates are hard to measure over time since people with different income levels actually are posed with a different tax rate. Also, the data for the depreciation rate of homes is hard to obtain for all five provinces since there are various kinds of dwellings which were constructed in different economic environments. As a result, it is assumed that the depreciation and tax rates are constant over the period of the study and they are sub-sum into the intercept. Moreover, the risk

[7] This follows Kuttner and Shim (2012), they started with the basic user cost model proposed by Himmelberg et al and translated the user cost relationship into reduced form regression for housing price and housing credit. However, they use panel data from total 57 economies going back to 1980 to assess several policies' effects.

premium and expected capital gains are unobserved. As a result, these items are put into the error term.

Another challenge is associated with transforming the user cost model into the reduced regression form since all of the variables in the user cost model are unlikely to be white noise. More specifically, the housing price, housing rent, as well as interest rates are all time series data with different trends over time. Taking the log form of the user cost model terms can help achieve a linear regression model for housing prices; however, the log form of housing prices and housing rent series in each province is still not stationary. One method to mitigate this issue is to take the first difference of these variables. As a result, the housing price, housing rent, as well as the provincial GDP are all in the first difference of log form to ensure consistency in the OLS regression when using time series data.

Apart from the above challenges, there are several modifications that were applied. First, provincial Gross Domestic Products (GDP) reflecting household income will affect demand of housing, as a result I include provincial GDP as an additional regressor for shifts in housing demand not captured in the rents data. Second, regressors are all lagged by one quarter accounting for the effects of these variables on housing prices could not be completed instantaneously. Third, inclusion of the inflation rate as a regressor into the regression model to capture the effect of price level changes on housing prices was made.

The last step of deriving the reduced form regression is to model the macro-prudential policy into the model. To assess the effectiveness of the four rounds of policy changes, as well as test whether the policy changes have a different impact on the five provinces, the following are two ways to model the macro-prudential policy.

First, four dummy variables are used to represent the four rounds of policy changes. Here X_t^i represents a matrix of four dummy variables including X_t^{2008}, X_t^{2010}, X_t^{2011}, and X_t^{2012}. For example on October 15, 2008, the government implemented the adjustments to the rules for government guaranteed mortgages, then dummy variable X_t^{2008} will take the value of 1 in that

month and in the following eight months, with the assumption that the impact of changes will finish working its way through the market after nine months to allow people to adapt to the changes[8]. By modeling four dummy variables to represent for the four rounds of policy changes, we can better identify which round of policy changes is more effective.

Second, to better identify which instrument used in macro-prudential policies is more effective in reining in housing price growth, the construction of an actual policy matrix was created. Now the policy variable X_t^i represents a matrix of actual value of tools frequently used in macro-prudential policies including LTV limits for new mortgages, LTV limits for mortgage refinancing, as well as amortization periods. For example, amortization period have been changed from 40 years to 35 years in October, 2008, then the value of the amortization period variable will be 40 before the month of policy implementation, and the value becomes 35 in October of 2008 and is kept as 35 until the next policy change.

The use of dummy variables to model the four rounds of policy changes separately represents a transitional effect of macro-prudential policies on housing prices, while using the actual value of policy instruments such as regressors captures the persistent effect of macro-prudential policies on housing prices.

4.2.2 Reduced Form Regression of Housing Credit

Due to the lack of theoretical model of housing credit, we use a similar regression for housing credit as what we do to the housing price. The reduced form regression of housing credit is as below.

$$\Delta \ln C_{jt} = \mu_j + \theta_1 \Delta \ln C_{jt-1} + \theta_2 i_{jt-1}^m + \theta_3 \pi_{jt-1} + \theta_4 i_{jt-1}^s + \theta_5 \Delta \ln Y_{jt-1} + \gamma X_{jt-1} + \varepsilon_{jt}$$

where $\Delta \ln C_{jt}$ and $\Delta \ln C_{jt-1}$ is the current and lagged one quarter first difference of log residential mortgage for each province respectively. Other control variables are identical to the housing price equation.

[8] See an article from CBC News, new mortgage rules pushing 1st-time homebuyers to wait. A TD research report in June said Flaherty's tightening of mortgage rules was expected to have impact for only six to nine months, as the markets adjust to the new standards.

4.3 Data Description

To empirically analyze how macro-prudential policy differently affects housing markets in the five major provinces, a time series OLS regression is applied for each province separately. As a result, the dataset consists of provincial level monthly time series data on housing and macroeconomic variables for the five provinces. The sample period for this paper is from January 1990 to June 2014. All the data except policy variable data is collected from Statistics Canada, which ensures the accuracy of the data. The housing price data is collected from the new housing price index calculated by Statistics Canada, and the housing rent data can be founded as a component of CPI. The housing credit value is the residential mortgage for each province and is provided by Bank of Canada. The inflation rate is calculated by the growth of CPI. As well, the mortgage interest rate is a typical five-year mortgage lending rate provided by CMHC, while the short-term interest rate is a six-month treasury bill rate in Canada.

The policy data is derived from the official website of Department of Finance, which is the institution in charge of announcing and implementing the policy changes. All details of the four rounds policy changes can be found in the news posted on the website of Department of Finance. Table 1 shows the details of four rounds of policy changes.

5. Empirical Results

The purpose of this section is to provide the empirical evidence regarding the effectiveness of four rounds of macro-prudential policies, as well as the different response of provinces to the nationwide macro-prudential policy.

5.1 Housing Price Equation

Table 2 shows the empirical results for the housing price equation. The coefficients for the four policy dummies are negative, indicating that the four rounds of macro-prudential policy changes have had an effect in suppressing house price growth in the five major provinces in Canada. Among all the five provinces, British Columbia had the most significant response in housing prices resulting from the mortgage rule changes since the coefficients of four policy dummies are significant at the 1% significance level and have the largest absolute value. More

specifically, the coefficient for 2008 policy dummy is -0.020 in BC and is significant at 0.1% significance level, indicating that the policy change in 2008 decreases the housing price growth in BC by 0.020%. The following 3 rounds of policy changes have also had a significant impact on reining in housing price growth in BC, however on a smaller magnitude. For example, the policy change in 2011 decreases the housing price growth in BC by 0.005%.

To examine the policy's effect on Alberta, the coefficient of 2008 policy dummy is -0.005, and the absolute value is greater than the absolute value of the coefficient for 2010 policy (-0.002), 2011 policy (-0.003) and 2012 policy (-0.003). However, the coefficients of the four policy dummies are all insignificant at 5% significance level in Alberta except the coefficient of 2011 policy dummy. The null hypothesis that the coefficient of each policy dummy is zero cannot be rejected at 5% significance level. As a result, we cannot say macro-prudential policy is able to rein the housing price growth in Alberta. As for Ontario, the coefficient of 2008 policy dummy is of greatest absolute value, indicating that policy change in 2008 has strong and statistically significant effect in reining housing price growth in Ontario. However, the coefficients of other three policy dummies in Ontario housing price regression are insignificant at 5% significance level. The coefficients of 2008 policy dummy and 2012 policy dummy in Manitoba housing price regression are -0.003 and -0.002 at 5% significance level, demonstrating that 2008 and 2012 policy changes decelerate housing price growth in Manitoba by 0.003% and 0.002% respectively. For Quebec, the macro-prudential policy in different year has significant effect in suppressing housing price growth, ranging from 0.002% to 0.005%.

