Adv. Math. Fin. App., 2024, **9**(1), P. 219-240

Advances in Mathematical Finance & Applications

www.amfa.iau-arak.ac.ir
Print ISSN: 2538-5569
Online ISSN: 2645-4610
Doi: 10.22034/AMFA.2022.1913615.1505

Applied-Research Paper

Investigation and Evaluation of Monetary Policy Transmission Channels in the Economy of Iran

Parisa Rafiei Shamsabadi [a], Gholamali Haji [a, *], Seyed Fakhreddin Fakhrhosseini [b]

[a] *Department of Economics, Arak Branch, Islamic Azad University, Arak, Iran*
[b] *Department of Accounting, Tonekabon Branch, Islamic Azad University, Tonekabon, Iran*

ARTICLE INFO

Article history:
Received 2020-10-28
Accepted 2022-06-06

Keywords:
DSGE Models,
Monetary Policy Transmission,
Variance Decomposition.

Abstract

Monetary policy plays an important role in managing the economy, but success in applying this policy requires that the monetary authority understands the process of monetary transmission in the economy. Thus, it is not possible to study the effects of monetary policy on the economy without studying the channels of monetary policy transmission. Therefore, in this paper, the effect of a monetary policy through different channels of monetary policy transmission on inflation and production in terms of time process and extent of effectiveness by using Iran's data over the period of (1960 to 2018) through the method of new Keynesian dynamic stochastic general equilibrium have been investigated. The accuracy of the model was confirmed by analysing the impulse-response functions and calculating the method of moments of the second order. The results of the model show that the effects of monetary policy shock are transmitted through the nominal growth rate of money, the real exchange rate on inflation and production without oil. Also, this effects by increasing the interest rates on bank deposits through the monetary base lead to increase production without oil, and through the monetary base, the exchange rate and the price index of domestic goods reduce inflation.

1 Introduction

According to theories and empirical studies, monetary policies influence on the macro nominal variables in the short or long run and on the real variables in the economy such as real production, employment and economic growth in the short run. A useful way to further examine monetary policy is focusing on each of the channels of monetary transmission through which the central bank's actions for monetary policy are effective. Each of the monetary transmission channels describes the monetary transmission mechanism. The mechanism of monetary transmission is one of the fields of monetary economics and it is a mechanism in which monetary policy influences the variables of the real sector of the economy by changing some variables to make the goals of monetary policy be achieved. According to "Laidler [17]", monetary transmission mechanism is a process starting from monetary policy and ending with

* Corresponding author. Tel.: *+989188625322*.
E-mail address: *g.haji2015@gmail.com*

production and price. In fact, the monetary transmission mechanism describes how to respond the economy to a monetary shock. Theoretically, the items such as the types of channels of monetary transmission, time process and extent of effectiveness have always been discussed by economists.

Therefore, reviewing and evaluating monetary transmission channels is important for many studies at any time for two reasons. First, it is necessary to understand how monetary policy influences the economy in order to evaluate the type and manner of policy implementation at any given time. The second reason is that to choose the type and size of monetary policy instruments, the monetary policymaker must have a careful assessment of the timing, intensity, and the extent of effectiveness of their monetary policies. Therefore, the main purpose of this article is to examine the different channels of monetary policy transmission on production and inflation and to examine the time process of the impact of each channel on the economy of Iran. This paper, hereunder, consists of three more sections: the second section provides a summary of the theoretical study of the research and the research background is reviewed. Section three deals with the methodology of the research and the structure of the estimated model and data. In section 4 the model is simulated by determining input values and calibrating the parameters. Finally, the last section presents the Conclusion.

2 Theoretical Framework and Literature Review

2.1 Theoretical Framework

The questions of this survey are: under what mechanisms and through what channels, the effects of monetary policy spread in the economy and consequently production and inflation are influenced? How are the time process and the effectiveness extent of each channel of monetary policy transmission on the production and the inflation? To answer the above questions, it is necessary to examine monetary transmission channels. In market-based economies, monetary policy through these channels influences prices and production, and this process is called the monetary transmission mechanism. According to “Mishkin [19]” the monetary transmission mechanism includes channels such as interest rates, exchange rates, asset prices and credit channels. Through these channels, monetary policy influences the decisions of firms, households, financial intermediaries, and government, and consequently changes the level of economic variables as follows:

Interest rate Channel: The oldest monetary transmission channel in macroeconomic models is the interest rate channel in early Keynesian models. Applying a tight monetary policy, assuming price stability, leads to an increase in interest rates and consequently reduces investment costs. The combination of these changes leads to a reduction in aggregate demand and ultimately leads to a reduction in production.

Tobin Q Channel: Tobin theory explains the mechanism by which monetary policy can influence the economy by influencing the total balance sheet debts. Keynesians believe that raising interest rates will make bonds more attractive than other assets and leads to a reduction in the price of assets in society.

Exchange rate channel: In the exchange rate channel, enforcement the value of the national currency makes domestic goods will be more expensive than foreign goods and the changes in the amounts of exports and imports leads to reduce net exports and consequently decreases production.

Wealth-based channels: One of the monetary transmission channels in this section is related to the effect of wealth on consumption. One of the most important parts of financial wealth is the value of the individual's stocks and assets. When the prices of assets and stocks fall due to tight monetary policies, the value of the individual's financial wealth decreases. As a result, households' consumption resources and their consumption expenses will decrease in over a lifetime.

Credit channel: In addition to these channels, many economists use the hypothesis of asymmetric information and credit market frictions to explain the effects of monetary policy on the economy that the first time proposed by the new Keynesians. Since this type of monetary policy transmission mechanism stems from credit market deficiencies, it is known as the monetary policy credit channel or credit perspective. In the same context, “Mishkin [19]”, has introduced two channels including balance sheet channels and loans lending channels.

Balance Sheet Channel: The balance sheet channel is based on a theory the external finance cost is assigned to the borrower's financial situation or net worth.

The monetary policy balance channel derives from the fact that changes in central bank policy influence not only market interest rates but also influence the financial situation of borrowers in two ways:

Method 1: Applying a tight monetary policy and raising interest rates directly increase the borrowers’ interest costs and reduces the firm's net cash flow, so borrower's financial situation. In other words, an increase in interest rates due to a tight monetary policy worsens the situation of firms due to the reduction in cash flow. This process increases the borrower's adverse selection and moral hazard and finally decreases the amount of the received loan and the amount of production.

Method 2: Applying a tight monetary policy and subsequently an increase in interest rates is accompanied by a decrease in the price of assets, which reduces the price and value of the borrower's collaterals. A decrease in the value of collaterals forces some firms to reduce their investment costs, as their ability for borrowing decreases.

Bank Lending Channel: In addition to the effect of monetary policy on the borrowers' balance sheet, monetary policy influences the external finance cost through the transmission of credit supply to commercial banks known as the bank lending channel. The course of the lending channel is based on the assumption that monetary policy can influence external finance costs by shifting the supply curve of credit resources, especially bank loans. If the supply to credit resources is reduced, the borrowers should look for another lender. In this case, either the borrowers do not have access to alternative resources, or they earn these resources at a higher cost, and as a result, the investment costs of the firms are influenced.

2.2 Literature Review

In 1995, “Bernanke and Gertler [5]” by using the vector autoregressive model, presented theoretical dimensions and empirical evidence on the mechanism of monetary transmission with emphasis on the credit channel. They showed the credit channel reinforces the direct effect of monetary policy on interest rates through endogenous changes in the external finance premium. In 1997, “Carlstrom and Fuerst [9]” showed the quantitative importance of the work of “Bernanke and Gertler and Gilchrist in 1999 [6]” calibrated a DSGE model with a financial accelerator mechanism in which endogenous financial market shocks act to deepen and propagate the effects of macroeconomic shocks. After these progressive and influential works, economists studied the various channels through which financial markets can influence the economy in the form of general equilibrium models. The literature emphasizes the three channels: the effect of wealth on consumption, the effect of Q Tobin on investment, and the effect of the financial accelerator on investment.

