Sticky Rent Prices, House Prices, and Monetary Policy in the Business Cycle

Homayoun Shirazi[1]

[1]PhD candidate of Economics, Toronto Metropolitan University

Abstract

Real rent prices and real house prices exhibit distinct behavior in Canada compared to the United States, particularly during the economic downturns of the early 1980s and 1990s, raising the question of whether greater rent price stickiness in Canada is the primary explanation. In this paper, by estimating a VAR model for the period from 1981Q1 to 2021Q4, we initially show that, unlike the United States, there is a negative correlation between rent prices and house prices in Canada when a contractionary monetary policy is implemented. Subsequently, we introduce a Three-Agent New Keynesian DSGE model that incorporates the rental market with rent price rigidity, providing a theoretical framework connecting the rental and housing markets. Additionally, we examine the effects of a tightening monetary policy on both rent prices and house prices, as well as other aggregate macroeconomic variables, while varying the degrees of rent price stickiness.

The results show that the presence of rent price rigidity is essential to explain the empirical outcomes obtained from the VAR models. Moreover, rent price rigidity results in negative correlation between house prices and rent prices during periods of economic downturns following a contractionary monetary policy. The findings also confirm that the overall inflation rate reacts less to a tightening monetary policy when there is a greater level of rent price stickiness. Furthermore, a greater level of rent prices stickiness leads to a reduction in aggregate output, non-durable consumption, and consumption of housing services.

1. Introduction

Rent prices are subject to stickiness, which means they do not adjust quickly or frequently in response to changes in market conditions. Many rental agreements are based on fixed-term contracts that last several months or years, resulting in unchanged rent prices during these contract periods. The presence of search or administrative costs involved in seeking new agreements, as well as legal regulations, are additional reasons for observing rent price rigidity. Regulations and the structure of the rental market can influence how rent prices adjust in response to changes in supply and demand, resulting in varying levels of rent price stickiness in different regions or countries. Genesove (2003) demonstrates that between 1974 and 1981, 29% of the nominal rent prices of the apartments studied in the United States do not change year to year, while, Hoffmann and Kurz-Kim (2006) report that 78% of units in Germany maintain consistent rent prices year to year. Shimizu, Nishimura, and Watanabe (2010) similarly find that the probability of no rent adjustment in Japan is around 89% per year.

Like many other countries, rent prices have been smoother than house prices over the past 40 years in Canada. As shown in Figure 1, the real house price index has experienced considerable fluctuations, while the real rent price index remained relatively stable until the mid-1990s, subsequently decreasing. This trend can be attributed mainly to rent price rigidity in Canada. The real house price index declined significantly during the early 1980s and 1990s, driven by economic recessions in Canada, followed by a substantial increase until the beginning of the financial crisis. The real house price index has remained relatively stable after the financial crisis. The stability of real house price index after the financial crisis coincided with a period of stable interest rates, while following the real house price, the interest rate has been more volatile before the crisis in Canada. The real rent price index, in contrast, has remained relatively stable during recessions and throughout the period from 1981 to 2002. In the last 20 years, rent prices in Canada have increased at a slower rate than the CPI, resulting in lower rent prices and rent-price ratios compared to those before 2000. Meanwhile, real rent prices have been gradually increasing in the United States, a country with lower level of rent prices stickiness compared with Canada, during the same period, leading to a smaller gap between real house prices and real rent prices in Canada, as can be seen in Figure 1. Housing serves as both shelter and an asset because it holds value and can appreciate or depreciate over time. Rent prices can be considered as the returns to housing, similar to the dividends of a stock in the finance literature (Campbell et al. 2009). The persistent increase in recent real house prices, following the declining return on real rent prices as a return to housing, in Canada raises an important question: Does rent price rigidity explain this continuous rise in rent prices in the United States while real rent prices in Canada have been decreasing?

Figure 1: Real house and rent price indices in Canada and the United States 1981Q1–2021Q4

Generally, two stylized facts can be discerned when studying house and rent prices over the past four decades in Canada: Firstly, real rent prices have exhibited lower volatility compared to house prices. Secondly, there is generally no persistent positive correlation between the two, despite the fact that both real rent prices and real house prices often move in the same direction over multiple quarters. Figure 2 illustrates the deviations from the long-run trend of both real house and rent prices over the period from 1981Q1 to 2021Q4 in Canada and the United States. The graph shows that real house prices have been more volatile in both Canada and the United States over the last few decades (with standard deviations of 0.049 in Canada and 0.032 in the United States) compared with real rent prices in both countries with standard deviations of 0.01, even though the volatility in Canada has reduced relatively substantial since the housing crisis of early 1990s. The relationship between real house prices and real rent prices over the last few decades has not been consistently positive in Canada, while in the United States, real rent and house prices have shown a relatively consistent co-movement (with a correlation coefficient of -0.63 for Canada and 0.38 for the United States during the period from 1981Q1 to 1993Q1. For the entire period, the correlation coefficients are -0.23 for Canada and 0.10 for the United States). Notably, there have been periods, such as from 1993Q1 to 2007Q4 or from 2010Q1 to 2018Q4, during which real house and rent prices exhibited positive correlations of 0.62 and 0.36, respectively. Conversely, during periods like the early 1990s and 1980s, which were marked by economic recessions, the correlation between real rent and house prices turned negative (-0.03). This occurred because real rent prices displayed distinct behaviors compared to real house prices in the years preceding or during recessions. Typically, they did not move in tandem during economic downturns, especially when the monetary authority implemented contractionary monetary policies to combat inflation and mitigate the effects of a recession. For instance, during the recessions of the early 1980s and 1990s real house prices experienced a significant drop, while real rent prices showed a slight increase in response to rising interest rates. In the financial crisis of 2008, house prices fell significantly, while rent prices did not follow the same trend and rose significantly. During the COVID-19 pandemic, real rent prices declined in response to the expansionary monetary policy implemented by the Bank of Canada, while real house prices experienced a significant rise. On the other hand, in the United States, real rent prices and real house prices typically move in tandem during most recessions, although some degree of divergence between real house and rent prices can be observed in various periods in the United States. The distinct behaviors observed in rent and house prices, particularly during economic downturns in Canada, raise important questions: How can we model this type of behavior observed in the housing and rental markets? Furthermore, is there a relationship between rent price smoothness and the rental housing market stickiness? How does rent price rigidity affect the co-movement of rent and house prices? What role does rent price rigidity play in explaining the divergence observed between real rent prices and real house prices, particularly during economic downturns in Canada compared to the United States?

Figure 2: Dynamics of Real House Prices and Real Rent Prices in Canada and the United States 1981Q1-2021Q4

Rent price rigidity is a prominent feature within the rental market and is the primary reason for the observed stability in rent prices over the past decades in Canada and many other countries. The presence of rent price stickiness is demonstrated to leave a considerable impact on the Consumer Price Index (CPI), as evidenced by Dias and Duarte (2019) and it changes the effectiveness of monetary policy. Furthermore, changes in rent prices directly influence the optimization problem faced by households renting their housing, which in turn can lead to changes in aggregate consumption and overall economic output. Lastly, the rent price, functioning as a return to housing, also exerts an impact on house prices, thereby indirectly influencing the broader economy through this channel.

Studying the behaviour of rent prices and rental market in general is an emerging field of research in comparison to research focusing on the housing market and there is a growing body of literature dedicated to understanding the dynamics observed within the rental market. This body of literature can be categorized into three main groups. The first group involves studying the degree of rent price stickiness and the impact of rent stickiness on the CPI index and overall inflation rate. Studies in this category typically employ micro price datasets and econometric techniques as demonstrated in studies like Shimizu et al. (2010) and Genesove (2003). The second group of studies, which is more recent, seeks to offer theoretical explanations for rent prices stickiness. These studies mostly consider rent prices as the outcome of repeated bargaining among market participants over contracts and attempt to explain rent stickiness through search and bargaining approaches (e.g., Gallin and Verbrugge, 2019; Wang, 2020). In the third group, the dynamics observed in housing and rent prices are examined. These studies mostly address the prolonged increase in the house-to-rent price ratio and attempt to analyze the behavior of housing and rent prices through a workhorse borrower-saver DSGE model (i.e. Rubio, 2009; Sommer, et. al. 2013 ; Sun and Tsang, 2017). This paper contributes to this strand of literature both theoretically and empirically by studying the effect of a monetary policy in the presence of varying levels of rent price stickiness. Specifically, it examines how aggregate macroeconomic variables such as output, consumption, house prices, and inflation rates behave when the rental market experiences different levels of stickiness. To address this, the rental market is introduced into the familiar borrower-saver model (a Two-agent New Keynesian model) by adding a new type of agents called Renters, who acquire housing services by renting them from Rental agencies. Moreover, rent price rigidity in the rental market is modeled by introducing another type of producer known as Rental agencies, which incur costs when attempting to change their prices. The findings of the study highlight the essential role of rent price rigidity in explaining the empirical evidence obtained from the VAR model and underscore the importance of including stickiness in the new Three-agent new Keynesian DSGE models (THANK) applied to the rental market. Furthermore, the results demonstrate that changes in aggregate variables such as output, real debt, and non-durable consumption are more pronounced as the level of rental market stickiness increases. Notably, in an environment with greater rent price rigidity, the consumption of housing services experiences a substantial reduction in response to tighter monetary policies. This underlines the impact of rental market stickiness in limiting housing returns and demand, offering a solution to the co-movement issue identified in the New Keynesian model (see Monacelli, 2009). This paper also demonstrates that the overall inflation rate and inflation rates in different sectors exhibit significantly stronger reactions to a contractionary monetary policy in a fully flexible rental market.