Based on the above analysis, we notice that the coefficients for each policy dummy are different in different provinces' regression. To empirically test whether different coefficients of policy dummies stand for statistically different response each province has towards the policy changes, I apply seemingly unrelated estimation[9] to combine five separate regressions together. Table 5 shows the test results for either two provinces combination. The null hypothesis of the

[9] Seemingly unrelated estimation combines the estimation results-parameter estimates and associated (co) variance matrices-stored under different name into one parameter vector and simultaneous (co) variance matrix of sand-wish/robust type. This (co) variance matrix is appropriate even if the estimates were obtained on the same or on overlapping data.

tests is that having a mortgage insurance rules change in a specific year has the same impact on housing price growth in either two different provinces. There are total ten pairs of combination that we need to analyze. The comparisons between Alberta and other provinces demonstrate that each of four policy changes has no statistically different effect in Alberta and Ontario, Alberta and Quebec as well as Alberta and Manitoba at 5% significance level. For the comparison between Alberta and British Columbia, the p value is 0.0142 when I test the null hypothesis that coefficients of 2008 policy dummy in these two provinces' housing price equation are same. As a result, the null hypothesis is rejected at 5% significance level and the coefficients in two provinces differ. As for 2010, 2011 and 2012 policy dummy coefficients comparison between Alberta and BC, I cannot reject the null hypothesis. Now we take a look at the comparisons between Ontario and other provinces. In terms of the response of housing price to macro-prudential policy, there are no statistical difference between Ontario and Manitoba. As for Ontario and Quebec, 2008 mortgage rules changes differently affect the two provinces housing price, so as for 2011 mortgages rules changes. The comparison between Quebec and Manitoba shows that we cannot deny macro-prudential policy has identical impact in housing price growth in these two provinces. Lastly we take a look at the comparison between BC and other provinces. We can find that except 2010 policy dummy, the coefficients of the other three policy dummies are statistically different in Ontario and BC at 5% significance level and responses of housing price in British Columbia to the four times policy changes are statistically different from that in Manitoba. Among all the ten pairs of comparisons, only the combinations between BC and Manitoba as well as BC and Ontario have at least of 3 rounds of policy changes that affect two provinces housing price differently. As a result, it will be interesting to investigate why housing price in BC is more responsive to the policy changes compared with Ontario and Manitoba.

Before we further analyze why macro-prudential affects BC housing price differently with Ontario and Manitoba, we take BC as an example to investigate why 2008 policy measure has the strongest impact in reining housing price growth in BC. 2008 measures contained LTV limit for new mortgages changing from 100% to 95%, this may have a greater impact in BC's housing market compared to the maximum amortization period change and refinance LTV change. A possible reason for this argument is that people in BC may not care amortization

period that much, because shortening amortization period requires higher income to cover higher monthly payment but does not require a higher down payment. It is possible that people in BC, especially first time homebuyer can afford relatively higher monthly payment but can not afford 5% more down payment. Also, refinance LTV has a smaller effect in BC housing price compared to first time LTV can be explained by that facts that when people are refinancing, they actually have at least one real estate in hand, their purpose to buy a shelter is not primarily for living but for investing. At this point, people may choose not to cross the refinance LTV limit. As a result, first time LTV limit has strongest impact in BC housing price. Table 4 empirically verifies the above argument. The specification 2 of BC shows that the coefficient of first time LTV is 0.84, indicating that 1% decrease in first time LTV limit can decrease the housing price growth rate by 0.084%. This coefficient is significant and much greater than the coefficient of amortization period and refinance LTV in specification 1 and 3 of BC.

Compared with BC, Ontario and Manitoba's housing price is not significantly responsive to the mortgage rules changes. The first possible reason is that the employment rate[10] of BC is low compared to other provinces (See Figure 4). To be more specific, the employment rate of BC is 59.9% in 2013, which is lowest compared with Quebec (60.3%), Ontario (61.4%), Manitoba (65%) and Alberta (69.7%). While the purpose of mortgage rules changes is not to prevent people from borrowing, but to prevent people from borrowing too much and too fast. The province with low employment rate such as BC maybe more responsive to the policy changes because it takes people in that province longer to save enough money to be qualified for the stricter rules. The policy change will have limited impact on housing price in the province with fast economic growth and relatively high employment rate such as Manitoba and Ontario.

The second possible reason is that BC has lowest household saving rate among all the five provinces (See Figure 5). Household saving rate in BC has been negative from 2007 (-2.7%) to 2012 (-1.6%) and it reaches to zero in 2013. However, household saving rate of Ontario and Manitoba is 4.6% and 0.9% respectively in 2013. With a lot of saving, shortening amortization

[10] The employment rate (formerly the employment/population ratio) is the number of persons employed expressed as a percentage of the population 15 years of age and over.

period may not have a significant effect. Also households can easily adapt to higher first time LTV limit and refinance LTV limit with enough money in banking account.

The third possible reason is that BC has highest household debt service ratio among all the five provinces. The household debt service ratio is household interest paid divided by household disposable income. The ratio is affected by both interest rate level and household income level in a specific province and measures the household affordability of debt interest payment. In 2013, household debt service ratio in BC is 8.77%, which is higher than that in Ontario (7.46%) and Manitoba (6.16%)(See Figure 6). Before the rules changes, the households in BC are faced with higher pressure of debt interest payment. The stricter mortgage insurance rules will increase the debt burden of household and province with higher debt service ratio is more likely to be affected by the stricter mortgage insurance rules. Combining these reasons together, we can explain why Ontario and Manitoba's housing price is less responsive to the policy change compared with BC.

5.2 Housing Credit Equation

Table 3 displays housing credit regression results by modeling macro-prudential policy using dummy variables. In terms of the policy's effect in reducing housing credit growth, the tightening mortgage insurance rules have an impact in suppressing housing credit growth since most coefficients of policy dummies are negative, but different provinces response to the policy changes differently. Among all the five provinces, Alberta's housing credit responses to the mortgage rules changes most significantly, because the coefficients of four policy dummies are all significant at 5% significance level and have the biggest absolute value. To be more specific, coefficient of 2008 policy dummy in Alberta is -0.113, indicating that the policy changes implemented in 2008 reduce the residential mortgage growth by 0.113% in Alberta. The following 3 rounds of policy changes also have significant impact in reining housing credit growth in Alberta but with a smaller magnitude. The policy change in 2010, 2011 and 2012 decreases the housing credit growth in Alberta by 0.029%, 0.037% and 0.031% respectively. Different from Alberta, coefficients of 2010 and 2011 policy dummies in other four provinces are not significant at 5% significance level. As a result, we cannot reject the null hypothesis that 2010 and 2011 mortgage insurance rules changes have no impact in controlling housing credit

growth in Ontario, Quebec, Manitoba and British Columbia. Coefficients of 2008 policy dummies are significant at 0.1% significance level for all five provinces and have the biggest absolute value compared with coefficients of 2010, 2011 and 2012 policy dummies. In terms of mortgage insurance rules changes in 2012, coefficients of 2012 policy dummy in Manitoba and BC are -0.021 and -0.019 respectively and significant at 5% significance level, indicating that the 2012 policy changes effectively reducing housing credit growth by 0.021% and 0.019% in Manitoba and BC.

Comparing the effectiveness of four rounds of policy changes, mortgage insurance rules changes in 2008 are most effective in all provinces. The reason is that there is a change of LTV limit on first time homebuyer in 2008, which strongly affects first time homebuyers' decision on residential mortgage. Moreover, the influence of 2008 global financial crisis in Canadian housing market cannot be ignored. Compared with 2010 and 2011 policy changes, 2012 policy changes seem more effective because the coefficients of 2012 policy dummy in Manitoba, Alberta and BC are significant at 5% level. The possible reason is that 2012 mortgage insurance rules changes include other macro-prudential tools such as total and gross debt service ratio besides LTV limit and amortization period, which put more limit on residential mortgage growth.

When we look at five provinces housing credit separately, the coefficients for each policy dummy are different in five provinces regressions. To empirically test whether Alberta's housing credit is most responsive to mortgage rules changes, I use seemingly unrelated estimation to combine five separate regressions together. Table 5 shows the test results for either two provinces combination. The null hypothesis of the tests is that having a mortgage insurance rules change in a specific year has the same impact on housing credit growth in either two different provinces. The responses of Alberta's housing credit to the last three rounds of policy changes are statistically different from other four provinces. It is interesting to investigate why Alberta's housing credit is most responsive to the mortgage insurance rules changes. With a large amount of young population, Alberta has lowest median age compared with other provinces. In 2013, median age of Alberta is 36, which is much lower than median age in Quebec (41.6), Ontario (40.3), Manitoba (37.3) and BC (41.7) (See Figure 7). Young people contribute to the fast

economic growth in Alberta and also form Alberta's housing market. In this market, first time homebuyers occupy a large share of all homebuyers, with tighter rules they have to adjust their timeline on buying first home, which causes a significant effect on residential mortgage growth. However, with fast economic growth and low unemployment rate, people will save enough money quickly and restart considering for mortgaging new homes. As a result, there is no enough transition space for housing price growth to slow down.