In 2011, “Gambacorta [18]”focuses on the credit channel in his study of monetary policy transmission mechanisms in Italy by using a dynamic stochastic general equilibrium model. In his research, he shows that the application of contractionary monetary policy leads to a reduction in bank credit by reducing the volume of bank deposits. In 2003, “Smets and Wouters [26]” developed and estimated a dynamic stochastic general equilibrium (DSGE) model with sticky prices and wages for the euro area. The model incorporated various other features such as habit formation, costs of adjustment in capital accumulation and variable capacity utilization. It is estimated with Bayesian techniques using seven key macroeconomic variables: GDP, consumption, investment, prices, real wages, employment, and the nominal interest rate. The introduction of ten orthogonal structural shocks (including productivity, labor supply, investment, preference, cost-push, and monetary policy shocks) allows for an empirical investigation of the effects of such shocks and of their contribution to business cycle fluctuations in the euro area. Using the estimated model, we also analyze the output (real interest rate) gap, defined as the difference between the actual and model-based potential. In 2005, "Idrees Agha et al [15]" used the vector autoregressive model to investigate the mechanism of monetary transmission in Pakistan. The results of their research showed that in addition to the interest rate channel, banks also play an important role in monetary transmission. In 2006, "Dabla-Norris and Floerkemeier [11] " by using VAR analysis of the mechanism of monetary transmission in the Armenian economy. According to the results of their study, the interest rate channel is weak in terms of its impact on inflation and the exchange rate channel is the most effective channel for monetary policy transmission. In 2009, "Boughrara [7]" by using the VAR framework analyzed and compared different mechanisms for the two developing countries, Tunisia and Morocco. The main results of the study showed that none of the channels of exchange rates and asset prices in the economies of these countries are efficient and active.

The credit channel is active in Tunisia and is stronger than the conventional interest rate channel. In 2008, "Atta-Mensah and Dib [3]" by employing a dynamic general-equilibrium model examine a standard sticky-price model with the addition of financial frictions in the credit markets. They determine the role of bank lending in the transmission of Canadian monetary policy shocks under alternative Taylor-type rules and assess the real effects of exogenous credit shocks. The financial frictions are modelled as spreads between loan and deposit rates. The intermediation process is assumed to be partly endogenous and the firms must borrow to finance their purchases of intermediate inputs used in their production technology. The paper also shows that these real effects depend on the specification of the policy rule the central bank follows. The contributions of exogenous credit shocks to output, inflation, and nominal interest rates fluctuations are highly significant in the short and long terms. In 2010, "Aleem [1]" by employing the VAR approach conducted a study on the mechanism of monetary transmission in India. The results showed that in the emerging economy of this country, if the exchange rate stability is to be applied with the intervention of the central bank, it will weaken the transmission channel by the exchange rate. In 2010, "Moshiri and Vashghani Farahani [20]" investigate the effects of a monetary policy through different channels of monetary policy transmission on inflation and production in terms of time process through VAR approach and showed that the effect of monetary shock on production is not statistically significant, but the response of inflation to monetary shock is almost significant. In 2012, "Komijani and Alinejad [16]" evaluated the mechanisms of monetary policy transmission through interest rate channels, exchange rates, stock prices and bank lending by using (VAR) models. According to their research findings, the effects of monetary policy in the short run through all of these four channels influence the growth rate of real production.

In 2018, "Raei et al [23]" investigated the effect of monetary policy shocks through monetary policy transmission channels on production. For this purpose, using the vector autoregressive method showed that the three channels of exchange rates, housing prices and credit are incapable of transmitting the effects of monetary policy in the long run, which means that monetary policy is neutralized in the long run. In 2019, "Rafee Shamsabadi et al [24]" have analysed the banks' roles as financial accelerators over

Iranian commercial eras may provide a better understanding of the effectiveness of shocks on the economy. This paper uses a New Keynesian standard dynamic stochastic general equilibrium model regarding price-stickiness, and structural parameters of the model and some of the variables are calibrated and the impacts of different shocks on some macroeconomic factors are analyzed in the following two ways. The first mode is a model that includes financial accelerators. The second is a model without a financial accelerator. Then the ability of each model in describing each key feature of data and the effects of momentums on key variables in Iranian economy are analyzed. All the data used in this paper refer to constant prices in 2011 and 1966-2016 period annually. Results of the estimates for the models indicate that the effect of money demand momentum on the investment variable, and also the effect of monetary policy momentum on consumption, investment and production variables in the model, taking into consideration the financial accelerators, are tenser than that of the model without financial accelerator.

In 2018, “Haeri Nasab et al [14]” showed there is a relationship between the facility interest rate and three main variables of the money market in Iran. This issue for equations the interest rate facility, the interest rate of deposit, inflation and credit risk utilizing the model simultaneous equation system and method of three-stage least squares estimated. Results show that in this 32-year period the interest rate of the facility with the interest rate on deposits is one of the most important macro- banking variables has a positive and significant relationship. So that with an increase in interest rate on deposits, the interest rate of facility also increases. It was also determined the interest rate of facility with inflation has a negative and significant relationship. This expresses with increasing inflation, the facility interest rate decreases. Because in Iran the rate of interest determined as an order, this result is not expected. The interest rate of facility and credit risk have a positive and significant relationship, which represents it when the interest rate of facility increases, likelihood of nonpayment increased by borrowers. Also, inflation rate with liquidity and exchange rate has a positive relationship which is consistent. In 2020, “Sharifnezhad et al [25]” have investigated evaluation of Monetary and Fiscal Policy Based on New Keynesian Dynamic General Equilibrium Model in Iran’s Economy. For this purpose, the model is estimated using Iran's data over the period of 2000-2017, through the method of generalized moments which leads to valuable insight. The results indicate that aggregate demand reacts to changes in interest rates. In the present study, the mechanisms of monetary policy transmission have been studied using stochastic dynamic general equilibrium (DSGE) models, which indicates the innovation in the present study. The innovation of this study are as follows:

1. The type of the research that compares the extent of effectiveness of transfer of monetary policy mechanism.
2. The Research method that examines the effects and mechanisms of monetary policy based on the general dynamic equilibrium model.
3. Introducing the bank as a large and influential part of the general dynamic equilibrium model.
4. Another innovation of this research is that we have shown that through which variables and to what extent monetary schocks affect production and inflation. The abovementioned case has been shown in the relative chart.

3 Methodology of the Research

In the present study, the mechanisms of monetary policy transmission have been studied using stochastic dynamic general equilibrium (DSGE). As per the studies that have been done by Walsh, “Tavakolian and Sarem [27]” DSGE models are based on microeconomic functions. This means all agents in economy must be identify their restrictions and then by considering them, maximize their objective functions. which indicates the innovation in the present study? There are five agents in this economy: households, Enterprises (including: final-good-producing firm and intermediate-goods-producing firms), Financial intermediaries (banks), Government and Central Bank.

3.1 Households

Households achieve utility from consuming goods and money demands. By doing more work, their utility diminishes because their leisure time decreases. According to Atta-Mensah and Dib [3] the present value of the utilities that the representative household achieves during its lifetime is as follows:

$$E_0 \sum_{i=0}^{\infty} \beta^i U_t^i(0) \tag{1}$$

Where β is the discount factor. The form of the household utility function, which is a function of total household consumption, real money balances, and labour supply, is as follows:

$$U_t^i = \left[\frac{1}{1-\sigma_c} \left(c_t^i - hc_{t-1} \right)^{1-\sigma_c} - \frac{1}{1+\sigma_l} \left(L_t^i \right)^{1+\sigma_l} + \frac{1}{1-\sigma_m} \left(\frac{M_t^{c,t}}{P_t^c} \right)^{1-\sigma_m} \right] \tag{2}$$

In equation (2), consumer goods include a combination of different domestic and imported products, which is supplied by domestic producers and importers. In utility function numion for consumption. The parameter σ_l represents the inverse elasticity of labour supply relative to real wages and the parameter σ_m represents the inverse elasticity of the real money balances $(m_t^{c,t} = \frac{M_t^{c,t}}{P_t^c})$ relative to the interest rate. The utility function in equation (2) reflects the external habits of the consumer, which depends on the average per capita consumption of the economy.

