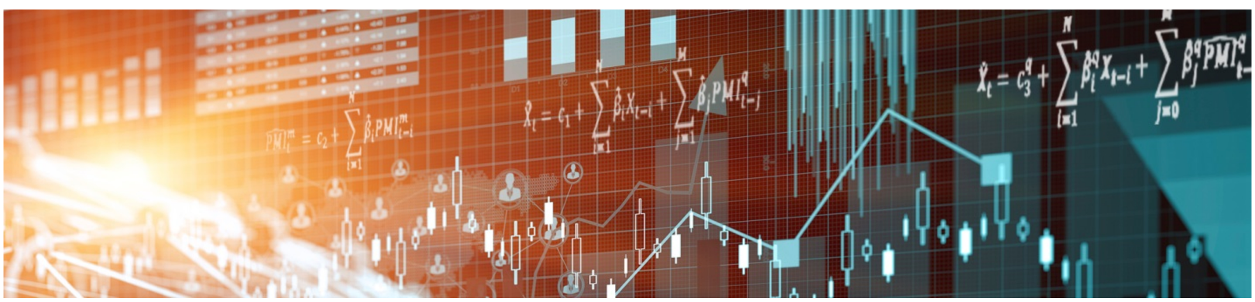
BANK OF CANADA
BANQUE DU CANADA

Staff Working Paper/Document de travail du personnel 2017-36

The Rise of Non-Regulated Financial Intermediaries in the Housing Sector and its Macroeconomic Implications



by Hélène Desgagnés

Bank of Canada staff working papers provide a forum for staff to publish work-in-progress research independently from the Bank's Governing Council. This research may support or challenge prevailing policy orthodoxy. Therefore, the views expressed in this paper are solely those of the authors and may differ from official Bank of Canada views. No responsibility for them should be attributed to the Bank.

www.bank-banque-canada.ca

Bank of Canada Staff Working Paper 2017-36

September 2017

The Rise of Non-Regulated Financial Intermediaries in the Housing Sector and its Macroeconomic Implications

by

Hélène Desgagnés

Canadian Economic Analysis Department
Bank of Canada
Ottawa, Ontario, Canada K1A 0G9
hdesgagnes@bankofcanada.ca

ISSN 1701-9397

© 2017 Bank of Canada

Acknowledgements

This paper is based on the first two chapters of my PhD dissertation and I am grateful to my advisor Margarida Duarte for her support and guidance. This work also greatly benefited from comments, discussions, and suggestions from Michelle Alexopoulos, Jason Allen, Bob Amano, José Dorich, Denis Gorea, Jessie Lamontagne, Francisco Ruge-Murcia, Joseph Steinberg, Alexander Ueberfeldt, Ronald Wolthoff, the Brown Bag workshop participants at the Bank of Canada, and the Macro Brown Bag workshop participants at the University of Toronto. The views expressed in this paper are mine. No responsibility for them should be attributed to the Bank of Canada. Any remaining errors or omissions are mine.

Abstract

I examine the impact of non-regulated lenders in the mortgage market using a dynamic stochastic general equilibrium (DSGE) model. My model features two types of financial intermediaries that differ in three ways: (i) only regulated intermediaries face a capital requirement, (ii) non-regulated intermediaries finance themselves by selling securities and cannot accept deposits, and (iii) non-regulated intermediaries face a more elastic demand. This last assumption is based on empirical evidence for Canada revealing that non-regulated intermediaries issue loans at a lower interest rate. My results suggest that the non-regulated sector contributes to stabilize the economy by providing an alternative source of capital when the regulated sector in unable to fulfill the demand for credit. As a result, an economy with a large non-regulated sector experiences a smaller downturn after an adverse financial shock.

Bank topics: Business fluctuations and cycles; Economic models; Financial system regulation and policies; Housing

JEL codes: E32, E44, E47, E60, G21, G23, G28

Résumé

À l'aide d'un modèle d'équilibre général dynamique et stochastique, j'analyse l'incidence des prêteurs non réglementés sur le marché hypothécaire. Dans mon modèle, on retrouve deux types d'intermédiaires financiers qui se distinguent sous trois aspects. Tout d'abord, seuls les intermédiaires réglementés sont soumis à des exigences de fonds propres. Ensuite, les intermédiaires non réglementés émettent des titres pour financer leurs activités puisqu'ils ne peuvent pas recevoir de dépôts. Enfin, les intermédiaires non réglementés font face à une fonction de demande plus élastique que les intermédiaires réglementés. Cette dernière hypothèse s'appuie sur des données empiriques canadiennes qui suggèrent que les intermédiaires financiers non réglementés émettent des prêts à des taux d'intérêt plus bas. Mes résultats montrent que le secteur non réglementé contribue à stabiliser l'économie puisqu'il constitue une source de capitaux de rechange lorsque le secteur réglementé est incapable de répondre à la demande de crédit. Par conséquent, le ralentissement économique qui suit un choc financier négatif sera moins important dans une économie dans laquelle le secteur non réglementé occupe une place considérable.

Sujets : Cycles et fluctuations économiques, Modèles économiques, Réglementation et politiques relatives au système financier, Logement

Codes JEL : E32, E44, E47, E60, G21, G23, G28

Non-Technical Summary

A growing share of financial transactions now takes place outside the scope of financial regulation. The market for the origination of mortgages is a specific example of this phenomenon. Some mortgage lenders do not face the same level of scrutiny as, for instance, chartered banks and credit unions. These lenders cannot finance their lending by accepting deposits and do not have to maintain a minimum level of bank capital (or equity). I refer to these financial institutions as non-regulated financial intermediaries.

In this paper, I first present empirical evidence for Canada, showing that non-regulated financial intermediaries offer loans at a lower rate than regulated financial intermediaries. Using this observation and the fact that non-regulated financial intermediaries do not accept deposits and are not subject to a minimum capital requirement, I build a structural model in which regulated and non-regulated financial intermediaries issue loans to households to analyze the impact of these non-regulated intermediaries on the economy. The results of the simulation suggest that having a non-regulated sector can be beneficial since households have access to an alternative source of funds when regulated intermediaries are unable to fulfill the demand because of a lack of bank capital.

1 Introduction

A growing share of financial transactions takes place outside the scope of financial regulation. The mortgage market is a specific example of this phenomenon. In Canada, federally and provincially regulated financial intermediaries still dominate the mortgage market, but another type of financial intermediary is gaining importance. In contrast to the federally or provincially regulated financial intermediaries (RFIs), these institutions cannot raise funds by accepting deposits and do not have to satisfy a capital requirement (or capital adequacy ratio). I will refer to these financial institutions as non-regulated financial intermediaries (NRFIs). A decline in the availability of funds in the regulated sector, due, for instance, to stricter regulation, will likely push more households toward the non-regulated sector, making it harder for regulatory authorities to accurately track the volume of credit and diminishing the potential benefits of the regulation. For these reasons, it is essential to understand the impact of NRFIs on the economy and to take them into account in the design of macroeconomic policies.

In this paper, I investigate the macroeconomic impact of a rise in the share of NRFIs in the origination of mortgages. I first present some stylized facts about NRFIs in Canada. The empirical evidence reveals that interest rates on loans are lower in the non-regulated sector. I then construct a dynamic and stochastic general equilibrium (DSGE) model featuring household heterogeneity and a housing sector along the lines of Iacoviello (2005) and add regulated and non-regulated financial intermediaries. The distinction between regulated and non-regulated financial intermediaries goes beyond the regulation faced by the former. There are three important differences between the two types in the model. First, only regulated financial intermediaries (RFIs) face a capital requirement. Second, RFIs raise funds by taking in deposits, while NRFIs issue securities and sell them to RFIs; that is, they originate-to-distribute. Third, NRFIs face a more elastic demand than RFIs and thus charge a lower interest rate. In order to ensure that both sectors coexist despite the spread in the lending rates, I introduce a competitive loan aggregator that combines loans from both sectors and issues loans to households. Finally, I analyze the responses to real and financial shocks of economies that differ only with respect to the long-run share of the non-regulated sector.

An economy with a relatively large non-regulated sector has access to an alternative source of credit when RFIs cannot issue more loans because of their capital requirement. For instance, after an adverse financial shock, a large non-regulated sector limits the decline in output and speeds up the recovery. It is worth mentioning that I focus on the impact of NRFIs on the dynamics of aggregate variables and not on the implications in terms of welfare because of the household heterogeneity.

The remainder of the paper goes as follow: in Section 2, I give some context on the Canadian mortgage market; and in Section 3, I present empirical evidence on the relative size of each sector and on the differences in mortgage rates. I describe my model in Section 4, discuss the simulations in Section 5, and conclude in Section 6.

2 The Canadian Mortgage Market

Lenders in the Canadian mortgage market can be divided into three groups.[1] The first group, the federally regulated institutions, includes chartered banks, trust and life insurance companies, as well as some specialized mortgage companies. The Office of the Superintendent of Financial Institutions (OSFI) oversees their activities and imposes a capital adequacy ratio (or capital requirement). In addition, the Bank Act sets the limit of the loan-to-value (LTV) ratio of mortgages. In particular, borrowers whose down payment is less than 20% of the value of the property must obtain mortgage insurance. Mortgage insurance is provided by private companies or by the Canadian Mortgage and Housing Corporation (CMHC), a Crown corporation of the Government of Canada.[2] The federal government provides an explicit guarantee on all insured mortgages, but imposes additional restrictions on the

[1] Private lenders (also known as B lenders) could be considered as a fourth group. They primarily issue non-insured loans to borrowers who cannot qualify for regular mortgages. Since they deal with a different type of borrower, issue non-insured mortgages, and tend to be active in specific geographic areas, I leave them aside, but we can expect the response of their lending to be generally similar to that of NRFIs.

[2] Even though the CMHC performs a role similar to government-sponsored enterprises (GSEs) in the U.S., it remains a Crown corporation subject to a higher level of scrutiny with an explicit guarantee from the federal government. For a detailed comparison of the housing market in Canada and the U.S., see Kiff, Mennill, and Paulin (2010), and for an overview of the U.S. housing finance system, see Hoskins, Jones, and Weiss (2013).

eligibility of borrowers and the maximum LTV ratio. As of 2010, insured mortgages cannot exceed 95% of the value of a new purchase (or 80% in the case of refinancing).[3]

The second group, the provincially regulated institutions, includes credit unions and brokers. As pointed out by Traclet (2010), provincial regulatory authorities tend to closely follow the regulations imposed by the OSFI. Moreover, borrowers who are required to obtain mortgage insurance have to meet the additional criteria set by the federal government. Mortgages issued by provincially regulated intermediaries are thus comparable to the ones issued by federally regulated institutions. For this reason, I combine federally and provincially regulated financial intermediaries in my analysis.

NRFIs constitute the third group. These lenders cannot receive deposits and are not subject to a minimum capital requirement. In principle, one could expect NRFIs to issue riskier loans, but this is not the case, at least in Canada. Since NRFIs cannot finance their loans with deposits, securitization is an important source of financing. Virtually all of the securitization in Canada takes place through the National Housing Act Mortgage-Backed Securities (NHA MBS) program, a government program aimed at facilitating the funding of mortgages. All mortgages securitized through the NHA MBS program have to be insured; therefore most mortgages issued by NRFIs have to satisfy the LTV limit as well as the other eligibility criteria set by the federal government.