The remainder of the paper proceeds as follows. Section 2 discusses the brief history of rent control in Canada. Section 3 discusses the VAR model estimated for the analysis. Section 4 presents the model constructed for the rental market. In Section 5, the model is calibrated and estimated, and we discuss the impacts of rent control on house prices, inflation rates, and aggregate macroeconomic variables. Finally, Section 6 concludes.

2. A Brief History of Rent Control in Canada

Rent prices tend to be inherently sticky due to the nature of the agreements, negotiations, and bargaining involved. However, regulations and policies can further intensify this stickiness within a rental market. In this section, we will explore a brief history of rent control in Canada.

Rent control policies in Canada have primarily fallen under the jurisdiction of provinces and territories. Each province and territory has established its own set of regulations, leading to significant variations in terms of scope and restrictions.

The first generation of rent control was introduced during World War II, beginning in 1940 in fifteen areas, including British Columbia and Ontario. Additional areas were added in November 1941 (Willis, 1950). These controls were designed to address housing shortages and prevent excessive rent increases. They typically limited the amount by which landlords could increase rents.

The second generation of rent control, often referred to as soft rent control regulations and policies, emerged in the 1970s in response to the oil shock and rising housing and rent prices. Ontario, for example, implemented the Rent Control Act in 1975, which significantly restricted rent increases. However, unlike the policies of the first generation, these regulations allowed landlords to pass through increases in their operating costs to renters and apply for rent increases above the automatic rent increase related to the inflation rate (Arnott, 1995).

In the 1980s and 1990s, some provinces began to scale back rent control measures. British Columbia, for instance, phased out its rent control policies in the early 1980s. Alberta abolished rent controls altogether in 1983. Other provinces, like Ontario, continued to maintain strict rent control regulations. Rent control policies have evolved in recent years, with policymakers considering exemptions for newly built units or allowing landlords to charge new rents when tenancies turn over. These alterations to rent control regulations have been extended, reintroduced, or strengthened in response to rising housing costs and affordability concerns. For instance, during the COVID-19 pandemic, many provinces expanded its rent control measures to include previously exempted units and introduced additional restrictions on rent increases to address the economic challenges and uncertainties faced by tenants. Currently, various forms of rent control have been implemented in British Columbia, Manitoba, Ontario, Quebec, and Prince Edward Island.

Even in provinces and territories with no rent control policies, such as Alberta, rents can only be changed once a year.

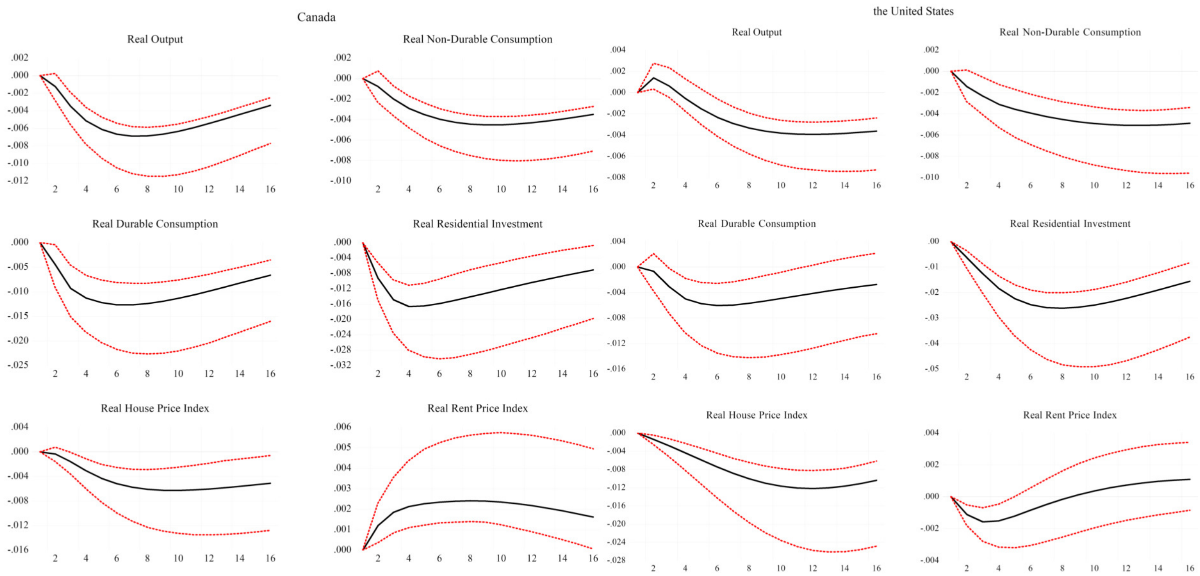
3. Monetary shocks, house and rent prices: the evidence

To assess the impact of monetary policy on house and rent prices with rent price stickiness,we estimate two quarterly vector autoregressive (VAR) models for the period 1981Q1 to 2021Q4: one for Canada, with supportive rent control regulations, and another for the United States, where rent control regulations are minimal and rental market stickiness is lower, as discussed in Weber (2017):

$$Y_t = \alpha_0 + \alpha_1 t + \alpha_2 D_t + \sum_{j=1}^{2} A_j Y_{t-j} + B\mathcal{E}_t \tag{1}$$

Where α_0 represents a constant term and t shows a time trend in the VAR system. D_t is a financial crisis dummy variable that takes on the value 1 during the financial crisis period and 0 otherwise. The vector Y_t comprises seven variables: real GDP (g), real non-durable consumption (nd), real durable consumption or housing services (d), real residential investment (I), real house price (hp), real rent price (Rn), and 3-month treasury bill rate (m). All variables except the treasury bill rate are measured in logs and seasonally adjusted. $\mathcal{E}_t$ represents a vector of contemporaneous disturbances and it includes $\mathcal{E}_t = [\mathcal{E}_t^g \;\; \mathcal{E}_t^{nd} \;\; \mathcal{E}_t^d \;\; \mathcal{E}_t^I \;\; \mathcal{E}_t^{hp} \;\; \mathcal{E}_t^{Rn} \;\; \mathcal{E}_t^m]$. As the goal is to study the effect of a monetary policy on the considered variables, measured by one standard deviation increase in $\mathcal{E}_t^m$], the monetary policy shock must be identified. To achieve this, the standard recursive identification scheme based on the Cholesky decomposition (a recursive VAR) is employed (Christiano et al., 1999). The lag order in the VAR model is selected by considering the Akaike (AIC), Hannah-Quinn (HQ) and Swartz Bayesian (BIC) information criteria. Figure 1 shows the impulse responses of the considered variables to one standard deviation innovations in the 3-month treasury bill rate variable in both Canada and the United States. The dashed lines indicates 95% confidence intervals using Hall's percentile bootstrap with 10000 bootstrap repetitions.

Figure 3: Impulse Responses to Cholesky One S.D. Innovations in Interest Rate in Canada and the United States (1981:Q1-2021:q4)



The empirical results from the estimated VAR model for Canada and the United States indicate that real GDP, non-durable consumption, durable consumption, and real residential investment respond negatively to a tightening monetary policy. However, the responses of real rent prices differ between the United States and Canada. In the United States, real rent prices initially follow real house prices for the first five quarters and decline in response to a tightening monetary policy. In contrast, in Canada, real rent prices do not follow real house prices and tend to rise for nine quarters in response to a contractionary monetary policy. The findings reveal two stylized facts: Firstly, the magnitude of responses in real house prices significantly exceeds that observed in real rent prices in both Canada and the United States. Secondly, real house prices experience considerable declines in response to the contractionary policy in both Canada and the United States, while real rent prices are observed to rise very gradually following the shock only in Canada.

As demonstrated earlier, the dynamics of real rent prices and house prices exhibit a degree of co-movement in several sub-periods, but their responses to monetary policy shocks differ, especially during economic crises in the early 1980s and 1990s characterized by significant interest rate adjustments to mitigate the crisis's impact. To account for these crisis effects, we extend the exogenous dummy variable, D_t, in the VAR model estimated for Canada to include all economic downturns, including those that occurred in the early 1980s and 1990s. This variable takes the value of 1 during a recession and 0 otherwise. The results indicate that, despite the tendency for real rent prices to rise in response to a tightening monetary policy, they are statistically insignificant (see Figure 6 in Appendix). This finding confirms the close-to-zero correlation coefficient between the cycles of real house and rent prices, as determined for the entire period.

4. Model

4.1. Household Preferences and Constraints

There exist three types of infinitely-lived households in this environment: Landlords (Savers in the Two-agent New Keynesian models), constituting a fraction μ_R of the entire population ($0 < \mu_R < 1$); Owner-occupiers (Borrowers in the Two-agent New Keynesian models), making up a fraction μ_W of the total population ($0 < \mu_W < 1$); and Renters, comprising a fraction μ_P of the overall population ($\mu_P = 1 - \mu_R - \mu_W$ and $0 < \mu_P < 1$).

Similar to the framework established by Iacoviello (2005) and Iacoviello and Neri (2010), Owner-Occupiers confront credit constraints, with their homes serving as collateral assets for loans borrowed from Landlords. In contrast, Renters do now own any homes and allocate all of their earnings for their expenses, without the capacity to borrow. Landlords possess home equities and have the option to rent them out to Renters. The diversity among households is reflected in their time preferences: Both Owner-Occupiers and Renters discount the future at a faster rate compared to Landlords. Consequently, Owner-Occupiers function as net borrowers, whereas Landlords emerge as net lenders in equilibrium.