3.1.1 Selecting the Consumption Bundle and Obtaining the Consumption Demand Functions

Equation (2) assumes that total consumption at real price (c_t^i) is a combination of consumption of domestic goods (c_t^d) and imported goods (c_t^m), which are produced by domestic and imported by enterprises respectively. According to Atta-Mensah and Dib [3] these goods are combined through a Dixit-Stiglitz collector [13], as follows:

$$c_t = \left[\xi_c^{\frac{1}{\mu_c}} \left(c_t^d \right)^{\frac{\mu_c - 1}{\mu_c}} + (1-\xi_c)^{\frac{1}{\mu_c}} (c_t^m)^{\frac{\mu_c - 1}{\mu_c}} \right]^{\frac{\mu_c}{\mu_c - 1}} \tag{3}$$

Where ξ_c and *(1-ξ_c)* show the share of domestic goods and the share of imported goods in the household consumption bundle. Finally, the parameter η_c is the intemporal elasticity of substitution between domestic and imported goods. In general, households decision-making process can be considered in two steps: In the first step, for any level of consumption, each household purchases a composite of domestic and imported goods in the period to minimize the total cost of its consumption bundle. In the second step, according to the cost of access at each given level of (c_t) consumption, the households select the optimal values of $c_t, L_t, \frac{M_t^c}{P_t}$, in a way that maximizes their utility.

$$\underset{c_t^i}{min}: P_t^d c_t^d + P_t^m c_t^m \tag{4}$$

$$c_t = \left[\xi_c^{\frac{1}{\mu_c}}\left(c_t^d\right)^{\frac{\mu_c-1}{\mu_c}} + (1-\xi_c)^{\frac{1}{\mu_c}}\left(c_t^m\right)^{\frac{\mu_c-1}{\mu_c}}\right]^{\frac{\mu_c}{\mu_c-1}}$$

Where c_t^d and c_t^m are the consumption of domestic and imported goods respectively, and P_t^d and P_t^m are the price index of domestic and imported goods respectively.

The first-order of Equation (4) helps to obtain the demand functions for domestic and imported consumer goods as follows:

$$C_t^m = (1-\xi_c)\left(\frac{P_t^m}{P_t^c}\right)^{-\mu_c} c_t \tag{5}$$

$$c_t^d = \xi_c\left(\frac{P_t^d}{P_t^c}\right)^{-\mu_c} c_t \tag{6}$$

By replacing equations (5) and (6) in the household's consumption bundle $P_t^d c_t^d + P_t^m c_t^m = P_t^c c_t$ the total consumer price index (P_t^c) together with its components are obtained, that is:

$$P_t^c = \left[\xi_c\left(P_t^d\right)^{1-\eta_c} + (1-\xi_c)\left(P_t^m\right)^{1-\eta_c}\right]^{\frac{1}{1-\eta_c}} \tag{7}$$

Where P_t^c represents the total consumer price index.

"Nisticò [21] and Castelnuovo and Nisticò [10]" studies are used to model stock assets. The wealth of the stock of the household j owning since the previous period can be figured as follows:

$$\Omega_{t-1}^{*,i} = \int_0^1 \left(P_t^s(j) + DV_t(j)\right)N_t(j)\,dj \tag{8}$$

Also, the periodical household's budget in terms of actual prices can be figured as follows:

$$c_t^i + I_t^i + b_t^i + \frac{1}{P_t^c}\int_0^1 P_t^s(j)\frac{N_t(j)}{\varepsilon_t^s}dj + m_t^{c,i} = \left(1 + r_{t-1}^d\right)\frac{b_{t-1}^i}{\pi_t^c} + \frac{m_{t-1}^{c,i}}{\pi_t^c} + \frac{1}{P_t^c}\Omega_{t-1}^{*,i} + TR_t^i - T_t^i + y_t^i \tag{9}$$

Where I_t^i is the amount of investment, b_t^i is bonds, r_{t-1}^d is the nominal interest rate of bonds, T_t^i is household taxes (direct, indirect and value-added tax), TR_t^i is transfer payment, P_t^I is the investment price index, $m_t^{c,i}$ is real money balances of households , π_t^c is Inflation rate based on the total consumr price index, ε_t^s is the shock of price stock. The other variables are already defined in the text, and y_t^i represents household income, which is defined as follows:

$$y_t^i = \frac{W_t^i}{P_t^c}L_t^i + R_t^k z_t^i k_{t-1}^i - \psi(z_t^i)k_{t-1}^i + Div_t^i \tag{10}$$

Total household income is obtained from the wage of labour, rent of capital minus costs related to changes in the rate and dividends of producers of intermediate goods.

3.1.2 Capital Stock and Investment

Households rent their capital stock to intermediate goods companies at the rate of R_t^k. Households can raise capital in two ways:

1- Increasing I_t investment, which leads to an increase in capital stock.
2- Change in the utilization of capital stock.

According to Atta-Mensah and Dib [3] it is assumed that the capital accumulation process is performed under the following equation:

$$k_t^i = (1-\delta)k_{t-1}^i\left[(1-S)\left(\frac{I_t^i}{I_{t-1}^i}\right)\right]I_t^i \tag{11}$$

Where δ is the depreciation rate of the investment, I_t^i i is the gross investment of the private sector, and *S (0)* is a function of the cost of adjusting the investment, which is a positive function of changes in investment. Given the above explanation, the problem for households is to maximize the utility function relative to the budget constraint. In the optimization process, households choose the amount of consumption, money, investment in stocks, deposits, labour supply, capital stock, investment, and the amount of capital utilization as a function of their goal is to maximize budge.

$$\begin{aligned} max\, E_t \sum_{t=0}^{\infty}\Bigg\{&\left[\frac{1}{1-\sigma_c}\left(c_t^i - hc_{t-1}\right)^{1-\sigma_c} - \frac{1}{1+\sigma_l}\left(L_t^i\right)^{1+\sigma_l} + \frac{1}{1-\sigma_m}\left(\frac{M_t^{c,t}}{P_t^c}\right)^{1-\sigma_m}\right] \\ &+ \lambda_t\left[\left(1+r_{t-1}^d\right)\frac{b_{t-1}^i}{\pi_t^c} + \frac{m_{t-1}^{c,i}}{\pi_t^c} + \frac{1}{P_t^c}\Omega_{t-1}^{*,i} + TR_t^i - T_t^i + \frac{W_t^i}{P_t^c}L_t^i \right.\\ &+ R_t^k z_t^i k_{t-1}^i - \psi\left(z_t^i\right)k_{t-1}^i + Div_t^i - c_t^i - I_t^i - b_t^i - m_t^{c,i} \\ &\left. - \frac{1}{P_t^c}\int_0^1 P_t^s(j)\frac{N_t(j)}{\varepsilon_t^s}dj\right] + Q_t\left[(1-\delta)k_{t-1}^i + \left[1 - S\left(\frac{I_t^i}{I_{t-1}^i}\right)\right]I_t^i - k_t^i\right]\Bigg\} \end{aligned} \tag{12}$$

Where λ_t is the budget constraint multiplier and Q_t is the capital stock multiplier. The first-order conditions for each period *t*≥0 are as follows:

$$(\partial c_t) \qquad (c_t - hc_{t-1})^{-\sigma_c} = \lambda_t \tag{13}$$

$$(\partial I_t) \quad Q_t\left[1 - S\left(\frac{I_t}{I_{t-1}}\right) - S'\left(\frac{I_t}{I_{t-1}}\right).\frac{I_t}{I_{t-1}}\right] + \beta E_t Q_{t+1} S'\left(\frac{I_{t+1}}{I_t}\right)\left(\frac{I_{t+1}}{I_t}\right)^2 = \lambda_t \tag{14}$$

$$(\partial z_t) \quad R_t^k = \psi'(z_t) \tag{15}$$

$$(\partial K_t) \quad Q_t = \beta E_t \lambda_{t+1}\left[z_{t+1}R_{t+1}^k - \psi(z_{t+1})\right] + \beta(1-\delta)E_t Q_{t+1} \tag{16}$$

$$(\partial b_t) \quad Q_t = \beta E_t \lambda_{t+1}\left(1 + r_t^d\right)\frac{1}{\pi_{t+1}^c} = \lambda_t \tag{17}$$

$$(\partial m_t^c) \quad \varepsilon_t^M (m_t^c)^{-\sigma_m} = \lambda_t - \beta E_t \lambda_{t+1}\frac{1}{\pi_{t+1}^c} \tag{18}$$

$$(\partial L_t) \quad -L_t^{\sigma_l} + \lambda_t \frac{W_t}{P_t^c} = 0 \tag{19}$$

$$(\partial N_t) \quad \frac{1}{P_t^c \varepsilon_t^s}\lambda_t P_t^s(j) + E\left\{\beta \frac{1}{P_{t+1}^c}\lambda_{t+1}\left(P_{t+1}^s(j) + DV_{t+1}(j)\right)\right\} = 0 \tag{20}$$

3.1.3 Household Savings and Consumption Behaviour

According to Atta-Mensah and Dib [3] Equation (13) represents the Euler equation of consumption and the following equation is obtained from the ratio of two Euler equations at the times t and *t*+1

$$E_t \frac{\lambda_t}{\lambda_{t+1}} = E_t \frac{(c_t - hc_{t-1})^{-\sigma_c}}{(c_{t+1} - hc_t)^{-\sigma_c}} \tag{21}$$

Using equation (21) for the time periods t and t + 1, the following equation can be reached:

$$E_t \frac{\lambda_t}{\lambda_{t+1}} = \beta E_t \lambda_{t+1} \left(1 + r_t^d\right) \frac{1}{\pi_{t+1}^c} \tag{22}$$

From the combination of equations (21) and (22) the following equation can be reached:

$$\beta E_t \lambda_{t+1} \left(1 + r_t^d\right) \frac{1}{\pi_{t+1}^c} = E_t \frac{(c_t)^{-\sigma_c}}{(c_{t+1})^{-\sigma_c}} \tag{23}$$

Equation (23) shows the optimal intertemporal allocation consumption that households make this allocation according to the discount rate and profit rate.