3 The Facts

3.1 Data

There is no comprehensive publicly available data on newly issued mortgages in Canada, so I use data on securitization of mortgages as a proxy. Even though not all mortgages are securitized, securitization has become an important funding channel for financial intermediaries, in particular the non-regulated ones that do not have access to deposits.

[3] As of February 2016, the maximum LTV had decreased to 90% of the portion of a loan above $500,000.

As I mentioned above, securitization in Canada takes place through the National Housing Act Mortgage-Backed Securities (NHA MBS) program administrated by the CMHC. To be eligible for securitization, a mortgage has to satisfy certain criteria. In particular, the loan has to be insured against default of the borrower,[4] and the payments made by the borrower have to be equal throughout the amortization period (CMHC, 2013). Issuers combine mortgages sharing similar characteristics (e.g., variable or fixed interest rates, single-family or multi-family properties, etc.) in pools.

I work with data extracted from the CMHC's Information Circulars for the period $2006-2013$. A circular is created each time a financial intermediary securitizes a pool of mortgages and contains information on the pool: the issuer, the date of securitization (month and year), the pool type, the total value of the loans in the pool, the numbers of loans in the pool, the weighted average mortgage rate in the pool, and the type of interest rate (fixed, variable, or floating). I separate the pools according to their issuers into two categories. This first category, the RFIs, includes financial institutions issuing mortgages and regulated by the OSFI or a provincial counterpart and their subsidiaries.[5] The other category, the NRFIs, consists of non-regulated mortgage issuers and other financial intermediaries that do not issue mortgages. Table 1 provides a brief summary of the data.

Table 2 presents the evolution of the relative share of securitization by each type of financial intermediary (in value of loans securitized) and Figure 1 shows the weighted average interest rate for each sector. The data clearly show that the market is dominated by RFIs, but NRFIs have expanded and own a significant market share. Pools securitized by NRFIs tend to be smaller and contain more highly leveraged loans. However, the evolution of the weighted average mortgage rate in each sector is probably the most striking feature of the data. Starting in the middle of 2009, mortgage rates in pools securitized by NRFIs appear to be lower. This observation would

[4]The regulation in place forces RFIs to require mortgage insurance when the down payment represents less than 20% of the price of the property; however, the insurance providers also offer portfolio insurance to lenders who wish to securitize low-leverage mortgages. In other words, securitized mortgages are not exclusively highly leveraged loans.

[5]Three chartered banks have subsidiaries that securitized mortgages during the period considered here. Some may argue that they belong to the other category, the NRFIs, so I add a control to measure their effect in the regressions.

Table 1: Data description. Data from the CMHC MBS Information Circulars (2006 − 2013).

	RFIs	NRFIs
Observations (number of pools)	10,355	3,700
Average number of mortgages per pool	252.85	106.51
Median mortgage (in current dollars)	217,105	248,607
Proportion of fixed-rate pools	0.76	0.69
Average share of portfolio insurance per pool (percent)	19.67	5.24

not surprise mortgage brokers. In the mortgage broker industry, NRFIs enter the category of monoline lenders (non-deposit-taking financial intermediaries specialized in mortgages) that are viewed as offering the lowest rates on the market to qualified applicants.

3.2 Regression Models

In order to determine whether or not this spread is significant once we control for composition factors (e.g., type of mortgage, loan size, etc.), I run a regression of the weighted average mortgage rate in pool i at date t ($rate_{i,t}$) over an indicator of market conditions (daily yield on 5-year government bonds at the time of securitization[6]: $yield\_5yr\_bonds_{i,t}$) and characteristics of the mortgages in the pool: average loan ($avg\_mortg_{i,t}$); dummies for the type of financial intermediary ($regul_i = 1$ if the issuer is an RFI); type of mortgage ($fixed_i = 1$ if the mortgages in the pool have fixed rates); the type of pool ($pool_i$); whether or not the issuer is a subsidiary of one of Canada's big banks ($subsidiary = 1$ if it is the case); and the month and year of securitization

[6]Since mortgages are typically not securitized at the moment they are issued, the appropriate indicator of the market conditions may be the return on 5-year government bonds a few months prior to the securitization date. However, using the return on bonds with a lag (from one to twelve months) does not affect the outcome of the estimation.

Table 2: Share of total securitization per year (percent). Data from the CMHC MBS Information Circulars (2006 – 2013).

Year	RFIs	NRFIs
2006	97.93	2.07
2007	92.15	7.85
2008	93.29	6.71
2009	88.67	11.33
2010	87.01	12.99
2011	89.79	10.21
2012	91.04	8.96
2013	85.58	14.42

($date_{i,t}$). The regression model 3.1 is given by:

$$rate_{i,t} = \beta_0 + \begin{pmatrix} \beta_1 \\ \beta_3 \end{pmatrix}' \begin{pmatrix} \log(avg\_mortg_{i,t}) \\ yield\_5yr\_bonds_t \end{pmatrix} + \begin{pmatrix} \gamma_1 \\ \Gamma_2 \\ \gamma_3 \\ \gamma_4 \\ \Gamma_5 \end{pmatrix}' \begin{pmatrix} regul_i \\ pool_i \\ fixed_i \\ subsidiary_i \\ date_{i,t} \end{pmatrix} + u_{i,t}. \tag{3.1}$$

Provincially regulated credit unions are included as RFIs; however, they tend to serve small markets, in particular in rural areas where the competition is not as fierce as in urban centers. Another factor that could affect the regression results is the Insured Mortgage Purchase Program (IMPP) implemented by the federal government in the autumn of 2008 to stimulate the mortgage market during the financial crisis. The IMPP was created in October 2008 and ended at the end of March 2010. During that period, the volume of securitization exploded, suggesting that financial intermediaries took advantage of the program and securitized older mortgages they kept on their balance sheet. To account for these concerns, in the regression model 3.2, I control

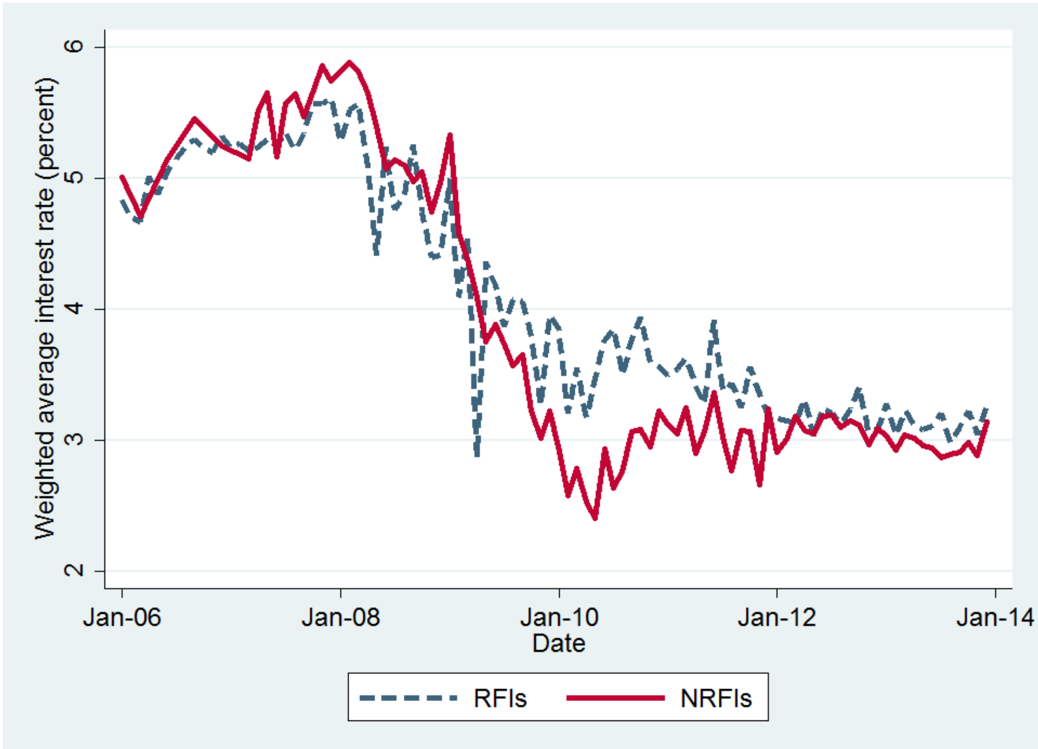


Figure 1: Weighted average interest rate. Calculation based on data from the CMHC MBS Information Circulars.

for the effect of credit unions and the effect of the IMPP:

$$rate_{i,t} = \beta_0 + \begin{pmatrix} \beta_1 \\ \beta_3 \end{pmatrix}' \begin{pmatrix} \log(avg\_mortg_{i,t}) \\ yield\_5yr\_bonds_t \end{pmatrix} + \begin{pmatrix} \gamma_1 \\ \Gamma_2 \\ \gamma_3 \\ \gamma_4 \\ \Gamma_5 \\ \gamma_6 \\ \gamma_7 \end{pmatrix}' \begin{pmatrix} regul_i \\ pool_i \\ fixed_i \\ subsidiary_i \\ date_{i,t} \\ CU_i \\ IMPP_{i,t} \end{pmatrix} + u_{i,t}. \tag{3.2}$$

The results of the two regressions are presented in Table 3. The RFI effect is measured by the estimated coefficient for $regul_i$ ($\hat{\gamma}_1$). The estimated RFI effect is between 25 and 29 basis points, which means that the weighted average mortgage rate in pools securitized by RFIs is between 25 and 29 basis points higher than the rate in pools securitized by NRFIs, and this effect is significant at the 1% level.

Table 3: Regression results. Dependent variable: weighted average mortgage rate. Additional controls: pool type, month and year of securitization, rate type, constant. Standard errors clustered by issuer in parentheses. Significance levels: *=10%, **=5%, ***=1%.

Variables	Model 3.1	Model 3.2
regul	0.289***	0.246***
	(0.081)	(0.076)
log(*avg_mortg*)	-0.041***	-0.034***
	(0.015)	(0.013)
yield_5yr_bonds	1.774***	1.646***
	(0.581)	(0.567)
subsidiary	-0.245***	-0.203**
	(0.087)	(0.083)
CU	-	0.382***
		(0.126)
IMPP	-	1.841*
		(0.962)
Observations	13,658	13,658
R-squared	0.7069	0.7120

Securitized mortgages are not exclusively highly leveraged loans. In some cases, lenders can obtain portfolio insurance in order to securitize uninsured mortgages. Since the average share of portfolio insurance in pools securitized by the regulated sector is almost four times bigger, I want to assess the impact of lower leverage on the findings described above. To this end, I run the regression models 3.1 and 3.2, excluding pools containing over 10% of portfolio securitization. The RFI effect decreases slightly (from 29 to 27 basis points for model 3.1 and from 25 to 21 basis points for model 3.2), but remains significant at the 1% level.

Finally, it is important to remember that I observe pools rather than individual mortgages. The number of mortgages in a pool varies considerably (from 1 to over 10,000) and a pool of only one mortgage has the same weight in the regression as a pool a thousand times bigger. An implication of the wide range of pool sizes is that pools are not equally representative of the distribution of mortgages. To account for this effect, I also perform a weighted least squares (WLS) estimation, which minimizes the squared residuals multiplied by the inverse of the pool size.[7] Table 4 shows the results for the regression models 3.1 and 3.2. The WSL estimation suggests a larger RFI effect (between 34 and 37 basis points), providing additional evidence of the positive interest rate spread between regulated and non-regulated financial intermediaries.

