Iranian Journal of Economic Studies, 8(1) 2019, 69-90

Shiraz University

Iranian Journal of Economic Studies

Journal homepage: ijes.shirazu.ac.ir

The Impacts of Monetary Policy on Macroeconomic Variables Assuming the Collateral Constraint

Hadi Keshavarz*, Hojat Parsa

Department of Economics, Persian Gulf University, Bushehr, Iran.

Article History

Received date: 15 November 2018
Revised date: 11 May 2019
Accepted date: 25 May 2019
Available online: 25 May 2019

JEL Classification:
E52
E58
G20
C60

Keywords:
Monetary Policy
Collateral Constraint
Macro-Prudential Rule
Dynamic Stochastic General Equilibrium Model
Iran

Abstract

This study aimed to examine the effects of monetary policy on macroeconomic variables with regard to the collateral constraint. For this purpose, a dynamic stochastic general equilibrium (DSGE) was developed for Iran's economic status. Two scenarios were considered as to account for the behavior of the central bank. In the first scenario, the monetary rule is modeled according to the GDP gap and inflation. In the second scenario that is modeled by macro-prudential rule, in addition to the GDP gap and inflation, it is also the central bank responses to the housing price gap that contributes to a steady state. An examination of the impulse response functions in the two scenarios indicated that the monetary shock increased production and inflation. A monetary shock has a positive impact on the consumption of patient households (lenders) and a negative effect on impatient households' (borrowers) consumption. The collateral constraint was assumed to cause the effects of shocks to be continued on both groups. A comparison between the two scenarios indicated that if the central bank responds to the housing price deviation, in addition to the GDP gap and inflation, the effectiveness of the monetary policy will be strengthened.

1. Introduction

The first difference between the present study and other studies conducted in Iran regarding the effect of the monetary policies is that the present study took into consideration the role of financial friction (collateral restrictions). The monetary and financial system can provide the backgrounds for the economic activities stimulating growth. This system is meant to allocate capital to competing expenditures by allotting resources to the most efficient expenditures. The monetary and financial system is also expected to monitor the flow of funds to ensure that they are consumed for the planned purposes. If the financial system fails to do its duty properly, the trading costs in the financial markets increase and the probability of problems occurring in the domestic investment and production enhances because of the breakdowns in funding.

* hd.keshavarz@gmail.com
DOI: 10.22099/ijes.2019.31442.1508
© 2019, Shiraz University, All right reserved

In Iran's economy, the banking system has a weak appraisal system due to various reasons; hence, the system cannot properly evaluate the projects and even control the allocation of loans. This leads to imperfect information in the financial sector of Iran’s economy, thus enhancing the risk premium. Accordingly, the lending’s interest rates, compared to the interest rate on deposits, enhance and cause an increase in the external borrowing costs. The banks thus get collaterals in exchange for credit payments to reduce the risk exposure. An increase in the lending’s interest rates and in collaterals reduces the financial flow in the financial market and affects investment and production, which is also referred to as financial friction.

Therefore, the present study was undertaken to answer the following questions: How is the effectiveness of the monetary policy in friction conditions? How can the central bank pursue its goals? However, it is not clear whether the central bank pursues its policies based on certain rules or acts based on discretionary policy entirely. The central question to this argument is that whether it considers inflation stability and increased national production as its goals or the growth of housing prices in its policy framework to play an active role in controlling the housing market with regard to the significant effects of the housing market on the fluctuations of macroeconomic variables.

Financial friction leads to the persistence of shocks effect due to the financial friction feedback. Also, in this study, the central bank reaction function and macroprudential policies are considered which makes it distinct from the other studies done previously. Studies in Iran have used various reaction functions to explain the behavior of the central bank as to demonstrate the positive effect of monetary shocks on inflation and production. For example, Faraji et al. (2015), Heidari and Molabahrami (2017), and Sahabi et al. (2017) used the Taylor rule to determine the interest rate for the central bank reaction function. Shahmoradi and Ebrahimi (2010) showed that the oil revenue shock had a significant effect on money growth. Fakhrehosseini et al. (2012) and Abolhassani et al. (2016) indicated that the government spending shock, alongside with the oil revenue shock, can affect money growth. In the central bank reaction function considered by Komijani and Tavakolian (2012), Jafari Samimi et al. (2014), Manzoor and Taghipour (2016), and Fotros et al. (2015), the policymaker determines the money growth reaction to the difference of actual and targeting inflation rate as well as the difference of actual and potential product (gross domestic product). Bayat et al. (2016) considered another scenario for the central bank, which included the production gap and inflation, and money growth responses to the gap in the stock price index.

In this study, two scenarios were considered in order to examine the behavior of the central bank by assuming the collateral constraint. The first scenario was based on a study by Komijani and Tavakolian (2012). In the second scenario, the central bank responded to housing prices in addition to the inflation and production gap. In this study, the effects of monetary policies on inflation and production under collateral constraint conditions were investigated using a DSGE model.

The advantage of DSGE models is that it allows the examination of the effects of the policy implementation or economic shock in the system, which enables the researchers to calculate and take into account the feedback and distribution effects of policy implementation on all economic sectors. The model proposed in this study included households (borrowers and lenders), firms (entrepreneurs and retailers), government, and the central bank. After solving the model and making a log-linear model, the model simulation was performed using Dynare software. Finally, the impulse response functions (IRFs) were investigated.

The remainder of the present study is as follows: The second section deals with the theoretical foundations of the monetary policy with regard to the financial friction. The third section presents the model of simulation and the analysis of results are covered in the fourth section. Finally, the study is concluded in the fourth section.

2. Theoretical Foundations

The early literature on the macroeconomics and financial friction, proposed by Bernanke and Gertler (1989) and Carlstrom and Fuerst (1997), focused on the fact that a temporary shock could have long-run effects. In a real business cycle model, temporary shocks can have permanent effects; however, the effects are more sustained because of the financial friction feedback in the models. Based on these models, the impact of negative shocks on net entrepreneurial assets is reinforced with financial frictions, and this makes the entrepreneurs reduce their investment. During the next periods, this leads to a lower level of net asset and capital for the entrepreneurs. Financial friction was mainly developed based on two approaches.

The first approach was introduced by Bernanke and Gertler (1989) and developed by Carlstrom and Fuerst (1997). Later on, the model was integrated with the New Keynesian framework and merged into a financial accelerator model proposed by Bernanke, Gertler, and Gilchrist (1999). In such a model, friction is assumed to be the costly mode of verification, which was first introduced by Townsend (1979). The second approach was introduced by Kiyotaki and Moore (1997), in which financial friction affects economic variables through collateral constraint.

In Kiyotaki and Moore's model, production is performed in two sectors, in which the productivity of one sector is greater than the other one and the discount rates also differ. On the one hand, this makes us focus on the dual role of durable assets as collateral for borrowing and as inputs for production. On the other hand, given their relative impatience, the productive agents are willing to borrow from non-productive agents; nevertheless, borrowing is subject to friction and the lender's application for collaterals would cause financial friction. Iacoviello (2005) and Monacelli (2009), adding the housing sector to the general equilibrium models with regard to the collateral constraints, provided the possibility of examining the effect of monetary policies under the collateral constraints. In the present study, Iacoviello's model was employed.

Following the global financial crisis of 2007-2009 and the Great Depression, the development of macroeconomic models examining the interaction between the financial system and the real economic sector has been highlighted. The crisis taught all financial stakeholders some lessons and revealed some policy imperfections. It was first revealed that the restrictions on lending, higher borrowing costs, and financial regulations directly affected credit markets and caused widespread economic distractions.

Until the recent crisis, it had generally been accepted that the main objective of the central banks was to stabilize prices. The crisis, however, raised the following question: Should the objective of the central bank be price stabilization? Maintaining price stability can be disadvantageous to financial stability. The new monetary transfer mechanism_ risk-taking channel (Borio & Zhu, 2012) suggests that the monetary policies can affect the risk level in the economy. The higher the output level and the credit, the higher the risk would be. When risk emerges, banking difficulties appear and a financial crisis is unavoidable. The second problem, posed by De Grauwe and Gros (2009), occurs when there is a bubble and the economy may face a trade-off among between price and financial stability. Based on these assumptions, a central bank which follows a price stability policy could not achieve the financial stability by perusing credit creation.