3.1.4 Demand for Money

The real demand for money has a positive relationship with consumption and its elasticity is equal to $\frac{\sigma_c}{\sigma_m}$.

3.1.5 Capital Accumulation and Investment

Combination of equations (13), (17) and (18), gives the equation for household's money demand as follows:

$$(m_t^c)^{-\sigma_m} = (c_t)^{-\sigma_c} \times \frac{r_t^d}{1 + r_t^d} \tag{24}$$

(14) and (16) gives the final *Q* Tobin ratio: $q_t = \frac{Q_t}{\lambda_t}$ which represents the value of the investment in terms of the cost of capital replacement. According to the definition of the final *Q* Tobin ratio, equations (14) and (16) after performing the necessary algebraic operations can be written as follows, respectively.

$$1 = q_t \left[1 - S\left(\frac{I_t}{I_{t-1}}\right) - S'\left(\frac{I_t}{I_{t-1}}\right) . \frac{I_t}{I_{t-1}}\right] + \beta E_t q_{t+1} \frac{\lambda_{t+1}}{\lambda_t} S'\left(\frac{I_{t+1}}{I_t}\right)\left(\frac{I_{t+1}}{I_t}\right)^2 \tag{25}$$

$$q_t = \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \left[q_{t+1}(1 - \delta) + z_{t+1} R_{t+1}^k - \psi(z_{t+1})\right] \tag{26}$$

Equation (25) can be interpreted as the Euler equation of investment, which indicates the optimal direction of investment.

3.1.6 Households Decision to Supply Labour and the Equation for Determining Wages

Households offer their labour at competitive price. Therefore, the equation of labour supply of households is expressed as follows:

$$P_t^s(j) = \varepsilon_t^S E\left\{\beta \frac{\varepsilon_{t+1}^{\beta}(C_{t+1} - hc_t)^{-\sigma_c}}{\varepsilon_t^{\beta}(C_t - hc_{t-1})^{-\sigma_c}}\left(P_{t+1}^s(j) + DV_{t+1}(j)\right)\frac{P_t^C}{P_{t+1}^C}\right\} \tag{27}$$

3.1.7 Stock Price Dynamics

Combination of equations (20) and (14) gives the dynamics of the return on stock (including dividends and capital gains) as follows:

$$P_t^s(j) = \varepsilon_t^S E\left\{\beta \frac{\varepsilon_{t+1}^{\beta}(C_{t+1} - hc_t)^{-\sigma_c}}{\varepsilon_t^{\beta}(C_t - hc_{t-1})^{-\sigma_c}}\left(P_{t+1}^s(j) + DV_{t+1}(j)\right)\frac{P_t^C}{P_{t+1}^C}\right\} \tag{28}$$

Or by using equation (23), the above equation can be written as follows:

$$P_t^s(j) = \varepsilon_t^S E\left\{\frac{\pi_{t+1}^c}{(1 + r_t^d)}\left(P_{t+1}^s(j) + DV_{t+1}(j)\right)\frac{P_t^C}{P_{t+1}^C}\right\} \tag{29}$$

Or t can be expressed in terms of real prices as follows:

$$\gamma_t^{sc}(j) = \varepsilon_t^S E\left\{\frac{\pi_{t+1}^c}{(1 + r_t^d)}\left(\gamma_{t+1}^{sc}(j) + dv_{t+1}(j)\right)\right\} \tag{30}$$

Where $\gamma_t^{sc}(j) = \frac{\pi_t^s(j)}{P_t^c}$ indicates the ratio between return on equity of firm j and the consumer price index. According to equation (29) the return per share of firm j is equal to the present value of all the future earnings of that share (including dividends and capital gains).

3.2 Firms

3.2.1 The Behaviour of Firms Producing Final Goods

We assume that a continuum of the intermediate goods is used in the production of the final good. Let Y_t be the output of a final-good firm. Then, assuming that all intermediate goods are imperfect substitutes with constant elasticity of substitution, *θ,* we can use the Dixit and Stiglitz [13] aggregator function to express the aggregate output, Y_t, of all final-goods firms as:

$$\left[\int_0^1 {Y_{jt}}^{(\theta-1)/\theta} dj\right]^{\theta/(\theta-1)} \geq Y_t \tag{31}$$

Where *θ>1*, The final good, Y_t is divided between consumption, investment, and inputs used in the production of each intermediate good. Given the price, P_{jt} the final-good firm chooses the quantity of intermediate output, Y_{jt}, that maximizes its profits. The profit-maximization problem is:

$$\max_{Y_{jt}}\left\{P_t Y_t - \int_0^1 P_{jt} Y_{jt} dj\right\} \tag{32}$$

The first-order conditions imply that the demand function facing each intermediate-good-producing firm is given as:

$$Y_{jt} = \left[\frac{P_{jt}}{P_t}\right]^{-\theta} \quad (33)$$

Where $-\theta$ represents the price elasticity of demand for intermediate goods j.

3.2.2 Firms Producing Intermediate Goods

According to Atta-Mensah and Dib [3] and Peiris and Saxegaard [22] firms are assumed to borrow from financial intermediaries (banks and credit institutions) at an interest rate of r^j_t and use it in the production process to finance working capital and intermediate inputs. According to Cobb-Douglas the production function of firms producing intermediate goods is as

follows:

$$Y_{jt} = A_t\left(cr_t^j\right)^{\xi}\left[\left(z_t k_{t-1}^j\right)^{\alpha}\left(L_{t-1}^j\right)^{1-\alpha}\right]^{1-\xi}\left(K_{t-1}^G\right)^{\kappa} \quad (34)$$

Where ξ is the share of loans in production, $\widetilde{K}_{t-1} = Z_t K_{t-1}^j$ is effective capital stock, K_{t-1}^G is the formation of government capital assumed as common to all firms in this sector, cr_t^j is the amount of bank credit and at indicates productivity. The producer of the intermediate goods *j* minimizes its costs according to a certain amount of production. Therefore, the objective function of firm *j* is as follows:

$$\min_{\tilde{k}_{t-1}, L_t, cr_t} \frac{W_t}{P_t^d} L_t^j + R_t^k z_t k_{t-1}^j + \left(1 + r_t^l\right) cr_t^j \quad (35)$$

$$Y_{jt} = A_t\left(cr_t^j\right)^{\xi}\left[\left(z_t k_{t-1}^j\right)^{\alpha}\left(L_{t-1}^j\right)^{1-\alpha}\right]^{1-\xi}\left(K_{t-1}^G\right)^{\kappa}$$

Where $\mathrm{W_t}$ is the nominal wage, R_t^k is the return on capital, Y_{jt} is the demand for the goods j.