Combing the results in housing price regression and housing credit regression, we notice the policy has a stronger effect in reducing residential mortgage growth compared with the effect in reducing housing price growth based on the coefficients values of policy dummy variables. This can be explained by the mechanism of how the policy takes effect on housing market. The mortgage loan insurance rules changes will firstly take effects on residential mortgage, since there is limit on borrowing money for buying new homes, the demand for housing market decreases causing housing price to go down. So we actually assume that the macro-prudential measures affect house prices indirectly through the residential mortgage. This can also explain why housing credit in different provinces responses to policy changes quite differently, while responses of housing price to policy changes in different provinces are relatively similar based on Table 5.

6. Conclusion and Discussion

The high level of household indebtedness and stretched valuation in various segments of the housing market poses a potential risk to financial stability in Canada. Although Canada survived the financial crisis during 2007 to 2009, policymakers still need to be cautious about overheated housing market. To protect and strengthen the Canadian housing market, the government has taken prudential measures during 2008 to 2012 in order to address the increasing risk associated with the housing market. The application of macro-prudential policies has become popular since it can better target the imbalances in the housing market while having smaller spillover costs when compared to monetary policy. As a result, assessing whether macro-prudential policies are effective in stabilizing the housing market can result in further policy improvements related to the implementation of macro-prudential policies.

6.1 Conclusion

This paper empirically analyzed the effectiveness of Canadian macro-prudential policy taken during 2008 to 2012. The interesting part of this paper is not only to assess the effectiveness of each round policy changes, but also to empirically test whether macro-prudential policy has different impact on different provinces in terms of reining housing price and housing credit growth. The main findings of this paper is that the four rounds of policy changes have an impact in reining housing price and housing credit growth in all five provinces. But housing market in different provinces response to macro-prudential policy differently based on diverse provincial economic background. The measures taken in 2008 and 2012 are found to be more effective in stabilizing housing market. In terms of housing price, the policy changes work most effectively in British Columbia. Because BC has lowest employment rate, lowest saving rate as well as highest debt service ratio among five provinces, it may take people in BC longer to save enough money for stricter mortgage rules. As a result, housing price will grow slowly under new mortgage rules. While for housing credit, the mortgage insurance rules changes reduced housing credit growth in Alberta most significantly. With lowest median age among five provinces, young people have a big share in population of Alberta. Young people are more likely to be the first time homebuyers who will be greatly affected by first time LTV change. As a result, Alberta housing credit is more responsive to mortgage insurance policy changes. In this paper, employment rate, saving rate as well as debt service ratio can be regarded as possible mechanisms through which macro-prudential policy suppressing housing price growth differently. The demographic characteristics is a possible mechanism through which housing credit growth rate be affected differently by mortgage insurance rules changes.

6.2 Limitation

Data limitation is one of the most important disadvantages of this paper. Canada's housing market information is not nearly as detailed as that available in the United States and the lack of data has contributed to strongly opposed views about the health of the market, with some commentators saying home prices are in bubble territory, while others insist there is nothing to worry about[11]. As I mentioned in the data description section, all data of this paper is derived

[11] See an article from The Globe and Mail; holes in housing market data have economists worried for more details.

from Statistics Canada. However, the housing related data provided in Statistics Canada is limited. For example, housing credit data applied in this paper is residential mortgage at the end of period by all chartered bank measured by dollars. This accumulated housing credit data will lose important information on people's housing finance behavior. Better data analysis can be done if we have more detailed housing credit data. First, it will be helpful if mortgage loan approval under national housing act[12] can be differentiated from total mortgage loan approvals. Since macro-prudential policy mainly applies to high ratio loans (LTV is greater than 80%), the effect of policy on housing finance will be more apparent using detailed data. Second, macro-prudential policy tools consist of LTV for first time homebuyers as well as refinance LTV. The effectiveness of the specific LTV tool can be tested if mortgage loan on new residential construction and existing residential properties can be differentiated from total mortgage loan approvals. Moreover, mortgage loan measured by dwelling units is also interesting to be investigated if data is available. Last but not least, mortgage loan on different type of housing can help us learn more about people's housing finance behavior. With stricter mortgage insurance rules, people may choose to buy smaller residence, data of housing credit on different type of housing can show whether people behave like what we assume.

Another difficulty of this paper is to address the causal effect of macro-prudential policy in decreasing housing price and housing credit growth. The first round of macro-prudential policy took place in 2008, while financial crisis swept the globe in the same year. It is important to control for financial crisis effect on housing demand to better gauge the 2008 macro-prudential policy impact on housing market. The inclusion of provincial GDP as a control variable can capture the financial crisis to a certain degree. However, it is still important to further identify the causal effect of macro-prudential policy on housing price and housing credit.

6.3 Future Work

In the future, it will be interesting to investigate other mechanisms through which Canadian macro-prudential policy can affects provincial housing markets differently. One possible mechanism is provincial immigration condition. Canada is an immigrant country and

[12] Mortgage loan approval under NHA means that the mortgage is backed by government mortgage loan insurance.

immigrants' housing purchase behavior will have a profound and lasting effect in housing price and housing credit. Moreover, in the empirical analysis we actually model the policy in two different ways. One is to assume macro-prudential policy has transitional effect on housing market; another is to assume persistent effect of policy. In the future work, it will be interesting to study how long the policy will take effect in the housing market.

Another interesting characteristic of Canadian macro-prudential policy is that each round of policy changes has a specific announcement date and implementation date. For example, in 2008 the policy was implemented on October 15, but announced on July 9. Borrowers and lenders had three months to get to know and be prepared for the new rules. With an announcement date, public will be informed that there will be a tightening mortgage insurance rule in the future. As a result, people will try to meet the deadline to apply for the mortgage with old rules. The possible result under this policy framework is that in the implementation month, a big drop in the amount and value of residential mortgage will be seen. In this paper, I focus on the implementation date of the policy instead of announcement date. However, announcement date has an effect in shaping public behavior on mortgage borrowing and is interesting to be looked into in the future.

In this paper, I use the biggest five provinces in Canada to proceed with empirical analysis. Empirical results comparison across these five provinces provides us with provincial evidence on the effectiveness of macro-prudential policy, especially the difference of policy effectiveness among different provinces. Using time series data, OLS regression analysis in each province is applied separately in this paper. However, panel data specification, pooling data in all provinces together, can also be implemented in the future work to study cross province difference. Under panel data methodology, data in more provinces will be needed.

In this paper, I bring up several potential explanations for different responses each province poses to macro-prudential policy. However, without enough empirical evidence, we cannot conclude that employment rate, saving rate, household debt service ratio as well as demographic characteristic are actual mechanism through which housing market be affected

differently by mortgage insurance rules changes. In the future, it is meaningful to empirically test the actual driver of different responses to macro-prudential policy and apply targeted measures accordingly.

6.4 Policy Implication

One of the most interesting findings of this paper is that housing market in different provinces response to macro-prudential policy differently based on diverse provincial economic background. Based on the results, the next best step for macro-prudential policy is of great interest. Former finance minister Jim Flaherty tightened the rules that determine which mortgages are eligible for insurance on four occasions in the wake of the financial crisis. His successor, Finance Minister Joe Oliver, has signaled he wants to play less of an active role in the housing market. As a result, we have not seen national level macro-prudential policy changes since 2012. However, as the largest mortgage insurer in Canada, CMHC can still apply mortgage loan insurance rules changes to mortgage loan appliers and play a role in stabilizing housing market. Since 2013, there are several changes of mortgage loan insurance rules made by CMHC. For example, CMHC stopped insuring mortgages on second homes, effective on May 30, 2014. This means that anyone who has an insured mortgage will no longer be able to act as a co-borrower on another mortgage that CMHC insures. Moreover, CMHC stopped offering mortgage insurance to self-employed people who do not have standard documents to prove their income. Although there are no changes made to the macro-prudential policy tools by Department of Finance since 2013, changes made by CMHC means that the era of tighter rules for homebuyers has not come to an end.

