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Reconnoitering the Effective Channels of Monetary Transmission Mechanism in Iran Using a Dynamic Stochastic General Equilibrium Model

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Abstract

The purpose of the present research is to investigate the effective channels of the monetary transmission mechanism in Iran. To do so, we devised a New Keynesian Dynamic Stochastic General Equilibrium Model. In our model, the different types of nominal rigidities are introduced beside all the related structural equations, which are extracted and linearized around a steady state point. Furthermore, to design the DSGE model, two different monetary rules—Taylor and McCallum rules—are used. In other words, the different channels of monetary mechanisms are investigated on the basis of these two rules. To estimate the two mentioned models, seasonal data for the period 1990–2015 are collected. The estimation method used in the study is the Bayesian method. According to the results obtained from variance decomposition, in the Taylor rule-based, q-Tobin, interest rate, wealth and expectation channels are the effective channels in monetary transmission mechanisms; also, in the McCallum rule-based model monetary policy, wealth and expectation channels are the effective channels in monetary transmission mechanisms. In addition, based on the simulation results in the Taylor model, increasing interest rate causes a reduction in output, consumption, investment and capital utilization rate, and in the McCallum model, a positive monetary shock can cause an increase in preceding variables, which is a result of price rigidity.

1. Introduction

Monetary policies are widely employed to achieve the final goals of an economic system. The degree of effectiveness of a monetary policy depends on the process through which the implemented shock would affect the outcome of the system. This process is called transmission mechanism. On the basis of transmission mechanism, monetary policy affects macroeconomic variables

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through different channels, where each has a unique process. By the way, a large body of the literature on monetary economics is devoted to investigating monetary channels.

At every point of time, an economy faces several sectorial and policy shocks, but their effects through the transmission mechanism remain ambiguous; while some of them have no effect on the system, others change the dynamic path of the variables. Reconnoitring monetary transmission channels is a helpful method to detect effective shocks that could alter the dynamic paths and it thereby constitutes a part of the core of monetary analysis.

The structure of the present paper is similar to earlier studies in this field, but the main difference is that since there are huge controversies regarding the monetary tool used by the Central Bank of Iran, we run two different models based on two uncorrelated policy rules and then extracted the effective channels; moreover, appropriate statistics were used to judge the models' findings.

The main objective of this paper is to identify the effective channels of monetary transmission mechanism in Iran's economy. To do this, we designed a dynamic stochastic general equilibrium (DSGE) model and estimated the structural parameters by using the Bayesian approach. After that, by using variance decomposition, we reconnoitred the important channels that transmit monetary policy into variables.

Based on the above mentioned statements, the first step to derive a comprehensive knowledge on monetary policy effects is to know its channels through transmission mechanism. So, in the next section, we first introduce these channels and the school of thoughts behind them, and then carry on with the other parts of the paper based on this literature.

2. Channels of Monetary Transmission Mechanisms

There are two basic viewpoints regarding monetary transmission mechanisms. One is the *monetary viewpoint* based on interest rate, exchange rate, and money supply channel, and the other is the *credit viewpoint* based on the two channels of banking loans and balance sheet activities. The two other channels of asset pricing and expectations are also dependent on the monetary policies in action. In practice, the monetary policy tools first affect the intermediate targets and later through the intermediate targets, affect the final goals; a particular intermediate goal can emphasize a particular channel through which monetary transmission mechanisms can function (McCallum, 1999).

The channel of quantity refers to the 'Quantity theory of money' of classical economists. According to this classical theory that assumes full employment, flexibility of prices and wages and no governmental intervention in the economy, in the long term, the volume of money will have no effect on the production level and will only cause a relative change in the price levels. Fisher's equation, also called the equation of exchange, is written as below:

$$MV = PT$$

Here *M*, *V*, *P* and *T* represent the volume of money, velocity speed, price levels and the volume of transactions, respectively.

The interest rate channel is the initial channel studied by many economists across the world. Central banks use the interest channel as the process of transmission of monetary policy rules.

The performance of the interest rate channel depends on the rate of openness of the economy and the success of floating exchange rate regime. In other words, in a floating exchange rate regime, by executing an expansionary monetary policy and increasing the velocity of money, the real interest rate decreases and the bank deposits of domestic currency seem to be less attractive than foreign exchange deposits. As a result, there is a decrease in the flow of capital in the direction of bank deposits of domestic currency.

The asset price channel uses the q-Tobin and wealth effect channels to exhibit transmission mechanisms. In other words, by implementing a certain monetary policy, the price of financial assets will change, thereby changing the value of real assets, and leading to fluctuations in total consumption and aggregate demand. The fluctuations in aggregate demand will also change the production and inflation levels. An alteration in asset price will affect general investment, production and inflation rate, consequently.

According to the wealth effect proposition, which is founded on the Life Cycle theory, the present value of an individual's consumption depends on the present value of his income. Thus, consumers smooth their consumptions over time in order to avoid the burden of low income at the beginning and at the end of their life.

The channel of bank loans and facilities emphasizes the role of banks in monetary policy transmission. Based on the studies by Bernanke and Blinder (1998) and Ford and Santoso (2003), a contradictory monetary policy will reduce bank savings and demand deposit accounts, thus reducing the availability of resources to grant loans to customers.

The balance sheet channel emphasizes the effect of monetary policy on the balance sheet of borrowers, and their revenue declaration variables such as net wealth value, cash flow and cash holdings. As per definition, the function of this channel is very similar to the channel of banking loans and facilities. This channel considers the balance sheet structure, which can affect the whole economy, and concentrates more on bank assets in the balance sheet. The constituent channels of balance sheet approach are the Net Worth Channel, the Cash Flow Channel and the Channel of Debt to Household Asset Ratio (Skaperdas, 2017).

According to Mohanty and Turner (2006), monetary policy changes such as changes in the interest rate could affect the expected inflation and the expected income, and thus in a general manner influence the expectation of all the people in a society as well as future economic activities.

According to the exchange rate channel, the nominal exchange rate is changed by a variation of the interest rate that is generated by a monetary policy. Then, the net exports alter and this changes the real output.

The function of the expectation channel in monetary policy transmission mechanism depends on several factors. First, the expectations of an economic agent are contingent to the inflation rate, interest rate, wage rate, stock price index and production level. Second is the degree of credibility and validity of Central Bank authorities. Third is the degree of predictability of Central Bank policies, and fourth is the severity of the Central Bank's commitment to follow the announced goals, while using an array of tools to facilitate the task.

This article is structured as follows: The second part of the present study will review the existing literature; the third part will concentrate on designing a general equilibrium model and extracting the structural equations. The fourth section will assess and discuss the derived results, and the fifth and last part will try to draw conclusions based on the conducted research.

3. Literature Review

Several studies have reported that the monetary transmission mechanism in Iran has more than one effective channel and the monetary policy could affect real variables such as the output gap. For example, the study by Komijani and Alinejad (2012) showed that the interest rate, asset price, exchange rate and bank credit channels greatly influenced the output growth rate and inflation rate. Shahraki et al. (2015) confirmed this result for the interest rate and exchange rate.