If we obtain the first-order condition for the firm optimization, then the firm's final cost in terms of actual prices will be as follows:

$$mc_t = \frac{1}{F} \times \frac{1}{A_t}\left(1 + r_t^l\right)^{\xi}\left(w_t\right)^{(1-\alpha)(1-\xi)}\left(R_t^k\right)^{\alpha(1-\xi)}\frac{1}{(K_{t-1}^G)^{\kappa}} \quad (36)$$

Where:

$$F = (1-\xi)\,(1-\alpha) \times (\xi / (1-\xi)\,(1-\alpha))\,^\wedge\, \xi\,(\alpha / (1-\alpha))\,^\wedge\, \alpha\,(1-\xi) \quad (37)$$

In this study, we use "Calvo [8]" method to adjust prices. That is, in each period, only $(1 - \theta_P)$ percent will be able to optimally adjust the price of their product, the rest (θ_P) that can not optimally set prices in the current period, they set prices on the basis of past prices Using the following formula.

$$P_{t+1}^i = \left(\pi_t^i\right)^{\tau_p} P_t^i \quad (38)$$

Where $\pi_t^i = \frac{P_t^i}{P_{t-1}^i}$ represents the inflation rate of the products of section i, and τ_p is a parameter that shows the degree of price indexation. Given that in each period only $1 - \theta_P$ percent of firms can adjust their prices optimally and the rest of the firm's index prices based on the prices of previous periods. Therefore, using Equation (34), the total price index at time t is based on the following weighted average formula.

$$[P_t^d]^{1-\zeta} = \theta_P\left[\left(\pi_{t-1}^d\right)^{\tau_p} P_{t-1}^d\right]^{1-\zeta} + (1-\theta_P)[\bar{P}_t]^{1-\zeta} \quad (39)$$

3.3 Financial Intermediaries (Banks)

According to Angelini et al [2] in this model, banks play the role of intermediaries of financial funds. They attract household deposits D_t and, after depositing required and precautionary reserves, RR_t and L_t to households and intermediary producers. Due to a shortage of resources, banks may raise some of their resources by borrowing from the central bank (DC_t^P) to provide facilities. Banks are also required to comply with the minimum capital adequacy ratio (ϑ^b) announced by the central bank and bank and incur adjustment costs ($K^B{}_t$) in case of violation. According to these assumptions, cash flow, banks' balance sheets and banks' profits are as follows:

$$L_t^f + L_t^g + RR_t = D_t + K_t^B + DC_t^P \quad (40)$$

The volume of facilities for the public sector and the enterprises will be as:

$$L_t = L_t^f + L_t^g \quad (41)$$

Suppose the amount of required reserve is a percentage of the total amount of demand deposits, i.e

$$RR_t = \alpha_r D_t \quad (42)$$

Where α_r is the average rate of required reserve. By replacing this equation with the previous equation and then dividing the parties by the price index according to the real prices; we will have:

$$l_t^f + l_t^g = (1-\alpha_r)d_t + k_t^B + dc_t^P \quad (43)$$

It is assumed that the interest rate of loans granted by banks to firms r_t^l is equal to the mark-up, μ plus the interest rate of bank deposits, r_t^d

$$r_t^l = r_t^d + \mu + u_t^l \quad (44)$$

Bank optimization means choosing the optimal amount of bank loans and deposits to maximize the real value of the bank's expected profit.

$$Max\, E_{.} \sum_{t=0}^{\infty}\left[(1-pd)r_t^l l_t - r_t^d d_t - r_t^c dc_t^p - \frac{\kappa_{kB}}{2}\left(\frac{k_t^B}{l_t} - \vartheta^b\right)^2 k_t^B\right] \quad (45)$$

In the Iranian economy, interest rates are set by the Monetary and Credit Council under the supervision of the Central Bank and are communicated to banks on an orderly basis.

$$r_t^d = \left(r_{t-1}^d\right)^{\rho} (\pi_{t-1} - \overline{\pi})^{\gamma^{\pi}(1-\rho)} (y_{t-1} - \overline{y})^{\gamma^{y}(1-\rho)} \varepsilon^{r^d} \quad (46)$$

In this equation $(\pi_{t-1} - \overline{\pi})$ is the amount of inflation deviation from its target value and $(y_{t-1} - \overline{y})$ is the amount of production deviation from its target value. γ^{π} and γ^{y} are parameters according to the central bank react to deviations of inflation and production from their target value. ρ is a percentage of the bank interest rate that is a function of the previous period and its value is between zero and one.

3.4 Government and Central Bank

Government: According to Berg et al [4] study for low-income, oil-producing developing countries and to "Dagher et al [12]" study for Ghana, the government budget is calculated in real prices as per the following equation:

$$g_t + \frac{\left(1 + r_{t-1}^d\right) b_{t-1}}{\pi_t^c} + TR_t = \frac{\omega . EX_t . o_t}{P_t^c} + T_t + other_t + fa_t + \frac{GBD_t}{P_t^c} \quad (47)$$

Where g_t is total government expenditure, EX_t is the nominal exchange rate, $o_t$is oil foreign exchange earnings, b_t is bonds, T_t is tax revenue, other_t is other revenues, and fa_t is the transfer of state-owned companies and GBD_t is the government budget deficit. As it turns out, the government spends ω percent of oil revenue through the budget. Government expenditures are defined as current expenditures C_t^g and construction expenditures I_t^g:

$$g_t = c_t^g + I_t^g \quad (48)$$

Monetary policy- Maker: The function of the monetary policy response (logarithm-linear form) is as follows:

$$\hat{\Theta}_t = \rho_{\Theta} \hat{\Theta}_{t-1} + \theta_{\pi} \hat{\pi}_t^c + \theta_y \hat{y}_t + \theta_{rer} \widehat{rer}_t + \theta_{\pi^s} \hat{\pi}_t^s + \varepsilon_t^{\Theta} \quad (49)$$

$$\hat{\Theta}_t = \rho_{\Theta} \hat{\Theta}_{t-1} + \theta_{\pi} \hat{\pi}_t^c + \theta_y \hat{y}_t + \theta_{rer} \widehat{rer}_t + \theta_{\pi^s} \hat{\pi}_t^s + \varepsilon_t^{\Theta} \quad (50)$$

$$\hat{\Theta}_t = \rho_{\Theta} \hat{\Theta}_{t-1} + \theta_{\pi} \hat{\pi}_t^c + \theta_y \hat{y}_t + \theta_{rer} \widehat{rer}_t + \theta_{\pi^s} \hat{\pi}_t^s + \varepsilon_t^{\Theta} \quad (51)$$

$$\hat{\Theta}_t = \widehat{m}_t^c - \widehat{m}_{t-1}^c + \hat{\pi}_t^c$$

$$\varepsilon_t^{\Theta} = \rho_{\Theta} \varepsilon_{t-1}^{\Theta} + u_t^{\Theta} \qquad u_t^{\Theta} \sim N(0, \sigma_{\Theta}^2)$$

Where $\hat{\Theta}_t$ is the nominal growth rate of the monetary base, $\hat{\pi}_t$ ،$\hat{y}_t$ and $\widehat{rer}_t$ are the deviation of the inflation rate and the logarithm of production and the real exchange rate from their steady values respectively, θ_{π} ،θ_y و θ_{rer} ،θ_{π^s} are coefficient of importance which the policy takes into account for the gap between inflation, production, exchange rate and total stock price index respectively. ε_t^{Θ} is the monetary policy shock that follows a random process AR (1).

3.5 Market Equilibrium

The final good market is in equilibrium when production equals households demand for consumption and investment, government expenditures, and exports minus imports:

$$y_t = c_t + i_t + g_t + \frac{ex_t(P_t^e x_t + o_t)}{P_t^c} - \frac{P_t^{m_c} c_t^{im} + P_t^{m_c} I_t^{im}}{P_t^c} \quad (52)$$

The amount of total production is equal to non-oil production plus oil production as follows:

$$Y_t = \left[\alpha_\mu^{\frac{1}{\mu_o}} (Y_t^{no})^{\frac{\mu_o - 1}{\mu_o}} + (1 - \alpha_\mu)^{\frac{1}{\mu_o}} (Y_t^o)^{\frac{\mu_o - 1}{\mu_o}} \right]^{\frac{\mu_o}{\mu_o - 1}} \quad (53)$$

4 Model Estimation and Result

By optimizing the objective functions of each of the above agents, the result of the yield economic equations is a system of non-linear differential equations under rational expectations.

4.1 Calibrate

In this research, all of the equations have been linear-logarithmic using Uhlig method. The model is simulated by determining the model input values and calibrating the parameters.