These led to some modifications in macro and micro policies. At the micro level, there were some modifications in banks' loans (microprudential policies), which was set up by the Basel Committee on Banking Supervision (2010), as a collection entitled Basel III, to prevent other financial crises[1].

At the macro level, the policy modifications are known as macroprudential policies, on which there is a growing literature although there is no consensus on whether or not the financial stability should be included in the monetary rule. Faia and Monacelli (2007), using Taylor's optimal interest rate, concluded that the monetary policies should respond to rising asset prices even though if they respond strongly, inflation, profit, and marginal prosperity would be removed in response to the asset price. Semmler and Zhang (2007) argued that the financial modifications should be considered in circumstances leading to a downturn in the low interest rates with the goal of escaping the liquidity trap of a monetary policy. Contrary to these studies, Badarau and Popescu (2014) found that adding a financial stability goal to the list of the traditional goals of the central bank did not improve the economy's reaction to a financial bubble since the central bank used only one instrument (for example, interest rates). Kannan et al. (2012), with modifications in a new Keynesian model, defined a special role for the housing sector and examined the economy's behavior under different policy regimes. They used interest rates and macroprudential policies and concluded that the

[1]. For further information, see Basel Committee of Banking Supervision (2011).

macroprudential policies could improve the economy's response to a monetary shock only if no technology shock occurred.

3. Model

The model presented in this study was based on the models presented by Iacoviello (2005) and Iacoviello and Neiri (2010). The model consisted of several sectors[2]. The household sector was divided into the patient (lenders) and impatient (borrowers) groups. Both households consume, work, and demand the real balance of money as a housing asset. Housing assets is an asset that borrowers can use as collateral to borrow from the lenders. The firms include retailers and entrepreneurs (producers of wholesale products); the entrepreneurs can borrow from the patient households to produce goods and services. We assume that the discount factor of impatient households and entrepreneurs is lower than that of the patient households which are more likely to be debtors.

The government and the central bank are other sectors in the model. The government income consists of oil revenues, seigniorage income, and taxes, by which it finances its own expenditures and pays subsidies. Two scenarios were considered to explain the behavior of the central bank with the assumption of the collateral constraint. In the first scenario, the monetary rule was modeled according to the GDP gap and inflation. In the second scenario, the reaction function of the monetary policymaker was in line with the policymaker's goals in reducing the deviations of production from potential production, inflation from target inflation, and housing prices from housing prices in a steady state.

3.1 Household

The household sector in this research was classified into two categories of patient (lenders) and impatient (borrowers) households. The patient household chose the consumption, real balance of money $\frac{M'_t}{P_t}$, housing stock h', and labor supply L'_t. The expected lifetime utility of a patient household is as follows:

$$E_t \sum_{t=0}^{\infty} \beta'^t \left\{ \frac{C_t'^{1-\sigma_c}}{1-\sigma_c} + \frac{\upsilon}{1-\varepsilon}\left(\frac{M'_t}{P_t}\right)^{1-\varepsilon} + \frac{d_t}{1-\sigma_h} h^{1-\sigma_h} - \psi \frac{L_t'^{1+\gamma}}{1+\gamma} \right\} \tag{1}$$

where E_t is expectation operator, β' is discount factor, σ_c is the inverse of the intertemporal elasticity of the consumption substitution, ε is the inverse of the demand elasticity for the real money balance, σ_h is the inverse of the demand elasticity for the housing stock, γ is the inverse of the labor supply elasticity, d_t is housing preference shock[3], and ψ and υ are constants.

A representative household has M_{t-1} holdings of money balance and h_{t-1}holdings of housing at the beginning of period t. During the period t, the

[2]. Financial friction was modeled in two ways: Collateral Limit and Financial Accelerated Model. The model of this research is based on the collateral limit. Adding a bank to a collateralization model will make the pattern very complex and will not help much to the axiom of assumption i.e. collateral in borrowing.

[3]. Housing preference shock is covered in Section 3.8.

household's income includes the wage from the labor supply (w_t), interest rate r_t^b from loans (B_t), and subsidies TR_t' and profits from retailers (D_t). Furthermore, the households pay taxes T_t' to the government. Accordingly, the patient household does want to maximize its utility level subjected to the following budget constraints at time t:

$$C_t' + \frac{Q_t}{P_t}h_t' + \frac{M_t'}{P_t} + \frac{B_t'}{P_t} \leq w_t L_t' + \frac{(1+r_{t-1}^n)B_{t-1}' + M_{t-1}'}{P_t} + \frac{Q_t}{P_t}h_{t-1}' + \frac{D_t'}{P_t} + TR_t' - T_t' \quad (2)$$

The future time for the impatient households is discounted with a higher discount rate. They choose consumption C'', real money balance $\frac{M_t''}{P_t}$, housing stock h'', and labor supply L'' so that their utility is maximized:

$$E_t \sum_{t=0}^{\infty} \beta''^t \left\{\frac{C_t''^{1-\sigma}}{1-\sigma} + \frac{\upsilon}{1-\varepsilon}\left(\frac{M_t''}{P_t}\right)^{1-\varepsilon} + \frac{d_t}{1-\sigma_h}h''^{1-\sigma_h} - \psi\frac{L_t''^{1+\gamma}}{1+\gamma}\right\} \quad (3)$$

where β'' is the impatient household's discount, and the assumption $\beta'' < \beta'$ ensures that impatient household will need to borrow from the lenders. The impatient household's budget constraint is alike to that of the patient households, with the difference that they do not receive profits from retailers.

$$C_t'' + \frac{Q_t}{P_t}h_t'' + \frac{M_t'}{P_t} + \frac{B_t''}{P_t} \leq w_t L_t' + \frac{(1+r_{t-1}^n)B_{t-1}'' + M_{t-1}''}{P_t} + \frac{Q_t}{P_t}h_{t-1}'' + TR_t'' - T_t' \quad (4)$$

Following Kiyotaki and Moore (1997), borrowers are assumed to face borrowing constraints (collateral constraint). In other words, they can use their housing assets as collateral to borrow. If the borrowers do not fulfill their obligation, the lenders may hold the borrowers' collateralized assets at the expense of the transaction cost $(1-m'')(q_{t+1}h_t'')$, where m'' is the ratio of the loan to the discounted value of the collateral and $q_t = \frac{Q_t}{p_t}$ is real housing price. Thus, the impatient household's restriction can be written as:

$$b_t'' \leq m''\left(\frac{q_{t+1}h_t''\pi_t}{r_t}\right) \quad (5)$$

Equation (5) indicates that the maximum loan for the impatient household is a percentage of the discounted value of the housing assets.

3.2 Firms

The firms consist of two groups of entrepreneurs and retailers. The entrepreneurs in each period use capital (Non-residential) K, housing h, and labor services supplied by the patient households L' and the impatient households L'' to produce intermediate goods using a Cobb-Douglas Production Function.

$$y_t = A_t K_{t-1}^{\mu} h_{t-1}^{\upsilon} L_t'^{\alpha(1-\mu-\nu)} L_t''^{(1-\alpha)(1-\mu-\nu)} \quad (6)$$

where μ is capital share, ν is housing stock, and α is labor supplied by the patient household. To install and set up, the capital adjustment cost is considered as follows:

$$\xi_{k,t} = \psi\left(\frac{I}{k_{t-1}-\delta}\right)^2 k_{t-1} \quad (7)$$

where ψ is the capital adjustment cost parameter and δ is the depreciation rate. Moreover, capital flow equation is:

$$I = k_t - (1-\delta)k_{t-1} \tag{8}$$

Entrepreneurs need to borrow to produce, and they, like the impatient households, can use the housing assets as the collateral for their loans. Therefore, their borrowing constraint is as follows:

$$b_t \le m\left(\frac{q_{t+1}h_t\pi_t}{r_t}\right) \tag{9}$$

Entrepreneurs maximize $E_t \sum_{t=0}^{\infty} \beta'''^t \left(\frac{C_t^{1-\sigma}}{1-\sigma}\right)$, in which β''' is the entrepreneurs discount factors and we have $\beta''' < \beta$. Entrepreneurs maximize the above function with regard to technology and borrowing constraints.