The macro-prudential policies as well as the changes made by CMHC we discussed in this paper are all conducted at national level. According to findings of this paper, it will be helpful if the policymaker can take into account the different economic conditions in various housing market segments when implementing macro-prudential policy. Employment rate, saving rate, household debt service ratio as well as demographic characteristic are important to be considered. Although macro-prudential policy is federally announced and implemented, Department of Finance can work with provincial regulators to apply additional macro-prudential

measures to address provincial housing markets. Although we find out that different provinces response to macro-prudential differently, it is too early to make the decision that we should have totally different housing regulations at provincial level. The empirical results show that BC's housing price as well as Alberta's housing credit is more responsive to the policy compared with other provinces. This reflects that the federally implemented macro-prudential policy has an effect in addressing housing market especially in provinces with more housing bubbles. As a result, policymaker can still use macro-prudential policy as a prudent tool to address stretched valuation in specific segments of Canadian housing market. Moreover, the effectiveness analysis and coordination from provincial regulation institutions is necessary. Provincial institution can closely monitor on provincial as well as major city housing markets when macro-prudential policy is announced and implemented, providing indispensable measures to assist the national level policy based on provincial housing market characteristics.

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Appendices

Appendix A. Additional Robustness Check

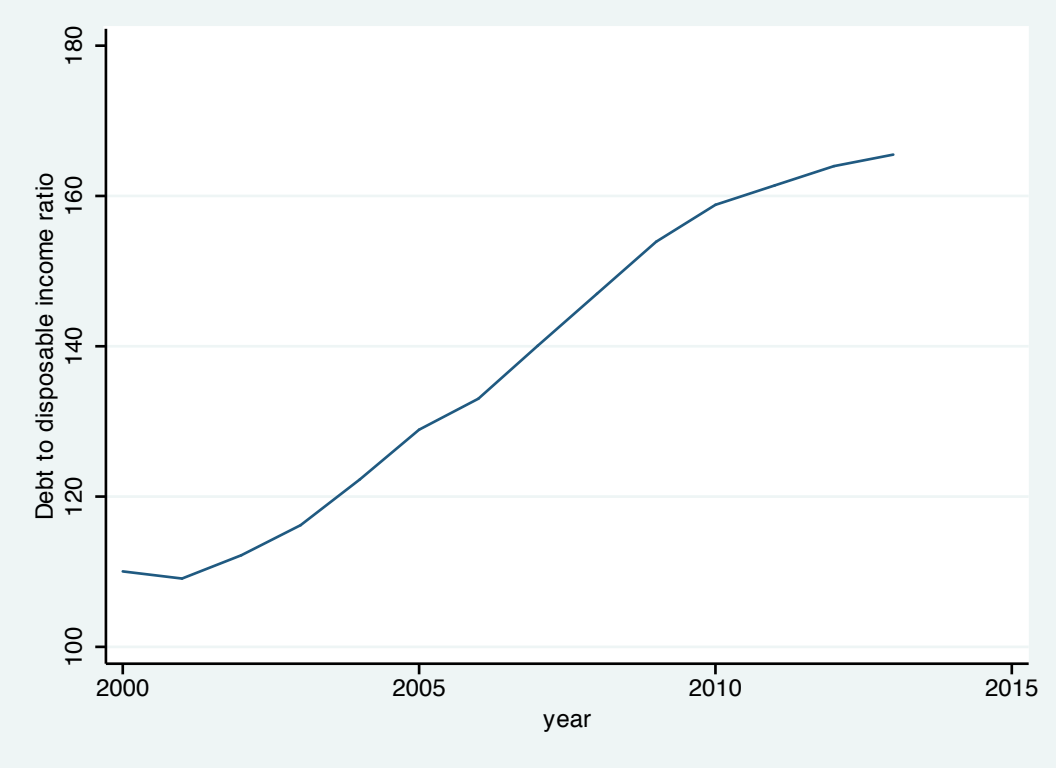
In this section, I provide additional robustness check on the assumption that the impact of policy changes will finish working its way through the market after six to nine months to allow people to adapt to the changes.

In Table 6, I model the policy dummy variables for each year in several different ways in housing price equation. In policy lasting for one-month specification, policy dummy takes value of 1 in the month that macro-prudential policy is implemented. As for policy lasing for one-quarter, we simply assume that the policy will have a temporary effect for three months, so policy dummy takes value of 1 in the month that macro-prudential policy is implemented and two following months. Same sense applies to the other specification with policy lasting for different time. However, for policy with persistent effect specification, we assume that the new mortgage rule has a persistent effect on housing market. As a result, policy dummy takes value of 1 in the implementing month until the end of the sample period. From Table 6 shows the policy has an impact in housing price for nine months for BC and Quebec, since the values of coefficients are in general increasing until about nine months and then decreasing. Moreover, the significance level and R square for BC and Quebec specifications are also increasing until nine months and then decreasing, this situation also applies to Ontario's case. The reason why the policy will have an effect on housing price for about nine months is that faced with new mortgage rules including shorter amortization period, lower refinance LTV limit and lower LTV limit on first-time homebuyers, people who are affected will reconsider their plan to buy a home. Moreover, they will strategize to maximize their saving to qualify the discipline to carry a mortgage, though they may have to wait longer. After a while, when these homebuyers have saved for enough money, they will start actively looking for homes again and the impact of the rule changes will finish working its way through the market. The robustness check results show it will take housing price about nine months to response to the macro-prudential policy. As a result, in the empirical analysis, policy dummy is modeled to last for nine months in housing price equation.

In Table 7, I model the policy dummy variables using same way as discussed above in housing credit equation. Table 7 shows that it takes the policy about 6 months to reaches the most significant effect in cooling down the housing credit, after that, the mortgage rule change gradually loses its effect in reining residential mortgage growth due to the market and people adjusting to the new standards. As a result, in the empirical analysis, policy dummy is modeled to last for six months in housing credit equation. Combining with the result in housing price equation, we can conclude that the policy will have impact for six months in reducing residential mortgage growth and nine months in reducing housing price growth. This can be explained by the mechanism of how the policy has impact on housing market. The mortgage loan insurance rules change will firstly take effects on residential mortgage, since there is limit on borrowing money for buying new homes, the demand for housing market decreases causing housing price to go down. So we actually assume that the macro-prudential measures affect house prices indirectly through the residential mortgage. That's why it takes longer for the policy to have an impact on housing price compared to housing credit. This can also explain why the policy has a stronger effect in reducing residential mortgage growth compared with the effect in reducing housing price growth based on the coefficients values of policy dummy variables.