4.1.1. Landlords

A representative Landlord maximizes the expected discounted value of a utility function that depends positively on the index of consumption X_t and negatively on hours worked N_t:

$$\mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left\{ ln(X_t) - \frac{\tau}{1+\varphi} N_t^{1+\varphi} \right\} \tag{2}$$

Where β is the discount factor, φ represents the inverse elasticity of labour supply, τ is a parameter that shows the disutility of hours worked for each agent, and X_t consists of both consumption (c_t) and housing services (h_t):

$$X_t = \left[(1-\alpha)^{\frac{1}{\nu}}(c_t)^{\frac{\nu-1}{\nu}} + \alpha^{\frac{1}{\nu}}(h_t)^{\frac{\nu-1}{\nu}}\right]^{\frac{\nu}{\nu-1}} \tag{3}$$

Where α represents the proportion of durable goods within the composite consumption index, while $\nu \geq 0$ indicates the elasticity of substitution between non-durable and durable goods services. The representative Landlord has the sequence of the following budget constraints (in nominal terms):

$$\begin{aligned} &q_t^c c_t + q_t^h\left[h_t - (1-\delta_h)h_{t-1}\right] + q_t^h\left[h_t^{Rn} - (1-\delta_{Rn})h_{t-1}^{Rn}\right] + B_t = W_t N_t + R_{t-1}B_{t-1} \\ &+ q_t^{Rb}h_t^{Rn} + \frac{q_t^c\hat{\Pi}_t^c}{\mu_R} + \frac{q_t^h\hat{\Pi}_t^h}{\mu_R} + \frac{q_t^{Rn}\hat{\Pi}_t^{Rn}}{\mu_R} \end{aligned}$$

Where h_t^{Rn} is houses purchased to rent, B_t represents end-of-period t nominal one-period debt, W_t represents the nominal wage, $\hat{\Pi}_t^c$, $\hat{\Pi}_t^h$, and $\hat{\Pi}_t^{Rn}$ are nominal profits received from consumption and housing sectors, and rental agencies, respectively. R refers to the gross interest rate on loans. Finally, q_t^c, q_t^h, and q^Rb are nominal prices of consumption, house, and rent.

With $p_t^h = q_t^h/q_t^c$ and $p_t^{Rn} = q_t^{Rn}/q_t^c$, and the real wage denoted as $w_t = W_t/q_t^c$, the budget constraint of Landlord can be formulated in terms of real prices as follows:

$$\begin{aligned} &c_t + p_t^h\left[h_t - (1-\delta_h)h_{t-1}\right] + p_t^h\left[h_t^{Rn} - (1-\delta_{Rn})h_{t-1}^{Rn}\right] + b_t = w_t N_t + \frac{R_{t-1}b_{t-1}}{\pi_t^c} \\ &+ p_t^{Rb}h_t^{Rn} + \frac{\Pi_t^c}{\mu_R} + \frac{p_t^h\Pi_t^h}{\mu_R} + \frac{p_t^{Rn}\Pi_t^{Rn}}{\mu_R} \end{aligned} \tag{4}$$

The representative Landlord maximizes her utility function (1) with respect to (2). The first-order conditions for utility maximization are as follows:

$$(1-\alpha)^{\frac{1}{\nu}}(c_t)^{\frac{-1}{\nu}}X_t^{\frac{1-\nu}{\nu}} = \lambda_t \tag{5}$$

$$\tau(N_t)^{\phi} = \lambda_t w_t \tag{6}$$

$$\beta^t[j_t\alpha^{\frac{1}{\nu}}(h_t)^{\frac{-1}{\nu}}X_t^{\frac{1-\nu}{\nu}} - \lambda_t p_t^h] + (1-\delta_h)\beta^{t+1}\mathbb{E}_t(\lambda_{t+1}p_{t+1}^h) = 0 \tag{7}$$

$$\beta^t[\lambda_t(p_t^{Rb} - p_t^h)] + (1-\delta_{Rn})\beta^{t+1}\mathbb{E}_t(\lambda_{t+1}p_{t+1}^h) = 0 \tag{8}$$

$$\beta^t[-\lambda_t] + \beta^{t+1}\mathbb{E}_t(\lambda_{t+1}\frac{R_t}{\pi_{t+1}^c}) = 0 \tag{9}$$

The relation between the house price, rent price, and the gross interest rate can be derived by combining equation (8) and (9) as follows:

$$\beta\mathbb{E}_t(\frac{\tilde{\beta}_{t+1}}{\tilde{\beta}_t}\frac{U'_{c^R_{t+1}}}{U'_{c^R_t}}) = \frac{p^h_t - p^{Rb}_t}{\mathbb{E}_t p^h_{t+1}(1-\delta_{Rn})} = \frac{\mathbb{E}_t \pi^c_{t+1}}{R_t} \tag{10}$$

Equation 8 indicate that current consumption is positively correlated with the expected house price of the next period, indicating the wealth effect of the house equities on consumption. In other words, increased expectations of higher house prices lead to higher current consumption levels. The equation also exhibit the negative relationship between the rent price and the current level of consumption. When the rent price rises, a representative Landlord has the incentive to reduce the current consumption level in order to acquire more houses for renting purposes. Equation 8 also show that a rise in the current house price negatively affect the current level of consumption. Both consumption and house services are considered as normal goods in this environment and a representative Landlord tries to substitute consumption for house services.

In this paper, all markets experience some levels of price rigidity. As a result, the rent price received by a representative Landlord is:

$$p^{Rb}_t = mc^{Rn}_t p^{Rn}_t A^{Rn} \tag{11}$$

Where mc^{Rn}_t is the marginal costs of rent, p^{Rn}_t indicates the final price paid by Renters in the rental market, and A^{Rn} represents the technological improvement in the rent sector. Substituting equation (9) for p^{Rb}_t in equation (8) provides a relationship between the market rent price, interest rate, the expected house price for the next period and the current house price:

$$p^h_t = \frac{(1-\delta_{Rn})\mathbb{E}_t(\pi^c_{t+1}p^h_{t+1})}{R_t} + \underbrace{mc^{Rn}_t p^{Rn}_t A^{Rn}}_{p^{Rb}_t} \tag{12}$$

Equation (12) shows that increases in the inflation rate in the consumption sector, the expected house price for the next period, and the rent price can positively affect the current house price. Conversely, the presence of rent stickiness in the rental market can have a negative impact on the current house price. In the absence of rent stickiness, $mc^{Rn}_t = 1$, whereas it falls below 1 in the presence of rent price stickiness, leading to a decrease in the house price compared to the scenario where no rent stickiness exists in the rental market. Equation 12 also indicates that even in an environment with low level of inflation, current house prices can rise significantly over an extended period due to the rigidity in the rental market. This rigidity causes rent prices to adjust slowly to changes in supply and demand. Consequently, a rise of the expected house price in the next period can compensate the low return from the rented houses. This phenomenon helps explain the significant price increases observed in Canada's housing market over the last decades. As homeowners anticipate future appreciation in their property values, they accept lower rent prices (returns) in the rental market. Equation (12) also demonstrates that a change in the nominal interest rate can have a significant impact on the gap between house prices and rent prices ($p_t^h - mc_t^{Rn} p_t^{Rn} A^{Rn}$). For example, when a monetary authority implements an expansionary monetary policy to mitigate the effects of a recession, the gap between house prices and rent prices widens due to one or more of the following factors: a larger increase in house prices compared to rent prices, a decrease in rent prices while house prices remain stable or increase, or a combination of both. Rent price rigidity can further influence this gap, with higher levels of stickiness resulting in a delayed response of rent prices to changes in the demand and supply dynamics of the rental market.

4.1.2. Owner-Occupiers

A representative Owner-Occupier desires consumption (c'_t) and housing services (h'_t) and maximizes an identical utility function as a representative Landlord:

$$\mathbb{E}_t \sum_{t=0}^{\infty} \beta'^t \Big\{ ln(X'_t) - \frac{\tau}{1+\varphi'} {N'_t}^{1+\varphi'} \Big\} \tag{13}$$

The representative Owner-Occupier does not own any houses to rent out. As a result, she does not receive any profits from the producers. She also tries to smooth her consumption by borrowing from the representative Landlord (B'_t). The budget constraint for the representative Owner-Occupier is as follows, presented in nominal terms:

$$q_t^c c'_t + q_t^h \left[h'_t - (1-\delta_h) h'_{t-1} \right] + R_{t-1} B'_{t-1} = W_t N'_t + B'_t$$

Using $p_t^h = q_t^h / q_t^c$, the representative Owner-Occupier's real budget constraint can be expressed as follows (Lowercase letters for W_t and B'_t refer to real variables):

$$c'_t + p_t^h \left[h'_t - (1-\delta_h) h'_{t-1} \right] + \frac{R_{t-1} b'_{t-1}}{\pi_t^c} = w_t N'_t + b'_t \tag{14}$$

The representative Owner-Occupier is credit constrained and her borrowing is subject to an endogenous limit. She must employ her durable stock (after depreciation) as collateral and the maximum borrowing B'_t is determined by the expected present value of her net home equity multiplied by the loan-to-value (LTV) ratio m:

$$B_t^W \leq \frac{m\mathbb{E}_t q_{t+1}^h (1-\delta_h) h_t^W}{R_t}$$

As the discount rate of the representative Owner-Occupier is lower compared with the representative Landlord, the borrowing constraint is proved to bind in a neighborhood of the deterministic steady state. The borrowing constraint can be written in real terms as follows:

$$R_t b_t^W \leq m\mathbb{E}_t p_{t+1}^h \pi_{t+1}^c (1-\delta_h) h_t^W \tag{15}$$