The retailers buy the products produced by the entrepreneurs, differentiate them as distinct goods, and sell them to final consumers. According to the Dixit-Stiglitz aggregator (1977), the production technology of the retail enterprise is as follows:

$$Y_t = \left(\int_0^1 y_t^{\frac{\eta-1}{\eta}} di\right)^{\frac{\eta}{\eta-1}} \tag{10}$$

In this equation, η is the substitution elasticity of the domestic goods. Based on the households' expenditure minimization problem, the price index, p_t, is given by:

$$p_t = \left[\int_0^1 p_t(i)^{1-\varepsilon} di\right]^{\frac{1}{1-\eta}} \tag{11}$$

The demand function for each retailer is obtained from the optimization of the retail problem:

$$y_t(j) = \left(\frac{p_t(j)}{p_t}\right)^{-\eta} Y_t \tag{12}$$

By inserting the above equation in (11), the domestic price index can be obtained by the following formula:

$$P_t = \left(\int_0^1 P_t^{1-\eta}(j)dj\right)^{\frac{1}{1-\eta}} \tag{13}$$

According to Calow (1983), no retailer can change the prices unless he/she receives a random signal. The probability of taking such a signal is $1-\theta$; therefore, only a fraction of the retailers $(1-\theta)$ in each period can adjust their prices while others do not change their prices. The firms that cannot afford optimal pricing are assumed to index their prices on the past period inflation as follows:

$$P_t(i) = (\pi_{t-1})^{\chi} P_{t-1}(i) \tag{14}$$

The indexation rate is determined by the coefficient $\chi \in [0,1]$. If $\chi = 0$, there is no indexation and $\chi = 1$ implies a complete indexation. Given θ^s and $s = 1, 2, \ldots$, an enterprise will not be allowed to change its prices during s period(s), so the price during the period $t+s$ can be calculated as shown below:

$$P_{t+s}(i) = P_t \prod_{h=1}^{s} (\pi_{t+h-1})^{\chi} \tag{15}$$

The retailer $p_t(i)$ chooses to maximize his/her expected real profit during some periods:

$$\max_{P_t} E_t \sum_{s=0}^{\infty} (\beta\theta)^s \lambda_{t+s} \left[y_{t+s}(j) \left(\prod_{h=1} (\pi_{t+h-1})^{\chi} \frac{P_t}{P_{t+s}} - p_{t+s}^{w} \right) \right] \quad (16)$$

where P_t is the optimal price chosen by all the adjusting retailers during the period t.

$$P_t = \left(\frac{\eta}{\eta-1}\right) \frac{E_t \sum_{s=0}^{\infty} (\beta\theta)^s \lambda_{t+s} P_{t+s} p_{t+s}^{w} y_{t+s}(i)}{E_t \sum_{s=0}^{\infty} (\beta\theta)^s \lambda_{t+s} \prod_{h=1}^{s} \pi_{t+h-1}^{\chi H} y_{t+s}(i)} \quad (17)$$

Using Equation (17) and the enterprise's price index Equation (15), the price flow is determined as follows:

$$(P_t)^{1-\eta} = \theta((\pi_{t-1})^{\chi} P_{t-1})^{1-\eta} + (1-\theta)(P_t)^{1-\eta} \quad (18)$$

3.3 Government

In this model, it is assumed that government expenditures are obtained from the oil revenue incomes, an increase in the monetary base ($M_t - M_{t-1}$), and taxation (T_t). Using the incomes, the government pays for its own expenditures as well as subsidies. Accordingly, the budget constraint is:

$$G_t + TR_t = \omega O_t + T_t + \frac{M_t - M_{t-1}}{P_t} \quad (19)$$

Following Manzoor and Taghipour (2016), the government's tax revenue includes value-added tax (T_t^{vat}) and other taxes (T_t^{d}). The value-added tax is a function of the total final consumption, and the other taxes are a function of the total national income. Consequently, the log-linear function of taxes is as follows:

$$\widehat{T_t^{vat}} = \tau^{vat} (\hat{c} + \hat{g})$$
$$\widehat{T_t^{d}} = \tau^{d} \hat{y} \quad (20)$$
$$T = T_t^{d} + T_t^{vat}$$

The oil revenues in the OPEC countries are determined based on their quotas because such oil revenues are a function of their quotas, global oil prices, and exchange rates, considering that all these factors are exogenous. Therefore, oil revenues can be considered as an exogenous process AR (1) with the assumption of a shock resulting from oil exports or changes in oil prices or exchange rate:

$$O_t = \rho O_{t-1} + \varepsilon_t^{O} \quad , \quad \varepsilon_t^{o} \approx i\, i\, d\, N(0, \sigma_o^2) \quad (21)$$

3.4 Central Bank

As noted in the theoretical framework, Taylor's monetary rule had been accepted before the recent financial crisis. Under this rule, the federal interest rate is determined on the basis of the weighted average of the inflation gap relative to the target inflation and actual production gap relative to the long-term and potential value. If inflation or production exceeds their target or potential values, according to this rule, the federal funds rate should be increased to eliminate this gap. On the other hand, if the production level is lower than the potential level and the inflation level is lower than its target level, the supply and the demand side of the economy can be motivated by reducing the interest rate of the federal funds (Erfani & Shamsiyan, 2016). One of the main challenges of the central bank is to or not to respond to potential asset price bubbles. Since asset prices are a central component in the mechanism of monetary transfer policy, the problem is how the monetary policy should respond to movements in asset prices (Frederick Meshkin, 2011). Bernanke and Gertler (2001) argued that responding to housing prices was beneficial for economic stability.

In Iran, the interest rate is determined based on orders; as a result, the majority of the studies that have used the dynamic stochastic general equilibrium method have employed the growth rate of money instead of the interest rate. According to Komijani and Tavakolian (2012), for example, the central bank determines the growth rate of money to minimize production deviation from the potential production and the inflation deviation from target inflation. On the contrary, Fakhreosseini et al. (2012) and Abolhassani et al. (2016) argued that oil revenue shock and government's expenditures had an impact on the monetary base due to the exchange of oil revenues to the domestic currency, the central bank's lack of independence, and the partial provision of the government's expenditures from seigniorage income.

Over the past decade, the government and the monetary authorities have been seeking to provide housing for low-income households. This can affect the volume of money, given the central bank's lack of independence and the partial provision of the government's expenditures from seigniorage income. The question to be addressed presently is that given the expanding literature on macroprudential policies and the status of Iran's economy, should the central bank respond to housing prices at the monetary rule? On the other hand, how influential would these policies be if the financial market is frictional? In line with Komijani and Tavakolian (2012), we first considered a basic rule to examine the effects of the monetary policy. In the other scenario, we modeled the monetary base with regard to the production, inflation, and housing prices, and examined the effects of the monetary policy against the collateral constraint.

3.4.1 Scenario I: Central Bank Reaction Function

In the first scenario, we assumed that the reaction function of the monetary policymaker was set in such a manner that the growth rate of money would reduce the production deviation from the potential production and inflation deviation from target inflation, where the implied target inflation (π_t^*) follows a first-order autoregressive process. Accordingly, the log-linear reaction function of the monetary policymaker was defined as follows:

$$
\begin{aligned}
&MB_t = \rho_M MB_{t-1} + \lambda_\pi(\pi_t - \pi_t^*) + \lambda_y y_t + \nu_t \\
&\pi_t^* = \rho_{\pi^*}\pi_{t-1}^* + \varepsilon_t^{\pi^*}
\end{aligned}
\tag{22}
$$

where MB_t is the growth rate of money during the period t ($MB = m_t/m_{t-1}$). The coefficients of inflation gap λ_π, product gap λ_y, and λ_q housing price gap have negative signs as with an increase in products, inflation, and housing prices, the monetary policymaker adopts a contractionary policy and reduces the volume of money. The monetary policy shock (ν_t) is also assumed to follow the process AR (1):

$$
\upsilon_t = \rho_\upsilon \upsilon_{t-1} + \varepsilon_t^\upsilon \quad , \quad \varepsilon_t^\upsilon \approx i.i.d\ N(0, \sigma_m^2) \tag{23}
$$

3.4.2 Scenario II: Central Bank Reaction Function with Macro-Prudential Rules

In the second scenario, we assumed that the goals of central bank were inflation and production and that they did not respond to the housing price deviation from the steady state. In this regards, the impulse response function of the policymaker will be defined as follows:

$$MB_t = \rho_M MB_{t-1} + \lambda_\pi(\pi_t - \pi_t^*) + \lambda_y y_t + \lambda_q Q + \nu_t \quad (24)$$

where λ_q is the coefficient housing price gap on monetary base and has negative signs. In other words, with inflation and housing prices, the monetary policymaker adopts a contractionary policy and reduces the volume of money.

