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The Effect of Oil Shocks on Foreign Trade under Inflation and Exchange Rate Targeting Policies (In the Form of a Dynamic Stochastic General Equilibrium Model for Iran)

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ABSTRACT

In this study we examined the effect of oil shocks on Iran's foreign trade in the presence of the exchange rate and inflation targeting policies. Therefore, we estimated an open economy new adjusted Keynesian dynamic stochastic general equilibrium (DSGE) model for Iran using Bayesian method under the assumption that these policies will have an important role in absorbing negative effects of oil shocks on the foreign trade. The results of model simulations show that the severity and duration of the negative effects of shock oil revenues have decreased on export and import in the case of inflation and exchange rate targeting, compared to the failure to adopt this policies. Also, the effects of the shock on the exports and imports of intermediate goods in the targeted exchange rate faster than the inflation targeting has gone out of the system, while the effects of the oil shock on imports of consumer goods in the case of inflation targeting is more quickly out of the system. In addition, in the event of a shock, changes in three variables is lower while targeted inflation.

Keywords: Inflation Targeting, Exchange Rate Targeting, Foreign Trade, Oil Shock, Dynamic Stochastic General Equilibrium Model
JEL Classifications: C53, E52, E58, F17, F14

1. INTRODUCTION

In oil-producing countries including Iran, because of governmental budget relying on oil revenues, a change in oil revenues has considerable effects on macroeconomic variables. When an oil shock is imposed on an economy, it affects import, export, inflation and other macroeconomic variables of the country. Hence, oil earnings can have an important economic position in relation to the balance of trade (non-oil), export (non-oil), and import so that governments' policy-making is very important to control oil revenue shocks and reduce the negative impact on foreign trade.

Among common policies which can be very effective on the reduction or increase of the negative impact of oil shocks is monetary policy. The main core of monetary policy is using a "nominal anchor" that due to the experiences of different countries in relation to monetary policy, 4 strategies of targeting can be introduced: Exchange rate targeting, monetary targeting, inflation targeting and monetary policy by an explicit nominal anchor[1].

In this study, we have focused on the effects of monetary policy of targeting exchange rate and inflation on Iran's foreign trade in response to oil revenue shocks because these two key variables, on the one hand play an effective role in export, import and consequently adjusting the balance of trade and payments of the country and on the other hand play an effective role in determining the competitiveness of domestic producers against foreign competition in domestic and foreign markets and consequently determining the level of output and employment.

To examine the effect of the above policies, given the unique characteristics of dynamic stochastic general equilibrium (DSGE) in the analysis of business fluctuations and the effects of various

1 Mishkin (1999).

shocks as well as consider the role of agents' expectations, new adjusted Keynesian DSGE model framework was used for a small open economy, so that as much as possible adjustments made show Iran's economic facts[2].

In New Keynesian models, the balance is achieved when for monetary policy-making behavior (the Central Bank) a response function is added to the model which is usually the norm Taylor (1993) is used in these models, also our model puts greater emphasis on the Central Bank's monetary response function. 2 points should be considered here, first, on the one hand in Iran Taylor rule is not applicable and in fact the government is more seeking to control the rate of money supply growth, so here we rather than Taylor rule use a rule following Komijani and Tavakolian (2012) in which the rate of money supply growth is determined. In the rule, 2 factors are important in determining the rate of money supply growth: Inflation deviation from the target inflation and exchange rate deviation from its long-term trend. Second, on the other hand, monetary policy-making in Iran's economy follows no certain rule and so consider a response function such as Taylor rule for the Iranian economy is not true but since using a new Keynesian model is subject to the introduction of the Central Bank's monetary policy-making response function, here we try to introduce a function that shows the Central Bank's policy-making discretionary behavior.

Although Iran's Central Bank presents no explicit target of inflation however, monetary policy makers always have a goal in the mind for inflation that are sensitive to it and by observing inflation deviation from this implicit goal respond as reduced or increased monetary basic growth rate. Therefore, the inflation of implicit goal can be entered the response function of money supply growth rate as an unobservable variable and in this way it was added to its flexibility in order to show the trueities of Iran's economy.

In addition to the above discussion, in order to mitigate as much as new Keynesian model to the Economy of Iran, the role of government has also been considered with significant changes in the model. In this way, current expenditures of the government have been considered as a public good that provides utility for the consumer, in such a way that it is assumed a combination of private and public consumption is entered the consumer utility function. It is also assumed that the government development expenditure has contributed to the firm's production, so as capital augmented is entered the firm's production function.

The general framework of the study is as follows: In the second section, adjusted Keynesian DSGE model is presented for a small open economy. In the third section, the data and the model calibration are presented and in the fourth section conducted simulation and the results of Bayesian estimation are discussed. Finally, we present conclusion in section 5.

2 One of the most important facts of Iran's economy that should be noted is the important role of the government in the economy that affects all economic sectors especially the following: Fiscal dominance of monetary policy and the allocation of governmental funds to current and development expenditures, the monetary policy, the role of oil in the economy and its effect channel on monetary policy.

2. THE MODEL

This study is built on the works of Komijani and Tavakolian (2012) and Adolfson et al. (2007). The model consists of firms, households, government behave in an open economy. There is a continuum of infinit-lived households derive utility from leisure, consumption money balances and bonds. There are four types of firms: Final and intermediate good producing, importing and exporting firms. Intermediate good producer sell their good to final good producers in a monopolistic competitive market and final good producers are only as retailers and sell the final good in a perfectly competitive market. The basic model of monopolistic competition has been presented by Dixit and Stiglitz (1977). The intermediate good producer and importing firms set prices in a Calvo-type staggered fashion. In addition, there is a monetary authority to control the money supply rate. Government finances its expenditures through household lump-sum tax, oil income and printing money.