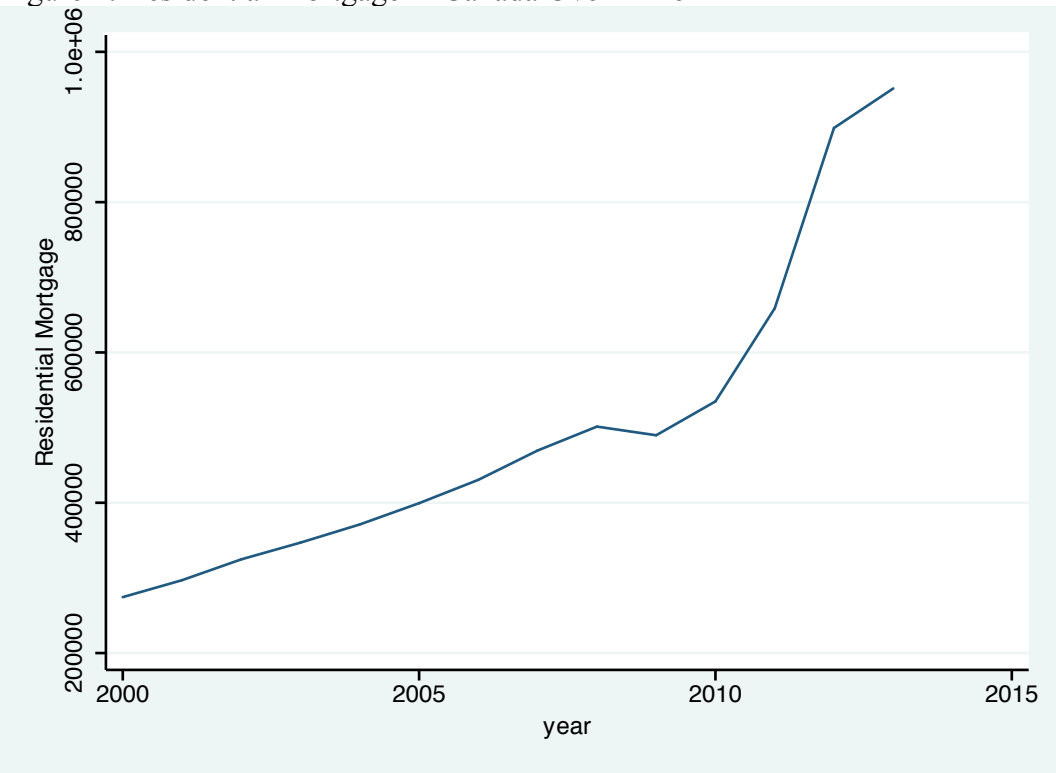
Appendix B. Figures and Tables

Figure 1: Household Debt to Disposable Income Ratio in Canada Over Time



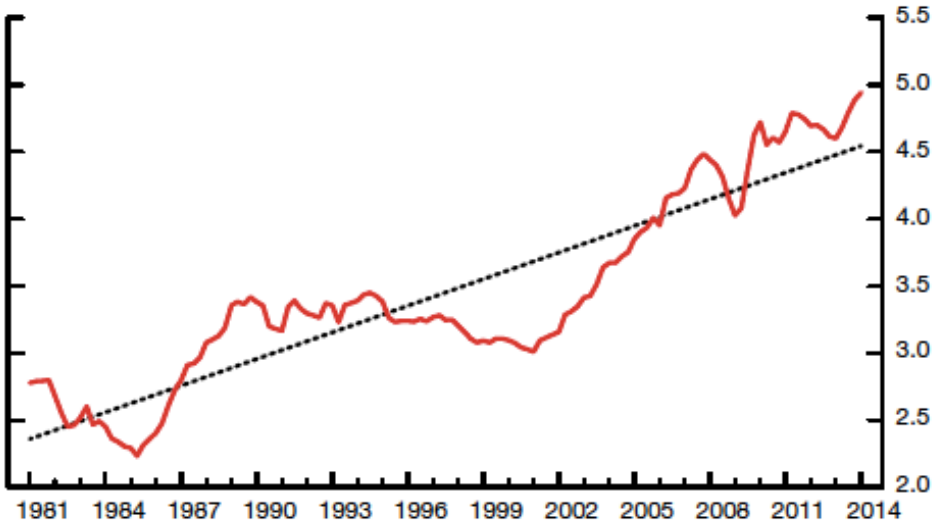
Source: Statistics Canada

Figure 2: Residential Mortgage in Canada Over Time



Source: Statistics Canada
Note: Over the course of 2011 data in this table were affected by conversion to International Financial Reporting Standards (IFRS).

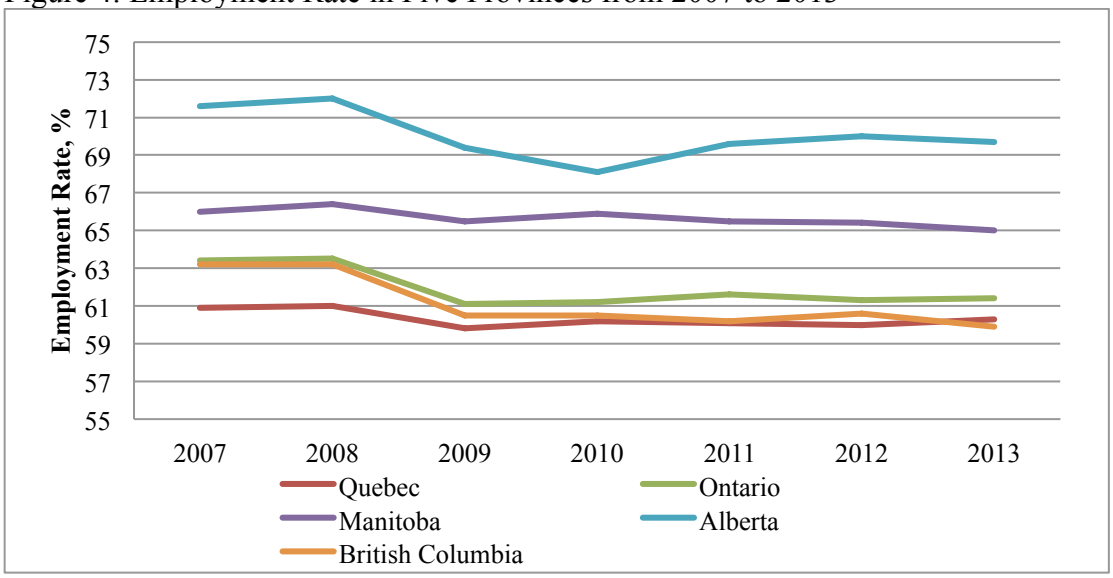
Figure 3: House Price to Income Ratio and Linear Trend[13]



Source: Statistics Canada, Canada Real Estate Association and Bank of Canada calculations

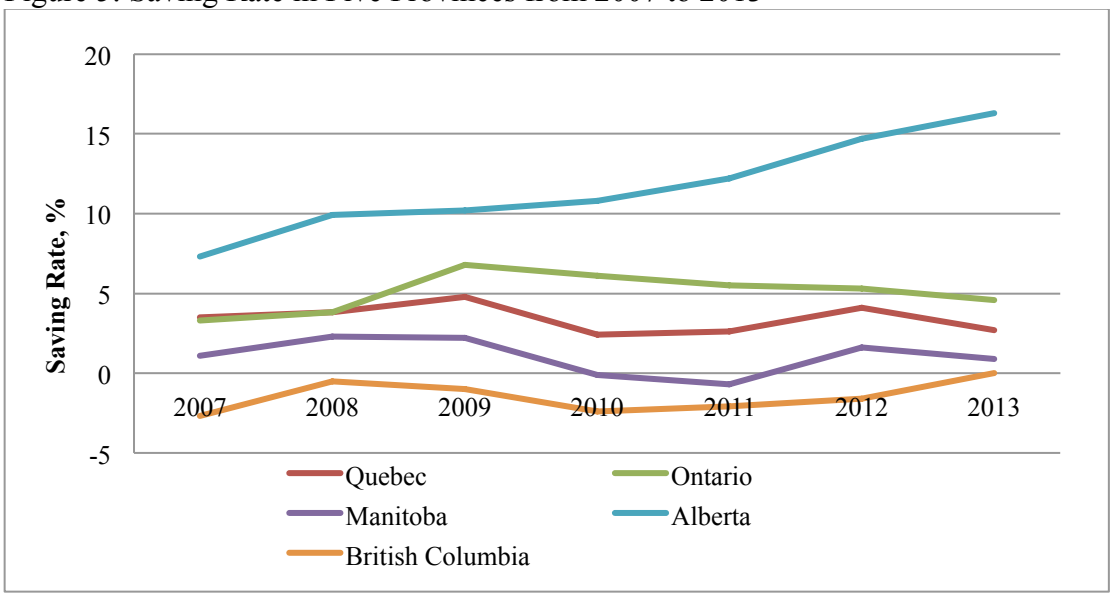
[13] The graph is derived from Financial System Review - June 2014 - Bank of Canada