3.5 Balance Requirement

To clear the accounts in the markets of goods and services, the total supply should be equal to the total demand (total consumption, private investment, and government expenditures).

$$Y_t = C_t + I_t + G_t \quad (25)$$

In order to balance the loan market, it is necessary to establish the following condition:

$$b_t + b_t' + b_t'' = 0 \quad (26)$$

According to Iacoviello (2005), the housing asset supply is also stable; therefore, the total supply should be equal to the total demand in the housing sector.

$$h_t' + h_t'' + h_t''' = H \quad (27)$$

4. Empirical Results

We used the seasonal data to estimate the log-linearized model[4] using the Bayesian method for the Iranian economy during the period of 2005-2017. To do such estimation, GDP, monetary base, consumption, government expenditures, and oil revenues were used. First, we calibrated the parameters or ratios that did not need to be estimated. Table 1 presents these parameters and the calibrated ratios. To estimate the parameters that are estimated, their prior distribution, mean, and standard deviation must be determined. The prior and posterior distribution (mean and standard deviation) and the results of the Bayesian estimation of their parameters are shown in Table 2.[5]

---

4. Appendix A contains the complete log-linear model.
5. The MCMC convergence diagnostics are presented in Appendix B.

Table1. Parameter values

Parameters	Explanation	Value	Source
o/g	The oil revenues to government expenditure	0.37	Computing research
t/g	The tax to government expenditure	0.31	Computing research
m/g	The monetary base to government expenditure	0.77	Computing research
Tr/g	Subsidies to government expenditure	0.34	Computing research
δ	Depreciation rate	0.014	Komijani & Tavakolian (2012)
ω_g	Money supply response to government spending shock	0.42	Fakhrehosseini et al. (2012)
ω_{or}	Money supply response oil revenue shocks	0.15	Fakhrehosseini et al. (2012)

Table 2. Prior and posterior distribution

Parameters	Explanation	Prior distribution (mean and standard deviation)*	Source**	Posterior distribution (mean and standard deviation)	
				Scenario I	Scenario II
σ_c	inter-temporal elasticity of substitution of consumption	G(1.14,0.5)	Ehsani et al. (2017).	(2.18,0.19)	(2.29,0.14)
γ	Labor Supply Aversion	G(2.21,0.5)	Komijani & Tavakolian (2012)	(2.37,0.16)	(2.41,0.18)
ε	inverse of elasticity of demand for real money balances	G(2.24,0.5)	Ehsani et al. (2017).	(2.22,0.19)	(2.23,0.2)
β'	Patient Household Discount Factor	B(0.98,0.05)	C. R.	(0.992,0.001)	(0.995,0.001)
β''	Impatient Household Discount Factor	B(0.93,0.05)	C. R.	(0.924,0.004)	(0.915,0.004)
β'''	entrepreneurs Discount Factor	B(0.94,0.05)	C. R.	(0.936,0.003)	(0.942,0.005)
μ	Variable capital share	B(0.42,0.02)	C. R.	(0.43,0.019)	(0.45,0.019)
υ	Housing share	B(0.03,0.02)	C. R.	(0.01,0.001)	(0.07,0.02)
α	Patient household wage share	B(0.64,0.02)	C. R.	(0.65,0.018)	(0.66,0.019)
ψ	Variable capital adjustment cost	G(1.2,0.5)	C. R.	(0.39,0.05)	(0.41,0.08)
θ	Percentage of firms unable to adjust their prices	B(0.58,0.01)	Ehsani et al. (2017).	(0.57,0.009)	(0.56,0.009)
m''	Impatient Loan-to-value ratio	B(0.55,0.05)	C. R.	(0.55,0.05)	(0.55,0.046)
m	entrepreneurs Loan-to-value ratio	B(0.89,0.5)	C. R.	(0.87,0.04)	(0.89,0.049)
λ_π	The coefficients of inflation gap	N(-1.64,0.05)	Ehsani et al. (2017).	(-1.57,0.051)	(-1.66,0.047)
λ_y	The coefficients of product gap	N(-1.6,0.05)	Ehsani et al. (2017).	(-1.55,0.057)	(-1.53,0.049)
λ_q	The coefficients of housing price gap	N(-0.4,0.05)	C. R.	(-0.6,0.025)	-

**B, G and N are the abbreviations for Beta, Gamma and Normal distributions.*

***C. R. is the abbreviation for Computing research.*

4.1 Examining the Impulse Response Functions

IRFs show the dynamic behavior of the variables over time when a momentum, as large as a standard deviation, affected each variable. We examined the impacts of the monetary momentum on production, inflation, and consumption under two different scenarios.

4.1.1 Results from Scenario I

In the first scenario, we assumed that the monetary policy rule was as follows:

$$MB_t = \rho_M MB_{t-1} + \lambda_\pi(\pi_t - \pi_t^*) + \lambda_y y_t + \nu_t$$

Figure (1) shows the impulse response functions of the monetary shock in the first scenario. As this figure shows, inflation (pi) increases when a shock affects the monetary base, which is matched to the theory, and this finding was confirmed in a large number of the empirical studies in Iran's economy. The real housing price (Q/p) is reduced by creating inflationary conditions; then, the households will increasingly borrow money and the demand for housing will increase among both lenders and borrowers. When the inflation increases and the real interest rate decreases, both investment and consumption will increases. Increasing investment and housing (production input) will result in an increase in the production.

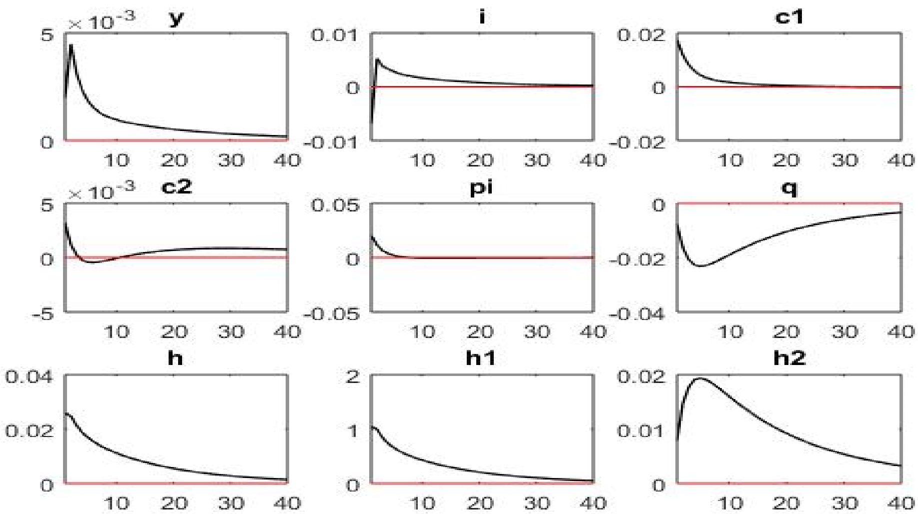


***Figure 1.* Impulse Responses to a monetary Shock based on Scenario I**

Note: *inflation (pi), housing price (q), investment (i), patient consumption (c1), impatient consumption (c2), production (y), housing stock of patient household (h1), housing stock of impatient household (h2)*

4.1.2 Results from Scenario II

In the second scenario, we assumed that the monetary policy rule was as follows:

$$MB_t = \rho_M MB_{t-1} + \lambda_\pi(\pi_t - \pi_t^*) + \lambda_y y_t + \lambda_q Q + \nu_t$$

Figure (2) shows the impulse response functions of the monetary shock in the second scenario. As in the first scenario, inflation (pi) increases when a shock affects the nominal growth rate of the monetary base.