Some other studies have shown that the financial sector could also be an important part of the transmission mechanism. For example, Komijani and Alinejad (2012) reported that banks credits play a major role in output fluctuations. Shah Hosseini and Bahrami (2016) drew a similar conclusion by including the banking sector. Their finding showed that the behaviour of banking sector variables was in line with cyclical variations and was thereby a main part of the transmission mechanism.

Although these studies set up a proper empirical background, they have some inherent problems: the Komijani and Alinejad model did not include the demand and supply sides simultaneously and therefore the position of economy equilibrium is not clear, and this shortcoming may lead to misunderstanding. The results of Shahraki et al. (2015) cannot be trusted; although they are beneficial for a general equilibrium model, the derived statistics of model (like MCMC) analysis is not satisfactory. Even though Shah Hosseini and Bahrami (2016) have reported acceptable results, these failed to monitor the channels' effects properly because of the lack of enough nominal rigidity. In our study, beside a variety of rigidities, we used variance decomposition, a powerful tool, for channel analysis, whereby some of the findings were in line with those of the mentioned studies. Pourahmadi et al. (2017) indicated that the decision of

Central Bank on monetary policy follows McCallum rule without any response to exchange rate shocks.

A broad range of studies have been devoted to analysing the monetary channels for foreign countries. Among them, a number of studies found the effectiveness of some channels changes over time; for example, Boivin et al. (2010) used a DSGE model to show that monetary policy shocks have been less effective on real production and inflation rates prior to 1980s, which was due to the changes in policy behaviour and their effect on expected inflation (expectation channel).

It is apparent from these studies that at least some monetary factors are effective during policy implementation. For example, Gerali et al. (2010) investigated the role of banks in monetary policy transmission mechanism in European countries by using a DSGE model. In this study, withdrawal shocks, bank liquidity shocks, bank capital shocks, supply of credit shocks and monetary shocks are investigated. The results revealed that a fall in deposit attraction leads to a decrease in bank resources and as a result, a decrease in the supply of credits and production. In addition, the imposition of restrictions on the supply of credits (supply of credit shock) leads to institutions having lower access to financial resources and eventually to a drop in production.

One major achievement of channel analysis is that recent studies do not limit themselves to the existing channels and add other channels to describe the transmission mechanism more precisely. One of these achievements is the information channel that is described by Sinelnikova (2017). Her findings show that the use of this channel in a model could help to describe the deposit channel as a major part of the mechanism. Sinelnikova's derivation has been proved by Senbet (2016), who showed that the credit channel is the main part of the transmission channel. Here, we should add that credit channels are mostly observed in advanced economies than in countries with less developed financial markets, but this channel is less important and, in some cases, has no effect.

4. Designing a DSGE Model for Iranian Economy

The DSGE model used in this study is based on a New-Keynesian structure with nominal rigidities in all the three sections of household, producer and foreign economy. A monetary transmission mechanism is derived on the basis of the effects of the monetary policy on real production and inflation. Based on the introduced mechanism, we investigated the role of each channel in monetary transmission mechanism. The participants of the model were the following:

4.1 Household

Private consumption constitutes a major part of the aggregate demand. The other components such as government expenditures, gross investment and net exports, are also consumption decisions made by firms, government and foreign entities. Thus, our first step was to analysis the household behaviour in the market.

The household utility function is expressed as the following equation[1]:

$$U_t = E\sum_{t=0}^{\infty}\beta^t \varepsilon_t^u [\frac{(C_t - hC_{t-1})^{1-\sigma_C}}{1-\sigma_C} + \frac{(M_t / P_t)^{1-\sigma_m}}{1-\sigma_m} - \frac{L_t^{1+\sigma_L}}{1+\sigma_L}] \quad (1)$$

where β is the subjective discount factor of the household, C_t consumption, M_t nominal balance of the money, P_t general level of prices, L_t working time, σ_C the inverse of intertemporal substitution elasticity of consumption. $H_t = hc_{t-1}$ with h act as habit persistence parameter, σ_m the inverse of money demand elasticity, σ_L the inverse of labor supply elasticity and ε_t^u is household preferences shock. According to this utility function household obtains utility from consumption of commodities and services, while maintaining the desired real balance of the money and leisure. Of course, there is a tradeoff between labor time and leisure time; therefore, labor work time has entered the utility function in a negative way.

Habit persistence assumption has two main outcomes. First, is embodied a hump shape behavior to consumption function where provides realistic reaction functions. Second, the effects of expectation channel, interest rate channel and asset price channel will alter, since habit persistence changes structural parameters of consumption function.

The household utility maximization is subject to its budget constraint. The representative household obtains resources through five channels: First channel is the supply of labor in a completive market, income is earned based on the working hours and wage rates. The second channel is via the last period bonds yield. The third channel is the nominal balance of the money kept from the previous period, which earns no interest reward and is kept by the household in the form of deposit in banks accounts or in cash. The forth channel is investment profit which is a percent of the capital formation obtained from the investment. The fifth method and last source of the household income is the net income gained from the government, which enters the budget constraint under the title of net transfer payment.

Considering all the above assumptions, household budget constraint can be demonstrating as:

$$P_t C_t + B_t + M_t + P_t I_t \le W_t L_t + R_{t-1} B_{t-1} + M_{t-1} + P_t (r_t^k Z_t K_{t-1} - \psi(Z_t) K_{t-1}) + TR_t - T_t$$

The household spends its resources on: consumption of commodities and services, buying bonds(B_t), investment expenditures (I_t), and keeping a nominal balance of the money. In Equation (2), W_t is the wage, R_{t-1} gross nominal interest rate ($R_{t-1} = 1 + i_{t-1}$), and r_t^k represents the real interest rate on the capital, K_t is the volume of the capital, Z_t shows the percentage of capital

[1] We used Smets and Wouters (2003) elements to model the household behavior.

that is utilized, TR_t is transfer payment and T_t is the tax paid. By using capital in the production process with utilization rate Z_t, a part of the capital will evaporate and hence would not gain rental rate and therefore impose a cost on household which is shown by $\psi(Z_t)$ in budget constraints.

Dividing both sides of the budget constraint by the price level, we can rewrite it, in terms of real variables, as follows:

$$C_t + m_t + b_t + I_t \leq w_t L_t + \frac{m_{t-1}}{\Pi_t} + (1 + i_{t-1})\frac{b_{t-1}}{\Pi_t} + (r_t^k Z_t K_{t-1} - \psi(Z_t) K_{t-1}) + tr_t - t_t \quad (2)$$

where m_t, b_t, w_t, tr_t and t_t are real money balance, real bond, real wage, real transfers and real taxes, respectively.

The household is the source of investment funds and capital formation. The usage rate of capital shows the amount of household income that is gained from this resource, and therefore the investment rate and the capital rate need a relation that shows the ratio of investment and capital. Such a relation is usually regulated by the capital accumulation rule; however, because it is expected that the process of capital formation is both expensive and time-consuming, only part of the investment funds and not all of it is converted into capital. This is what we call capital adjustment cost.