The representative Owner-Occupier maximizes their utility function (12) with respect to her budget and borrowing constraints (13) and (14). The first-order conditions for this optimization problem are as follows:

$$(1-\alpha)^{\frac{1}{\nu}} (c'_t)^{\frac{-1}{\nu}} {X'_t}^{\frac{1-\nu}{\nu}} = \lambda'_t \tag{16}$$

$$\tau' (N'_t)^{\phi'} = \lambda'_t w_t \tag{17}$$

$$\beta'^{\,t}[j_t \alpha^{\frac{1}{\nu}} (h'_t)^{\frac{-1}{\nu}} {X'_t}^{\frac{1-\nu}{\nu}} - \lambda'_t p_t^h + \lambda'_t \Lambda'_t m p_{t+1}^h \pi_{t+1}^c (1-\delta_h)] + \beta'^{\,t+1} \lambda'_{t+1} p_{t+1}^h (1-\delta_h) = 0 \tag{18}$$

$$\beta'^{\,t} \lambda'_t (1-\Lambda'_t R_t) - \beta'^{\,t+1} [\lambda'_{t+1} \frac{R_t}{\pi_{t+1}^c}] = 0 \tag{19}$$

4.1.3. Renters

A representative Renter also desires consumption and housing services (c'' and h'', respectively) and receive disutiliy from working (N''), which they acquire through renting from rental agencies, and she faces the same utility function as Owner-Occupiers in this environment:

$$\mathbb{E}_t \sum_{t=0}^{\infty} \beta''^{\,t} \left\{ ln(X''_t) - \frac{\tau}{1+\varphi''} {N''_t}^{1+\varphi''} \right\} \tag{20}$$

The representative Renter does not own any houses and cannot smooth her consumption by accumulating houses or borrowing from other agents. The budget constraint for the representative Renter can be shown in nominal terms as follows:

$$q_t^c c''_t + q_t^{Rn} h''_t = W_t N''_t$$

Using $p_t^{Rn} = q_t^{Rn}/q_t^c$, the real budget constraint can be expressed as:

$$c''_t + p_t^{Rn} h''_t = w_t N''_t \tag{21}$$

The representative Renter maximizes her utility function (19) with respect to (20). The first-order conditions for this optimization problem are as follows:

$$(1-\alpha)^{\frac{1}{\nu}}(c''_t)^{\frac{-1}{\nu}}X''_t{}^{\frac{1-\nu}{\nu}} = \lambda''_t \tag{22}$$

$$\tau''(N''_t)^{\phi''} = \lambda''_t w_t \tag{23}$$

$$\beta''^{\,t}[j_t\alpha^{\frac{1}{\nu}}(h''_t)^{\frac{-1}{\nu}}X''_t{}^{\frac{1-\nu}{\nu}} - \lambda''_t p^{Rn}_t] = 0 \tag{24}$$

4.2. Producers

There are three sectors in this environment: Consumption (c), Housing (h), and Rental (Rn). In each sector j ($j = c, h, Rn$), there is a perfectly competitive final good producer that manufactures the final good Y^j_t by purchasing $y_{j,t}(i)$ units of intermediate good i from other monopolistically competitive intermediate goods producers in sector j.

$$Y^j_t = \left(\int_0^1 y_{j,t}(i)^{\frac{\varepsilon_j-1}{\varepsilon_j}}di\right)^{\frac{\varepsilon_j}{\varepsilon_j-1}} \qquad \varepsilon_j > 1, \quad j = c, h, Rn \tag{25}$$

Where ε_j is the elasticity of substitution between differentiated varieties in sector j. Each final producer tries to maximize its profit while taking into account the costs of purchasing the intermediate goods employed in the production process:

$$\max_{y_{j,t}(i)} q^j_t Y^j_t - \int_0^1 q^j_{i,t} y_{j,t}(i)di \qquad j = c, h, Rn$$

This maximization of profits provides demand functions for the typical intermediate good i in sector j.

$$y_{j,t}(i) = y(q^j_{i,t}; q^j_t, Y^j_t) = \left(\frac{q^j_{i,t}}{q^j_t}\right)^{-\varepsilon_j} Y^j_t \qquad j = c, h, Rn \tag{26}$$

Where $q^j_t = \left(\int_0^1 q^{j\,1-\varepsilon_j}_{i,t}di\right)^{\frac{1}{1-\varepsilon_j}}$ corresponds to the price index that results in zero profits for the final good producer in sector j.

4.2.1. Consumption and Housing Sectors

As previously discussed, both non-durable and durable goods producers try to maximize their profits by accounting for the costs associated with the intermediate goods they employ within each sector.

Monopolistically competitive intermediate firms in the Consumption and Housing sectors employ a simple linear technology to produce the non-durable and durable goods

$$y_{j,t}(i) = A^j L^j_{i,t} \qquad j = c, h \tag{27}$$

Where A^j is a parameter that indicates technological advancement in sector j and $L^j_{i,t}$ represents labour hired by intermediate producer i in sector j (Labours can freely move between sectors). The intermediate firm i in sector j follows a two-step approach to optimize its profits. Firstly, it tries to hire an amount of labour that minimizes its nominal production costs:

$$\Phi(y_{j,t}(i)) = \min_{L^j_{i,t}} W_t L^j_{i,t} + \lambda^j_{i,t}(-y_{j,t}(i) + A^j_t L^j_{i,t})$$

As a result, the nominal wage must be equal to the nominal marginal costs (MC^j_t) of each sector.

$$W_t = MC^j_t A^j \tag{28}$$

In the second step, each intermediate firm maximizes its profit with respect to the optimum level of input obtained from the previous minimization problem ($MC^j_t A^j_t$). In order to incorporate price stickiness into the model, it is assumed that each firm faces a quadratic costs proportional to output when changing prices as in Monacelli (2009). As a result, prices do not adjust immediately as each intermediate firm is reluctant to change prices frequently due to the costs involved. The profit maximization of intermediate firm i in sector j can be written as follows:

$$\max_{q^j_{i,t}} \mathbb{E}_t \sum_{t=0}^{\infty} \Lambda^j_t [q^j_{i,t} y_{j,t}(i) - MC^j_t y_{j,t}(i) - \frac{\phi_j}{2}(\frac{q^j_{i,t}}{q^j_{i,t-1}} - 1)^2 q^j_t Y^j_t]$$

Where the parameter $\phi_j \geq 0$ measures the degree of nominal price stickiness in each sector and $\Lambda^j_t = \beta\tilde{\lambda}_{t+1}/\tilde{\lambda}_t$ is Landlord's stochastic discount factor, in which $\tilde{\lambda}$ is the marginal utility of Landlord's nominal income. In line with Sterk (2010), solving the firm's profit maximization problem and replacing the real marginal costs, $mc^j_t = MC^j_t/q^j_t$, and the gross inflation rate in sector j, $\pi^j_t = q^j_t/q^j_{t-1}$ results in the following equation that relates the marginal costs of the goods produced in sector j to inflation in that sector:

$$(1 - \varepsilon_j) + \varepsilon_j mc^j_t - \phi_j(\pi^j_t - 1)(\pi^j_t) + \phi^j \mathbb{E}_t[(\pi^j_{t+1} - 1)(\pi^j_{t+1})\frac{\Lambda^j_{t+1}}{\Lambda^j_t}\frac{Y^j_{t+1}}{Y^j_t}\frac{q^j_{t+1}}{q^j_t}] = 0 \tag{29}$$

4.2.2. Rental Sector

Similar to non-durable and durable final producers, a representative rental agency employs $y_t^{Rn}(i)$ units of intermediate rental housing good i to produce final rental housing goods through a production function expressed as Dixit-Stiglitz aggregator. These rental houses will be sold at final price q_t^{Rn} to Renters in the rental market.

Monopolistically competitive intermediate rental housing producers use a simple linear technology to convert rental housing purchased from Landlords at price q_t^{Rb} to the inputs used by the final rental agency:

$$y_t^{Rn}(i) = A^{Rn} h_{i,t}^{Rn} \tag{30}$$

Where A^{Rn} is advancements in technology in the rental sector. An intermediate rental housing producer minimizes its costs and faces the following optimization problem:

$$\Phi(y_t^{Rn}(i)) = \min_{h_{i,t}^{Rn}} q_t^{Rb} h_{i,t}^{Rn} + \lambda_t^{Rn}[-y_t^{Rn}(i) + A_t^{Rn} h_{i,t}^{Rn}]$$

The above equation indicates that the nominal rent price paid to landlords must be equal to the nominal marginal costs of the rental housing good:

$$q_t^{Rb} = MC_t^{Rn} A^{Rn} \tag{31}$$

Given the optimum level of inputs intermediate rental housing producer i needs to hire, the producer aims to maximize its profit over the entire period. As discussed earlier, prices cannot be adjusted immediately, as the producer suffers certain costs (see Rotemberg, 1982):

$$\max_{q_{i,t}^{Rn}} \mathbb{E}_t \sum_{t=0}^{\infty} \Lambda_t [q_{i,t}^{Rn} \mu_R y_{i,t}^{Rn} - MC_t^{Rn} \mu_R y_{i,t}^{Rn} - \frac{\phi_{Rn}}{2} (\frac{q_{i,t}^{Rn}}{q_{i,t-1}^{Rn}} - 1)^2 q_t^{Rn} Y_t^{Rn}]$$

Where the parameter ϕ_{Rn} indicates the degree of nominal price rigidity in the rental market. The profit maximization problem of intermediate rental housing producer i pins down the relationship between the marginal costs of rental housing goods to the inflation rate in the rental market as follows:

$$(1-\varepsilon_{Rn}) + \varepsilon_{Rn} mc_t^{Rn} - \phi^{Rn}(\pi_t^{Rn} - 1)(\pi_t^{Rn}) + \phi^{Rn} \mathbb{E}_t[(\pi_{t+1}^{Rn} - 1)(\pi_{t+1}^{Rn}) \frac{\Lambda_{t+1}}{\Lambda_t} \frac{Y_{t+1}^{Rn}}{Y_t^{Rn}} \frac{q_{t+1}^{Rn}}{q_t^{Rn}}] = 0 \tag{32}$$

Where $mc_t^{Rn} = p_t^{Rb}/(A_t^{Rn} p_t^{Rn})$ and $\pi_t^{Rn} = q_t^{Rn}/q_{t-1}^{Rn}$.