The real housing price (Q/p) is reduced by creating inflationary conditions; then, the households will increasingly borrow money and the demand for housing will increase among both lenders and borrowers. Similar to the first scenario, by increasing investment and housing, production will increase too. The increase in the monetary shock will, on the one hand, raise inflation and, on the other hand, decrease the real housing price. This would make the borrowers (i.e., impatient households and entrepreneurs) reduce their consumption and increase their housing demand, but the consumption of the patient households (lenders) will grow.

A comparison between the two scenarios indicated that if the central bank operated according to the precautionary macroeconomic rule, the impact of monetary policy on macroeconomic variables would be strengthened. In other words, with the implementation of a monetary policy, despite the high precautionary principle, the consumption of the borrowing group would decrease, but the consumption of the lending group would increase. As a result, the demand for housing in all three groups would increase and since housing is assumed to be a productive input, it would strengthen the effect of this policy on production.

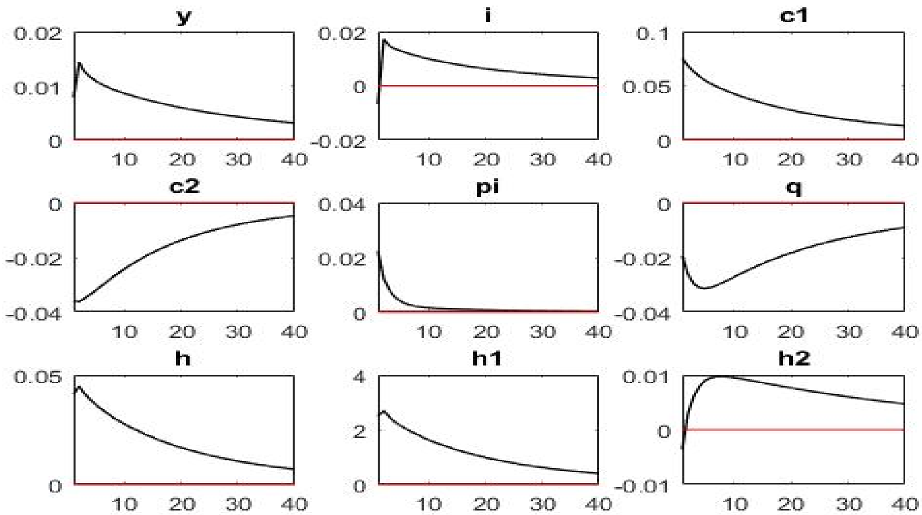


Figure 2. **_Impulse Responses to a monetary Shock based on Scenario II_**

Note: *inflation (pi), housing price (q), investment (i), patient consumption (c1), impatient consumption (c2), production (y), housing stock of patient household (h1), housing stock of impatient household (h2)*

5. Concluding Remarks

This study was aimed to examine the effects of monetary policies on production and inflation with regard to collateral restrictions. To this end, after stating the problem and presenting the relevant literature, a DSGE model was developed for Iran's economy based on the models offered by Iacoviello (2005) and Iacoviello and Neiri (2010). Two scenarios were considered to explain the behavior of the central bank. In the first scenario, the goals of the central bank were production and inflation and controlling the growth rate of money in a way that helped it achieve its goals. In the second scenario modeled by precautionary macroeconomic rules, the monetary rule was modeled based on the production, inflation, and housing price.

After solving the model and estimating it using Bayesian method, it was simulated. An examination of the impulse response functions in the two scenarios indicated that the monetary shock could increase inflation and by creating inflationary conditions, real housing prices and real interest rate would decrease. Consequently, investment and housing demand would increase in both lending and borrowing households groups. By the increase in the investment and housing as the production inputs, production will also increase. In the second scenario, by reducing the real price of housing, the impatient households (borrower) would reduce their consumption and increase their housing demand, but the consumption of the patient households will increase. However, we must bear in mind that in the first scenario, consumption was increased in both lending and borrowing households groups.

The results of the two scenarios showed that due to the friction by collateral restrictions method, monetary shock resulted in the continuation of the impulse effect in the model, which was in line with the theoretical expectations of the research.

The comparison of the impulse response curve of the two scenarios suggests that if the central bank, in addition to the GDP gap and inflation, respond to the housing price deviation (precautionary macroeconomic rule), the effectiveness of the monetary policy will be strengthened.

References

Abolhassani, A., Ebrahimi I., Hosseinpour, M., & Bahraminia, E. (2016). The effect of oil shocks and monetary shocks on production and inflation in the housing sector of the Iranian economy: New Keynesian dynamic stochastic general equilibrium approach. *Quarterly Journal of Economic Growth and Development Research*, 7(25), 97-112.

Badarau, C., & Popescu, A. (2014). Monetary policy and credit cycles: A DSGE analysis. *Economic Modelling*, 42, 301–312.

Bayat, M., Afshari, Z., & Tavakolian, H. (2016). Monetary policy and stock price index (on the basis of the wealth effect of the stock market boom) in a DSGE framework. *Applied Economics Studies in Iran,* 5(20), 33-61.

Bernanke, B. S., & Gertler, M. (1989). Agency costs, net worth, and business fluctuations. *American Economic Review*, 79(1), 14-31.

Borio, C., & Zhu, H. (2012). Capital regulation, risk-taking and monetary policy: A missing link in the transmission mechanism. *Journal of Financial Stability*, 8 (4), 236–251.

Carlstrom, C. T., & Fuerst, T. S. (1997). Agency Costs, net worth, and business fluctuations: A computable general equilibrium analysis. *American Economic Review*, 87(5), 893-910.

De Grauwe, P., & Gros, D. (2009). A new two-pillar strategy for the ECB. *CESifo Working Paper*, No. 2818.

Ehsani, M. A., Keshavarz, H., & Keshavarz, M. (2017). The impact of monetary and fiscal policies on employment fluctuations with an emphasis on private sector employment. *Quarterly Journal of Economic Growth and Development Research*, 7(26), 124-113

Erfani, A., & Shamsiyan, S. (2016). Application of Taylor's rule in Iran economy and policies influence from real estate market. *Journal of Investment Knowledge*, 5(18), 197-210.

Faia, E., & Monacelli, T. (2007). Optimal interest rate rules, asset prices, and credit frictions. *Journal of Economic Dynamics & Control,* 31, 3228–3254.

Fakhrehosseini, S. F., Shahmoradi, A., & Ehsani, M. A. (2012). Sticky prices, wages and monetary policy in the Iranian economy. *The Economic Research*, 12(1), 1-30.

Faraji, M., Afshari, Z., & Ebrahimi, I. (2015). Oil price shocks and monetary policy in Iran: The New Keynesian approach. *Journal of Monetary & Banking Research*, 7(22), 533-568.

Fotros, M. H., Tavakolian, H., & Maaboudi, R. (2015). Impact of fiscal and monetary shocks on macroeconomic variables in Iran, dynamic stochastic general equilibrium approach 1961-2012. *Quarterly Journal of Economic Growth and Development Research*, 5(19), 73-94.

Heidari, H., & Molabahrami, A. (2017). The impact of credit shocks on dynamics of financial and macroeconomic variables using a DSGE model for the Iran economy. *Journal of Economic Research and Policies*, 24(80), 85-118.

Iacoviello, M. (2005). House prices, borrowing constraints, and monetary policy in the business cycle. *American Economic Review*, 95(3), 739-764.

Iacoviello, M., & Neri, S. (2010). Housing market spillovers: Evidence from an estimated DSGE model. *American Economic Journal: Macroeconomics,* 2 (2),125–64.

Jafari-Samimi, A., Tehranghian, A. M., Ebrahimi, I., & Balonezhad Noori, R. (2014). The effect of monetary and non-monetary shocks on inflation and output in dynamic stochastic general equilibrium model in open economy condition: Case study of Iran economy. *Applied Economics Studies in Iran,* 3(10), 1-32.