Table 1: Calibrated Parameters of the Model Based on Iranian Economic Data

Values of Parameters	Symbol	Parameters
0.9849	gama_dcbar	The ratio of the producer price index to the consumer price index
0.9357	gama_mcbar	The ratio of the imported price index to the consumer price index
0.0139	Delta	Capital depreciation rate
0.046	R_kbar	Real return of capital rate
0.510	c_ybar	Consumption to production ratio
0.321	i_ybar	Total investment to production ratio
0.123	c_g_ybar	Government consumption expenditures to production ratio
0.175	Txoybar	Oil exports to production ratio
0.105	Txnoybar	Non-oil exports to production ratio
0.234	Tmybar	Total imports to production ratio
0.728	ibar_i_Tbar	Private investment to total investment ratio
0.272	i_gbar_i_Tbar	Public investment to total investment ratio
1.6810	obar_frbar	Oil exports to net foreign assets of the central bank ratio
0.5125	pe_xx_frbar	Non-oil exports to the net foreign assets of the central bank ratio
1.2873	gama_mc_cm_im_rer	Total imports to net foreign assets of the central bank ratio
0.7313	c_gbar_gbar	Current government expenditures to total government expenditures ratio

Table 1: Calibrated Parameters of the Model Based on Iranian Economic Data

Values of Parameters	Symbol	Parameters
0.2687	i_gbar_gbar	Construction expenditures to total government expenditures ratio
0.3942	o_gbar	The share of oil revenues in the government budget
0.2066	o_y	Value added of the oil sector to total production ratio

Source: Researcher calculations

Table 2: Calibrated Parameters (Calibrated)

Source	Value	Parameter	
Research findings	0.97	Consumer time preference rates	β
Fakhr Hosseini (1393)	0.30	The degree of stability of habits	h
Kavend (1388)	0.80	Inverse of elasticity of intertemporal substitution	σ_c
Zanganeh (1388)	1.315	Inverse of elasticity of real balance of money	σ_m
Rahbar et al. (1393)	3.943	The elasticity of adjustment costs investment function	φ
Taie(1385)	2.92	Inverse of elasticity of labor force to real wages	σ_l
Shahmoradi (1387)	0.42	Capital ratio in production	α
Rahbar et al. (1393)	0.21	Inverse of elasticity of cost function to operating cost	ψ
Rahbar et al. (1393)	0.511	Degree of price indexation	τ_p
Parsa et al. (1394)	0.20	Percentage of firms that are unable to adjust their prices	θ_p
Parsa (1394)	1.05	Substitution elasticity between consumer and imported goods	η_c
Manzoor and Taghipour (1394)	0.15	Substitutions elasticity between oil and non-oil production	μ^o
Parsa et al. (1394)	0.249	Coefficient of auto-regression process of oil revenue shock	ρ_o
Shah Hosseini et al. (2013)	-1.548	Inflation significance coefficient in the monetary policy reaction function	ϖ_π
Shah Hosseini et al. (2013)	-1.70	The coefficient of importance of production in the monetary policy reaction function	ϖ_y
Manzoor and Taghipour (1394)	0.80	The coefficient of importance of the real exchange rate in the monetary policy reaction function	ϖ_{rer}
Manzoor and Taghipour (1394)	0.90	The coefficient of the autoregression process in the foreign exchange reaction function of the Central Bank	υ_{EX}
Manzoor and Taghipour (1394)	-1.55	The coefficient of importance of foreign reserves to the monetary base in the foreign exchange reaction function of the Central Bank	υ_{rer}
Manzoor and Taghipour (1394)	0.397	Monetary autoregression process coefficient in the reaction function	ρ_μ

4.2 Simulation Results

To evaluate the accuracy of the model, we compare of the moment of the variables present in the model and moment of real data of Iran economy. In this research is used the parameters and calculating some parameters with the application of economic of data of Iran, the liner-logarithm equations systems is simulated in MATLAB applying Dynare Software, the basis of which is evaluated according to the analysis of effects of “Monetary base”, “interest rate of bank deposits” shocks on variables of macroeconomics.

Table 3: Comparison of Moment from Model with Real World Data Moment

Relative Fluctuations (Ratio of Variable Standard Deviation to Production Standard Deviation)		Fluctuations (Standard Deviation)		Variables
Value Calibrated in the Model	Value Observed in Real Data	Value Calibrated in the Model	Value Observed in Real Data	
0.96	0.62	0.025	0.018	Inflation
0.84	1.10	0.021	0.032	Consumption
1.65	1.52	0.043	0.044	Investment
1	1	0.026	0.019	Production

* The sample contains quarterly data from 2002 to 2017.

To de-trend the variables, the Hedrick-Prescott filter method with λ= 677 was used.

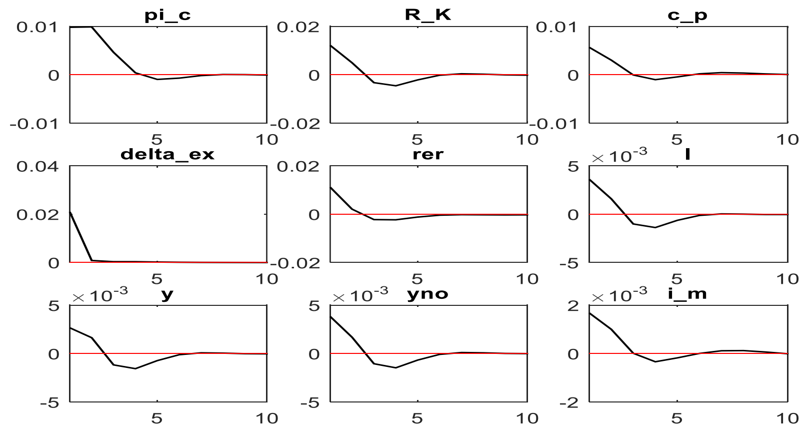

Fig. 1: Instantaneous Response Functions of Variables to Monetary Base Shock of 10%

4.3 Analysis of Impulse-Responses

Dynamic stochastic general equilibrium model is computed by solving the first-order approximation of the equilibrium conditions. Here are presented the results of calculations and diagrams of impulse-responses of various economic variables. That is, the effects of monetary base shocks and deposit interest rates on the desired variables are examined

4.3.1 Monetary Base Shock

By a 10% shock to the nominal growth of the monetary, inflation increases by 10% and consequently wages increase. Creation of inflationary conditions due to the reduction of the real interest rate, leads also to increases of the amount of consumption as shown in Euler equation. At first investment increases by less than 3 percent and then gradually decreases and employment decreases. Production after two seasons increases to its maximum value of 0.3%. A part of the created liquidity is kept in the form of new deposits in banks and another part is allocated to productive activities in the form of bank credits, but a large part of the created liquidity is directed to inflationary activities. It should be noted that the increase in the growth of the monetary base has led to an increase in imports, especially imports of consumer goods. Monetary shocks increase the nominal exchange rate growth through demand for foreign exchange for imports. With the shock of increasing the monetary base, people invest their surplus monetary in the stock market. Based on a 10% shock to the monetary supply, stock prices increase by 7%. After that the effect of different shocks as monetary transmission channels on macroeconomic variables is examined.

4.3.2 Interest Rate Shock on Bank Deposits

According to Fig. 2 with a positive shock to the interest rate of bank deposits, the interest rate of loans will also increase and the profit of intermediary firms will decrease. Thus, increasing the interest rate of deposits will reduce the demand for loans in both public and private enterprises, so the amount of production will decrease and the prices increase.

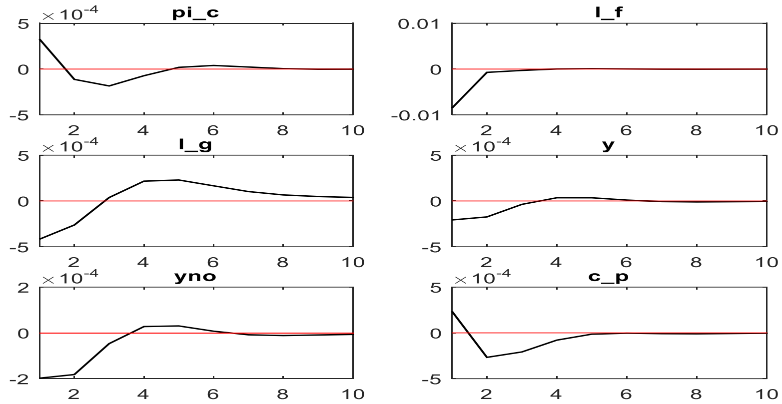

Fig. 2: Impulse-Response Functions of Variables to Interest Rate Shock of Bank Deposits of 5%

4.4 Variance Decomposition

In this section, using the decomposition of impulse-response functions, the mechanism of monetary policy transmission in DSGE models is explained. Fig. 3 shows the inflation impulse-response and variance-decomposition to monetary policy. The inflation response was initially positive after the monetary policy shock, but this response will return to zero. In the first period adjustment, (*pi_c* is inflation) will increase with the direct effect of an increase in monetary policy. Indirect effects or the release of monetary policy will operate in the second period. In the second period, the nominal growth rate of monetary (*eps_liqu*), exchange rate (*rer*), domestic commodity price index (*pi_d*), monetary base (*mb*) and other variables (other) pushed inflation upwards positively.

And a quantity amount of the central bank's external reserves (*fr*) variable neutralizes the effect of other variables by dragging the inflation variable downwards. In the third period, the reduction of the effect of the variables of nominal growth rate of monetary and exchange rate has reduced the effect of monetary policy shock on inflation. In the fourth period, the exchange rate has reduced the effect of monetary policy on inflation, so that the exchange rate variable has caused the effect of monetary policy on inflation to be zero at the end of the period. Until the seventh period, the negative effects overwhelm the positive effects. After that, with the disappearance of indirect effects, the impact of monetary policy shock on inflation will be zero.