Figure 4: Employment Rate in Five Provinces from 2007 to 2013



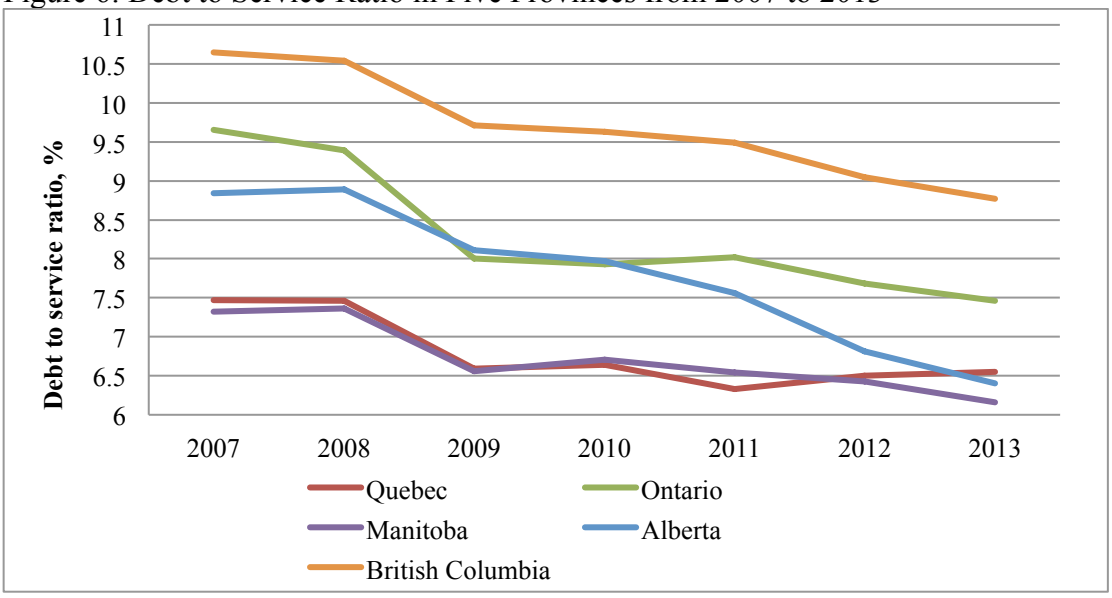
Source: Statistics Canada

Figure 5: Saving Rate in Five Provinces from 2007 to 2013



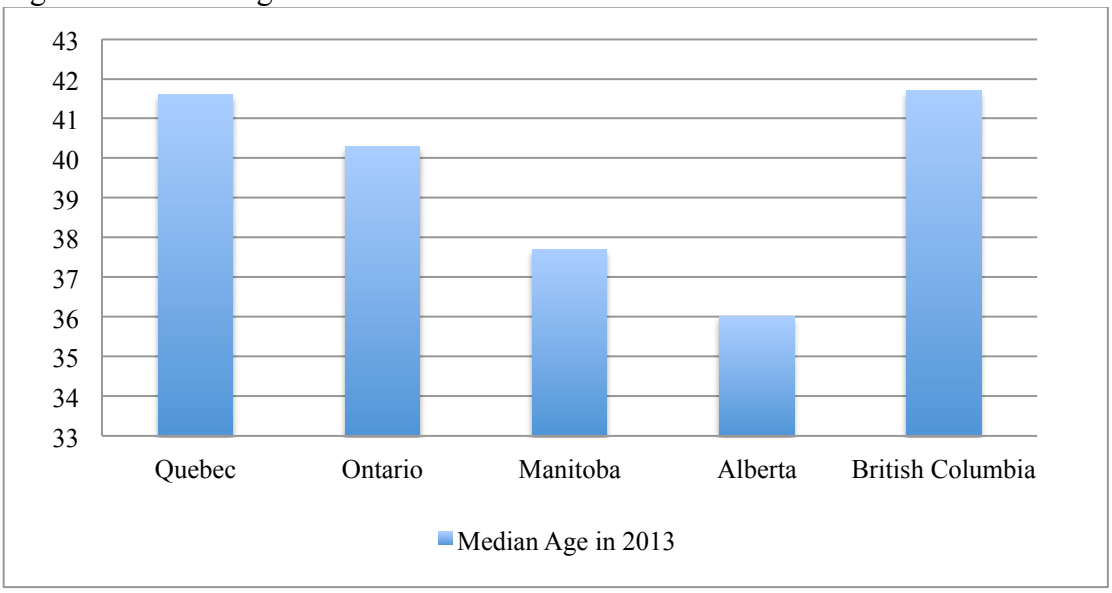
Source: Statistics Canada

Figure 6: Debt to Service Ratio in Five Provinces from 2007 to 2013



Source: Statistics Canada

Figure 7: Median Age in Five Provinces in 2013



Source: Statistics Canada

Table 1: Key changes in government-backed mortgage insurance rules: 2008-2012

	2008	2010	2011	2012
Announcement date	9 July	16 February	17 January	21 June
Implementation date	15 October	19 April	18 March	9 July
Maximum amortization period	From: 40 to 35 years		From: 35 to 30 years	From: 30 to 25 years
Loan-to-value (LTV) limit for new mortgages	From: 100% to 95%			
LTV limit for mortgage refinancing		From: 95% to 90%	From: 90% to 85%	From: 85% to 80%
LTV limit for investment properties		From: 95% to 80%		
Debt-service criteria	Total-debt-service (TDS) ratio capped at 45%	Required that all borrowers qualify for their mortgage amount using the greater of the contract rate or the interest rate for a 5-year fixed-rate mortgage in the case of variable-rate mortgages or mortgages with terms less than 5 years		Gross-debt-service (GDS) ratio capped at 39% and TDS ratio at 44%
Other selected changes	(i) Established a requirement for a consistent minimum credit score, with limited exceptions (ii) Strengthened loan documentation standards to ensure reasonableness of property value and of the borrower's sources and level of income		As of 18 April 2011, mortgage insurance is no longer available for non-amortizing home-equity lines of credit	Mortgage insurance limited to homes with a purchase price less than $1 million

Source: The table is derived from Financial System Review – December 2012 - Bank of Canada

Table 2: Empirical results of housing price equation

$\Delta \ln P_{jt}$	Ontario	Quebec	Manitoba	Alberta	British Columbia
$\Delta \ln P_{jt-1}$	0.106 (0.119)	0.036 (0.081)	0.046 (0.081)	0.577*** (0.092)	0.158*** (0.070)
$\Delta \ln R_{jt-1}$	-0.249 (0.381)	0.152 (0.098)	-0.034 (0.248)	-0.047 (0.386)	0.815 (0.576)
$\ln R_{jt-1}$- $\ln P_{jt-1}$	0.004 (0.004)	-0.004 (0.004)	-0.004 (0.003)	0.003 (0.004)	-0.001 (0.003)
$\Delta \ln Y_{jt-1}$	0.030 (0.017)	0.054** (0.019)	-0.005 (0.015)	0.005 (0.019)	0.042 (0.046)
i^m_{jt-1}	-0.046 (0.041)	-0.018 (0.035)	-0.074 (0.039)	-0.251** (0.079)	-0.041 (0.062)
π_{jt-1}	0.109 (0.110)	0.115 (0.069)	-0.037 (0.050)	0.041 (0.075)	0.255* (0.106)
i^s_{jt-1}	-0.081* (0.035)	-0.025 (0.029)	0.025 (0.029)	0.141* (0.056)	-0.102* (0.051)
2008 measures	-0.006*** (0.001)	-0.002* (0.000)	-0.003** (0.001)	-0.006 (0.004)	-0.020*** (0.005)
2010 measures	-0.003 (0.001)	-0.005*** (0.001)	-0.001 (0.002)	-0.003 (0.002)	-0.005** (0.002)
2011 measures	-0.000 (0.001)	-0.003** (0.001)	-0.002 (0.001)	-0.003* (0.001)	-0.005*** (0.002)
2012 measures	-0.002 (0.001)	-0.002* (0.001)	-0.002* (0.001)	-0.003 (0.002)	-0.006*** (0.002)
Constant	0.006* (0.003)	0.002 (0.002)	0.009*** (0.002)	0.011** (0.004)	0.001 (0.004)
Number of observations	264	264	264	264	264
R^2	0.227	0.093	0.042	0.486	0.285