Kannan, P., Rabanal, P., & Scott, A. (2012). Monetary and macroprudential policy rules with house price booms. *The B.E. Journal of Macroeconomics*, 12(1), 1- 44.

Kiyotaki, N., & Moore, J. (1997). Credit Cycles. *Journal of Political Economy*, 105(2), 211-248.

Komijani, A., & Tavakolian, H. (2012). Monetary policy under fiscal dominance and implicit inflation target in Iran: A DSGE approach*. Journal of Economic Modeling Research*, 2(8), 87-117.

Manzoor, D. & Taghipour, A. (2016). A dynamic stochastic general equilibrium model for an oil exporting and small open economy: The case of Iran. *Journal of Economic Research and Policies*, 23(75), 7-44.

Monacelli, T. (2009). New Keynesian models, durable goods, and collateral constraints. *Journal of Monetary Economics,* 56 (2),242–54.

Sahabi, B., Asgharpur, H., & Qorbani, S. (2017). The monetary shocks' asymmetry within dynamic stochastic general equilibrium model. *The Economic Research*, 17(2), 73-100.

Semmler, W., & Zhang, W. (2007). Asset price volatility and monetary policy rules: A dynamic model and empirical evidence. *Economic Modelling*, 24, 411–430.

Shahmoradi, A., & Ebrahimi, E. (2010). The impacts of monetary policies in Iran: A DSGE approach. *Journal of Monetary and Banking Researches*, 2(3).31-56.

Townsend, R. M. (1979). Optimal contracts and competitive markets with costly state verification. *Journal of Economic Theory*, 21(2), 265-293.

Appendices

Appendix A: Log-linearized System of Equations

$$\sigma_c \hat{c}_t' = \sigma_c \hat{c}_{t+1}' - \hat{r}_t + \hat{\pi}_{t+1}$$

$$-\varepsilon \hat{m}_t' + \sigma_c \hat{c}_t' - \sigma_c \hat{c}_{t+1}' \hat{r}_t - \hat{\pi}_{t+1} = 0$$

$$\hat{q}_t = \beta' \hat{q}_{t+1} + (1-\beta')(\hat{d}_t - \sigma_h \hat{h}_t') + \sigma_c \hat{c}_t' - \beta' \sigma_c \hat{c}_{t+1}'$$

$$\gamma \hat{L}_t' = \hat{w}_t' - \sigma_c \hat{c}_t'$$

$$\beta' \sigma_c \hat{c}_t'' = \beta'' \sigma_c \hat{c}_{t+1}'' - (\beta' - \beta'') \hat{\lambda}_t'' - \beta' \hat{r}_t + \beta'' \hat{\pi}_{t+1}$$

$$-\varepsilon \hat{m}_t'' + \sigma_c \hat{c}_t'' - \sigma_c \hat{c}_{t+1}'' - \hat{\pi}_{t+1} = 0$$

$$\gamma \hat{L}_t'' = \hat{w}_t'' - \sigma_c \hat{c}_t''$$

$$\hat{q}_t = \gamma_h \hat{q}_{t+1} + (1-\gamma_h)(\hat{d}_t - \sigma_h \hat{h}_t'') + m_h(\hat{\lambda}'' + \hat{\pi}_t) + \sigma_c \hat{c}_t'' - \beta'' \sigma_c \hat{c}_{t+1}''$$

$$\hat{y}_t = \hat{z}_t + \nu \hat{h}_{t-1} + \mu \hat{k}_{t-1} + \alpha(1-\nu-\mu)\hat{L}_t' + (1-\alpha)(1-\nu-\mu)\hat{L}_t''$$

$$\hat{y}_t = \hat{x}_t + \gamma \hat{L}_t'' - (\hat{\lambda}_t'' + \hat{r}_t)$$

$$\hat{y}_t = \hat{x}_t + \gamma \hat{L}_t' + \hat{c}_t'$$

$$\hat{q}_t = \gamma_e \hat{q}_{t+1} + (1-\gamma_e)(\hat{y}_{t+1} - \hat{h}_t - \hat{x}_{t+1}) + \mathrm{m}_e(\hat{\lambda}_t + \hat{\pi}_{t+1} + \sigma_c \hat{c}_{t+1}) + \sigma_c \hat{c}_t - \sigma_c \hat{c}_{t+1}$$

$$\sigma_c \beta' \hat{c}_{t+1} = \sigma_c \beta''' \hat{c}_{t+1} - (\beta' - \beta''') \hat{\lambda}_t + \beta' \hat{r}_t + \beta''' \hat{\pi}_{t+1}$$

$$\sigma_c \hat{c}_t = \sigma_c \hat{c}_{t+1} - \zeta(\hat{y}_t - \hat{x}_{t+1} - \hat{k}_t) + \phi(\hat{i}_t - \hat{k}_{t-1} - \beta'''(\hat{i}_{t+1} - \hat{k}_t))$$

$$\hat{k}_t = (1-\delta)\hat{k}_{t-1} + \hat{i}_t$$

$$\frac{\bar{b}}{\bar{y}} \hat{b}_t = \frac{\bar{c}}{\bar{y}} \hat{c}_t + \frac{\overline{qh}}{\bar{y}} (\hat{h}_t - \hat{h}_{t-1}) + \frac{\bar{i}}{\bar{y}} \hat{i}_t + \frac{\overline{rb}}{\bar{y}} (\hat{r}_{t-1} + \hat{b}_t - \hat{\pi}_t) - (1 - S_1 - S_2)(\hat{y}_t - \hat{x}_t)$$

$$\frac{\bar{b}''}{\bar{y}} \hat{b}_t'' = \frac{\bar{c}''}{\bar{y}} \hat{c}_t'' + \frac{\overline{qh}''}{\bar{y}} (\hat{h}_t'' - \hat{h}_{t-1}'') + \frac{\bar{i}}{\bar{y}} \hat{i}_t + \frac{\overline{rb}''}{\bar{y}} (\hat{r}_{t-1} + \hat{b}_t'' - \hat{\pi}_t) - S_2(\hat{y}_t - \hat{x}_t)$$

$$\hat{b}_t = \hat{q}_{t+1} + \hat{h}_t + \hat{\pi}_{t+1} - r_t$$

$$\hat{b}_t'' = \hat{q}_{t+1} + \hat{h}_t'' + \hat{\pi}_{t+1} - r_t$$

$$\hat{\pi}_t = \frac{\beta}{1+\beta\chi} \hat{\pi}_{t+1} + \frac{\chi}{1+\beta\chi} \hat{\pi}_{t-1} + \frac{(1-\theta)(1-\beta\theta)}{\theta(1+\beta\chi)} mc_{t+1}$$

$$\hat{g}_t + \frac{\overline{tr}}{\bar{g}} \hat{tr}_t = \frac{\bar{t}}{\bar{g}} \hat{t}_t + \frac{\bar{o}}{\bar{g}} \omega \hat{o}_t + \frac{\bar{m}}{\bar{g}} \hat{m}_t - \frac{\bar{m}}{\bar{g}} (\hat{m}_{t-1} - \hat{\pi}_t)$$

$$\widehat{T_t^{vat}} = \tau^{vat} (\hat{c} + \widehat{g})$$

$$\widehat{T_t^d} = \tau^d \hat{y}$$

$$\hat{t}_t = \frac{\bar{T}^d}{\bar{t}} T_t^d + \frac{\bar{T}^{vat}}{\bar{t}} T_t^{vat}$$

$$\hat{y}_t = \frac{\overline{c'}}{y}\hat{c}_t' \frac{\overline{c''}}{y}\hat{c}'' + \frac{\bar{c}}{y}\hat{c}_t + \frac{\overline{g}}{y}\hat{g}_t + \frac{\bar{i}}{y}\hat{i}_t$$

$$\hat{h}_t = \frac{\overline{h'}}{\overline{h}}\hat{h}_t' + \frac{\overline{h''}}{\overline{h}}\hat{h}_t''$$