4.3. Monetary Policy

As in Monacelli (2009), there is a monetary authority in this economy, which conducts the monetary policy by means of the following Taylor rule:

$$\frac{R_t}{R} = (\frac{\tilde{\pi}_t}{\tilde{\pi}})^{\phi_\pi} \varepsilon_t^R, \qquad \phi_\pi > 1 \tag{33}$$

Where R and $\tilde{\pi}$ indicate the gross interest rate and the inflation rate in the steady-state, respectively. The parameter ϕ_π is the weight of the inflation rate in the monetary policy and $\tilde{\pi}_t = (\pi_t^c)^{\alpha_c}(\pi_t^h)^{\alpha_h}(\pi_t^{Rn})^{1-\alpha_c-\alpha_h}$ represents the composite inflation index, which is a weighted average of the inflation rate in Consumption, Housing, and Rental sectors. ε_t^R is a monetary policy shock that follows an AR(1) process:

$$ln\varepsilon_t^R = \rho_R ln\varepsilon_{t-1}^R + u_t^R \tag{34}$$

Where u_t^R is independently and identically distributed process with variance σ_R^2. The sectoral inflation rate and relative prices are related as follows:

$$\frac{\pi_t^c}{\pi_t^h} = \frac{p_{t-1}^h}{p_t^h} \tag{35}$$

$$\frac{\pi_t^c}{\pi_t^{Rn}} = \frac{p_{t-1}^{Rn}}{p_t^{Rn}} \tag{36}$$

4.4. Equilibrium and Market Clearing Conditions

There exists 5 markets in this environment: The non-durable goods market produces aggregate consumption. The durable goods market produces new homes (I_t^h). The rental housing goods are sold in the rental market and all Consumption and Housing producers hire their labours (N_t^d) from the labour market. There is also a debt market in this environment. The aggregate consumption (C_t), stock of housing (H_t), change in housing stock (I_t^h), and hours worked (N_t^s) characterized by:

$$C_t = \mu_R c_t + \mu_W c_t' + \mu_P c_t'' \tag{37}$$

$$H_t = \mu_R h_t + \mu_W h_t' + \mu_P h_t'' \tag{38}$$

$$I_t^h = \mu_R\big[h_t - (1-\delta_h)h_{t-1} + h_t^{Rn} - (1-\delta_{Rn})h_{t-1}^{Rn}\big] + \mu_W\big[h_t' - (1-\delta_h)h_{t-1}'\big] \tag{39}$$

$$N_t^s = \mu_R N_t + \mu_W N_t' + \mu_P N_t'' \tag{40}$$

The equilibrium conditions in this environment are as follows:

$$C_t + \frac{\phi_c}{2}(\pi^c - 1)^2 Y_t^c = Y_t^c \tag{41}$$

$$I_t^h + \frac{\phi_h}{2}(\pi^h - 1)^2 Y_t^h = Y_t^h \tag{42}$$

$$\mu_P h_t'' + \frac{\phi_{Rn}}{2}(\pi^{Rn} - 1)^2 Y_t^{Rn} = \mu_R Y_t^{Rn} \tag{43}$$

$$\mu_R b_t^R + \mu_W b_t^W = 0 \tag{44}$$

$$N_t^d = N_t^s = N_t \tag{45}$$

Where total hours worked (Labours) demanded by intermediate non-durable and durable goods producers must be equal to total supply of hours worked by all agents in the housing (L_t^h) and consumption sectors (L_t^c), meaning that $N_t^d = L_t^h + L_t^c$. Finally, the equilibrium condition for the entire economy can be written as:

$$Y_t = p_t^h Y_t^h + Y_t^c = A_t^h L_t^h + A_t^c L_t^c \tag{46}$$

It is assumed that landlords own all the firms and the profits paid to them as dividends are equal:

$$\Pi_t^c = (1 - mc_t^c) Y_t^c - \frac{\phi_c}{2}(\pi_t^c - 1)^2 Y_t^c \tag{47}$$

$$\Pi_t^h = (1 - mc_t^h) Y_t^h - \frac{\phi_h}{2}(\pi_t^h - 1)^2 Y_t^h \tag{48}$$

$$\Pi_t^{Rn} = \mu_R (1 - mc_t^{Rn}) Y_t^{Rn} - \frac{\phi_{Rn}}{2}(\pi_t^{Rn} - 1)^2 Y_t^{Rn} \tag{49}$$

5. Empirical Results

5.1. Calibration

Table 1 summarizes the calibrated values set for parameters. The shares of Landlords, Owner-Occupiers and Renters are set to be 0.2, 0.5, and 0.3 respectively. These shares are in line with the number of households by tenure determined by Canada Mortgage and Housing Corporation (CMHC) and Canada's Survey of Financial Security (SFS) 2012 and 2016. The discount factor of representative Landlord (β) is set to 0.995, implying the quarterly real net interest rate of 0.5 %, which aligns with the real 3-month Treasury Bill rate during the considered period. The discount factors for Owner-Occupiers (β') and Renters (β'') are set to 0.98. Setting a larger value for Landlords' discount factor compared to that of Owner-Occupiers results in the borrowing constraint binding around the steady state. Consequently, Owner-Occupiers are always borrowers, while Landlords are always savers in the steady state. The value of the share of durable goods (housing services) in the composite consumption index, denoted as α, is set to 0.25 to match with the non-durable goods consumption to GDP ratio, 0.7 , over the considered period. The depreciation rates for housing and rental housing are assumed to be 0.02. The value of the loan to value parameter m is set to 0.55. The values of depreciation rates and the loan to value ratio are set in a way that the debt to GDP ratio match with actual data which is 0.73 over the period. These values are selected in such a way that the debt-to-GDP ratio obtained from the model aligns with the actual data (0.73). The elasticity of substitution between verities in all sectors is set equal to 6, indicating the mark-up of 20% in the steady-state. The inverse elasticity of labour supply for all types of households are set to be 1 ($\varphi = \varphi' = \varphi'' = 1$). Similar to Ogaki and Reinhart (1998), the elasticity of substitution between non-durable and durable services (ν) is set to 1.16.

To achieve a desired frequency of price adjustment, we adopt a similar approach to that used in Monacelli (2009). In this method, the slope of the Phillips curve in the standard Calvo-Yun model, given by $(1-\theta)(1-\beta\theta)/\theta$ (where θ represents the probability of not resetting prices), is equated with the slope of the Phillips curve derived from the log-linearization of the optimal pricing condition in each sector, denoted as $(\varepsilon_j - 1)/\phi_j$. Consequently, we are able to measure the stickiness parameter ε_j using the formula $\phi_j = \theta(\varepsilon_j - 1)/[(1-\theta)(1-\beta\theta)]$. To achieve a price adjustment frequency of approximately three quarters ($\theta = 2/3$) in the consumption sector, ϕ_c is set to 3.37. The level of price rigidity in the housing market is assumed to be lower than that in the consumption sector, with house prices adjusting after 2 quarters. Consequently, ϕ_h is set to 2.5. To account for the generally higher stickiness of rent prices compared to consumption and housing goods in the base case, price rigidity of six quarters ($\theta = 5/6$) is selected for the rent prices, with ϕ_{Rn} set to 4.27. For the monetary policy, the weight assigned to the inflation rate (ϕ_π) is set at 1.5. The weight of consumption (α_c) in the composite inflation index is selected as 0.7 to align with the weight of the non-shelter component of the CPI index in Canada. As a result, the weights assigned to the housing and rental components are set to 0.15 each, in order to correspond with the weight of the shelter component of the CPI index. Finally, the steady-state level of hours worked for each type of household is chosen in such a way that each type of agent works one-third of their time endowment.

Table 1: Calibrated Parameters

Parameter	Value	Parameter	Value
μ_R	0.2	β	0.995
μ_W	0.3	β'	0.98
μ_P	0.5	β''	0.98
α	0.25	m	0.55
δ_h	0.02	ν	1.16
ε_c	6	φ	1
ε_h	6	φ'	1
ε_{Rn}	6	φ''	1
ϕ_c	3.37	ϕ_π	1.5
ϕ_h	2.5	α_c	0.7
ϕ_{Rn}	4.27	α_h	0.15

5.2. Impulse Responses

To study the impact of monetary policy in the presence of rent price rigidity on various aggregate variables and inflation rates in Consumption, Housing, and Rental sectors, different levels of stickiness is considered within the rental market. In the first case, the rental market is considered to have complete flexibility. The second case involves a level of stickiness greater than that of the housing market and non-housing goods, with rent prices taking six quarters to reach full adjustment. The third case assumes rent prices adjust after eight quarters or two years, while the fourth case assumes the rental market adapts to changes in supply and demand dynamics after 12 quarters or three years.