Table 4: Regression results (WLS). Dependent variable: weighted average mortgage rate. Additional controls: pool type, month and year of securitization, rate type, constant. Standard errors clustered by issuer in parentheses. Significance levels: *=10%, **=5%, ***=1%.

Variables	Model 3.1	Model 3.2
regul	0.369***	0.340***
	(0.101)	(0.107)
log(*avg_mortg*)	-0.058***	-0.053***
	(0.013)	(0.014)
yield_5yr_bonds	2.703***	2.656***
	(0.864)	(0.862)
subsidiary	-0.406***	-0.378**
	(0.114)	(0.119)
CU	-	0.256*
		(0.149)
IMPP	-	3.841*
		(1.620)
Observations	13,658	13,658
R-squared	0.7507	0.7516

[7] It is worth mentioning that the residuals from the ordinary least squares (OLS) estimation do not suggest the presence of heteroskedasticity Residuals of the OLS and WLS regressions are presented in Appendix A.

3.3 Discussion

The results presented above suggest that RFIs charge a higher rate than NRFIs. Economists have suggested numerous theories to explain why we observe different prices for seemingly homogenous products and to generate such dispersion in models. Reinganum (1979) suggests a theoretical framework based on differences in firms' marginal costs. However, there is no reason to believe that NRFIs have lower marginal costs than RFIs. NRFIs cannot finance their lending activities by accepting deposits or by borrowing from the central bank. Only RFIs have access to these cheaper sources of funds. Thus, differences in marginal costs are unlikely to explain the pricing patterns in the mortgage market.

Price dispersion can also arise because of the market structure. In a monopolistically competitive industry, such as the Canadian mortgage market, sellers may be able to price discriminate between different types of consumers. Borenstein and Rose (1991) show that pricing of airlines tickets in the U.S. is consistent with price discrimination in a monopolistically competitive industry. Allen, Clark, and Houde (2014) document the price dispersion in the Canadian mortgage market and conclude that lenders set prices based on the relative bargaining power or negotiation ability of consumers.

Other authors generate price dispersion through differences in information across consumers. In the model of Wilde and Schwartz (1979), consumers differ in their willingness to shop for the best price, and some consumers only observe one price. According to Salop and Stiglitz (1977), acquiring information is costly and the cost of becoming perfectly informed differs across consumers. Information heterogeneity can also arise ex post as in Burdett and Judd (1983), who show that an equilibrium with price dispersion exists if there is a non-zero probability that some consumers observe only one price. Carlson and McAfee (1983) develop a model of equilibrium price dispersion due to heterogeneity in consumers' search costs and firms' costs that generates testable predictions. Dahlby and West (1986) use Carlson and McAfee's (1983) model to show that a costly consumer search explains the price dispersion in the automobile insurance market. More empirical evidence of price dispersion due to a costly consumer search is presented by Sorensen (2000), who looks at the market for prescription drugs. He finds that drugs for chronic conditions that must be purchased frequently exhibit less price dispersion than other drugs for which consumers have less of an incentive to shop for a better price.

Heterogeneity in consumers' search costs can explain the pricing pattern described above. Mortgages are complex loans and the whole process associated with the purchase of a home can be very intimidating for some households. As the findings of Allen, Clark, and Houde (2014) show, the cost of obtaining multiple quotes is high for some households and they may limit their search to their primary financial institution. For other households who feel more comfortable with financial negotiation, or who hire a broker, the cost of searching for the best quote is smaller and they are more likely to observe prices from both types of financial intermediaries. If NRFIs mostly serve consumers with lower search costs, they have to offer better rates. Moreover, since consumers with lower search costs typically observe more prices, the equilibrium price dispersion should be lower in the non-regulated sector.

In what follows, I assume that regulated and non-regulated financial intermediaries face a different demand function. In particular, the demand faced by NRFIs is more elastic, which is an implication of lower search costs.

4 Model Description

Building on the empirical evidence presented above, I develop a DSGE model featuring regulated and non-regulated financial intermediaries. RFIs accept deposits from patient households and issue loans. They also purchase securities sold by NRFIs.[8] These securities are the only source of funds for the NRFIs; in other words, they originate-to-distribute.

In order to have an interest rate differential, I assume that the demand faced by NRFIs is more elastic than the demand faced by RFIs. A loan aggregator combines loans issued by regulated and non-regulated financial intermediaries to create a composite lending product for impatient households. This assumption allows the two sectors to coexist despite the difference in in-

[8] In Canada, banks own most of the NHA MBS issued by NRFIs because they are considered high-quality assets by the OSFI in the calculation of their minimum level of capital.

terest rates. As in Iacoviello (2005), heterogeneity among households ensures a positive flow of funds between lenders (patient households) and borrowers (impatient households) in equilibrium.

In what follows, upper case letters represent nominal variables and lower case letters represent real variables. Let x_t and X_t be, respectively, the real and nominal levels of the same variable. In general, we have $x_t \equiv \frac{X_t}{P_t}$, where P_t is the aggregate price level in the economy.

4.1 Regulated Financial Intermediaries

I base the regulated sector on the banking model of Gerali et al. (2010). They model the banking sector as a monopolistically competitive industry, an assumption consistent with the findings of Allen and Liu (2007) and Allen and McVanel (2009) on the market structure of the Canadian banking industry.

Banks offer differentiated services, giving them market power over their deposit and lending rates. Each RFI is divided into three units: (i) the headquarters in charge of managing the bank capital, (ii) a deposit branch, and (iii) a loan branch.

4.1.1 Headquarters

Let $i \in [0,1]$ be the index of NRFIs. The headquarters manages the bank capital $K_t^B(i)$ and makes decisions about the total amount of securities $B_t(i)$ to purchase from NRFIs, deposits $D_t(i)$ to accept, and loans $L_t^R(i)$ to issue in order to maximize the discounted[9] real cash flows:

$$\max_{L_\tau^R, B_\tau, D_\tau} E_t \sum_{\tau=t}^{\infty} \beta_P^{\tau-t} \frac{\lambda_\tau^P}{\lambda_t^P} \left(cashflow_\tau\right),$$

subject to the following balance sheet identity:

$$L_t^R(i) + B_t(i) = D_t(i) + K_t^B(i). \tag{4.1}$$

[9] Patient households own all the firms and financial intermediaries in the model, so future cash flows are discounted at the representative patient household's discount rate.

Let P_t represent the aggregate price level, R_t^W the (gross) wholesale lending rate, R_t^B the return on securities, and R_t^F the financing cost of RFIs in the wholesale market. The one-period cash flow is:

$$\begin{aligned} cashflow_t &= (1+R_{t-1}^W)\frac{L_{t-1}^R(i)}{P_t} + (1+R_{t-1}^B)\frac{B_{t-1}(i)}{P_t} - (1+R_{t-1}^F(i))\frac{D_{t-1}(i)}{P_t} \\ &\quad + \frac{D_t(i)}{P_t} - \frac{L_t^R(i)}{P_t} - \frac{B_t(i)}{P_t} + \left(\frac{K_t^B(i)}{P_t} - \frac{K_{t-1}^B(i)}{P_t}\right) - adj\_cost_t^{HQ}(i), \end{aligned}$$

where $adj\_cost_t^{HQ}(i)$ is a quadratic adjustment cost faced by the headquarters. More specifically, the headquarters faces a cost whenever the capital-to-assets ratio deviates from ν, the capital requirement (capital adequacy ratio) imposed by the regulatory authority:

$$adj\_cost_t^{HQ}(i) = \frac{\kappa_{kB}}{2}\left(\frac{K_t^B(i)}{\nu_l L_t^R(i) + (1-\nu_l)B_t(i)} - \nu\right)^2 \frac{K_t^B(i)}{P_t}. \quad (4.2)$$

The parameter ν_l represents the relative weight of loans in the calculation of the leverage ratio. In Canada, the weight on NHA MBS securities is zero, so we can rewrite the adjustment cost (4.2) more simply as:

$$adj\_cost_t^{HQ}(i) = \frac{\kappa_{kB}}{2}\left(\frac{K_t^B(i)}{L_t^R(i)} - \nu\right)^2 \frac{K_t^B(i)}{P_t}. \quad (4.3)$$

The inflation rate is defined as $\pi_t \equiv \frac{P_t}{P_{t-1}}$. The optimal choices of the headquarters lead to the following conditions:

$$R_t^W - R_t^F = -\kappa_{kB} E_t \frac{\lambda_t^P}{\lambda_{t+1}^P}\frac{\pi_{t+1}}{\beta_P}\left(\frac{K_t^B(i)}{L_t^R(i)} - \nu\right)\left(\frac{K_t^B(i)}{L_t^R(i)}\right)^2 \quad (4.4)$$

and

$$R_t^W - R_t^B = -\kappa_{kB} E_t \frac{\lambda_t^P}{\lambda_{t+1}^P}\frac{\pi_{t+1}}{\beta_P}\left(\frac{K_t^B(i)}{L_t^R(i)} - \nu\right)\left(\frac{K_t^B(i)}{L_t^R(i)}\right)^2. \quad (4.5)$$

Following Gerali et al. (2010), I assume that RFIs can always borrow from the central bank at the policy rate R_t. As a result, we can rewrite (4.4) as:

$$R_t^W - R_t = -\kappa_{kB} E_t \frac{\lambda_t^P}{\lambda_{t+1}^P}\frac{\pi_{t+1}}{\beta_P}\left(\frac{K_t^B(i)}{L_t^R(i)} - \nu\right)\left(\frac{K_t^B(i)}{L_t^R(i)}\right)^2. \quad (4.6)$$

According to equation (4.6), if the capital-to-asset ratio is too low, for instance, because of a fall in the real value of bank capital, there are upward pressures on the wholesale lending rate R_t^W causing a decline in the volume of loans issued.

By combining equations (4.5) and (4.6), we find that

$$R_t^B = R_t. \tag{4.7}$$

In other words, RFIs purchase securities until the return earned (R_t^B) is equal to the cost of funds (R_t).