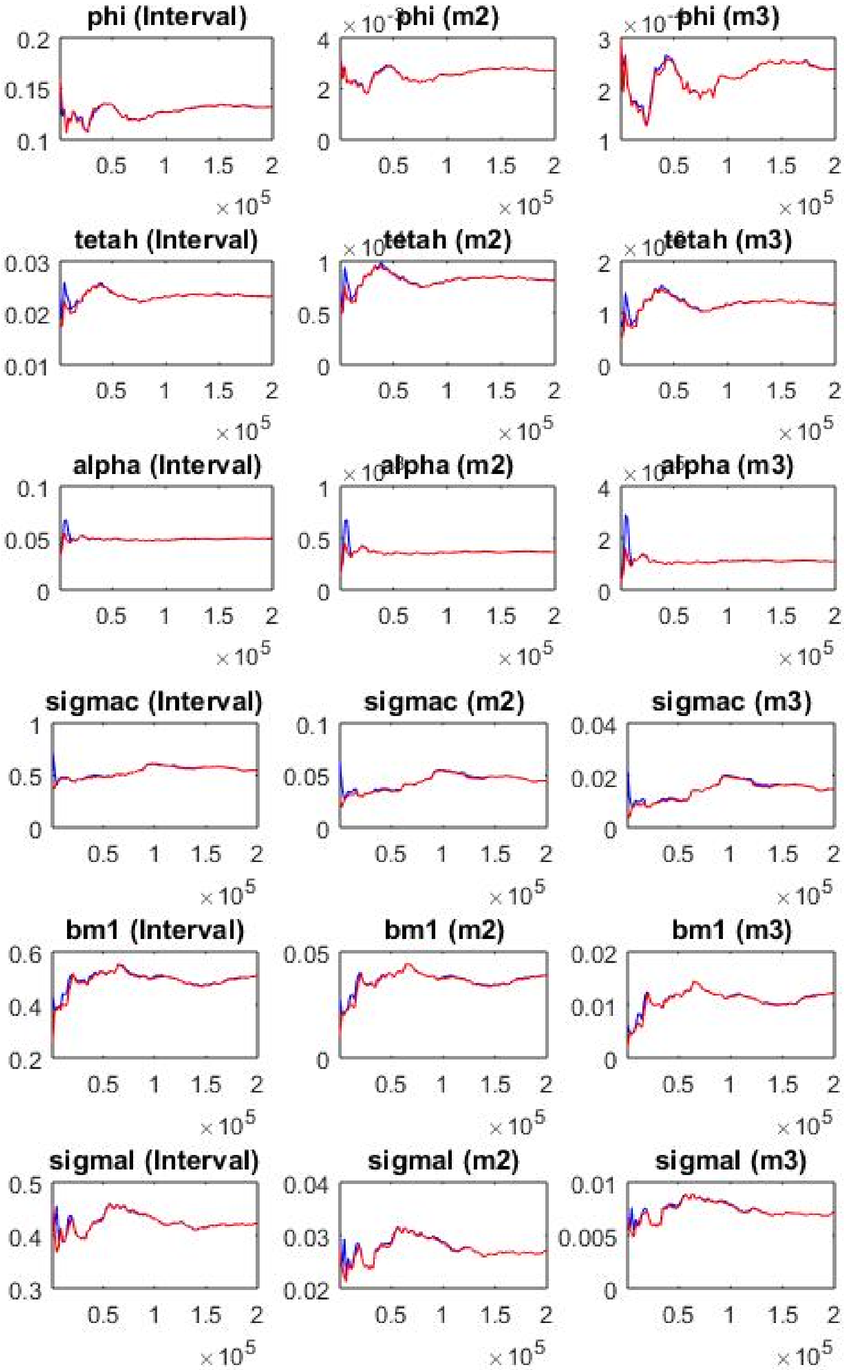
$$\hat{b}_t = \frac{\overline{b'}}{\overline{b}}\hat{b}_t' + \frac{\overline{b''}}{\overline{b}}\hat{b}_t''$$

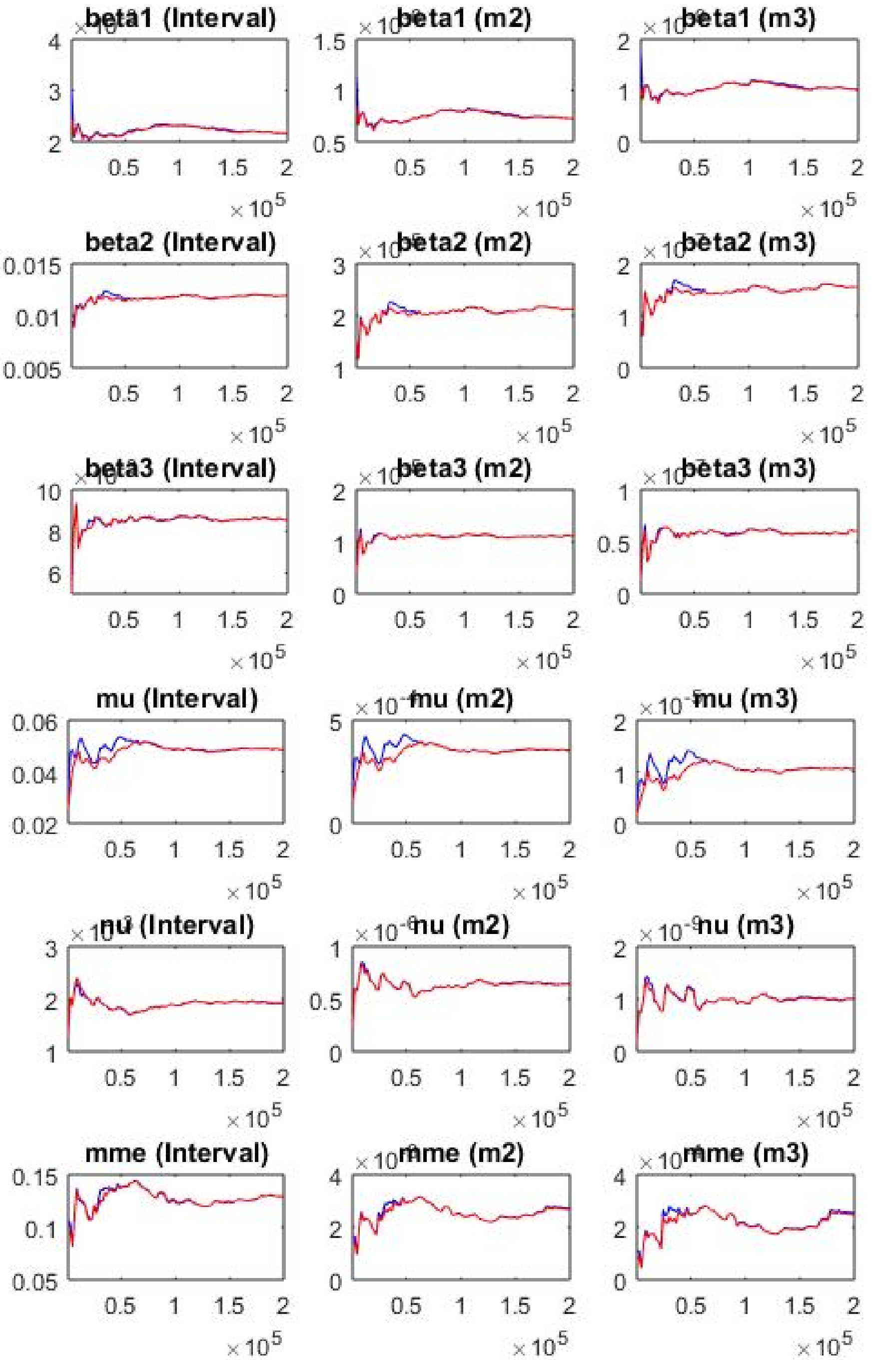
$$\hat{g}_t = \rho_g \hat{g}_{t-1} + e\_g$$