Figure 4 shows the impulse responses of aggregate variables and overall inflation rate and total social welfare in different sectors to a one percentage point innovation in the monetary policy shock (A contractionary monetary policy). The results show that Output, Non-housing Consumption (aggregate), and Housing services fall when a tightening monetary policy is imposed. As can be seen in Figure 4, the higher the levels of stickiness in the rental market, the greater the drop in aggregate variables specially in the initial quarters. The findings also indicate that house prices drop significantly following a negative monetary policy shock. However, the level of rent price rigidity plays a crucial role in determining whether the rent price experiences a decline or an increase in response to a tightening monetary policy shock. When the level of stickiness in the rental market is 6 quarters (greater than in other sectors), the rent price rises in response to the monetary policy. Greater rent price rigidity leads to a more prolonged period of rent price increase. Conversely, when the rent prices are fully flexible, they closely follow the dynamics observed in the house prices. The responses of housing services (aggregate) also depend on rent price rigidity, and they decline more when the rental market is more rigid. This can be explained from equation (12): Greater rent price rigidity alters the marginal costs in the rental market (the second term on the right-hand side of the equation), and it has a negative impact on house prices.

The larger negative response of housing services to a constractionary monetary policy shock when the rent price rigidity is greater can solve the co-movement problem between the non-durable consumption and durable consumption as well. In Monacelli (2009), the level of stickiness in the prices of durable goods (here, housing prices) plays a critical role in generating the co-movement between non-durable and durable consumption. Specifically, when the level of stickiness for the prices of durable goods exceeds three quarters (with prices for non-durable goods adjusting after four quarters), the model yields a strong co-movement effect. In our model, rent price rigidity can amplify the decline in house prices and demands from Owner-Occupiers and Renters, consequently leading to a more pronounced co-movement between non-durable and durable consumption.

The findings show that real debt decreases as well. The magnitude of the fall in real debt depends on the rent price rigidity as higher levels of stickiness in the rental market affect house prices. In other words, the greater the level of rent price rigidity, the more substantial the observed decrease in the real debt variable. The findings also indicate that the overall inflation rate is affected by a tightening monetary policy shock in the presence of rent price rigidity. As shown in Figure 4, the overall inflation rate experiences a significant decline and gradually converges to the steady state after six quarters in a fully flexible rental market. However, higher stickiness in the rental market results in a less pronounced decrease over the same six quarters to reach the steady-state value. Notably, the disparity in the overall inflation rate remains relatively minor when considering different levels of stickiness within the rental market. In Dias and Duarte (2020), in contrast to other components of the CPI, inflation rates in housing rents and owner's equivalent rent (components that form the shelter components of the CPI) increase in response to a contractionary monetary policy shock, thereby impacting the CPI in the United States. Shimizu et al. (2010) also find that if Japanese housing rents were as flexible as those in the United States, the CPI inflation rate would have shown a rise of 1% during the bubble period (late 1980s and early 1990s) and a decline of over 1% in the aftermath of the bursting of the bubble. In our model, the overall inflation rate is also influenced by rent price rigidity, but the mechanism is distinct: rent price rigidity results in a slower adjustment of the overall inflation rate, which can compromise the efficacy of a contractionary monetary policy.

Finally, the findings show that the increase in rent prices while house prices decline causes the Price-to-Rent ratio to decrease. A greater level of stickiness in the rental market can further amplify this drop when a contractionary monetary policy is implemented.

Figure 4: Impulse Responses of Aggregate Variables to a monetary policy tightening

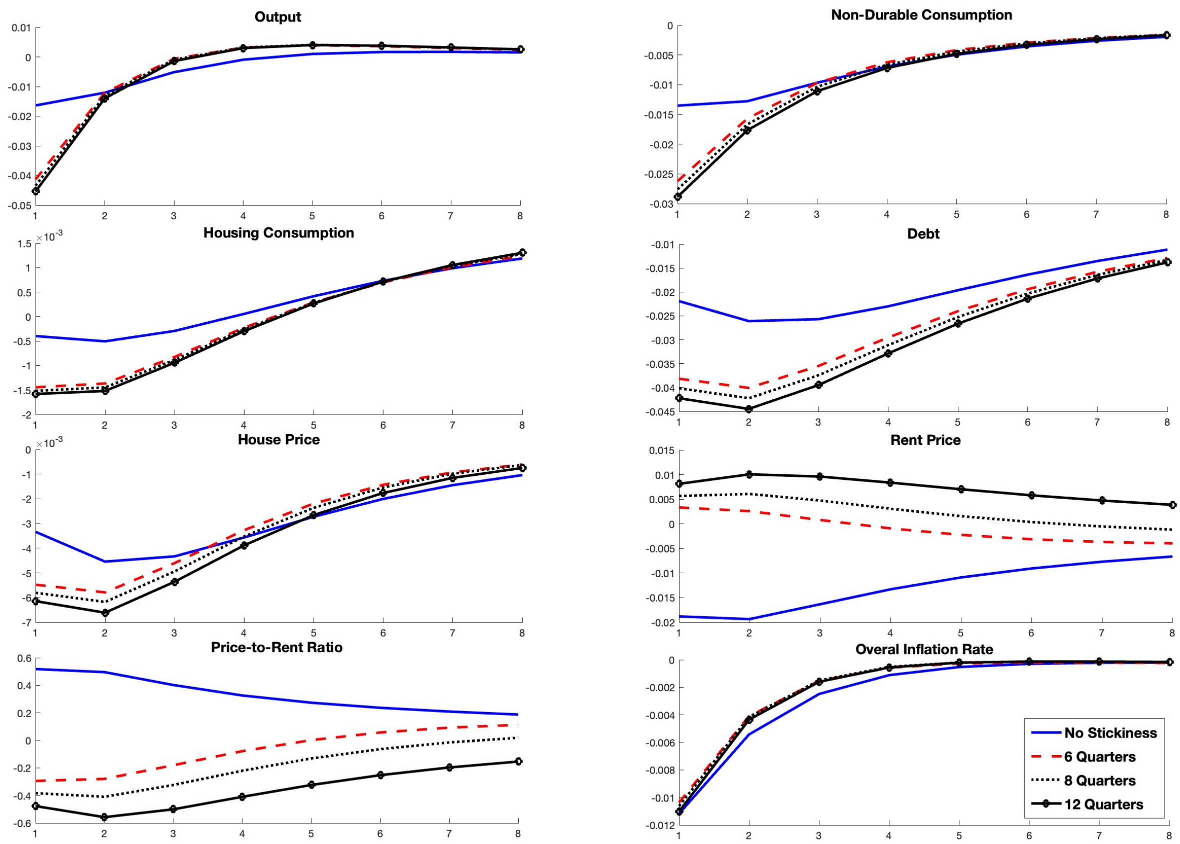


Figure 5 illustrates the impulse responses of non-housing (non-durable) and housing consumption for various types of households, as well as the output produced in each sector. These responses are analyzed in the context of varying levels of rent stickiness following a tightening of monetary policy. The findings indicate that all types of households reduce non-housing consumption in response to a contractionary monetary policy. However, different levels of stickiness in the rental market can influence the speed of convergence towards the steady state. This behavior can be explained by the change in the real interest rate, as it decreases initially, then rises significantly over the next quarters when the rental market is more rigid (see Figure 6).

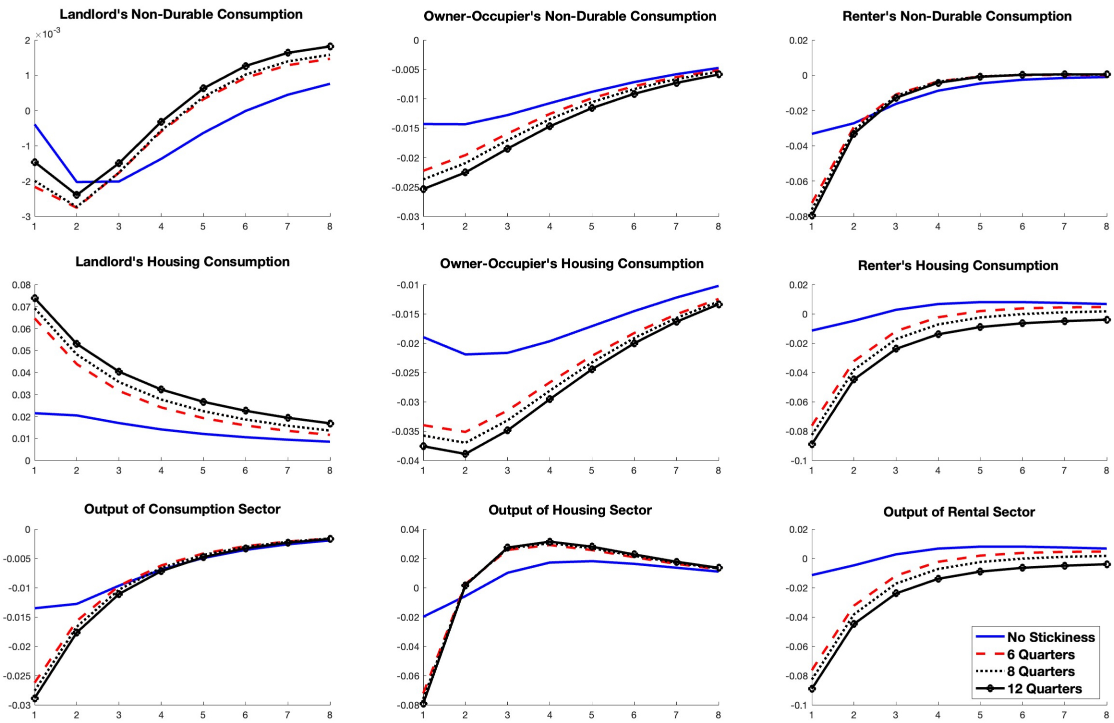
As discussed before, in general, house prices decline in response to a tightening monetary policy, but higher rent price rigidity causes house prices to fall more significantly. Consequently, the collateral value of houses declines for Owner-Occupiers, leading them to have less incentive to acquire additional houses. Renters also reduce their consumption of housing services as renting becomes more expensive for them. However, in a fully flexible rental market, housing consumption for renters decreases only slightly in the first quarter and then rises. The level of stickiness in the rental market also impacts the consumption of housing services across various household types. Both Owner-Occupiers and Renters experience more significant declines in housing services due to the presence of rent price rigidity. Given that rent price rigidity leads to an increase in rent prices and a more substantial decrease in house prices, renting becomes more costly for Renters, and there is less incentive for Owner-Occupiers to expand their housing services due to the reduced collateral value of houses. Conversely, Landlords increase their consumption of housing services. Landlords do not face the same demand for lending from Owner-Occupiers. As a result, they reallocate their assets to acquire more housing services as the house price has dropped. Since the higher rigidity in the rental market leads to a higher drop in prices, Landlords increase their level of housing services. As the decline in housing services is greater for both Owner-Occupiers and Renters compared to the increase in housing services for Landlords, the aggregate housing services decrease in response to a tightening monetary policy shock.