4.1.2 Deposit Branch

The monopolistically competitive structure of the regulated financial sector implies that patient households hold a portfolio of deposits. They allocate their total deposits D_t across all RFIs to maximize the total return on their savings. The aggregation of deposits follows the Dixit-Stiglitz technology:

$$D_t = \left(\int_0^1 D_t(i)^{\frac{\epsilon_D - 1}{\epsilon_D}} di \right)^{\frac{\epsilon_D}{\epsilon_D - 1}}, \tag{4.8}$$

where ϵ_D is the elasticity of substitution between deposits at different institutions. The demand for deposits faced by an RFI ($D_t(i)$) depends on the total volume of deposits (D_t), the RFI's rate on deposits ($R_t^D(i)$) compared with the composite rate (R_t^D), and the elasticity of substitution (ϵ_D):

$$D_t(i) = D_t \left(\frac{R_t^D(i)}{R_t^D} \right)^{-\epsilon_D}. \tag{4.9}$$

The composite rate R_t^D is thus given by:

$$R_t^D = \left(\int_0^1 R_t^D(i)^{1-\epsilon_D} di \right)^{\frac{1}{1-\epsilon_D}} \tag{4.10}$$

The deposit branch sets $R_t^D(i)$ to maximize the flow of net earnings:

$$\max_{R_\tau^D(i)} E_t \sum_{\tau=t}^{\infty} \beta_P^{\tau-t} \frac{\lambda_\tau^P}{\lambda_t^P} \left[(R_\tau - R_\tau^D(i) \frac{D_\tau(i)}{P_\tau} - adj\_cost_t^{RD}(i) \right],$$

subject to the demand (4.9) and a quadratic adjustment cost (in real terms):

$$adj\_cost_t^{RD}(i) = \frac{\kappa_{RD}}{2}\left(\frac{R_t^D(i)}{R_{t-1}^D(i)} - 1\right)^2 R_t^D(i)\frac{D_t(i)}{P_t}.$$

Once we perform a first-order Taylor expansion of the optimal $R_t^D(i)$ around its steady state value, we obtain:

$$\hat{R}_t^D(i) = \Phi_1^{RD}\hat{R}_t + \Phi_2^{RD}\hat{R}_{t-1}^D + \Phi_3^{RD}E_t\hat{R}_{t+1}^D, \tag{4.11}$$

where a hatted variable represents the percentage deviation from this variable's steady state. Gerali et al. (2010) and Kwapil and Scharler (2010) cite empirical evidence of incomplete monetary policy pass-through to motivate the interest rate stickiness. Along the lines of Kwapil and Scharler (2010), $\Phi_1^{RD} \equiv \frac{(1-\epsilon_D)}{1-\epsilon_D+\kappa_{RD}(1+\beta_P)}$ represents the immediate pass-through or the fraction of a change in the policy rate that is transferred contemporaneously to the deposit rate. In the absence of adjustment costs, the deposit rate is a constant markup over the policy rate:

$$R_t^D(j) = \frac{\epsilon_D}{\epsilon_D - 1}R_t. \tag{4.12}$$

4.1.3 Loan Branch

The problem of the loan branch is analogous to the one of the deposit branch. Loans issued by RFIs are aggregated according to:

$$L_t^R = \left(\int_0^1 L_t^R(i)^{\frac{\epsilon_R-1}{\epsilon_R}}di\right)^{\frac{\epsilon_R}{\epsilon_R-1}}, \tag{4.13}$$

where ϵ_R is the elasticity of substitution between loans at different RFIs. The demand for loans faced by an RFI ($L_t^R(i)$) depends on the volume of loans issued by the regulated sector (L_t^R), the RFI's lending rate ($R_t^R(i)$) compared with the composite rate (R_t^R), and the elasticity of substitution (ϵ_R):

$$L_t^R(i) = L_t^R\left(\frac{R_t^R(i)}{R_t^R}\right)^{-\epsilon_R}. \tag{4.14}$$

The composite rate R_t^R is:

$$R_t^R = \left(\int_0^1 R_t^R(i)^{1-\epsilon_R}di\right)^{\frac{1}{1-\epsilon_R}}. \tag{4.15}$$

The loan branch sets $R_t^R(i)$ to maximize the flow of net earnings:

$$\max_{R_\tau^R(i)} E_t \sum_{\tau=t}^{\infty} \beta_P^{\tau-t} \frac{\lambda_\tau^P}{\lambda_t^P} \left[(R_\tau^R(i) - R_\tau^W) \frac{L_\tau^R(i)}{P_\tau} - adj\_cost_\tau^{RR}(i) \right],$$

subject to the demand (4.14) and a quadratic adjustment cost (in real terms):

$$adj\_cost_t^{RR}(i) = \frac{\kappa_{RR}}{2} \left(\frac{R_t^R(i)}{R_{t-1}^R(i)} - 1 \right)^2 R_t^R(i) \frac{L_t^R(i)}{P_t}.$$

Again, the adjustment cost means that there is an incomplete contemporaneous pass-through between the cost of funds in the wholesale market R_t^W and the lending rate of a regulated financial intermediary $R_t^R(i)$. The first-order approximation around the steady state can be written as:

$$\hat{R}_t^R(i) = \Phi_1^{RR} \hat{R}_t^W + \Phi_2^{RR} \hat{R}_{t-1}^R + \Phi_3^{RR} E_t \hat{R}_{t+1}^R. \quad (4.16)$$

4.1.4 Bank Capital

An RFI retains earnings to increase its bank capital $K_t^B(i)$. Let $J_t^B(i)$ represent the total profit from the three branches, net of all adjustment costs:

$$\begin{aligned} \frac{J_t^B(i)}{P_t} &= R_t^R(i) \frac{L_t^R(i)}{P_t} + R_t^B \frac{B_t(i)}{P_t} - R_t^D(i) \frac{D_t(i)}{P_t} \\ &\quad - adj\_cost_t^{HQ}(i) - adj\_cost_t^{RD}(i) - adj\_cost_t^{RR}(i). \end{aligned} \quad (4.17)$$

Following Gerali et al. (2010), I assume that the RFI retains all of the profits. Under this assumption, the law of motion of bank capital is:

$$K_t^B(i) = (1 - \delta_{KB}) \frac{K_{t-1}^B(i)}{\eta_t^{KB}} + J_{t-1}^B(i), \quad (4.18)$$

where δ_{KB} represents the cost of managing the bank capital and η_t^{KB} is a perturbation affecting the value of the bank capital. The perturbation evolves according to:

$$\eta_t^{KB} = e^{z_t^{KB}} \quad (4.19)$$

$$z_t^{KB} = \rho_{KB} z_{t-1}^{KB} + \varepsilon_t^{KB}, \quad (4.20)$$

where ε_t^{KB} is a zero-mean normally distributed financial shock with standard deviation σ_{KB}.

4.2 Non-Regulated Financial Intermediaries

A continuum of NRFIs owned by patient households forms the non-regulated sector. NRFIs issue loans, but in contrast to RFIs, they do not face a capital requirement and cannot finance their lending with deposits or borrow from the central bank. Instead, they issue securities and sell them to RFIs. I assume that the market for those securities is perfectly competitive, but the market for loans is monopolistically competitive. This assumption follows Verona, Martins, and Drummond (2013), who model their shadow sector as monopolistically competitive in the lending market, but perfectly competitive in the market for financing.

Let $j \in [0,1]$ be the index of NRFIs and L_t^{NR} be the total amount of loans issued by the non-regulated sector given by:

$$L_t^{NR} = \left(\int_0^1 L_t^{NR}(j)^{\frac{\epsilon_{NR}-1}{\epsilon_{NR}}} dj \right)^{\frac{\epsilon_{NR}}{\epsilon_{NR}-1}}. \tag{4.21}$$

The composite lending rate in the non-regulated sector is:

$$R_t^{NR} = \left(\int_0^1 R_t^{NR}(j)^{1-\epsilon_{NR}} dj \right)^{\frac{1}{1-\epsilon_{NR}}}. \tag{4.22}$$

The parameter ϵ_{NR} represents the elasticity of substitution in the non-regulated sector. I assume $\epsilon_{NR} > \epsilon_R$ meaning that the demand in the non-regulated sector is more price-elastic than in the regulated sector. A direct implication of this assumption is that the interest rate is lower in the non-regulated sector in steady state.

Each NRFI sets its lending rate $R_t^{NR}(j)$ to maximize the flow of earnings:

$$\max_{R_\tau^{NR}(j)} E_t \sum_{t=\tau}^{\infty} \beta_P^{\tau-t} \frac{\lambda_\tau^P}{\lambda_t^P} \left[R_\tau^{NR}(j) \frac{L_\tau^{NR}(j)}{P_\tau} - R_\tau^B \frac{B_\tau(j)}{P_\tau} - adj\_cost_\tau^{RNR}(j) \right],$$

subject to the demand for loans:

$$L_t^{NR}(j) = L_t^{NR} \left(\frac{R_t^{NR}(j)}{R_t^{NR}} \right)^{-\epsilon_{NR}}; \tag{4.23}$$

a balance sheet identity:

$$L_t^{NR}(j) = B_t(j); \tag{4.24}$$

and a quadratic adjustment cost:

$$adj\_cost_t^{RNR}(j) = \frac{\kappa_{RNR}}{2}\left(\frac{R_t^{NR}(j)}{R_{t-1}^{NR}(j)} - 1\right)^2 R_t^{NR}(j)\frac{L_t^{NR}(j)}{P_t}.$$

In the absence of adjustment costs ($\kappa_{RNR} = 0$), the rate chosen by an NRFI is a constant markup over the return it has to pay on securities:

$$R_t^{NR}(j) = \frac{\epsilon_{NR}}{\epsilon_{NR} - 1} R_t^B. \tag{4.25}$$

From (4.7) and (4.12), we know that the deposit rate is below the policy rate and that the return on securities is equal to the policy rate. This means that the cost of raising funds is higher for NRFIs than it is for RFIs. Nonetheless, the interest rate is lower in the non-regulated sector in steady state.

4.3 Loan Aggregator

A perfectly competitive loan aggregator owned by patient households possesses the technology to combine loans issued by both types of financial intermediaries and create a composite loan L_t for impatient households:

$$L_t = \left(\tau^{\frac{1}{\epsilon_L}} L_t^{R\,\frac{\epsilon_L - 1}{\epsilon_L}} + (1-\tau)^{\frac{1}{\epsilon_L}} L_t^{NR\,\frac{\epsilon_L - 1}{\epsilon_L}}\right)^{\frac{\epsilon_L}{\epsilon_L - 1}}. \tag{4.26}$$

The parameter ϵ_L represents the elasticity of substitution between loans from the regulated and the non-regulated sectors and τ is the relative weight on loans issued by RFIs in the loan aggregation. This parameter allows me to control the relative size of the non-regulated sector in steady state.

Given the equilibrium household lending rate R_t^L, the problem of the aggregator consists in choosing how much to borrow from each sector to maximize the cash flow:

$$\max_{L_t^R, L_t^{NR}} \left[(1 + R_t^L)L_t - (1 + R_t^R)L_t^R - (1 + R_t^{NR})L_t^{NR}\right];$$

subject to the technology (4.26). The optimal demands for loans from each sector are given by:

$$L_t^R = \tau L_t \left(\frac{1 + R_t^R}{1 + R_t^L}\right)^{-\epsilon_L} \tag{4.27}$$

and

$$L_t^{NR} = (1-\tau)L_t \left(\frac{1+R_t^{NR}}{1+R_t^L}\right)^{-\epsilon_L}. \tag{4.28}$$

The effective rate faced by impatient households is:

$$(1+R_t^L)^{(1-\epsilon_L)} = \tau(1+R_t^R)^{(1-\epsilon_L)} + (1-\tau)(1+R_t^{NR})^{(1-\epsilon_L)}. \tag{4.29}$$

4.4 Patient Households

As in Iacoviello (2005) and Gerali et al. (2010), patient households are the ultimate lenders in my model. Let $k \in [0,1]$ be the index of patient households. In each period, a patient household chooses savings (bank deposits $D_t(k)$ and investment in physical capital $i_t^k(k)$) and their consumption of goods ($c_t^P(k)$) and housing ($h_t^P(k)$) to maximize the following intertemporal utility function:

$$\max_{D_\tau(k), i_\tau^k(k), c_\tau^P(k), h_\tau^P(k)} E_t \sum_{\tau=t}^{\infty} \beta_P^{\tau-t} \left[\log\left(c_\tau^P(k) - \gamma c_{\tau-1}^P(k)\right) + \phi_h \eta_\tau^h \log h_\tau^P(k) - \frac{n_\tau^P(k)^\sigma}{\sigma}\right],$$

where $n_t^P(k)$ represents the labour supply and η_t^h is a perturbation affecting the relative demand for housing evolving according to:

$$\eta_t^h = e^{z_t^h} \tag{4.30}$$

$$z_t^h = \rho_h z_{t-1}^h + \varepsilon_t^h. \tag{4.31}$$

The preference shock ε_t^h has a zero mean and standard deviation σ_h.