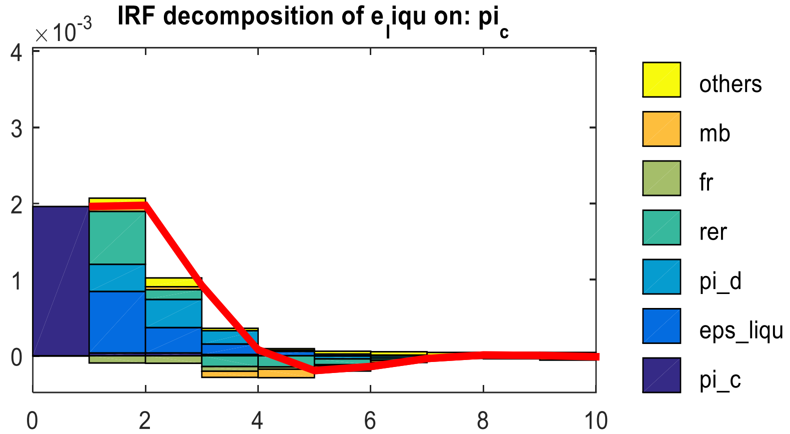

Fig. 3: Variance Decomposition of Inflation Variable Relative to the Monetary Base Shock of 10%

Fig. 4 shows the analysis of the impulse-response functions of a production without oil cycle to a monetary base shock. After the monetary policy shock, the response of non-oil production was positive, but this response will return to zero. In the first period adjustment, (*yno*) production without oil will increase directly with increasing monetary policy. In the second period, effects the nominal rate of the monetary (*eps_liqu*), exchange rate (*rer*), and other variables (other) will increase, but the domestic commodity price index (*pi_d*) and the central bank external reserves variable (*fr*), by decreasing output reduce some of the positive effects of monetary policy on production. In the third period, with a large decrease due to the exchange rate variable and the nominal growth rate of money, the effect of monetary policy on the production without oil variable has been negative. In the fourth period, there are no effects of exchange rate variables and other variables. Therefore, the effect of monetary policy on production without oil has been decreasing, and finally, the effect of monetary policy on production without oil will be zero.

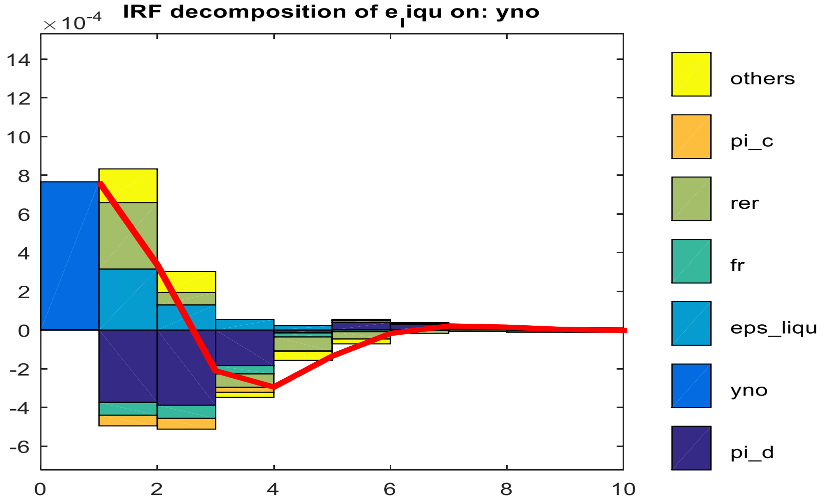

Fig. 4: Variance Decomposition of Production without Oil Variable Relative to the Monetary Base Shock of 10%

Fig. 5 shows the impulse-response and the decomposition of inflation to the interest rate shock on bank deposits. In the first adjustment period, inflation (*pi_c*) will increase with the direct effect of an increase in interest rates on bank deposits. Indirect effects or the release of interest rates on bank deposits during the second period decrease the monetary base (*mb*), the exchange rate (*rer*) and the ratio of prices of imported goods to inflation (*gama_mc*) and the external reserves of the central bank (*fr*), increases inflation. The result of these changes decreases inflation at the end of the second period. In the third period, by enforcing the monetary base effect, inflation decreases.

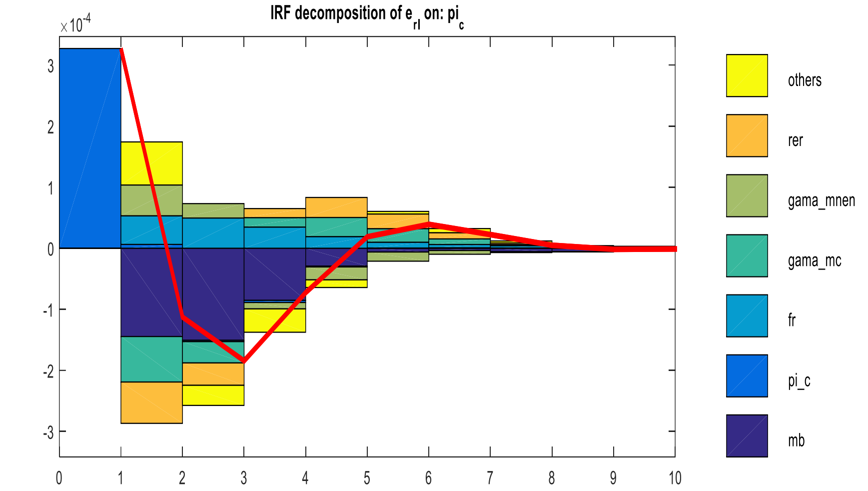

Fig. 5: Variance Decomposition of Inflation Variable to Interest Rate Shock of Bank Deposits of 5%

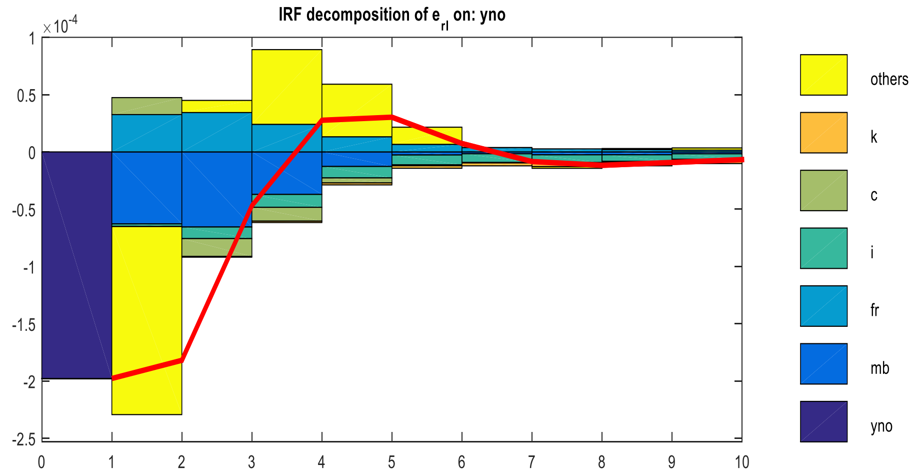

Fig. 6: Variance Decomposition of Production without Oil Variable Relative to Interest Rate Shock of Bank Deposits of 5%

Fig. 6 shows the decomposition of impulse-response functions production without oil to the interest rate shock on bank deposits. The response of non-oil production to this shock is negative, and will return to zero after 6 periods. In the first adjustment period (*yno*), production without oil will directly decrease with increasing the interest rates on bank deposits. Under the indirect effects in the second period, other variables (other), and the monetary base (*mb*) will decrese the production without oil variable, and foreign reserves of the central bank (*fr*) , and total consumption (*c*) variables will slightly neutralize the effects of the variables. Variables which caused a decrease in production. From period 6 the effect of this shock on the production without oil variable will be zero.

5 Conclusions and Discussion

This study is aimed to investigate the different channels of monetary policy transmission in Iran and to estimate the impact of each channel on production, and inflation within a dynamic stochastic general equilibrium model for the Iranian economy. Hence, the nominal growth of the monetary base, and the interest rate on bank deposits are considered as two monetary shocks. In order to investigate this issue, using shock analysis, the extent, and importance of each variable in the transmission of monetary shocks were analyzed. After specifying the appropriate model, the next step is to find the first-order conditions for optimizing economic activists. Then, the stationary of the model is de-trended, and the resulting non-linear model is linearized using the Uhlig approach. Calibration the parameters of the linearized model of the coefficients of correlation, and standard deviation of the simulated model, and the realities of the Iranian economy indicate a relative success in this model.