Therefore, the capital accumulation rule enters the subject of household constraint as is shown in the following relation (3):

$$K_t = (1-\delta)K_{t-1} + \left(1 - S\left(\frac{\varepsilon_t^I I_t}{I_{t-1}}\right)\right) I_t \quad (3)$$

In this relation, $S(.)$ is the capital adjustment cost function and ε_t^I is the investment shock. Since $0<S<1$ only a part of the investment changes into capital. This assumption is compatible with the accepted principle that a time lag exists between investment and capital formation[1].

Hence, the household faces budget constraint in Equation (2) and capital accumulation constraint in Equation (3). The household intends to maximize the utility function in Equation (1). This maximization process involves the meeting of two constraints in such a way that optimal private consumption, portfolio choice of government bonds and balance of money, proper supply of labour, the optimal investment costs and the optimal use of capital are achieved. In order to solve this problem, we first have to make a Lagrange equation as given in Equation (4):

[1] Kydland and Perscott (1982).

$$L = E_t \sum_{t=0}^{\infty} \beta^t \left\{ \begin{aligned} & \varepsilon_t^u \left[\frac{(C_t - H_t)^{1-\sigma_C}}{1-\sigma_C} + \frac{1}{1-\sigma_m} \left(\frac{M_t}{P_t} \right)^{1-\sigma_m} - \frac{L_t^{1+\sigma_L}}{1+\sigma_L} \right] \\ & + \lambda_t (w_t L_t + \frac{m_{t-1}}{\Pi_t} + (1+i_{t-1}) \frac{b_{t-1}^p}{\Pi_t} + (r_t^k Z_t K_{t-1} - \psi(Z_t) K_{t-1}) \\ & + tr_t - t_t - C_t - m_t - b_t^p - I_t) + \mu_t [(1-\delta) K_{t-1} + I_t (1 - S(\frac{\varepsilon_t^I I_t}{I_{t-1}})) - K_t] \end{aligned} \right\} \tag{4}$$

Here the lower-case variables are the real variables. From the Lagrangian optimization in Equation (4), the first order conditions are derived, which demonstrate the optimal paths of consumption variables, real balance of money, labour supply, bonds, optimal capital usage rate, capital and investment volumes. Besides, λ_t is the Lagrangian coefficient related to budget restraint and μ_t is the Lagrangian coefficient related to capital accumulation.

The first order conditions is:

$$\frac{\partial L}{\partial C_t} = 0 \Rightarrow \varepsilon_t^u (C_t - H_t)^{-\sigma_C} = \lambda_t \tag{5}$$

$$\frac{\partial L}{\partial L_t} = 0 \Rightarrow -\varepsilon_t^u L_t^{\sigma_L} + \lambda_t w_t = 0 \tag{6}$$

$$\frac{\partial L}{\partial m_t} = 0 \Rightarrow \varepsilon_t^u (m_t)^{-\sigma_m} - \lambda_t + \beta E_t \frac{\lambda_{t+1}}{\Pi_{t+1}} = 0 \tag{7}$$

$$\frac{\partial L}{\partial b_t} = 0 \Rightarrow -\lambda_t + \beta (1+i_t) \frac{E_t \lambda_{t+1}}{\Pi_{t+1}} = 0 \tag{8}$$

$$\begin{aligned} \frac{\partial L}{\partial I_t} = 0 \Rightarrow & -\lambda_t + \mu_t - \varepsilon_t^I \mu_t S\left(\frac{\varepsilon_t^I I_t}{I_{t-1}} \right) \\ & -\mu_t \varepsilon_t^I I_t \frac{1}{I_{t-1}} S'\left(\frac{\varepsilon_t^I I_t}{I_{t-1}} \right) + \beta E_t \mu_{t+1} \left(\frac{I_{t+1}}{I_t} \right)^2 S'\left(\frac{\varepsilon_{t+1}^I I_{t+1}}{I_t} \right) = 0 \end{aligned} \tag{9}$$

$$\frac{\partial L}{\partial z_t} = 0 \Rightarrow r_t^k = \psi'(Z_t) \tag{10}$$

$$\frac{\partial L}{\partial K_t} = 0 \Rightarrow \beta^{t+1} \left[\lambda_{t+1} (r_{t+1}^k Z_{t+1} - \psi(Z_{t+1})) + \mu_{t+1} (1-\delta) \right] - \beta^t \mu_t = 0 \tag{11}$$

Relations (5) to (11) are simultaneous non-linear differential equations system. This system is linearized around a steady state by using Taylor expansion. In these equations, the variables with the sign ^ show the linearized logarithm of variables around a steady state situation:

$$\hat{C}_t = \frac{h}{1+h} \hat{C}_{t-1} + \frac{1}{1+h} E_t \hat{C}_{t+1} - \frac{1-h}{\sigma_C (1+h)} (\hat{i}_t - E_t \hat{\pi}_{t+1}) - \frac{1-h}{\sigma_C (1+h)} (\varepsilon_{t+1}^u - \varepsilon_t^u) \tag{12}$$

$$\hat{m}_t = \frac{\sigma_C}{\sigma_m}[\frac{1}{1-h}\hat{c}_t - \frac{h}{1-h}\hat{c}_{t-1}] - \frac{1}{\sigma_m}\frac{1}{\bar{i}}\hat{i}_t - \frac{1}{\sigma_m}(\varepsilon^m_{t+1}) \quad (13)$$

$$\hat{I}_t = \left(\frac{1}{\varphi(1+\beta)}\right)\hat{q}_t + \left(\frac{1}{1+\beta}\right)\hat{I}_{t-1} + \left(\frac{\beta}{1+\beta}\right)\hat{I}_{t+1} + (\varepsilon^I_{t+1} - \varepsilon^I_t) \quad (14)$$

$$\hat{q}_t = -(\hat{i}_t - \hat{\pi}_{t+1}) + \frac{(1-\delta)}{1+\bar{r}^k - \delta}\hat{q}_{t+1} + \frac{\bar{r}^k}{1+\bar{r}^k - \delta}\hat{r}^k_{t+1} + eq \quad (15)$$

Relations (12), (13), (14) and (15) stand for linearized consumption, real money demand, investment and q-Tobin. Moreover, *eq* is a shock to the q-Tobin equation.

The consumption index is a composite aggregator of domestic and imported goods. By the way, we can write the consumption index as a bundle of home and foreign goods in the following manner:

$$C_t = \left[a^{1/x}C_{I,t}^{(x-1)/x} + (1-a)^{1/x}C_{O,t}^{(x-1)/x}\right]^{x/(x-1)}$$