The stocks of physical capital $k_t(k)$ and housing $h_t^P(k)$ are both subject to depreciation and installation costs. Let q_t^k and q_t^h represent respectively the real prices of capital and housing (in terms of the final good). The real total spending on physical capital and housing are given by:

$$q_t^k\left(k_t(k) - (1-\delta_k)k_{t-1}(k)\right) + \frac{\phi_k}{2}\left(\frac{k_t(k)}{k_{t-1}(k)} - 1\right)^2 q_t^k k_{t-1}(k)$$

and

$$q_t^h\left(h_t(k) - (1-\delta_h)h_{t-1}(k)\right) + \frac{\phi_h}{2}\left(\frac{h_t^P(k)}{h_{t-1}^P(k)} - 1\right)^2 q_t^h h_{t-1}^P(k).$$

On the income side of the budget constraint, a patient household earns a return r_t^k on each unit of capital rented to firms and R_{t-1}^D on the deposits from the previous period. Each household supplies a differentiated labour service, giving them market power over their nominal wage $W_t^P(k)$. In each period, a household faces a constant probability $(1-\varphi_w)$ of being able to update the nominal wage subject to the demand for their labour service:

$$n_t^P(k) = n_t^P \left(\frac{W_t^P(k)}{W_t^P}\right)^{-\epsilon_P}, \tag{4.32}$$

where n_t^P is the aggregate labour supply of patient households, W_t^P is the wage index of patient households (defined below), and ϵ_P is the elasticity of substitution between the different types of labour. Let $w_t^{P*}(k) \equiv \frac{W_t^{P*}(k)}{P_t}$ be the real wage chosen by a household re-optimizing at time-t:

$$w_t^{P*}(k) = \frac{\epsilon_P}{\epsilon_P - 1} \frac{E_t \sum_{\tau=t}^{\infty} (\beta_P \varphi_w)^{\tau-t} \left(n_\tau^P(k)\right)^\sigma}{E_t \sum_{\tau=t}^{\infty} (\beta_P \varphi_w)^{\tau-t} \lambda_\tau^P(k) n_\tau^P(k) \Pi_{s=1}^{\tau} \pi_s{}^{-1}}, \tag{4.33}$$

where $\lambda_t^P(k)$ is the Lagrange multiplier on the budget constraint. In a symmetric equilibrium, without loss of generality, we have $w_t^{P*} = w_t^{P*}(k)$, and the real wage index of patient households is defined as:

$$w_t^P = \left[\varphi_w \left(\frac{w_{t-1}^P}{\pi_t}\right)^{1-\epsilon_P} + (1-\varphi_w) w_t^{P*1-\epsilon_P}\right]^{\frac{1}{1-\epsilon_P}}. \tag{4.34}$$

4.5 Impatient Households

The economy is also populated by a continuum of impatient households that do not own any physical capital and have a lower discount rate than patient households. As Iacoviello (2005) explains, this assumption ensures that there is a strictly positive flow of funds between lenders (patient households) and borrowers (impatient households) in steady state. Let $l \in [0,1]$ be the index of impatient households. In each period, an impatient household chooses consumption $c_t^I(l)$, housing $h_t^I(l)$, and loans $L_t(l)$ to maximize their lifetime utility:

$$\max_{c_\tau^I(l), h_\tau^I(l), L_\tau(l)} E_t \sum_{\tau=t}^{\infty} \beta_I^{\tau-t} \left[\log\left(c_\tau^I(l) - \gamma c_{\tau-1}^I(l)\right) + \phi_h \eta_\tau^h \log h_\tau^I(l) - \frac{n_\tau^I(l)^\sigma}{\sigma}\right],$$

subject to the budget constraint:

$$\frac{W_t^I(l)}{P_t}n_t^I(l) + \frac{L_t(l)}{P_t} = c_t^I(l) + (1 + R_{t-1}^L)\frac{L_{t-1}(l)}{P_t}$$
$$+ q_t^h\left(h_t^I(l) - (1-\delta_h)h_{t-1}^I(l) + \frac{\phi_h}{2}\left(\frac{h_t^I(l)}{h_{t-1}^I(l)} - 1\right)^2 h_{t-1}^I(l)\right) \quad (4.35)$$

and a borrowing constraint:

$$\frac{L_t(l)}{P_t} \leq \rho_b\frac{L_{t-1}(l)}{P_t} + (1-\rho_b)mq_t^h h_t^I(l). \quad (4.36)$$

The parameter m in the borrowing constraint represents the maximum loan-to-value ratio set by the regulatory authority. Along the lines of Iacoviello (2015), the borrowing constraint exhibits inertia to reflect the fact that lending criteria do not change every quarter. The rest of the problem of an impatient household, in particular the wage setting decision, is analogous to the problem of a patient household.

4.6 Production of Goods

A competitive final good producer assembles intermediate goods according to the technology:

$$y_t = \left(\int_0^1 y_t(m)^{\frac{\epsilon_y - 1}{\epsilon_y}} dm\right)^{\frac{\epsilon_y}{\epsilon_y - 1}}, \quad (4.37)$$

where $y_t(m)$ with $m \in [0,1]$ represents one of the intermediate goods, and ϵ_y is the elasticity of substitution between the intermediate goods. Let $P_t(m)$ be the price of the intermediate good $y_t(m)$ and P_t the price of the final good (and the aggregate price level). The demand for $y_t(m)$ is:

$$y_t(m) = y_t(\frac{P_t(m)}{P_t})^{-\epsilon_y}, \quad (4.38)$$

and the aggregate price level is:

$$P_t = \left(\int_0^1 P_t(m)^{1-\epsilon_y} dm\right)^{\frac{1}{1-\epsilon_y}}. \quad (4.39)$$

Intermediate goods are produced by monopolistically competitive firms that hire both types of households and rent physical capital. The technology to produce intermediate good $y_t(m)$ is:

$$y_t(m) = A_t k_{t-1}(m)^{\alpha} \left(h_t^P(m)^{\theta} h_t^I(m)^{1-\theta} \right)^{(1-\alpha)}, \tag{4.40}$$

where A_t is the total factor productivity evolving according to:

$$A_t = e^{z_t^A} \tag{4.41}$$
$$z_t^A = \rho_A z_{t-1}^A + \varepsilon_t^A. \tag{4.42}$$

ε_t^A is a zero-mean technology shock with standard deviation σ_A.

In each period, the producer of an intermediate good chooses the optimal level of inputs $k_{t-1}(m)$, $n_t^P(m)$, and $n_t^I(m)$ to maximize the discounted sum of real profits:

$$\max_{k_{t-1}(m), n_t^P(m), n_t^I(m)} E_t \sum_{\tau=t}^{\infty} \beta_P^{\tau-t} \frac{\Lambda_\tau^P}{\Lambda_t^P} \left(\frac{P_t(m)}{P_t} y_t(m) - w_t^P n_t^P(m) - w_t^I n_t^I(m) - r_t^k k_{t-1}(m) \right),$$

subject to the demand (4.38) and the technology (4.40).

Because of the monopolistically competitive market structure, producers of intermediate goods have market power over their price $P_t(m)$. Each producer faces a constant probability φ_p of being able to update its price in any given period. Let $p_t(m)^* \equiv \frac{P_t(m)^*}{P_t}$ be the relative optimal price given by:

$$p_t(m)^* = \frac{\epsilon_y}{\epsilon_y - 1} \frac{E_t \sum_{\tau=t}^{\infty} (\beta_P \varphi_p)^{\tau-t} \lambda_\tau^P s_\tau(m) y_\tau(m)}{E_t \sum_{\tau=t}^{\infty} (\beta_P \varphi_p)^{\tau-t} \lambda_\tau^P y_\tau(m) \left(\Pi_{s=t+1}^{\tau} \pi_s \right)^{-1}}, \tag{4.43}$$

where $s_t(m)$ is the real marginal cost of the producer. Without loss of generality, we have $p_t{}^* = p_t(m)^*$ and can re-write the aggregate price index (4.39) as:

$$P_t = \varphi_p P_{t-1}^{1-\epsilon_y} + (1 - \varphi_p) P_t^{*1-\epsilon_y}. \tag{4.44}$$

Using the definition of inflation, we have:

$$1 = \varphi_p \left(\frac{1}{\pi_t} \right)^{1-\epsilon_y} + (1 - \varphi_p) p_t^{*1-\epsilon_y}. \tag{4.45}$$

4.7 Housing and Capital Producers

Following Alpanda, Cateau, and Meh (2014), competitive firms owned by patient households produce housing and physical capital. At the end of each period, a housing producer (capital producer) purchases all of the undepreciated stock of housing (capital) at the current real market price q_t^h (q_t^k), combines it with i_t^h (i_t^k) units of the final good, and resells the new stock to households.

The problem of a housing producer is to choose its level of investment i_t^h to maximize profits:

$$E_t \sum_{\tau=t}^{\infty} \beta_P^{\tau-t} \frac{\lambda_\tau^P}{\lambda_t^P} \left[q_\tau^h h_\tau - q_\tau^h (1-\delta_h) h_{\tau-1} - i_t^h \right],$$

subject to the law of motion for the aggregate stock of housing:

$$h_t = (1-\delta_h) h_{t-1} + \left[1 - \frac{\kappa_h}{2} \left(\frac{i_t^h}{i_{t-1}^h} - 1 \right)^2 \right] i_t^h. \tag{4.46}$$

Similarly, the capital producer chooses the level of investment in physical capital i_t^k to maximize:

$$E_t \sum_{\tau=t}^{\infty} \beta_P^{\tau-t} \frac{\lambda_\tau^P}{\lambda_t^P} \left[q_\tau^k k_\tau - q_\tau^k (1-\delta_k) k_{\tau-1} - i_t^k \right],$$

subject to:

$$k_t = (1-\delta_k) k_{t-1} + \left[1 - \frac{\kappa_k}{2} \left(\frac{i_t^k}{i_{t-1}^k} - 1 \right)^2 \right] i_t^k. \tag{4.47}$$

4.8 Closing the Model

The monetary authority adjusts the policy rate R_t in response to deviations of inflation from its steady state level (π) and output growth:

$$\frac{1+R_t}{1+R} = \left(\frac{1+R_{t-1}}{1+R} \right)^{\chi_R} \left(\left[\frac{\pi_{t-1}}{\pi} \right]^{\mu_\pi} \left[\frac{y_t}{y_{t-1}} \right]^{\mu_y} \right)^{1-\chi_R} \eta_t^R. \tag{4.48}$$

R represents the steady state interest rate and η_t^R is a perturbation evolving according to:

$$\eta_t^R = e^{z_t^R} \tag{4.49}$$
$$z_t^R = \rho_R z_{t-1}^R + \varepsilon_t^R, \tag{4.50}$$

where the monetary policy shock ε_t^R has a zero-mean and a standard deviation σ^R.