Note: *p<0.05, **p<0.01, ***p<0.001, 2008 measures, 2010 measures, 2011 measures and 2012 measures are four separate policy dummies to indicate four rounds of macro-prudential policy implemented by Department of Finance. The regression is

$$\Delta \ln P_{jt} = \alpha_j + \beta_1 \Delta \ln P_{jt-1} + \beta_2 \Delta \ln R_{jt-1} + \beta_3 (\Delta \ln R_{jt-1} + \Delta \ln P_{jt-1}) + \beta_4 i^m_{jt-1} + \beta_5 \pi_{jt-1} + \beta_6 i^s_{jt-1} + \beta_7 \Delta \ln Y_{jt-1} + \gamma X^i_t + \varepsilon_{jt}$$

Table 3: Empirical results of housing credit equation

$\Delta \ln C_{jt}$	Ontario	Quebec	Manitoba	Alberta	British Columbia
$\Delta \ln C_{jt-1}$	-0.092* (0.039)	-0.158* (0.069)	-0.108* (0.048)	-0.171* (0.080)	-0.054 (0.054)
$\ln y_{jt}$- $\ln y_{jt-1}$	0.158 (0.115)	-0.090 (0.151)	0.012 (0.107)	0.291* (0.147)	0.238* (0.109)
i^{m}_{jt-1}	0.499* (0.217)	0.377 (0.291)	-0.186 (0.320)	-0.108 (0.314)	0.872*** (0.246)
π_{jt-1}	1.099 (0.736)	1.264 (0.730)	1.258 (0.765)	1.402 (0.806)	0.880 (0.522)
i^{s}_{jt-1}	-0.747** (0.235)	-0.970*** (0.260)	-0.595* (0.279)	-0.378 (0.280)	-0.774** (0.242)
2008 measures	-0.104*** (0.014)	-0.106*** (0.016)	-0.107*** (0.017)	-0.113*** (0.018)	-0.088*** (0.016)
2010 measures	-0.010 (0.011)	-0.008 (0.012)	0.007 (0.010)	-0.029* (0.012)	-0.020 (0.011)
2011 measures	0.002 (0.014)	-0.022 (0.015)	-0.018 (0.014)	-0.037* (0.017)	-0.004 (0.013)
2012 measures	-0.013 (0.008)	-0.014 (0.008)	-0.021* (0.010)	-0.031** (0.011)	-0.019** (0.007)
Constant	-0.001 (0.011)	0.017 (0.015)	0.036* (0.016)	0.026* (0.013)	-0.022 (0.012)
Number of observations	264	264	264	264	264
R^2	0.085	0.104	0.091	0.111	0.097

Note: *p<0.05, **p<0.01, ***p<0.001, 2008 measures, 2010 measures, 2011 measures and 2012 measures are four separate policy dummies to indicate four rounds of macro-prudential policy implemented by Department of Finance. The regression is $\Delta \ln C_{jt} = \mu_j + \theta_1 \Delta \ln C_{jt-1} + \theta_2 i^{m}_{jt-1} + \theta_3 \pi_{jt-1} + \theta_4 i^{s}_{jt-1} + \theta_5 \Delta \ln Y_{jt-1} + \gamma X_{jt-1} + \varepsilon_{jt}$

Table 4: Model actual policy instruments into housing price equation

	$\Delta \ln P_{jt}$	Amortization Period	LTV on first time homebuyers	LTV on refinance loans	R^2
Ontario	Specification 1	**0.000 (0.000)**			**0.202**
	Specification 2		**0.048* (0.023)**		**0.211**
	Specification 3			**0.005 (0.009)**	**0.199**
	Specification 4	**0.000 (0.000)**	**0.049* (0.037)**	**-0.022* (0.028)**	**0.207**
Quebec	Specification 1	**0.000*** (0.000)**			**0.098**
	Specification 2		**0.080*** (0.021)**		**0.117**
	Specification 3			**0.026*** (0.007)**	**0.088**
	Specification 4	**-0.001 (0.000)**	**0.112** (0.039)**	**0.040 (0.022)**	**0.118**
Manitoba	Specification 1	**0.000*** (0.000)**			**0.068**
	Specification 2		**0.099*** (0.027)**		**0.086**
	Specification 3			**0.018* (0.008)**	**0.050**
	Specification 4	**0.001 (0.000)**	**0.050 (0.042)**	**-0.053* (0.026)**	**0.087**
Alberta	Specification 1	**0.000* (0.000)**			**0.487**
	Specification 2		**0.076* (0.036)**		**0.489**
	Specification 3			**0.023* (0.011)**	**0.486**
	Specification 4	**-0.000 (0.001)**	**0.092 (0.059)**	**0.019 (0.053)**	**0.486**
British Columbia	Specification 1	**0.000** (0.000)**			**0.182**
	Specification 2		**0.084** (0.029)**		**0.185**
	Specification 3			**0.030* (0.014)**	**0.180**
	Specification 4	**-0.000 (0.001)**	**0.078 (0.041)**	**0.017 (0.076)**	**0.180**

Note: *p<0.05, **p<0.01, ***p<0.001, here I use actual value of policy tool to replace policy dummy in housing price equation. The regression for each specification of all provinces is still

$$\Delta \ln P_{jt} = \alpha_j + \beta_1 \Delta \ln P_{jt-1} + \beta_2 \Delta \ln R_{jt-1} + \beta_3 \left(\Delta \ln R_{jt-1} + \Delta \ln P_{jt-1}\right) + \beta_4 i^m_{jt-1} + \beta_5 \pi_{jt-1} + \beta_6 i^s_{jt-1} + \beta_7 \Delta \ln Y_{jt-1} + \gamma X^i_t + \varepsilon_{jt}$$

In specification 1, X^i_t is the actual value of amortization period, for example, 35 in Oct. 2008. In specification 2, X^i_t is the actual value of first time LTV limit, for example, 0.95 in Oct. 2008. In specification 3, X^i_t is the actual value of refinance LTV limit, for example, 0.90 in Apr. 2010. In specification 4, X^i_t includes the actual value of amortization period, first time LTV limit as well as refinance LTV limit.

Table 5: Test whether coefficients of policy dummies are statistically different in either two provinces combination

Comparison	Housing Market	2008 policy	2010 policy	2011 policy	2012 policy
Ontario & Quebec	Housing Price	Reject P = 0.0325	Can't reject	Reject P = 0.0207	Can't reject
	Housing Credit	Can't reject	Can't reject	Reject P = 0.0206	Can't reject
Ontario & Manitoba	Housing Price	Reject P = 0.0874	Can't reject	Can't reject	Can't reject
	Housing Credit	Can't reject	Reject P = 0.0308	Reject P = 0.0129	Reject P = 0.0227
Ontario & BC	Housing Price	Reject P = 0.0088	Can't reject	Reject P = 0.0030	Reject P = 0.0342
	Housing Credit	Reject P = 0.0346	Reject P = 0.0009	Reject P = 0.0228	Reject P = 0.0438
Ontario & Alberta	Housing Price	Can't reject	Can't reject	Can't reject	Can't reject
	Housing Credit	Can't reject	Reject P = 0.0000	Reject P = 0.0000	Reject P = 0.0002
Quebec & Manitoba	Housing Price	Can't reject	Reject P = 0.0952	Can't reject	Can't reject
	Housing Credit	Can't reject	Can't reject	Can't reject	Reject P = 0.0851
Quebec & BC	Housing Price	Reject P = 0.0018	Can't reject	Can't reject	Reject P = 0.0389
	Housing Credit	Can't reject	Reject P = 0.0001	Reject P = 0.0599	Can't reject
Quebec & Alberta	Housing Price	Can't reject	Can't reject	Can't reject	Can't reject
	Housing Credit	Can't reject	Reject P = 0.0000	Reject P = 0.0325	Reject P = 0.0325
Manitoba & BC	Housing Price	Reject P = 0.0012	Reject P = 0.0339	Reject P = 0.0269	Reject P = 0.0823
	Housing Credit	Can't reject	Reject P = 0.0045	Reject P = 0.0999	Can't reject
Manitoba & Alberta	Housing Price	Can't reject	Can't reject	Can't reject	Can't reject
	Housing Credit	Can't reject	Reject P = 0.0000	Reject P = 0.0005	Reject P = 0.0019
BC & Alberta	Housing Price	Reject P = 0.0142	Can't reject	Can't reject	Can't reject
	Housing Credit	Reject P = 0.0000	Reject P = 0.0482	Reject P = 0.0000	Reject P = 0.0104

Note: The test is based on the seemingly unrelated estimation. The null hypothesis of the test is equality of either two coefficients combination. When p value of the test is smaller than 0.1, I reject the null hypothesis that the coefficients of a policy dummy in either two provinces' regressions are equal. If I reject the null hypothesis, the macro-prudential policy in a specific year has statistically different effect in the two provinces' housing market at 10% significance level.