In the above equation, parameter a is the share of domestic goods ($C_{I,t}$) in total consumption and x is the substitution elasticity between domestic and imported goods ($C_{O,t}$). The household demand for each item of goods is derived from minimizing the total expenditure on domestic and foreign goods with respect to the consumption index, as given below, where $P_{I,t}$ is the price level of domestic goods and $P_{O,t}$ is the price level of foreign goods:

$$C_{I,t} = x\left(\frac{P_{I,t}}{P_t}\right)^{-x}C_t$$

$$C_{O,t} = (1-x)\left(\frac{P_{O,t}}{P_t}\right)^{-x}C_t$$

The household as a labour supplier determines the level of wage that brings the maximum level of welfare for it. In our model, the households are divided into two groups: a fraction of households (ξ_w) update their wages according to past inflation with indexation parameter ι_w. The remaining households (1-ξ_w) set a new optimal wage rate for each period. Thus, the wage relation in the economy is represented as:

$$\widehat{w}_t = \frac{1}{1+\beta}\widehat{w}_{t-1} + \frac{\beta}{1+\beta}\left(E(\widehat{w}_{t+1}) + E(\hat{\pi}_{t+1})\right) - \frac{1+\iota_w\beta}{1+\beta}\hat{\pi}_t + \frac{\iota_w}{1+\beta}\hat{\pi}_{t-1} - \frac{1}{1+\beta}\frac{(1-\xi_w)(1-\beta\xi_w)}{\xi_w}\hat{\mu}^w_t + \varepsilon^w_t \quad (16)$$

In Equation (16):

$$\hat{\mu}^w_t = \widehat{w}_t - \sigma_l\hat{l}_t - \frac{\sigma_c}{1-\lambda}(\hat{c}_t - \lambda\hat{c}_{t-1})$$

Therefore, the percentage change in nominal wage is:

$$\hat{\pi}^w_t = \widehat{w}_t - \widehat{w}_{t-1} + \hat{\pi}_t \quad (17)$$

The foreign side of this model consists of the terms of trade, the real exchange rate and the law of one price gap. The terms of trade (S_t) is defined as the ratio of foreign goods price ($P_{f,t}$) to the home price of a country ($P_{h,t}$),

$S_t = \frac{P_{f.t}}{P_{h.t}}$, and based on this definition, the logarithmic deviation of the terms of trade from its steady state is identified as[1]:

$$\Delta\hat{s}_t = \hat{\pi}_{f.t} - \hat{\pi}_{h.t} \quad (18)$$

In Equation (18), $\pi_{f.t}$ represents the imported goods inflation and $\pi_{h.t}$ is the domestic products inflation. We introduced the real exchange as the linearized logarithmic function of domestic inflation, foreign interest rate and foreign inflation.

$$\Delta\widehat{qq}_t = -(\hat{\imath}_t - E\hat{\pi}_{t+1}) - \left(\hat{\imath}_t^f - E\hat{\pi}_{t+1}^f\right) + \varepsilon_t^q \quad (19)$$

In the above relation, qq_t is the real exchange rate, π_t is the total domestic inflation, i_t^f is the foreign bank's interest rate, π_t^f is the foreign inflation rate and ε_t^q is the real exchange rate shock.

We assumed that importers have the power to determine the prices of imported goods, and so the price of imported goods will differ from their international price. This is contrary to the law of one price, which requires equal prices for similar commodities across the world. The gap between domestic price and international price is written as follows:

$$\hat{\psi}_t = -[\widehat{qq}_t + (1-\tau)\hat{s}_t] \quad (20)$$

4.2 Firms

In this study, firms are classified into two categories: domestic producers and international traders. Both types of firms have the power to determine the price in the market.

4.2.1 Domestic Firms

Domestic producers produce commodities by using capital and labour. We assumed that firms utilize *z* rate of the capital available in each period. Therefore, the effective production capital k^s is equal to $K^s=zK$.

$$Y_t = (K_t^s)^\alpha L_t^{1-\alpha} \varepsilon_t^\alpha \quad (21)$$

where Y_t is the output level. It is also assumed that the producer firms work in a monopolistic competition environment and have the capacity to determine prices. The probability of exercising this capacity is identified randomly in each period (Calvo, 1983). In order to model the pricing method of a firm, we use the Christiano et al. (2005) method. Thus, firms are classified into two groups. The first group $1-\omega$ includes those firms that can determine the optimal prices in each period and specify the optimal price path based on the maximization of their profit. The second group, however, comprises those firms that are not able to identify their optimal price and adjust their prices based on the previous period inflation.

[1] Gali (2007), Chapter 7, provides a solid theoretical foundation for including the foreign sector in DSGE models.

Since the production function has constant return to scale property, the real marginal cost (mc_t) shows the real average cost and we can thereby write the profit optimization problem as follows[1]:

$$Max_{P_t(j)} E_t \sum_{s=0}^{\infty} (\omega\beta)^s \Delta_{s,t+s} \left[\frac{P_{t+s}(j)}{P_{t+s}} Y_{t+s}(j) - mc_{t+s} Y_{t+s}(j) \right]$$
$$S.t \quad Y_{t+s}(j) = \left(\frac{P_{t+s}(j)}{P_{t+s}} \right)^{-\theta} Y_{t+s} \tag{22}$$

Here, partial adjustment brings about a hybrid new–Keynesian Philips curve:

$$\hat{\pi}_{I,t} = \frac{1}{1+\beta}\hat{\pi}_{I,t-1} + \frac{\beta}{1+\beta}E_t(\hat{\pi}_{I,t+1}) + \frac{(1-\omega\beta)(1-\omega)}{\omega(1+\beta)} m\hat{c}_t + \varepsilon_t^p \tag{23}$$

In (23), $\hat{\pi}_{I,t}$ and ε_t^p represent the domestic inflation and the cost pressure shock, respectively. Furthermore, the linear-logarithmic production function, marginal cost, marginal product of capital (*mpk*) and utilization rate, respectively, are:

$$\hat{Y}_t = \alpha \hat{K}_t^s + (1-\alpha)\hat{L}_t + \alpha\varepsilon_t \tag{24}$$
$$\widehat{mc}_t = \alpha\left(\hat{K}_t^s - \hat{L}_t\right) - \hat{w}_t + \alpha\varepsilon_t \tag{25}$$
$$\widehat{mpk}_t = -\left(\hat{K}_t^s - \hat{L}_t\right) + \hat{w}_t \tag{26}$$
$$\hat{Z}_t = \frac{1-\psi}{\psi}\widehat{mpk}_t \tag{27}$$

4.2.2 Importing Firms

Usually, the importing firms buy commodities directly from foreign suppliers and import them into the home market. In this study, we assumed that importers are able to change the prices of imported goods and therefore act similar to domestic firms and face price stickiness. The gap of law of one price confirms this capability too[2].

For these importing firms, the exchange rate is the only effective factor. Hence, their marginal costs entirely depend on the gap of one price law. Using the Christiano et al. (2005) method, the Phillips curve of this part is:

$$\hat{\pi}_{f.t} = \beta\left(1-\theta_f\right)E\hat{\pi}_{f.t+1} + \theta_f\hat{\pi}_{f.t-1} + \lambda\hat{\psi}_t + \varepsilon_t^f \tag{28}$$

In Equation (28), ε_t^f is the import inflation shock. Therefore, the general level of inflation is defined as:

$$\hat{\pi}_t = \epsilon\hat{\pi}_{h.t} + (1-\epsilon)\hat{\pi}_{f.t} \tag{29}$$

[1] Smets and Wouters (2003) provide the complete process of deriving the hybrid new–Keynesian Phillips curve.

[2] Elements of this section are borrowed from Gali (2007).

4.3 Monetary Policy

Monetary policy consists of a selection of tools employed by the Central Bank to control and respond to economic fluctuations. In the context of the literature on economics, we followed the two road maps of McCallum and Taylor rules.