In a symmetric equilibrium, the prices and allocation of resources maximize the utility of all households and profits of all financial intermediaries and firms subject to their respective constraints. All agents of a given type make the same decisions and all markets clear. In particular, we have the following market clearing conditions for the final good:

$$y_t = c_t^P + c_t^I + i_t^k + i_t^h \tag{4.51}$$

and the housing market:

$$h_t = h_t^P + h_t^I. \tag{4.52}$$

4.9 Calibration and Solution of the Model

The parameters are calibrated to represent the Canadian economy. A complete list of all parameters and their value can be found in Appendix B.

The parameter τ representing the weight on loans from the regulated sector in the loan aggregation technology (4.26) is one of the key parameters. I set its value to target different relative sizes of the regulated sector in the simulations. The elasticity of substitution between regulated and non-regulated loans in the aggregation, ϵ_L, is arbitrarily large, to capture the fact that there is very little difference between the two types of loans beyond the interest rate.

Using equation (4.12), I set the elasticity of substitution of demand for deposits, ϵ_D, to match the average ratio of the rate on 90-day term deposits to the return on 5-year government bonds between 1995 and 2015. Similarly, ϵ_R targets the ratio of 5-year conventional mortgage rates of chartered banks to the return on 5-year government bonds. I choose the value of the elasticity of demand in the non-regulated sector, ϵ_{NR}, to have a steady state annual spread of 25 basis points between the regulated and the non-regulated sector. I assume interest rate stickiness in the regulated sector only and I set the adjustment cost parameters to have an immediate pass-through of 85% on the deposit rate and 35% on the lending rate.

I assume a very high cost of deviating from the capital requirement (κ_{KB}) and set the value of the parameter δ_{KB} representing the cost of managing the bank capital to have a steady-state bank capital-to-loan ratio of 8.5%, a value consistent with the rules of the OSFI. The maximum LTV ratio, m, is 0.9 – which is the maximum LTV ratio for refinancing in Canada – and ρ_b is set to 0.85.

The discount rate of patient households is consistent with the average 90-day term deposit rates between 1995 and 2016, and the discount rate of impatient households ensures a positive flow of funds between lenders and borrowers in steady state. I set σ to 1.01, a standard value. To calibrate ϕ_h, the weight on housing in the the utility function, and θ, the share of patient households in the production function, I target ratios presented in Alpanda, Cateau, and Meh (2014) (share of housing investment in total output and share of impatient households in housing).

The housing and capital production adjustment costs, κ_h and κ_k, are set respectively to 5 and 2.5 and the depreciation rate of capital and housing, δ_k and δ_h, are set to match the steady-state capital-to-output and housing-to-output they report.

The weights in the Taylor rule are from Alpanda, Cateau, and Meh (2014). Three parameters (habit persistence parameter γ and installation costs parameters ψ_h and ψ_k), as well as the autocorrelation coefficients and standard deviations for the four shocks, are estimated using Bayesian techniques. The priors are based on those of Iacoviello and Neri (2010). The model is log-linearized and solved using Dynare. A comparison of the simulated second moments of the model with the data is available in Appendix C.

5 Simulations

In this section, I analyze the impact of the relative size of the non-regulated sector on the responses of the economy to real and financial shocks. More specifically, I compare the impulse response functions of economies that differ only with respect to the value of the parameter τ, the weight on the regulated sector in the loan aggregation technology.

In the benchmark economy, $\tau = 0.85$, which means the relative share of non-regulated intermediaries is around 15%, in line with their estimated market share in recent years. I compare this benchmark with two more extreme cases: an economy with a very small non-regulated sector ($\tau = 0.95$) and an economy in which the non-regulated sector dominates ($\tau = 0.1$). The size of the shocks is one standard deviation and the sign is chosen to tighten the capital requirement of RFIs. All figures can be found in Appendix D.

5.1 Financial Shock

The financial shock (see Figure 4) decreases the real value of the bank capital and affects the ability of RFIs to lend to households, causing upward pressures on the lending rate. Borrowers are forced to cut borrowing, housing investment and consumption. Lenders, in contrast, increase their level of consumption and investment because prices fell, mitigating the effects of the shock. Overall, output, inflation, the real price of housing, and aggregate consumption all decrease on impact.

In order to rebuild the loss capital, RFIs increase their lending rate and purchase more securities. This allows the NRFIs to expand their balance sheet and moderate the drop in aggregate lending that we would otherwise observe. In other words, NRFIs alleviate the impact of a shock affecting the banking system by providing an alternative source of funds to borrowers.

5.2 Technology Shock

The impulse response functions in Figure 5 present a one standard deviation shock increasing the total factor productivity. The estimated autocorrelation coefficient of the disturbance affecting the total factor productivity is close to one, which implies very high persistence of the technology shock.

On impact, output rises and capital investment becomes more appealing to lenders. Low inflation leads to a lower policy rate and the borrowers' lending rate falls, in particular in economies with a large non-regulated sector. As income rises, households demand more consumption goods and housing, and the demand for credit rises. However, since aggregate demand rises, inflation pressures lead to an increase in the policy rate. Since the interest rate in the non-regulated sector follows more closely the policy rate, it becomes more attractive to borrow from RFIs than from NRFIs.

5.3 Preference Shock

The impulse response functions to the preference shock in Figure 6 present an increase in the relative preference for housing for both types of households. As we could expect, output, inflation, the real price of housing, and aggregate lending all increase in response to the shock. The impact of the shock on housing investment and aggregate lending (or household debt) is very persistent.

The policy rate increases in response to higher inflation, causing an increase in lending rates, in particular in the non-regulated sector, which is more sensitive to movements in the policy rate. For this reason, we observe a change in the composition of lending in favour of RFIs, but the increase in aggregate lending remains the same across all specifications. This suggests that even though the presence of NRFIs affects the composition of aggregate lending, it does not cause a larger increase in indebtedness when the demand for credit rises. It is worth pointing out that when NRFIs are relatively large, the regulated sector is not able to absorb all of the demand for credit. As a result, the balance sheet of NRFIs does not contract as much and the lending rate faced by households increases more.

5.4 Monetary Policy Shock

Figure 7 presents the responses to an unexpected policy rate cut. On impact, output, inflation, consumption, and investment rise. However, because the Taylor rule responds strongly to deviations of inflation from the steady state, rates quickly start rising. Again, since the lending rate in the non-regulated sector is very sensitive to the policy rate, we observe a change in the composition of lending. The balance sheet of NRFIs is not as affected by this recomposition when NRFIs are relatively large and it is harder for RFIs to meet the demand for credit.

5.5 Sensitivity Analysis

5.5.1 Elasticity of Substitution in Loan Aggregation

The parameter ε_L in equation (4.26) represents the elasticity of substitution between loans from each sector. In the analysis presented above, I assumed that loans issued by regulated and non-regulated financial intermediaries are almost perfect substitutes ($\varepsilon_L = 100$). To determine the impact of this assumption on the predictions of the model, I consider a case with a much lower elasticity of substitution($\varepsilon_L = 1.01$). The main implication of this change is that the volume of loans issued by regulated and non-regulated financial intermediaries will tend to move together instead of in opposite directions.

The assumption regarding the elasticity of substitution of loans matters the most when we look at the responses to a financial shock (see Figure 8). With a lower elasticity of substitution, it is harder to replace loans from RFIs with loans from NRFIs when RFIs are unable to fulfill the demand for credit. As a result, the stabilization effect of NRFIs is smaller than in the baseline calibration.[10]

5.5.2 Interest Rate Stickiness

In the baseline calibration, movements in the policy rate are transmitted to the non-regulated sector more quickly than to the regulated sector because of the adjustment costs faced by the loan and deposit branches of an RFI. In this second sensitivity analysis, I relax this assumption and assume that all financial intermediaries can adjust their rates at no cost (κ_{RR}=κ_{RR}=0). This change will affect the response of the interest rates faced by households, in particular the lending rate when RFIs dominate the market.

[10]Unless NRFIs are the most important players in the mortgage market (case with $\tau = 0.1$) because the financial shock has a negligible impact on the economy.

Figure 9 shows the impulse response functions to the negative financial shock. As we would have expected, the shock has a stronger impact on the economy, but the qualitative observations on the effects of NRFIs still hold.

In Figure 10, we can see the responses to a monetary policy shock without any interest rate adjustment costs. Interest rate stickiness affects the speed and magnitude of the recomposition of lending, but has a negligible impact on the dynamic of the main real macroeconomic variables.

6 Concluding Remarks

In this paper, I first documented the pricing differences between regulated and non-regulated issuers of insured mortgages in Canada. Then, building on these facts, I built a DSGE model with housing, household debt, and two types of financial intermediaries to analyze the impact of the rise of NRFIs in the mortgage market. In my model, regulated and non-regulated financial intermediaries differ in three ways. First, RFIs raise funds with retail deposits while NRFIs issue securities to finance their lending. Second, the demand faced by NRFIs is more elastic. This assumption implies that the interest rate on mortgages is lower in the non-regulated sector, an assumption consistent with the empirical evidence. Finally, RFIs have to hold bank capital in order to satisfy the capital requirement imposed by the regulatory authority, but NRFIs are not subject to this regulation.

The simulations suggest that NRFIs contribute to an economy's rebounding when it has been hit by a financial shock because they are able to issue more loans when the capital requirement prevents RFIs from fulfilling the demand, in particular when loans issued by the two sectors are easily substitutable.

References

[1] Allen, J., R. Clark, and J.-F. Houde. 2014. "Price Dispersion in Mortgage Markets." *The Journal of Industrial Economics.* 62(3). p.377-416.

[2] Allen, J., and Y. Liu. 2007. "A Note on Contestability in the Canadian Banking Industry." Bank of Canada Discussion Paper No. 2007-7.

[3] Allen, J., and D. McVanel. 2009. "Price Movements in the Canadian Residential Mortgage Market." Bank of Canada Working Paper No. 2009-13.

[4] Alpanda, S., G. Cateau, and C. Meh. 2014. "A Policy Model to Analyze Macroprudential Regulations and Monetary Policy." Bank of Canada Working Paper No. 2014-6.

[5] Borenstein, S., and N. L. Rose. 1991. "Competition and Price Dispersion in the U.S. Airline Industry." National Bureau of Economic Research Working Paper No. 3785.

[6] Burdett, K., and K. L. Judd. 1983. "Equilibrium Price Dispersion." *Econometrica.* 51(4). p.955-969.

[7] Carlson, J. A., and R. P. McAfee. 1983. "Discrete Equilibrium Price Dispersion." *Journal of Political Economy.* 91(3). p.480-493.

[8] CMHC. 2013. "The NHA Mortgage-Backed Securities Guide 2013." Canadian Housing and Mortgage Corporation, Ottawa.

[9] Dahlby, B., and D. S. West. 1986. "Price Dispersion in an Automobile Insurance Market." *Journal of Political Economy.* 94(2). p.418-438.