As shown in Figure 5, output in all sectors decreases in response to the contractionary monetary policy, and greater rent price stickiness amplifies this decline in outputs. However, the output of the housing sector rises after the first quarter due to an increase in demand for housing services from Landlords. This natural mechanism is also present in the Two Agents New Keynesian (TANK) model. In TANK models, households without credit constraints tend to consume more housing services as they become relatively cheaper when a tightening monetary policy is implemented. The output of the rental sector represents the number of units available for rent. When the interest rate increases, the incomes of all types of households, including Renters, decline. As a result, consumption of both non-durable goods and housing services declines. In the absence of sticky rent prices, both rent and house prices decrease, leading Renters to take advantage of lower rent prices and slightly increase their consumption of housing services. However, with greater levels of rent price stickiness, the supply of rental units decreases as Landlords prefer to accumulate more houses due to their reduced cost. Consequently, rent prices increase more compared to scenarios with lower levels of rent price stickiness.

The inflation rates in different sectors are affected by the level of stickiness in the rental market as well (see Figure 7 in Appendix). The results show that the inflation rate in the rental sector falls significantly in the first quarter when the rental market is fully flexible. Moreover, the rent prices tend to remain stable when the level of stickiness is higher. As a result, the inflation rate in the rental market converges to zero faster when the prices are flexible. The behavior of inflation rates in the housing and consumption markets differs from that observed in the rental market. Notably, the inflation rate experiences a more substantial decline in the first quarter when rent price rigidity is a factor. However, the house and non-durable goods prices adjust faster after the first quarter. The results also confirm that the overall inflation rate in the economy falls to a relatively lesser extent when rent price rigidity is greater, although the difference is not substantial.

Residential investment also experiences a decline in response to a contractionary monetary policy, as depicted in Figure 7. Different levels of rent price rigidity have minor effects on the impulse responses of the residential investment variable. However, residential investment experiences a relatively smaller drop in the first period when the rental market is fully flexible and it gradually converges to the steady-state.

Figure 5: Impulse Responses of Agents to a monetary policy tightening



6. Conclusion

Rent price rigidity is an inherent characteristic of the rental market, influencing the efficacy of monetary policy through diverse channels, including changing the inflation rate, house prices, and adjustments to the optimal combination of non-durable and housing consumption for households within the economy. The VAR models estimated for Canada and the United States over the period from 1981Q1 to 2021Q4 reveal differences in the behavior of rent and house prices when a tightening monetary policy is implemented. The data also indicate a negative correlation between real rent and house prices in Canada, particularly during economic downturns when a contractionary monetary policy is in effect. This divergence in behavior can be attributed to the higher level of rent price stickiness in Canada compared to the United States. To address the role of rent price rigidity, a model of the Canadian economy that explicitly models the rental market is developed. The results show that the presence of rent price rigidity is essential to explain the empirical outcomes obtained from the estimated VAR models. Furthermore, they indicate that rent price rigidity results in negative correlation between house prices and rent prices during periods of economic downturns when a contractionary monetary policy is implemented. Additionally, the overall inflation rate reacts more substantially when the rental market experience lower level of stickiness in rent prices. Lastly, the findings highlight the influence of rent price rigidity on aggregate macroeconomic variables, including output and consumption. Specifically, a higher level of stickiness in rent prices leads to a more substantial decline in aggregate macroeconomic variables in response to a tightening monetary policy shock.

References

Arnott, R. (1995). "Time for Revisionism on Rent Control?," *The Journal of Economic Perspectives*, 9 (1): 99-120.

Campbell, S. D., Davis, M. A., Gallin J., and Martin, R. F. (2009). "What moves housing markets: A variance decomposition of the rent–price ratio," *Journal of Urban Economics*, 66 (2): 90-102.

Dias, D. A., and Duarte, J. B. (2019). "Monetary policy, housing rents, and inflation dynamics." *Journal of Applied Econometrics*, 34: 673–687.

Gallin, J., and Verbrugge, R.J., (2019). "A theory of sticky rents: Search and bargaining with incomplete information," *Journal of Economic Theory*, 183: 478-519.

Genesove, D. (2003). "The Nominal Rigidity of Apartment Rents,"*The Review of Economics and Statistics*, 85 (4): 844-853.

Hoffmann, J., and Kurz-Kim, J. R. (2006). "Consumer price adjustment under the microscope: Germany in a period of low inflation," *Deutsche Bundesbank Discussion Paper Series 1: Economic Studies*, 16.

Iacoviello, Matteo. (2005). "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle." *American Economic Review*, 95 (3): 739-764.

Iacoviello, M., and S. Neri (2010). "Housing Market Spillovers: Evidence from an Estimated DSGE Model." *American Economic Journal: Macroeconomics*, 2 (2): 125-64.

Monacelli, T. (2009). "New Keynesian models, durable goods, and collateral constraints," *Journal of Monetary Economics*, 56 (2): 242-254.

Ogaki, M., and Reinhart, C. M. (1998). "Measuring Intertemporal Substitution: The Role of Durable Goods." *Journal of Political Economy*, 106(5): 1078–1098. Rotemberg, J. J. (1982). "Sticky Prices in the United States." *Journal of Political Economy*, 90(6): 1187–1211.

Rubio, M. (2019). "Rented vs. owner-occupied housing and monetary policy," *The B.E. Journal of Macroeconomics*, 19 (1): 20160110.

Sun, X., and Tsang, K.P. (2017). "What Drives the Owner-Occupied and Rental Housing Markets? Evidence from an Estimated DSGE Model." *Journal of Money, Credit and Banking*, 49: 443-468.

Shimizu, C., Nishimura, K. G., and Watanabe, T. (2010). "Residential rents and price rigidity: Micro structure and macro consequences," *Journal of the Japanese and Interna-*

tional Economies, 24 (2): 282-299.

Sommer, K. Sullivan, P., and Verbrugge. (2013). "The equilibrium effect of fundamentals on house prices and rents," *Journal of Monetary Economics*, 60 (7):854-870.

Wang, H. (2020). "Stickiness of rental rate and housing vacancy rate," *Economics Letters*, 195, 109487.

Willis, J. W. (1950). "Short History of Rent Control Laws" , *Cornell Law Review*, 36 (1): 54-94.

Weber, J. P. (2017). "Private Tenancies - A Multi-Country Analysis," *PhD Dissertation*, University of Regensburg, Faculty of Business, Economics, and Management Information Systems.

Appendix

1. Steady-State

It is assumed that $A^c = A^h = A^{Rn} = 1$ and $\pi = \pi^c = \pi^h = \pi^{Rn} = 1$ in the steady-state. Additionally, marginal costs in different sectors is $mc^j = (\varepsilon_j - 1)/\varepsilon_j$ where $j = c, h, Rn$.

1. Landlords

$$(1-\alpha)^{\frac{1}{\nu}}(c)^{\frac{-1}{\nu}}X^{\frac{1-\nu}{\nu}} = \lambda \tag{1}$$

$$\tau N^{\phi} = \lambda w \tag{2}$$

$$j\alpha^{\frac{1}{\nu}}(h)^{\frac{-1}{\nu}}X^{\frac{1-\nu}{\nu}} - \lambda p^h + (1-\delta_h)\beta\lambda p^h = 0 \tag{3}$$

$$\lambda(p^{Rb} - p^h) + (1-\delta_{Rn})\beta\lambda p^h = 0 \quad \Rightarrow \quad p^{Rb} = p^h[1-\beta(1-\delta_{Rn})] \tag{4}$$

$$-\lambda + \beta\lambda\frac{R}{\pi^c} = 0 \quad \Rightarrow \quad R = \frac{\pi^c}{\beta} \tag{5}$$

Wage (w) and house Price (p^h) can be determined using $w = mc^c A^c$ and $p^h = w/(mc^h A^h)$, respectively, in the steady-state.