As per the McCallum rule, the Central Bank chooses the growth rate of monetary base as a policy tool. In other words, the monetary authority uses the changes in money growth rate as the main tool at his disposal to respond to economic fluctuations. On the other hand, according to the Taylors rule, the Central Bank treats the interest rate as the main policy tool. Although the ultimate goal for both rules is the same, most central banks nowadays use the Taylor rule to implement monetary policies.

In Iranian economist cycles, overwhelming discussions on the topic of monetary policy ends with the conclusion that there is no adherence to an economic rule. Moreover, even if one accepts that there is a monetary rule, it is often difficult to figure out whether it is the McCallum type or the Taylor type. Hence, there is no general agreement on the subject; however, one may conclude that for certain periods, the monetary policy has been closer to McCallum rule, and for some other periods, the monetary policy has reacted to economic fluctuations more in line with the Taylor rule than the other rule.

In this research, however, we first estimated both the models and then based on the obtained results the monetary transmission mechanism was envisaged.

The Taylor rule used is:

$$\hat{\imath}_t = \rho_i \hat{\imath}_{t-1} + (1-\rho_i)\left[\rho_{i.\pi}\hat{\pi}_t + \rho_{i.y}\hat{Y}_t\right] + \varepsilon_t^i \tag{30}$$

where ε_t^i represents the monetary policy shocks based on interest rate fluctuations.

The McCallum rule is:

$$\widehat{m}_t = \rho_m \widehat{m}_{t-1} - (1-\rho_m)\left[\rho_{m.\pi}\hat{\pi}_t + \rho_{m.y}\hat{Y}_t\right] + \varepsilon_t^m \tag{31}$$

where ε_t^m represents the monetary base shocks when economic fluctuations are observed. The linearized monetary base of resources is[1]:

$$\widehat{m}_t = \frac{\overline{fr}}{\overline{m}}\widehat{fr}_t + \frac{\overline{BS}}{\overline{m}}\widehat{BS}_t \tag{32}$$

In Equation (32), fr shows the international reserves of the Central Bank and BS is the banking network debt to the Central Bank. $\bar{X}$ Shows the steady state value of the variables. We assume that the banking network debt to the Central Bank is also a function of government bond (b):

$$\widehat{BS}_t = a\frac{\bar{b}}{\overline{BS}}\hat{b}_t + \varepsilon_t^b \tag{33}$$

Taking the government budget constraint into consideration, the government debt over time is a process represented as:

[1] Monetary and fiscal policies equations have been written by using existing know how and accepted identities.

$$\hat{b}_t = \frac{\bar{g}}{\bar{b}}\hat{g}_t + \frac{1}{(1+\bar{\pi})}\hat{b}_{t-1} - \frac{\bar{t}}{\bar{b}}\hat{t}_t - (\frac{\bar{m}}{\bar{b}}\hat{m}_t - \frac{\bar{m}}{\bar{b}(1+\bar{\pi})}\hat{m}_{t-1}) \tag{34}$$

Here we assume that government expenditure ($\hat{g}_t$) and real tax ($\hat{t}_t$) evolve according to a first order autoregressive trend:

$$\hat{g}_t = \rho_{ga}\hat{g}_{t-1} + eg$$

$$\hat{t}_t = \rho_{ta}\hat{t}_{t-1} + et$$

A country's exports have two components—oil-export and non-oil export—that are defined as:

$$\widehat{Ex}_t = \frac{\overline{Oil}}{\overline{Ex}}\widehat{Oil}_t + \frac{\overline{Noil}}{\overline{Ex}}\widehat{Noil}_t \tag{35}$$

In Equation (35), *Ex* is the total export volume, Oil is oil export income and Noil is non-oil export income. Accordingly, the net export is:

$$\widehat{Nex}_t = \frac{\overline{Ex}}{\overline{Nex}}\widehat{Ex}_t - \frac{\overline{Im}}{\overline{Nex}}\widehat{Im}_t \tag{36}$$

Nex here is the net export and *Im* is the total volume of import, and we assume that both have first order Markov chain Monte Carlo. Moreover, international reserves of the Central Bank evolve as follows:

$$\widehat{fr}_t = \widehat{fr}_t + \frac{\overline{oil}}{\overline{fr}}\widehat{oil}_t - \frac{\overline{dfr}}{\overline{fr}}\widehat{dfr}_t \tag{37}$$

where, *dfr* is the sale of international reserves by the Central Bank.

Since our model consists of consumption, investment, government spending and net export, therefore the market clearance condition can be written as:

$$\hat{Y}_t = \frac{\bar{C}}{\bar{Y}}\widehat{oil}_t + \frac{\bar{I}}{\bar{Y}}\hat{I}_t + \frac{\bar{g}}{\bar{Y}}\hat{g}_t + \frac{\overline{Nex}}{\bar{Y}}\widehat{Nex}_t \tag{38}$$

5. Model Estimation

In this research, we used the Bayesian method[1] for estimating the relevant parameters. The data are seasonal and cover the period from 1990 to 2015. The data used for estimation are consumption, inflation rate, government debt, investment, capital, money base and tax, which are derived from the time series data base of the Central Bank. As mentioned earlier, the two monetary rules of McCallum and Taylor are applied to estimate the two distinct models. The results would be analysed later on.

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[1] See Koop (2003) for more details.

Table 1. The results of the Taylor-based model parameter estimation

Symbol	Parameters	Prior Distribution Function	Prior mode	Posterior Mode	Standard Error
H	Habit formation	Beta	0.5	0.17	0.2
β	Discount factor	Beta	0.97	0.97	0.02
δ	Depreciation rate	Beta	0.04	0.05	0.02
α	Capital Weight in Production Function	Beta	0.7	0.49	0.1
ψ	Utilization rate cost	Beta	0.6	0.57	0.05
θ_f	Share of Non Optimizing Importer Firms	Beta	0.6	0.6	0.1
ω	Share of Non Optimizing Domestic Firms	Beta	0.75	0.71	0.1
σ_m	Inverse of Money Demand Elasticity	Gamma	2.5	2.57	0.2
σ_c	Inverse of Consumption Inter temporal Elasticity	Gamma	1.5	1.36	0.2
φ	Adjustment cost	Gamma	5	4.23	2
ξ_w	Share of Non Optimizing Households	Beta	0.75	0.78	0.1
ι_w	Indexation of wage to past inflation	Beta	0.5	0.59	0.25
τ	Share of terms of trade in lopg	Beta	0.45	0.45	0.1
$\in$	Share of domestic inflation in total inflation	Beta	0.6	0.82	0.2
λ	Share of lopg in importing inflation	Beta	0.45	0.44	0.1
ρ_i	Coefficient of lagged interest rate in taylor rule	Beta	0.75	0.67	0.1
$\rho_{i.\pi}$	Reaction of interest rate to inflation	Gamma	1.55	1	0.5
$\rho_{i.y}$	Reaction of interest rate to output gap	Normal	0.1	0.11	0.02
Eg	Government spending shock	Inv-Gamma	0.005	0.17	INF
ε_t^a	Productivity shock	Inv-Gamma	0.005	0.004	INF
ε_t^α	Marginal cost shock	Inv-Gamma	0.005	0.004	INF
Eq	Q- Tobin Shock	Inv-Gamma	0.005	0.003	INF
ε_t^I	Investment shock	Inv-Gamma	0.005	0.08	INF
ε_t^P	Domestic inflation shock	Inv-Gamma	0.005	0.02	INF
ε_t^w	Wage inflation shock	Inv-Gamma	0.005	0.004	INF
ε_t^i	Monetary policy shock	Inv-Gamma	0.005	0.02	INF
ε_t^m	Money demand shock	Inv-Gamma	0.005	0.03	INF
ε_t^f	Importer inflation shock	Inv-Gamma	0.005	0.005	INF
ε_t^u	Consumption shock	Inv-Gamma	0.005	0.09	INF
ε_t^q	Exchange rate Shock	Inv-Gamma	0.005	0.004	INF
ε_t^{nex}	Net export shock	Inv-Gamma	0.005	0.005	INF