Table 6: Robustness check, how long the policy will be effective on housing price

	$\Delta \ln P_{jt}$	Policy last for 1 month	Policy last for 1 quarter	Policy last for 6 month	Policy last for 9 month	Policy last for 12 month	Policy has persistent effect
British Columbia	2008 measures	-0.021***	-0.013	-0.021**	-0.020***	-0.010	-0.003
		(0.002)	(0.007)	(0.006)	(0.005)	(0.006)	(0.004)
	2010 measures	0.001	-0.002	-0.005**	-0.005**	-0.004*	-0.001
		(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.004)
	2011 measures	0.003*	0.000	-0.004*	-0.005***	-0.004**	0.000
		(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
	2012 measures	-0.003**	-0.002	-0.004*	-0.006***	-0.005**	-0.001
		(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
	R^2	0.187	0.187	0.277	0.285	0.198	0.176
Ontario	2008 measures	-0.004**	-0.003*	-0.004**	-0.006***	-0.005**	-0.003*
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
	2010 measures	-0.002**	0.000	-0.002	-0.003	-0.002	0.001
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
	2011 measures	-0.000	0.002	0.001	-0.000	-0.001	0.001
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
	2012 measures	-0.004***	-0.001	-0.001	-0.002	-0.002	-0.001
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
	R^2	0.194	0.196	0.203	0.227	0.216	0.207
Quebec	2008 measures	-0.003**	-0.003*	-0.001	-0.002*	-0.002*	-0.003*
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
	2010 measures	0.003***	-0.004	-0.003*	-0.005***	-0.003*	-0.002
		(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
	2011 measures	-0.001**	-0.000	-0.002	-0.003**	-0.003**	0.000
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
	2012 measures	-0.002***	-0.002**	-0.002	-0.002*	-0.002**	0.001
		(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
	R^2	0.049	0.061	0.063	0.093	0.092	0.114
Manitoba	2008 measures	-0.001	-0.003*	-0.003***	-0.003**	-0.004***	-0.006***
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
	2010 measures	-0.000	0.001	-0.001	-0.001	-0.001	-0.003
		(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
	2011 measures	-0.001*	-0.002**	-0.002	-0.002	-0.003*	-0.002
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
	2012 measures	-0.002***	-0.002*	-0.002*	-0.002*	-0.003**	-0.001
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
	R^2	0.030	0.036	0.043	0.042	0.057	0.084
Alberta	2008 measures	-0.023***	-0.008	-0.007	-0.005	-0.004	-0.003
		(0.001)	(0.007)	(0.005)	(0.004)	(0.003)	(0.003)
	2010 measures	-0.002	-0.001	-0.001	-0.003	-0.003*	-0.001
		(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.003)
	2011 measures	-0.002**	-0.001	-0.002	-0.003*	-0.003*	0.000
		(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
	2012 measures	-0.005***	-0.002	-0.002	-0.003	-0.003	0.000
		(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
	R^2	0.499	0.482	0.486	0.486	0.484	0.484

Note: *p<0.05, **p<0.01, ***p<0.001

Table 7: Robustness check, how long the policy will be effective on housing credit

	$\Delta \ln C_{jt}$	Policy last for 1 month	Policy last for 1 quarter	Policy last for 6 month	Policy last for 9 month	Policy last for 12 month	Policy has persistent effect
British Columbia	2008 measures	-0.103***	-0.110***	-0.088***	-0.054**	-0.034	-0.019
		(0.009)	(0.009)	(0.016)	(0.019)	(0.018)	(0.015)
	2010 measures	0.011	0.006	-0.020	-0.010	0.001	0.025
		(0.007)	(0.008)	(0.011)	(0.008)	(0.009)	(0.016)
	2011 measures	0.041***	0.020*	-0.04	0.062	0.085*	0.063
		(0.005)	(0.010)	(0.013)	(0.041)	(0.041)	(0.037)
	2012 measures	-0.012	-0.012	-0.019**	-0.014*	-0.008*	-0.074*
		(0.007)	(0.006)	(0.007)	(0.006)	(0.004)	(0.034)
	R^2	0.029	0.090	0.097	0.139	0.201	0.154
Ontario	2008 measures	-0.104***	-0.110***	-0.104***	-0.078***	-0.061***	-0.040**
		(0.011)	(0.011)	(0.014)	(0.014)	(0.014)	(0.012)
	2010 measures	0.017*	0.014	-0.010	-0.006	0.005	0.052***
		(0.008)	(0.009)	(0.011)	(0.008)	(0.011)	(0.014)
	2011 measures	0.055***	0.027*	0.002	0.081	0.114*	0.083
		(0.005)	(0.013)	(0.014)	(0.049)	(0.049)	(0.043)
	2012 measures	-0.004	-0.003	-0.013	-0.008	-0.002	-0.094*
		(0.008)	(0.007)	(0.008)	(0.006)	(0.004)	(0.040)
	R^2	0.005	0.051	0.085	0.187	0.289	0.226
Quebec	2008 measures	-0.090***	-0.096***	-0.106***	-0.062**	-0.047**	-0.039**
		(0.014)	(0.014)	(0.016)	(0.020)	(0.015)	(0.012)
	2010 measures	0.025**	0.023**	-0.008	-0.008	-0.017	0.032**
		(0.008)	(0.009)	(0.012)	(0.010)	(0.013)	(0.012)
	2011 measures	-0.018**	0.002	-0.022	0.067	0.098	0.089*
		(0.006)	(0.012)	(0.015)	(0.055)	(0.051)	(0.043)
	2012 measures	-0.008	-0.006	-0.014	-0.008	-0.005	-0.084*
		(0.008)	(0.007)	(0.008)	(0.007)	(0.005)	(0.041)
	R^2	0.025	0.055	0.104	0.129	0.217	0.191
Manitoba	2008 measures	-0.101***	-0.110***	-0.107***	-0.072***	-0.045**	-0.023
		(0.016)	(0.016)	(0.017)	(0.017)	(0.016)	(0.014)
	2010 measures	0.015	0.013	0.007	0.004	-0.002	0.037**
		(0.009)	(0.010)	(0.010)	(0.009)	(0.014)	(0.013)
	2011 measures	-0.005	0.000	-0.018	0.086	0.122*	0.088
		(0.007)	(0.010)	(0.014)	(0.063)	(0.060)	(0.050)
	2012 measures	-0.012	-0.010	-0.021*	-0.015	-0.009	-0.105*
		(0.010)	(0.010)	(0.010)	(0.008)	(0.005)	(0.050)
	R^2	0.022	0.053	0.091	0.157	0.241	0.189
Alberta	2008 measures	-0.127***	-0.131***	-0.113**	-0.073***	-0.051**	-0.036*
		(0.013)	(0.012)	(0.018)	(0.021)	(0.019)	(0.016)
	2010 measures	-0.001	-0.005	-0.029*	-0.023*	-0.022	0.021
		(0.010)	(0.010)	(0.012)	(0.009)	(0.012)	(0.015)
	2011 measures	-0.003	-0.011	-0.037*	0.066	0.106	0.095
		(0.008)	(0.011)	(0.017)	(0.061)	(0.058)	(0.051)
	2012 measures	-0.023*	-0.023*	-0.031**	-0.024**	-0.019***	-0.099
		(0.011)	(0.011)	(0.011)	(0.008)	(0.004)	(0.050)
	R^2	0.030	0.079	0.111	0.127	0.209	0.152

Note: *p<0.05, **p<0.01, ***p<0.001