2. Owner-Occupier

$$(1-\alpha)^{\frac{1}{\nu}}(c')^{\frac{-1}{\nu}}X^{\frac{1-\nu}{\nu}} = \lambda' \tag{6}$$

$$\tau' N'^{\phi'} = \lambda' w \tag{7}$$

$$j\alpha^{\frac{1}{\nu}}(h')^{\frac{-1}{\nu}}X'^{\frac{1-\nu}{\nu}} - \lambda' p^h + \lambda'\Lambda' m p^h \pi^c(1-\delta_h) + \beta'\lambda' p^h(1-\delta_h) = 0 \tag{8}$$

$$\beta'\lambda'(1-\Lambda' R) - \beta'\lambda'\frac{R}{\pi^c} = 0 \quad \Rightarrow \quad (1-\frac{\beta R}{\pi^c}) = R\Lambda' \tag{9}$$

$$c' = -p^h\delta_h h' - (\frac{R}{\pi^c} - 1)b' + wN' \tag{10}$$

$$b' = \frac{mp^h\pi^c(1-\delta_h)h'}{R} \tag{11}$$

Substituting $X'^{\frac{1-\nu}{\nu}}$ form equation 6 into equation 8, c'/h' can be written as:

$$\frac{c'}{h'} = [p^h - \Lambda' m p^h \pi^c(1-\delta_h) - \beta' p^h(1-\delta_h)]^{\nu} \times \frac{(1-\alpha)}{\alpha} \times j^{-\nu} \tag{12}$$

c'/h' can be found from Owner-Occupier's budget constraint, equation 10, and the borrowing constraint, equation 11, as follows:

$$\frac{c'}{h'} = -\delta_h p^h - (\frac{R}{\pi^c} - 1) \times \frac{mp^h\pi^c(1-\delta_h)}{R} + \frac{wN'}{h'} \tag{13}$$

Assuming $N = N' = N'' = 1/3$, the solution to equations (12) and (13) determines the steady-state value of h'. Subsequently, c' and b' can be determined from equations (12) and (11) respectively. Once c' and b' are obtained, X' can be computed. Finally, the value of τ' is pinned down by the value of λ'.

3. Renters

$$(1-\alpha)^{\frac{1}{\nu}}(c'')^{\frac{-1}{\nu}}X''^{\frac{1-\nu}{\nu}} = \lambda'' \tag{14}$$

$$\tau''(N'')^{\phi''} = \lambda'' w \tag{15}$$

$$j_t \alpha^{\frac{1}{\nu}}(h'')^{\frac{-1}{\nu}}X''^{\frac{1-\nu}{\nu}} - \lambda'' p^{Rn} = 0 \tag{16}$$

$$c'' + p^{Rn}h'' = wN'' \tag{17}$$

c''/h'' can be determined using equation 14 and 16:

$$\frac{c''}{h''} = (p^{Rn})^{\nu} \times \frac{(1-\alpha)}{\alpha} \times j^{-\nu} \tag{18}$$

c''/h'' can be found from the budget constraint as well:

$$\frac{c''}{h''} = w\frac{N''}{h''} - p^{Rn} \tag{19}$$

Given $p^{Rb}/(mc^{Rn}A^{Rn})$, equations 18 and 19 pin down h''. Subsequently, c'', X'', and λ'' can be determined. Finally, τ'' is pinned down by the value of λ'' and N'' in the steady-state.

4. Aggregates and Equilibrium

To determine the steady-state values of h and c, the equilibrium condition of the entire economy can be used:

$$\frac{C}{1-\frac{\phi_c}{2}(\pi^c-1)^2} = Y^c \qquad \Rightarrow \qquad \frac{\mu_R c + \mu_W c' + \mu_P c''}{1-\frac{\phi_c}{2}(\pi^c-1)^2} = Y^c \tag{20}$$

$$\frac{I^h}{1-\frac{\phi_h}{2}(\pi^h-1)^2} = Y^h \qquad \Rightarrow \qquad \frac{\mu_R\delta_h h + \delta_{Rn}h^{Rn} + \mu_W\delta_h h'}{1-\frac{\phi_h}{2}(\pi^h-1)^2} = Y^h \tag{21}$$

$$\frac{\mu_P h^P}{\mu_R - \frac{\phi_{Rn}}{2}(\pi^{Rn}-1)^2} = Y^{Rn} \tag{22}$$

$$Y = p^h Y^h + Y^c = A^h L^h + A^c L^c \tag{23}$$

Replacing Y^c and Y^h from equations (20) and (21), respectively, into equation (23), provides the following equation:

$$p^h \times \frac{\mu_R \delta_h h + \delta_{Rn} h^{Rn} + \mu_W \delta_h h'}{A^h \underbrace{[1 - \frac{\phi_h}{2}(\pi^h - 1)^2]}_{adjh}} + \frac{\mu_R c + \mu_W c' + \mu_P c''}{A^c \underbrace{[1 - \frac{\phi_c}{2}(\pi^c - 1)^2]}_{adjc}} = N = \mu_R N + \mu_W N' + \mu_P N'' \quad (24)$$

c/h can be measured from equations (1) and (3) as follows:

$$\frac{c}{h} = \underbrace{\left[1 - \beta(1 - \delta_h)\right]^{\nu} (\frac{1-\alpha}{\alpha})(\frac{p^h}{j})^{\nu}}_{CtoH} \quad (25)$$

Substituting the values of h^{Rn} from $Y^{Rn} = \mu_R h^{Rn} A^{Rn}$ and values obtained for h', c', and c'' provides the steady-state value of h as follows:

$$h = \frac{N - \frac{\mu_W c' + \mu_P c''}{A^c \times adjc} - p^h \times \frac{\mu_W \delta_h h' + \mu_R \delta_{Rn} h^{Rn}}{A^h \times adjh}}{p^h \times \mu_R (\frac{\delta_h}{A^h \times adjh} + \frac{CtoH}{A^c \times adjc})} \quad (26)$$

Subsequently, after finding the value of h, the values of c, X, λ, and τ can be determined in the steady state.

Figure 6: Impulse Responses to Cholesky One S.D. Innovations in Interest Rate in Canada (The VAR Model with a Crisis Dummy Variable from 1981:Q1 to 2021:q4)

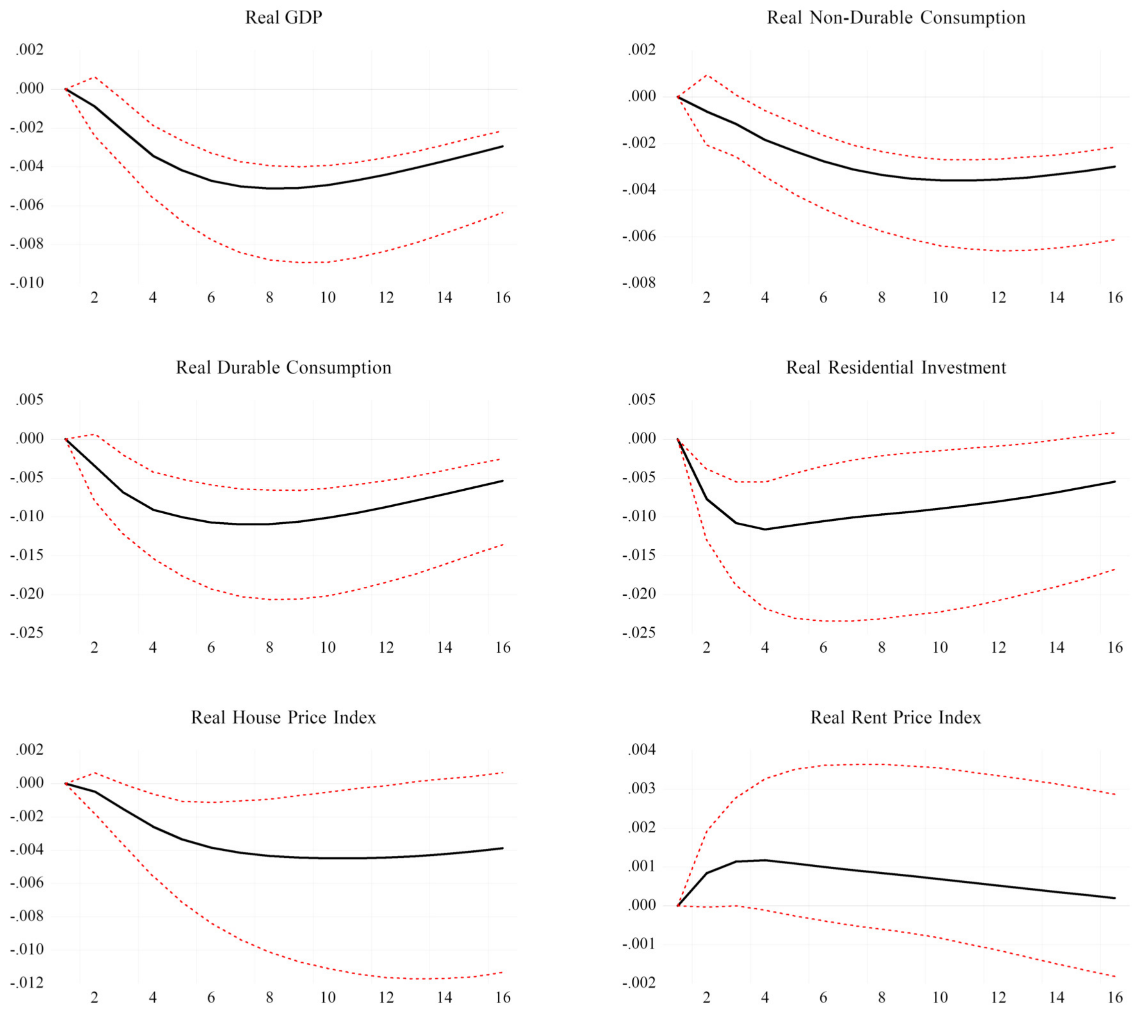


Figure 7: Impulse Responses of Other Variables to a monetary policy tightening