Sources: Authors computations. The initial values are provided by the theoretical considerations of parameters intervals, where the prior distribution functions were obtained on the basis of their initial values.

As Table (1) shows, based on the consumption equation, the share of lagged consumption is 14.5% and the expected consumption is 85.5%, and therefore the Impulse Response Function of consumption is a concave function and its maximum reaction will occur several periods after receiving the shock. This result is compatible with the theory that claims there is a time lag between the time of the shock and the maximum reaction of the economic variable. This result confirms that the rigidities of nominal consumption will encourage the emergence of the asset channel in monetary policy mechanism.

For the Phillips curve, the coefficient of the lagged inflation is 50.7%, and so the current inflation will respond to economic shocks with a lag. This feature along with the assumption of the stickiness of prices reveals that in reaction to economic policies, including monetary policy, the changes in price levels are less than the changes in the nominal values of the variables and we can observe real effects. The real effects of monetary policy will depend on the role that the interest rate channel plays in monetary transmission mechanism.

The inflation and output gap coefficients in the Taylor rule are estimated to be 0.33 and 0.03, respectively. This shows that the nominal interest rate increases in reaction to positive fluctuations of inflation in order to decrease the pressure of aggregate demand.

The nine expectation variables in the model include consumption, investment, domestic inflation, wage, q-Tobin, marginal product, capital, overall inflation, imported inflation and foreign inflation. In monetary transmission mechanism, based on the Taylor rule, we specified the coefficients of all the variables. With regard to the obtained coefficients, we concluded that the expectation channel played an important role in the transmission and effectiveness of the monetary policy. It is also expected that this channel affects production and inflation fluctuations.

In order to investigate the role of each mentioned channel, we used the two methods of variance analysis and shock simulation. Table (2) shows the variance analysis of production, consumption and inflation variables that caused the shocks created in the system.

Table 2. The variance analysis results of production, consumption and inflation based on the Taylor rule (exchange rate shock= productivity shock =0)

Variable	Government Shock	q – Tobin Shock	Investment Shock	Domestic Inflation Shock	Money Demand Shock	Wage Shock	Preference Shock	Monetary Policy Shock	Total
Bank lending	97.53	0	0.02	0.42	0.89	0	0.34	0.8	100
q- Tobin	4.04	0.44	42.75	30.46	0	0.17	0	21.79	100
Nominal Exchange rate	0.58	0.01	59.85	8.89	0	0.26	0.05	30.37	100
Net export	0.58	0.01	59.85	8.89	0	0.26	0.05	30.37	100
Real interest rate	5.11	1.08	12.76	38.93	0	0.17	0.46	41.49	100
Production	1.2	0.01	47.04	2.73	0	0.32	42.51	6.19	100
Consumption	1.21	0.01	0	0.06	0	0	74.85	25.07	100
Inflation	5.88	0.13	1.57	58.96	0	0.31	0.26	32.9	100
Investment	0.38	0	96.67	1.79	0	0.05	0.06	1.04	100
Capital	0.51	0	96.27	1.76	0	0.1	0.09	1.27	100
Wage	2.62	0.07	20.79	54.46	0	0.24	0	21.73	100
Money base	4.19	0.02	17.86	21.34	14.03	0.38	4.86	37.33	100

From Table (2), we can detect the monetary transmission channels as follows:

- *Interest rate channel*: With a positive interest rate shock, the real interest rate increased by 41.49% and then investment and output decreased by 1.04% and 6.19%, respectively.
- *Exchange rate channel*: With a positive interest rate shock, the exchange rate and net export decreased by 30.37%. Since we did not observe any effect of net export on real output, so the exchange rate fluctuations did not change the output by the net export mechanism.
- *q-Tobin channel*: With a positive interest rate shock, the q-Tobin, investment and real output changed by 21.79%, 1.04% and 6.19%, respectively.
- *Bank lending channel*: There is no connection between bank lending and investment, and therefore this channel has no effect on monetary transmission mechanism.
- *Balance sheet channel*: Since there is no relation between investment and bank lending, this channel has no effect on monetary transmission mechanism.

- *Expectation channel*: In this model, the expected inflation coefficient in Phillips curve is 0.49. With one S.D variation in the expected inflation, the current inflation will have changed by 0.49 and from the Table 2, the real output will have changed by 2.73%.
- *Wealth channel*: With a positive interest rate shock, q-Tobin and consumption change by 21.79% and 25.07%, respectively.

As we expected in a country with a very low financial development, the channels of credit and balance sheet have no effect on variance analysis.

In order to simulate the model, we assumed the occurrence of a positive one-unit shock of the nominal interest rate and later, its effect on some variables of the model of monetary transmission mechanism is investigated. Figure (1) shows the reactions of the variables on the interest rate shock:

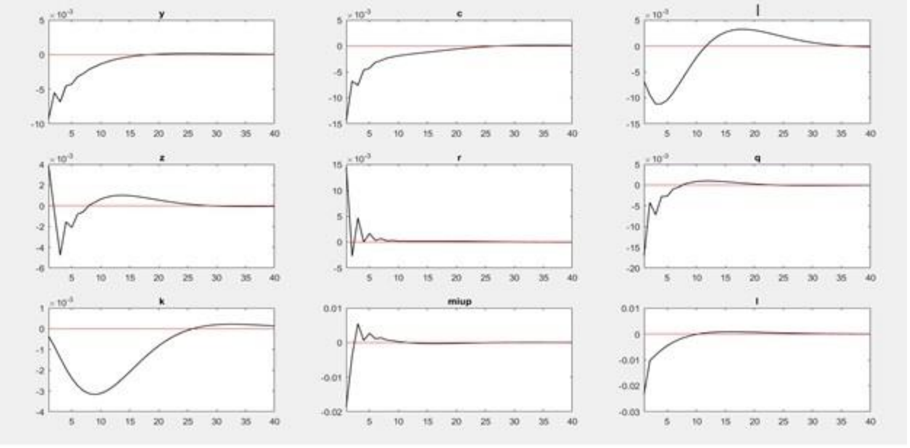

Figure 1. The reaction of variables on interest rate shock

As the figure 1 shows, a positive nominal interest rate shock increases the real interest rate[1] (r) and reduces output (y), consumption (c) and investment (I). A decrease in investment will decrease the values of capital (k) and q-Tobin (q), but will increase the utilization rate (z). A reduction in the total economic demand will cause a reduction in the demand for labour (l) and decrease the marginal cost (miup). Therefore, in the Taylor rule-based model, the nominal interest rate shock, notwithstanding nominal stickiness, has a real effect. In other words, the interest rate channel can be considered to be effective in the Taylor-based model. In order to verify the simulation results, we compared the moments from the generated model and from real data, as reported in Table (3):