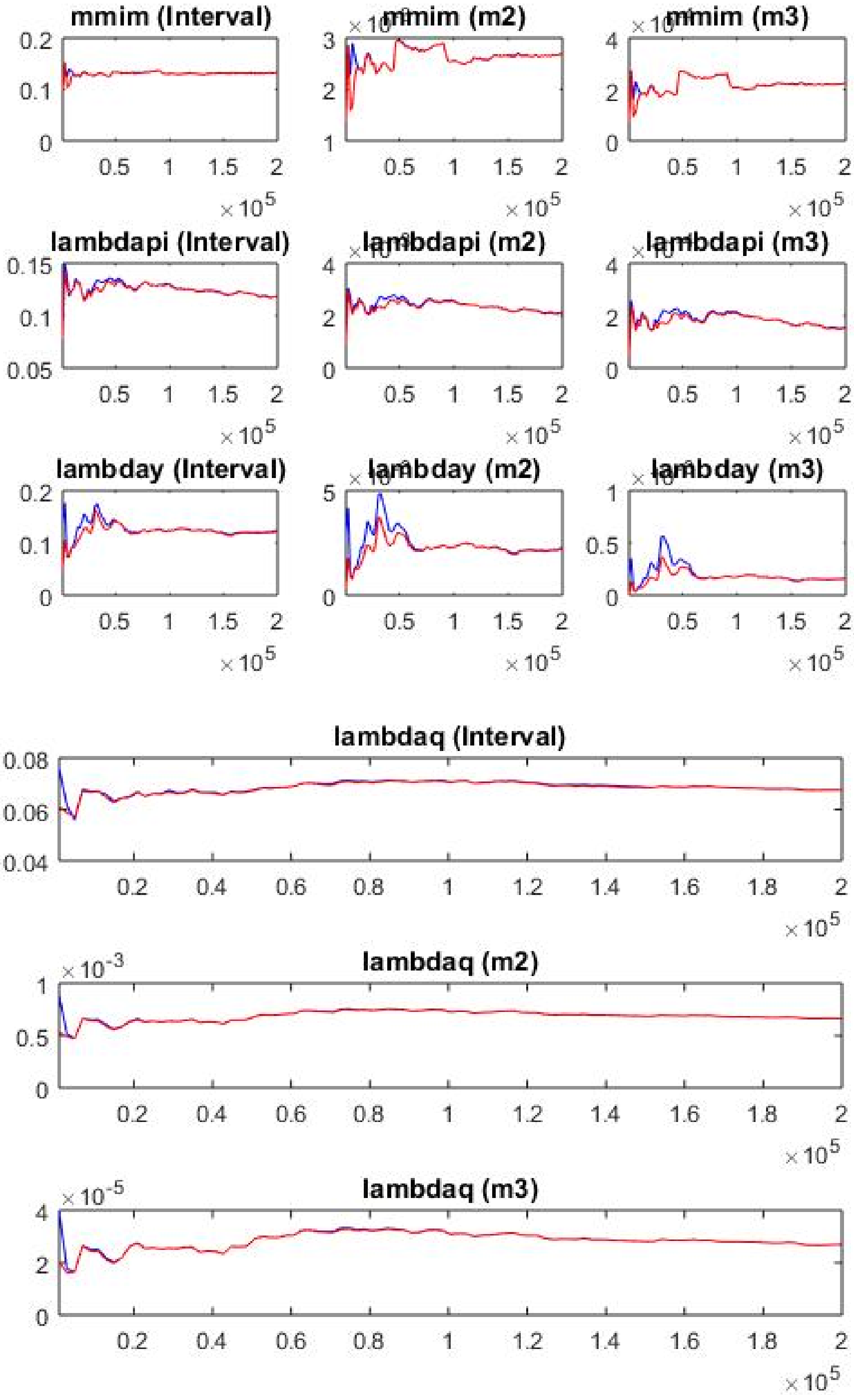
$$\hat{o}_t = \rho_o \hat{o}_{t-1} + e\_o;$$

$$\hat{\upsilon}_t = \rho_\upsilon \hat{\upsilon}_{t-1} + e\_\upsilon;$$

Appendix B: MCMC Univariate Convergence Diagnostics




beta1 (Interval)
beta1 (m2)
beta1 (m3)
beta2 (Interval)
beta2 (m2)
beta2 (m3)
beta3 (Interval)
beta3 (m2)
beta3 (m3)
mu (Interval)
mu (m2)
mu (m3)
nu (Interval)
nu (m2)
nu (m3)
mme (Interval)
mme (m2)
mme (m3)


mmim (Interval)
mmim (m2)
mmim (m3)
lambdapi (Interval)
lambdapi (m2)
lambdapi (m3)
lambday (Interval)
lambday (m2)
lambday (m3)
lambdaq (Interval)
lambdaq (m2)
lambdaq (m3)
× 10^-3
× 10^-5
× 10^5

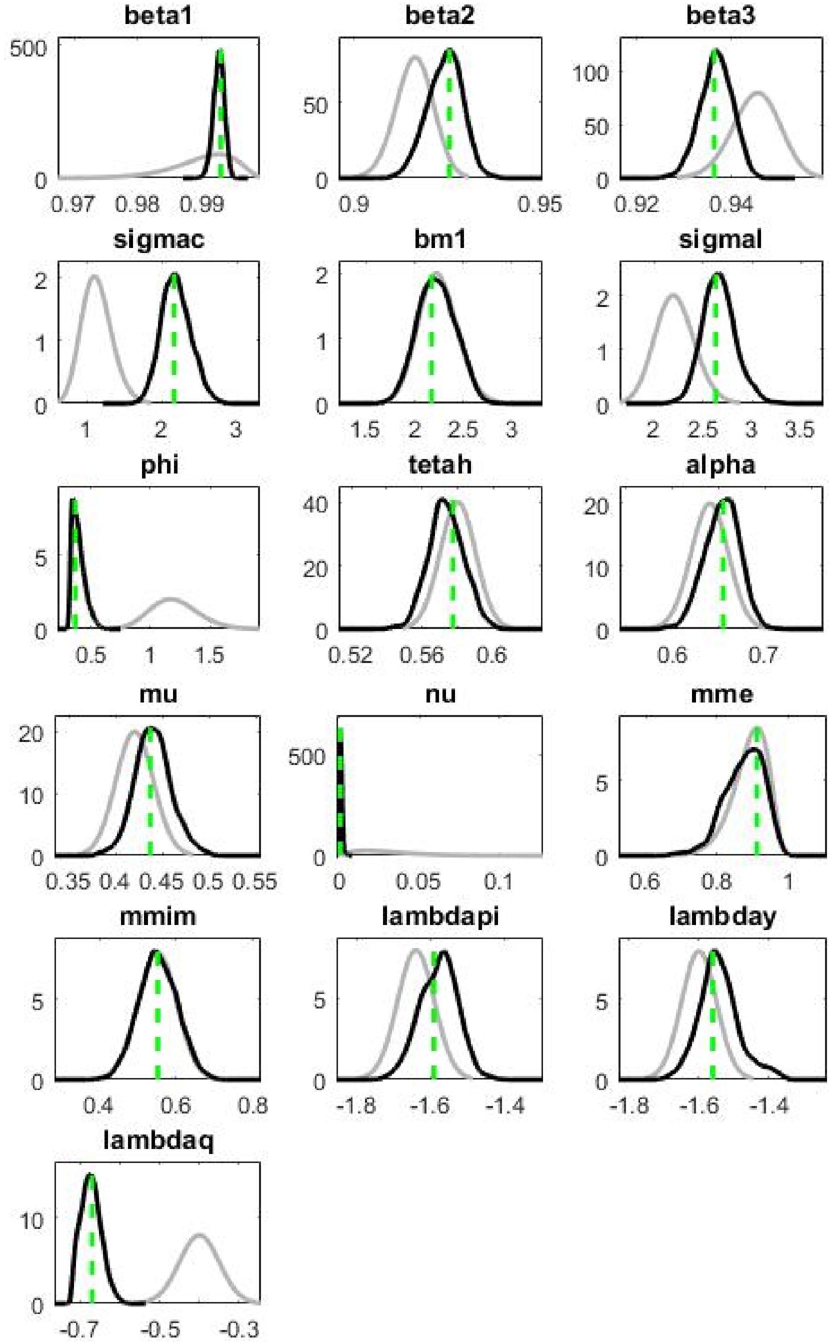


Figure 3. Prior and Posterior distribution of the model