The results show that with the applying of the shock of nominal growth of the monetary base, inflation increases, and due to the reduction of real interest rates, the amount of consumption also increases, then the Investment, and production increase. Furthermore, by applying a positive shock to the interest rate on bank deposits, the interest rate on facilities will increase, and the profit margin of intermediary firms will decrease. Thus, the increase of interest on deposits will lead to a decrease in the demand for facilities for public and private enterprises, and consequently the amount of production will decrease, , and with the increase of interest paid on bank deposits, will increase liquidity, demand and inflation in the economy. Surving the results of the research about the impulse- response of a period of inflation to the monetary policy shock and Variance decomposition show:

The direct effect of increasing monetary policy on inflation is positive, and the indirect effects in the second period, through the nominal growth rate of monetary increase exchange rate, domestic good price index and inflation partly, and the central bank's external reserves variable offsets partially the effect of monetary policy on the inflation. The response of inflation to the direct effect of the interest rate shock on bank deposits is positive, but the indirect effects of this shock through the variables of monetary base, exchange rate and the ratio of prices of imported goods to inflation will cause the shock effect on inflation would be negative. In the next periods, reduction of the indirect effects of variables makes inflation will return to its stable position. The results also show that production without oil increases directly through expansionary monetary policy, and the indirect effects of this shock, through the variables of nominal growth rate of money, exchange rate, and other variables, will increase the production without oil variable, but the price index of domestic goods and the variable of foreign reserves of the Central Bank offset part of the increase in production without oil. With increase interest rates on bank deposits will decrease Production without oil directly.

References

[1] Aleem, A., Transmission Mechanism of Monetary Policy in India, *Journal of Asian Economics*, 2010; **21**(2): 186-197. doi: 10.1016/j.asieco.2009.10.001.

[2] Angelini, P., and Neri, S., and Panetta, F., Monetary and Macroprudential Policies, *ECB Working Paper*, 2012; **1449**. doi: 10.2139/ssrn.2091137.

[3] Atta-Mensah, j., and Dib, A., Bank Lending, Credit Shocks, and The Transmission of Canadian Monetary Policy, *International Review of Economics and Finance*, 2008; **17**(1): P.159–176. doi: 10.1016/j.iref.2006.06.003.

[4] Berg, A., and Miao, Y., The Real Exchange Rate and Growth Revisited: The Washington Consensus Strikes Back? *IMF Working Paper,* 2010; **10**(58); 24. doi: 10.5089/9781451963755.001.

[5] Bernanke, B., and Gertler, M., Inside the Black Box: The Credit Channel of Monetary Policy Transmission, *Journal of Economic Perspectives,* 1995; **9**(4): 27-48. doi: 10.1257/jep.9.4.27.

[6] Bernanke, B., Gertler, M., and Gilchrist, S., The Financial Accelerator in a Quantitative Business Cycle Framework, *Handbook of Macroeconomics,* 1999; 1(C):1341-1393. Doi: 10.1016/S1574-0048(99)10034-X.

[7] Boughrara, A., Monetary Transmission Mechanisms in Morocco and Tunisia, *Economic Research Forum, Workshop Monetary Policy and Inflation Targeting*, 2008; **460**: P. 1–31.

[8] Calvo, G.A., *Staggered Price Setting in a Utility- Maximizing Framework*, Journal of Monetary Economics,1983; **12**(3):383-398. Doi: 10.1016/0304-3932(83)90060-0.

[9] Carlstrom, C., and Fuerst, T., Agency Costs, Net Worth, and Business Fluctuations: A Computable General Equilibrium Analysis, *The American Economic Review*, 1997, **87**(5), P. 893–910.

[10] Castelnuovo, E., and Nisticò, S., Stock Market Conditions and Monetary Policy in a DSGE Model for the U.S., *Journal of Economic Dynamics and Control*, 2010; **34**(9): 1700-1731. doi: 10.1016/j.jedc.2010.06.028.

[11] Dabla-Norris, E., and Floerkemeier, H., Transmission Mechanisms of Monetary Policy in Armenia: Evidence from VAR Analysis, *IMF Working Papers,* 2006; **06**(248), ISBN/ISSN: 9781451865080/1018-5941.

[12] Dagher, J., Gottschalk, J., and Portillo, R., Oil Windfalls in Ghana: a DSGE Approach, *IMF Working Paper,* 2010; **10**(116):doi: 10.5089/9781455200757.001.

[13] Dixit, A.K., and Stiglitz, J.E., Monopolistic Competition and Optimum Product Diversity, American Economic Review, 1977; **67**: 297–308.

[14] Haeri Nasab, Z., Sohali, K., and Fattahi, S., *Investigating the Relationship Between the Facility Interest Rate and the Bank Deposit Interest Rate in Iran, Advances in Mathematical Finance and Applications,* 2018; **3**(4): 53-66. doi: 10.22034/AMFA .579317.1136.

[15] Idrees Agha, A., Ahmed, N., Mubarik, Y.A., and Shah, H., Transmission Mechanism of Monetary Policy in Pakistan, *SBP Research Bulletin, State Bank of Pakistan,* Research Department, 2005; **1**: 1-23.

[16] Komijani, A., and Alinejad, F., Evaluating Effectiveness of Monetary Transmission Channels on the Output and Inflation Rate and Analyzing Their Relative Importance in Iran Economy, *Budget and Planning Journal,* 2012; **17**(2): 39-64. (in Persian). doi: 20.1001.1.22519092.1391.17.2.2.4.

[17] Laidler, D., Money and money income: An Essay on the Transmission Mechanism, *Journal of Monetary Economics,* 1978; **4**(2): 151-191.

[18] Gambacorta, L., Bank-Specific Characteristics and Monetary Policy Transmission: the Case of Italy, *Temi di discussione (Economic working papers)*, Bank of Italy, Economic Research and International Relations Area, **430**: 1-37.

[19] Mishkin, F. S., The Channel of Monetary Transmission: Lessons for Monetary Policy, *NEBR working paper series, National Bureau of economic research*, 1996; **5464**.

[20] Moshiri, S., and Vashaghani, M., Study of Monetary Policy Transmission Mechanism and its Timing in Iran, *Journal of Economical Modelling,* 2010; **4**(11):1-32. (in Persian).

[21] Nisticò, S., *Monetary Policy and Stock-Price Dynamics in a DSGE Framework*, Journal of Macroeconomics,

2012; **34**(1): 126-146. doi: 10.1016/j.jmacro.2011.09.008.

[22] Peiris, S. J., and Saxegaard, M., An Estimated Dynamic Stochastic General Equilibrium Model for Monetary Policy Analysis in Mozambique, *IMF Staff Papers,* 2010; **57**(1): 256-280.

[23] Raei, R., Iravani, M.J., and Ahmadi, T., Monetary Shocks and Monetary Policy Transmission Channels in the Iranian Economy: With Emphasis on Exchange Rates, Housing Prices and Credits, *Journal of Economic Growth and Development Research*, 2018; **8**(31): 29-44. (in Persian). Doi: 20.1001.1.22285954.1397.8.31.2.9.

[24] Rafee Shamsabadi, P., Haji, G., and Fakhrhosseini, S.F., Significance of Financial Acceler-ators in a New Keynesian Model in Iranian Economy, *Applied Economics Studies in Iran,* 2019: **7**(28): 215-49. (in Persian). doi: 10.22084/AES.2018.15787.2608.

[25] Sharifnezhad, M., Bakhtiari Koohsorkhi, S., Daei-Karimzadeh, S., and Ghobadi, S., Evaluation of Monetary and Fiscal Policy Based on New Keynesian Dynamic General Equilibrium Model in Iran's Economy, *Advances in Mathematical Finance & Applications,* 2020; **5**(3): P.403-418. doi: 10.22034/AMFA.2019.1867660.121.

[26] Smets, F., and Wouters, R., An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area, *Journal of the European Economic Association*, 2010; 1(5): 1123-1175. doi: 10.1162/154247603770383415

[27] Tavakolian, H., and Sarem, M., DSGE Patterns in DYNARE Software (Modeling, Solving and Estimation Based on Iran's Economy, *Monetary and Banking Research Institute of the Central Bank of the Islamic Republic of Iran*, 2017.

[28] Walsh, C., Monetary Theory and Policy, *Cambridge, MA: MIT Press,* 2010.