[1] Due to price rigidity

Table 3. Comparison of the moments of simulated data and real data for the Taylor-based model

	Simulated data				Real data			
	Output	Consumption	Investment	Inflation	Output	Consumption	Investment	Inflation
Standard error	0.19	0.08	0.27	0.06	0.04	0.04	0.1	0.06
Variance	0.03	0.006	0.07	0.004	0.001	0.001	0.01	0.003

In order to verify the validity of the obtained results, the Monte Carlo-Markov chain (MCMC) statistic is used. MCMC is an important statistic for checking the validity of Bayesian estimation of the overall model. In this method, the different curve fittings of the Metropolis-Hastings simulation are carried out. If the results of each chain are correct, the results will all be the same in the Metropolis-Hasting repetitions, and the inter-chain results from the different chains should be very close to each other. The parameters in and between the chains are shown with red and blue lines, respectively. To prove the correctness of the results, these lines must be consistent and converging.

The related indices are the confidence interval of 80% around the mean of the parameters, which is called the 'interval', the variance of parameters or m2 and the third moment of parameters or m3. The results of this estimation for the Taylor-based model are shown in Figure (2):

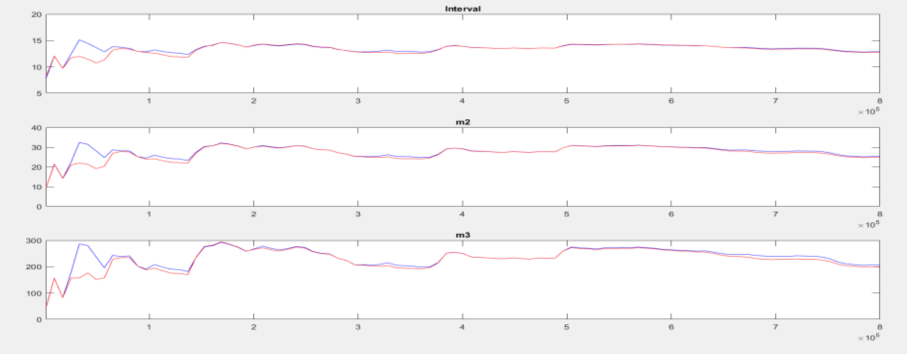

Figure 2. MCMC estimate for the Taylor-based model

As is evident, all the three moments converged over time.

Table (4) shows the estimation results obtained by using the McCallum rule.

Table 4. The results of the McCallum-based parameter estimation

Symbol	Parameters	Prior Distribution Function	Prior mode	Posterior Mode	Standard Error
H	Habit formation	Beta	0.5	0.26	0.2
β	Discount factor	Beta	0.97	0.99	0.02
δ	Depreciation rate	Beta	0.04	0.03	0.02
α	Capital weight in production function	Beta	0.7	0.51	0.1
ψ	Utilization rate cost	Beta	0.6	0.61	0.05
θ_f	Share of non-optimizing importer firms	Beta	0.6	0.59	0.1
ω	Share of non-optimizing domestic firms	Beta	0.75	0.85	0.1
σ_m	Inverse of money demand elasticity	Gamma	2.5	2.35	0.2
σ_c	Inverse of consumption inter temporal elasticity	Gamma	1.5	1.47	0.2
φ	Adjustment cost	Gamma	5	2.29	2
ξ_w	Share of non-optimizing households	Beta	0.75	0.95	0.1
ι_w	Indexation of wage to past inflation	Beta	0.5	0.38	0.25
τ	Share of terms of trade in LOPG	Beta	0.45	0.4	0.1
$\in$	Share of domestic inflation in total inflation	Beta	0.6	0.57	0.2
λ	Share of LOPG in importing inflation	Beta	0.45	0.49	0.1
ρ_m	Coefficient of lagged money growth rate in McCallum rule	Beta	0.75	0.66	0.1
$\rho_{m.\pi}$	Reaction of money growth rate to inflation	Gamma	1.55	1.06	0.5
$\rho_{m.y}$	Reaction of money growth rate to output gap	Normal	0.1	0.1	0.02
Eg	Government spending shock	Inv-Gamma	0.005	0.16	INF
ε_t^a	Productivity shock	Inv-Gamma	0.005	0.004	INF
ε_t^α	Marginal cost shock	Inv-Gamma	0.005	0.004	INF
Eq	Q- Tobin shock	Inv-Gamma	0.005	0.003	INF
ε_t^I	Investment shock	Inv-Gamma	0.005	0.09	INF
ε_t^P	Domestic inflation shock	Inv-Gamma	0.005	0.003	INF
ε_t^w	Wage inflation shock	Inv-Gamma	0.005	0.02	INF
ε_t^i	Monetary policy shock	Inv-Gamma	0.005	0.07	INF
ε_t^m	Money demand shock	Inv-Gamma	0.005	0.004	INF
ε_t^f	Importer inflation shock	Inv-Gamma	0.005	0.004	INF
ε_t^u	Consumption shock	Inv-Gamma	0.005	0.1	INF
ε_t^q	Exchange rate shock	Inv-Gamma	0.005	0.005	INF
ε_t^{nex}	Net export shock	Inv-Gamma	0.005	0.005	INF

Sources: Authors computations. The initial values are provided by the theoretical considerations of parameters intervals, in which the prior distribution functions were obtained on the basis of their initial values.

In the McCallum-based model, the coefficient of the lagged consumption was 20% and the expectation consumption coefficient was 80%. Therefore, the nominal stickiness of consumption and the real effects of wealth growth brought about the appearance of the asset channel in the monetary policy mechanism. The coefficient of the lagged inflation was 50% and in reaction to monetary policy shock, we could observe the real effects and thereby clarify the effective role of the asset channel on the monetary transmission mechanism.

The inflation and the output gap coefficient in the McCallum rule were estimated to be 0.36 and -0.03, respectively. If the inflation and the output increase over their long-term levels, the monetary level will decrease in respect to its long-term level. Thereby, it decreases the pressure on the aggregate demand and the inflation and the economic equilibrium will be restored. The above discussion proves the effectiveness of bank loans and the facilities channel in a McCallum rule-based model.

To investigate the role of each of the mentioned channels, we resorted to variance analysis and shock simulation methods. Table (5) shows the variance analysis of the three variables of production, consumption and inflation based on the shocks that affected them.