[10] Gerali, A. S. Neri, L. Sessa, and F. M. Signoretti. 2010. "Credit and Banking in a DSGE Model of the Euro Area." *Journal of Money, Credit, and Banking.* 42(6). p.107-139.

[11] Hoskins, S. M., K. Jones, and N. E. Weiss. 2013. "An Overview of the Housing Finance System in the United States." Congressional Research Service.

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

[13] Iacoviello, Matteo. 2015. "Financial Business Cycles." *Review of Economic Dynamics.* 18(1). p.140-163.

[14] Iacoviello, M., and S. Neri. 2010. "Housing Market Spillovers: Evidence from an Estimated DSGE Model." *American Economic Journal: Macroeconomics.* 2(2). p.125-164.

[15] Kiff, J., S. Mennill, and G. Paulin. 2010. "How the Canadian Housing Finance System Performed Through the Credit Crisis: Lessons for Other Markets." *Journal of Structured Finance.* 16(3). p.44-64.

[16] Kwapil, C., and J. Scharler. 2010. "Interest Rate Pass-Through, Monetary Policy Rules, and Macroeconomic Stability." *Journal of International Money and Finance.* 29. p.236-251.

[17] Reinganum, Jennifer. 1979. "A Simple Model of Equilibrium Price Dispersion." *Journal of Political Economy.* 87(4). p.851-858.

[18] Salop, S., and J. Stiglitz. 1977. "Bargains and Ripoffs: A Model of Monopolistically Competitive Price Dispersion." *The Review of Economic Studies.* 44(3). p.493-510.

[19] Sorensen, Alan T. 2000. "Equilibrium Price Dispersion in Retail Markets for Prescription Drugs." *Journal of Political Economy.* 108(4). p.833-850.

[20] Traclet, Virginie. 2010. "An Overview of the Canadian Housing Finance System." *Housing Finance International.* Autumn 2010. p.6-13.

[21] Verona, F., M. F. Martins, and I. Drumond. 2013. "(Un)anticipated Monetary Policy in a DSGE Model with a Shadow Banking System." Bank of Findland Research Discussion Papers No. 4-2013.

[22] Wilde, L. L., and A. Schwartz. 1979. "Equilibrium Comparison Shopping." *The Review of Economic Studies.* 46(3). p.543-553.

A Residuals of the Regressions

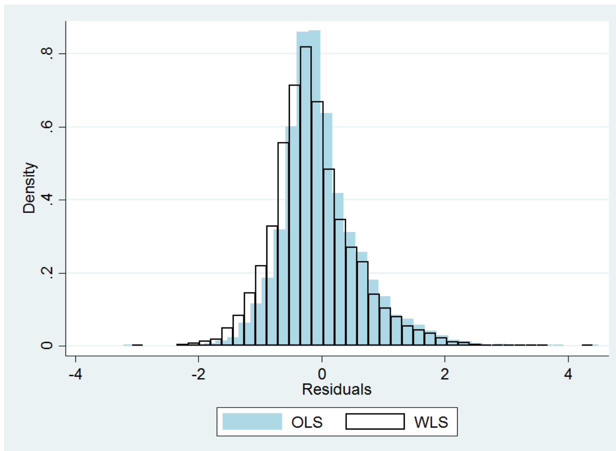


Figure 2: Residual from the regression model 3.1

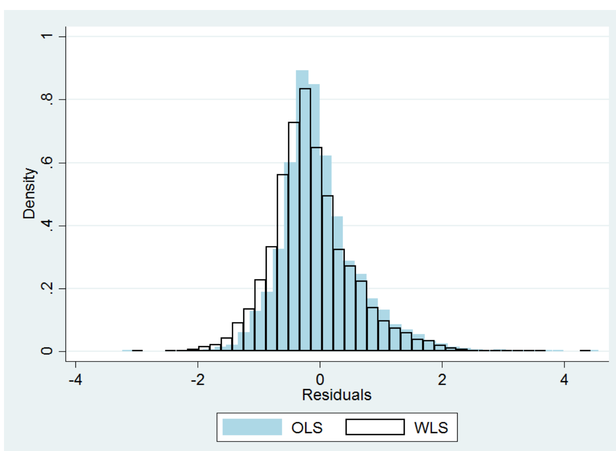


Figure 3: Residual from the regression model 3.2

B Parameter Values

Table 5: Calibrated parameters

Financial sector	
ϵ_D, ϵ_R, ϵ_{NR}, ϵ_L	-0.7038, 2.4066, 2.5381, 100
δ_{KB}	To get $\nu = 0.085$
κ_{RD}, κ_{RR}, κ_{RNR}, κ_{KB}	0.1542, 1.4192, 0.00, 25
ρ_b	0.85
τ	$\{0.1, 0.85, 0.95\}$
Preferences	
β_P, β_I	0.9962, 0.98
ϕ_h, σ	0.2, 1.01
Goods, capital, and housing sectors	
α, θ	0.35, 0.40
δ_h, δ_k	0.015, to get $k/y = 8$
κ_h,κ_k	5.00, 2.50
Pricing decisions	
ϵ_y, ϵ_P, ϵ_I	21.00, 5.00, 5.00
φ_p, φ_w	0.75, 0.60
Policy rules	
m	0.90
χ_r, μ_π, μ_y	0.75, 2.50, 0.00

Table 6: Estimated parameters

Parameter	Prior distribution	Posterior mean	Posterior median
ρ_A	Beta (0.8,0.1)	0.9976	0.9977
ρ_R	Beta (0.8,0.1)	0.7293	0.7369
ρ_{kB}	Beta (0.8,0.1)	0.3387	0.3351
ρ_h	Beta (0.8,0.1)	0.9613	0.9639
σ_A	Inv. Gamma(0.001,0.01)	0.0348	0.0346
σ_R	Inv. Gamma(0.001,0.01)	0.0020	0.0020
σ_{KB}	Inv. Gamma(0.001,0.01)	0.2524	0.2509
σ_h	Inv. Gamma(0.001,0.01)	0.1257	0.1205
γ	Beta (0.5,0.075)	0.3962	0.3933
ψ_h	Gamma (10,2.5)	5.7506	5.6901
ψ_k	Gamma (10,2.5)	7.1944	7.0788

Observed variables: consumption, investment in residential structures, deposits, and lending rate in the regulated sector. Data sources: CANSIM Tables 176-0015, 176-0043, 282-0092, 380-0066, 380-0084.

C Comparison of Empirical and Simulated Moments

Table 7: Volatility of variables relative to the volatility of output. Simulated moments are for the benchmark specification ($\tau = 0.85$)

Variable	Empirical moments	Simulated moments
y	1.00	1.00
$c^P + c^I$	0.62	0.93
i^h	3.30	1.58
i^k	5.64	1.01
${n^P}^\theta {n^I}^{1-\theta}$	0.73	0.11
d	1.42	2.72
l^R	4.84	1.34
k^B	3.05	1.88
R	12.55	9.57
R^D	62.66	9.56
R^R	5.83	4.63
π	0.18	0.04

I use the posterior mode of the estimates to compute the simulated moments. Data sources: CANSIM Tables 176-0015, 176-0043, 282-0092, 380-0066, 380-0084. Output (y) is measured as real GDP at market price; consumption ($c^P + c^I$) as households' final consumption expenditure; housing investment (i^h) as investment – residential structures; physical capital investment (i^k) as investment – non-residential structures, machinery and equipment; and employment (${n^P}^\theta {n^I}^{1-\theta}$) as total hours worked. Real deposits d, real loans from the regulated sector l^R, and real bank capital k^B are defined as (Canadian dollar) total deposit, residential mortgages, and shareholders' equity of chartered banks divided by the GDP deflator. The policy rate R is measured as the 5-year yield on the federal government's bonds, the deposit rate R^D as the rate on 90-days term deposits, and the lending rate in the regulated sector R^R as the rate on conventional 5-year mortgage charged by chartered banks. Finally, inflation is measured as the CPI and all variables are in log.

D Impulse Response Functions

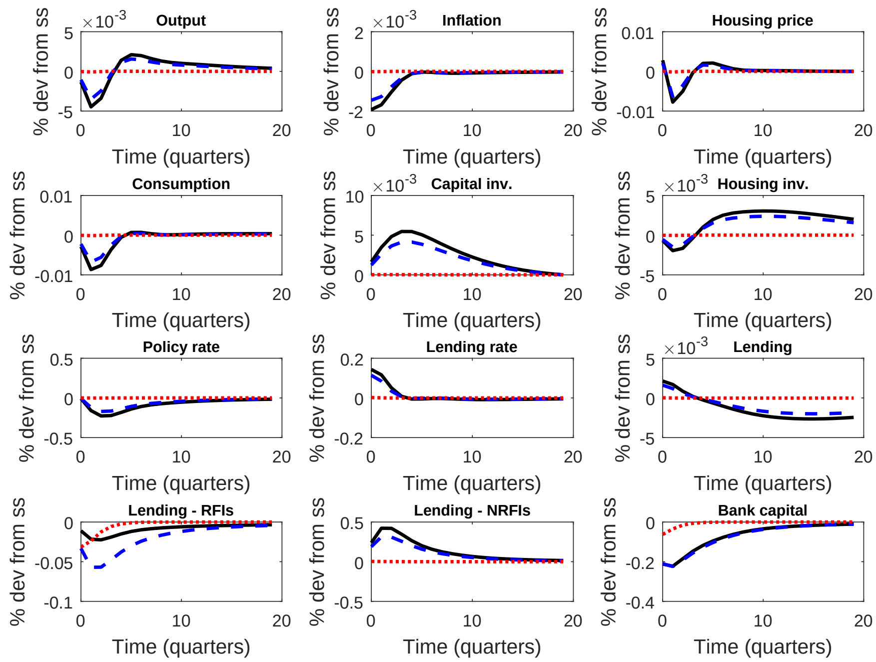


Figure 4: Financial shock. Black solid line: $\tau = 0.95$; blue dashed line: $\tau = 0.85$; red dotted line: $\tau = 0.1$.

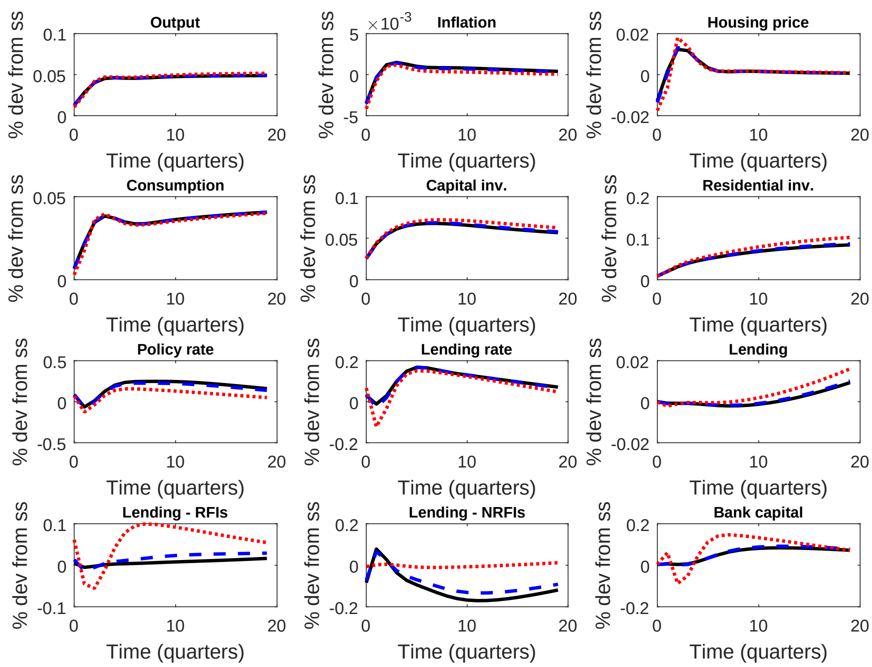


Figure 5: Technology shock. Black solid line: $\tau = 0.95$; blue dashed line: $\tau = 0.85$; red dotted line: $\tau = 0.1$.