Table 5. The results of the variance analysis of production, consumption and inflation in the McCallum model (productivity shock =0)

Variable	Monetary policy shock	Preference shock	Nominal exchange rate shock	Wage shock	Money demand shock	Domestic inflation shock	Investment shock	q- Tobin shock	Government shock	total
Bank lending	1.23	0	0	0.03	0	0	0	0	98.73	100
q- Tobin	34.04	0.74	0	0.72	0.01	0.91	62.82	0.55	0.21	100
Nominal Exchange rate	2.85	0.57	0.02	61.44	0	19.62	12.69	0	2.79	100
Net export	2.85	0.57	0.02	61.44	0	19.62	12.69	0	2.79	100
Real interest rate	74.97	6.24	0	1.72	0.06	0.65	14.79	1.39	0.19	100
Production	0.62	4.16	0	0.07	0	0.02	2.71	0	92.42	100
Consumption	8.22	88.37	0	1.17	0	0.27	1.92	0.01	0.03	100
Inflation	15.84	1.65	0	77.02	0	1.09	4	0.13	0.26	100
Investment	2.57	0.02	0	0.08	0	0.29	96.98	0	0.05	100
Capital	3.96	0.02	0	0.72	0	0.75	94.42	0	0.14	100
Wage	39.92	1.91	0	11.91	0	10.18	34.46	0.12	1.51	100
Money base	96.56	0.09	0	3.16	0	0.07	0.07	0	0.05	100

From Table (5), we can detect the monetary transmission channels as follows:

- *Interest rate channel*: With positive money base shock, the real interest rate changed by 74.97% and then the investment and the output were influenced by 2.57% and 0.62%, respectively.
- *Exchange rate channel*: With positive money base shock, the exchange rate and the net export changed by 2.85% and 0.02%, respectively; Since there was no effect of the net export on real output, we did not observe the effect of exchange rate channel.
- *q- Tobin channel*: With positive money base shock, the q-Tobin changed by 34%, but it had no effect on investment and real output.
- *Bank lending channel*: There was a connection between money base and bank lending, but not of bank lending on investment; thereby this channel has no effect in monetary transmission mechanism.
- *Balance sheet channel*: There is a channel between q-Tobin and money base shock, but not for investment and bank lending; therefore, we did not observe this channel in the monetary mechanism.
- *Expectation channel*: In this model, the expected inflation coefficient in the Phillips curve was 0.50. With one S.D variation in expected inflation, the current inflation would have changed by 0.5 and from the Table 5, the real output would have changed by 2%.
- *Wealth channel*: With a positive money base shock, q-Tobin and consumption changed by 34% and 8.22%, respectively.

Figure (3) shows the simulation of the model variables on the monetary policy:

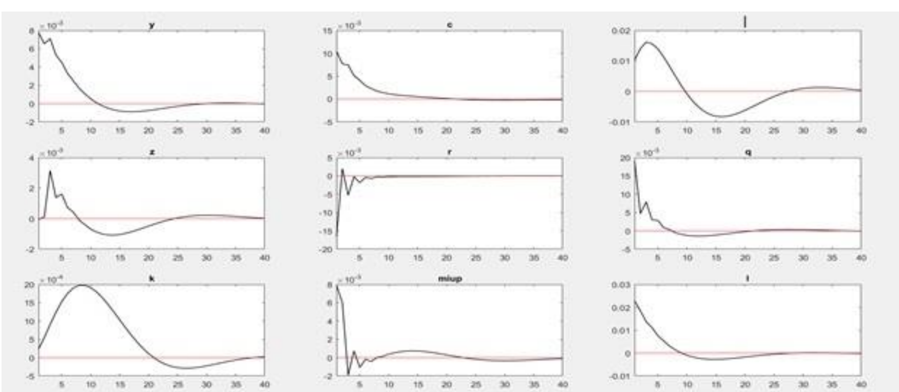

Figure 3. The reaction of the model variables to the monetary policy shock based on the McCallum rule

According to Figure (3) because of the price stickiness, a positive monetary policy shock could increase the output, consumption, investment, capital and capital utilization rate due to the decrease in real interest rate. Furthermore, due to the increase in output and the pressure of demand, an increase in inflation increases the marginal cost and leads to more labour supply as well. The moments from the simulated data and the real data are reported in table (6):

Table 6. Comparison of the moments of simulated data and real data for the McCallum-based model

	Simulated data				Real data			
	Output	Consumption	Investment	inflation	Output	Consumption	Investment	Inflation
Standard error	0.19	0.05	0.26	0.06	0.04	0.04	0.1	0.06
Variance	0.03	0.003	0.06	0.004	0.001	0.001	0.01	0.003

In order to test the validity of the results, we used the T-value of the MCMC. The MCMC chart based on the McCallum rule is as follows :

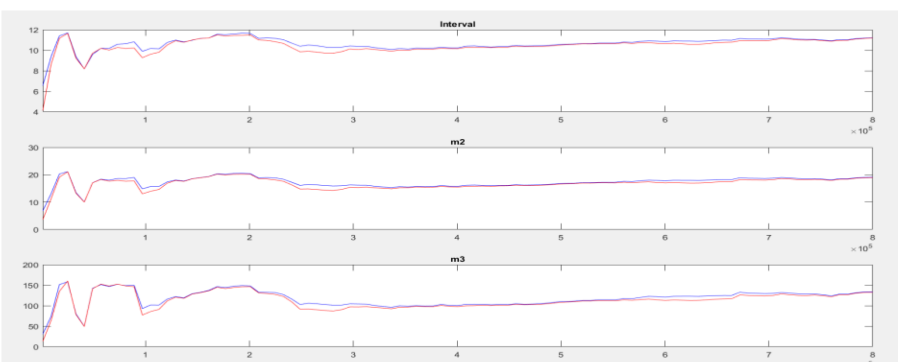

Figure 4. The output of the MCMC model based on the McCallum rule

As is evident from this figure, the model shows convergence for all the moments.

6. Conclusion

In this study, a DSGE model was used to derive macroeconomic structural equations, which included the dynamics of indicator variables such as production and inflation. The component part of the model had different kinds of nominal and real stickiness, different economic sectors, government's budget constraint and monetary rules of the Central Bank. The purpose of deriving such a structure was to investigate the effectiveness of the different channels of monetary transmission mechanism in response to a monetary policy shock.

Regarding the discussions pertaining to the tools used by the Central Bank, the present research developed two models based on two different monetary rules: The first model was based on the Taylor rule (the tool was the interest rate) and the second model was based on the McCallum rule (the tool was the monetary base growth rate).

The results obtained from the Taylor rule-based model revealed that the channels of interest rate, q-Tobin, expectation and wealth are effective channels in monetary policy mechanism. As per the McCallum rule-based model, the channels of monetary policy, expectation and wealth are effective channels in monetary policy mechanism.

These results clarify that the monetary policymaker's behaviour has real effects on Iran's economy and, therefore, once the economy reaches periods of cycles, an effective approach to leave the disequilibrium outcome is to run an appropriate policy based on his knowledge of effective channels. More precisely, in this model, an expansionary monetary policy, for example, due to price rigidity, raised the total consumption and due to the q-Tobin effect, increased investment.

The simulation model output of the two models revealed that a positive monetary shock can increase consumption and production due to the presence of price stickiness. In this case, the nominal interest rate decreased and consequently, the investment and capital use rate increased. The ultimate result was an expansion of inflation due to the rise in consumption and demand pressure.

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