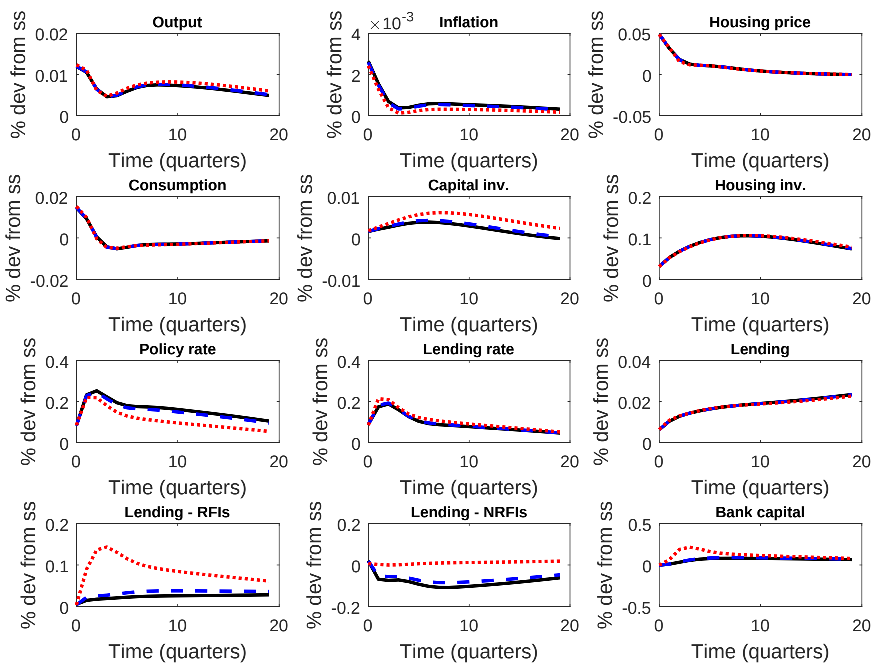


Figure 6: Preference shock. Black solid line: $\tau = 0.95$; blue dashed line: $\tau = 0.85$; red dotted line: $\tau = 0.5$.

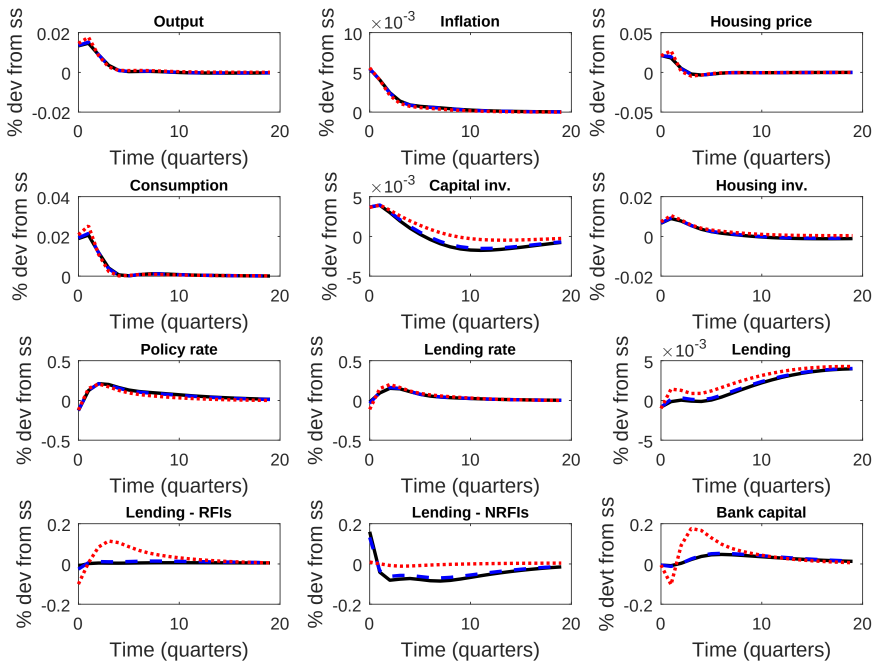


Figure 7: Monetary policy shock. Black solid line: $\tau = 0.95$; blue dashed line: $\tau = 0.85$; red dotted line: $\tau = 0.1$.

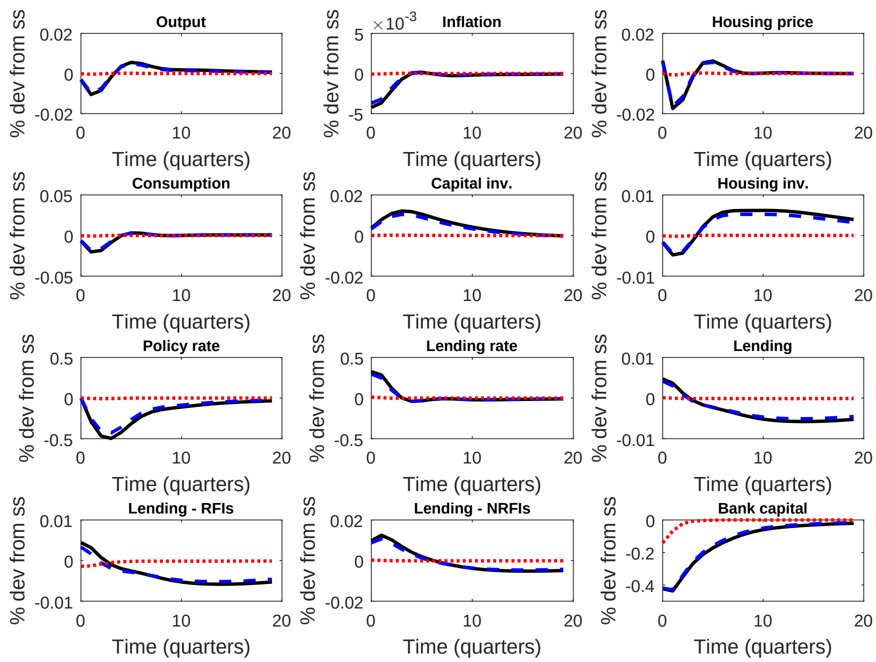


Figure 8: Financial shock with $\varepsilon_L = 1.01$. Black solid line: $\tau = 0.95$; blue dashed line: $\tau = 0.85$; red dotted line: $\tau = 0.1$.

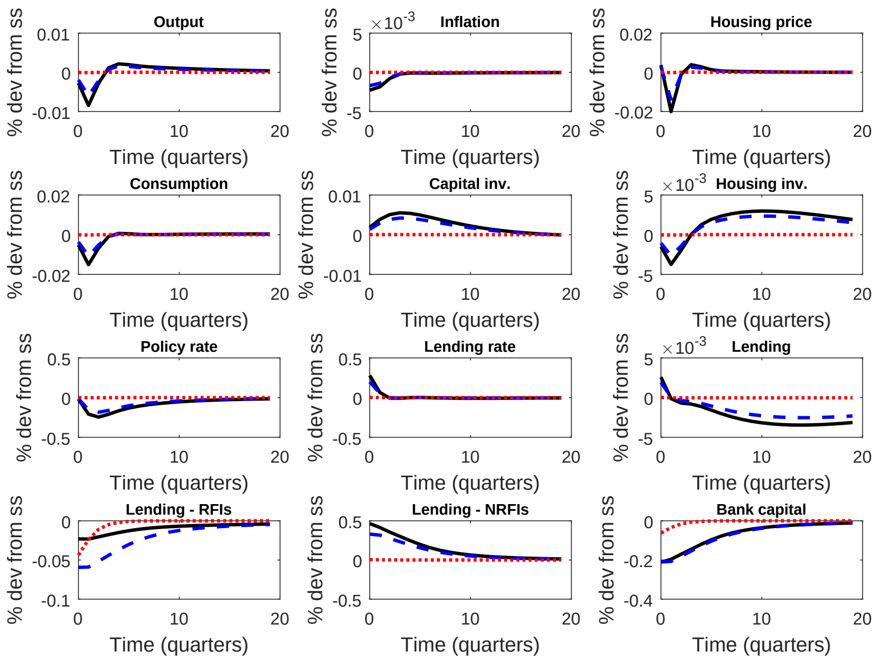


Figure 9: Financial shock with $\kappa_{RR} = \kappa_{RD} = 0$. Black solid line: $\tau = 0.95$; blue dashed line: $\tau = 0.85$; red dotted line: $\tau = 0.1$.

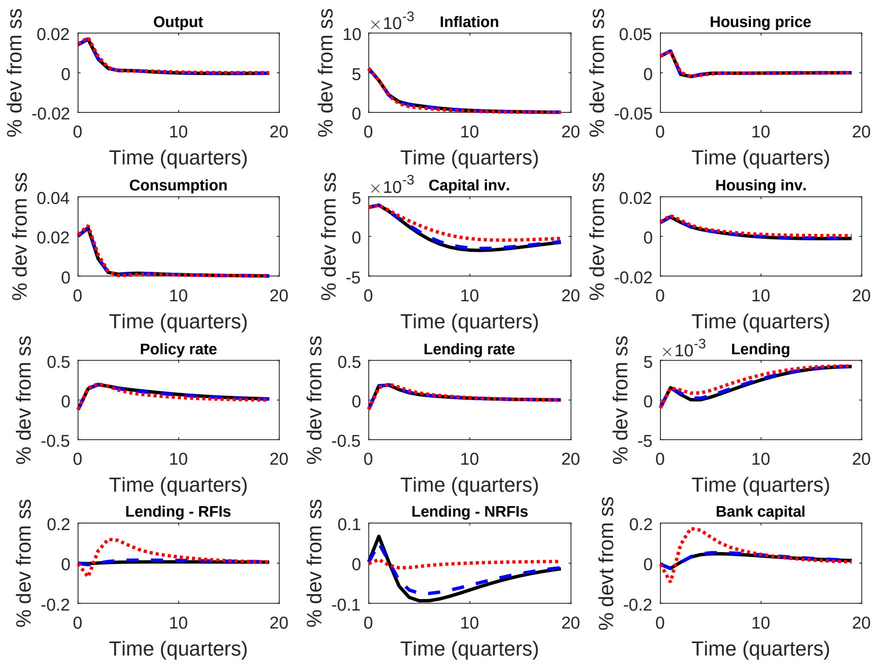


Figure 10: Monetary policy shock with $\kappa_{RR} = \kappa_{RD} = 0$. Black solid line: $\tau = 0.95$; blue dashed line: $\tau = 0.85$; red dotted line: $\tau = 0.1$.