2.1. The Household

The utility function of representative households consists of consumption C_t, leisure L_t, real money balances $\frac{M_t}{P_t}$, bonds B_t in a way that maximize the following expected lifetime utility function:

$$E_t \sum_{i=0}^{\infty} \beta^i \left\{ \frac{\left(C_t G_t^{\gamma}\right)^{1-\sigma}}{1-\sigma} - \chi \frac{L_t^{1+\eta}}{1+\eta} + \frac{\varpi}{1-b}\left(\frac{M_t}{P_t}\right)^{1-b} \right\} \tag{1}$$

Where $\beta \in (0,1)$ is inter-temporal discount factor, $\frac{1}{\sigma} \geq 0, \frac{1}{\sigma} \geq 0, \frac{1}{b} \geq 0$ and χ are respectively the elasticity of inter-temporal substitution of consumption, wage elasticity of labor supply, preference parameter on real balance of and dis-utility factor of work. In the utility function, it is assumed that a combination of private consumption C_t and public goods and services (cost of property rights) is as Cobb-Douglas function that increases the consumer utility. In the function, $\gamma \in (0,1)$ is the parameter that determines the effect of a public good on the consumer preferences. $\gamma=0$ means public consumption has no effect on the household preferences while $\gamma=1$ means that public consumption affects preferences like the effect of private consumption.

The household budget constraint is as follows:

$$C_t + I_t + \frac{B_t}{P_t} + \frac{M_t}{P_t} + T_t \leq w_t L_t + R_{t-1} K_{t-1} + \left(1 + r_{t-1}\right)\frac{B_{t-1}}{P_t} + \frac{M_{t-1}}{P_t} + D_t \tag{2}$$

And the capital accumulation equation is given by:

$$K_t = (1-\delta)\, K_{t-1} + I_t \tag{3}$$

In Equation (2) and (3), w_t is real wage rate, R_{t-1} is real rent of capital, B_{t-1} is bonds, r_{t-1} is real return of bonds, T_t is household tax payments, P_t is the general level of prices, D_t is divided profit of intermediate goods producing firms, K_t is capital stock in the period t and $\delta \in (0,1)$ is depreciation rate of capital.

Aggregate consumption is assumed to be given by a constant elasticity of substitution function, consisting of domestically produced goods and imported products.

$$C_t = \left[\left(1-\gamma_1\right)^{\frac{1}{\theta_1}} \left(C_{d,t}\right)^{\frac{(\theta_1-1)}{\theta_1}} + \left(\gamma_1\right)^{\frac{1}{\theta_1}} \left(C_{m,t}\right)^{\frac{(\theta_1-1)}{\theta_1}} \right]^{\frac{\theta_1}{(\theta_1-1)}} \quad (4)$$

Where θ_1 is elasticity of substitution between consumption of domestic and imported goods, and γ_1 shows imported goods contribution in aggregate consumption. The demand functions for consumption of domestic-produced and imported goods are obtained as follows:

$$C_{d,t} = \left(1-\gamma_1\right)\left(\frac{P_{d,t}}{P_t}\right)^{-\theta_1} C_t \quad (5)$$

$$C_{m,t} = \gamma_1 \left(\frac{P_{m,t}}{P_t}\right)^{-\theta_1} C_t \quad (6)$$

P_t is the consumer price index (CPI) and is obtained from the following Equation (7):

$$P_t = \left[\left(1-\gamma_1\right)\left(P_{d,t}\right)^{1-\theta_1} + \gamma_1 \left(P_{m,t}\right)^{1-\theta_1} \right]^{\frac{1}{1-\theta_1}} \quad (7)$$

So maximizing the utility function subject to budget constraint yields the following FOCs are:

$$\varpi m_t^{-b} = \left(\frac{r_t}{1+r_t}\right) G_t^{\gamma} \left(C_t G_t^{\gamma}\right)^{-\sigma} \quad (8)$$

$$\chi \frac{L_t^{\eta}}{G_t^{\gamma}\left(C_t G_t^{\gamma}\right)^{-\sigma}} = w_t \quad (9)$$

$$\beta E_t \frac{G_{t+1}^{\gamma}\left(C_{t+1} G_{t+1}^{\gamma}\right)^{-\sigma}}{\pi_{t+1}} = \frac{G_t^{\gamma}\left(C_t G_t^{\gamma}\right)^{-\sigma}}{1+r_t} \quad (10)$$

$$R_t + \left(1-\delta\right) = E_t \frac{1+r_t}{\pi_{t+1}} \quad (11)$$

Assuming $\bar{X}$ shows steady state value X, steady state of the consumer problem is as follows:

$$\varpi \bar{m}^{-b} = \left(\frac{\bar{r}}{1+\bar{r}}\right) \bar{G}^{\gamma} \left(\bar{C}\bar{G}^{\gamma}\right)^{-\sigma} \quad (12)$$

$$\chi \frac{\bar{L}^{\eta}}{\bar{G}^{\gamma}\left(\bar{C}\bar{G}^{\gamma}\right)^{-\sigma}} = \bar{w} \quad (13)$$

$$\bar{R} + \left(1-\delta\right) = \frac{1+\bar{r}}{\bar{\pi}} = \frac{1}{\beta} \quad (14)$$

That Equation 14 is obtained from steady state combination of 10 and 11.

Assuming that $\hat{x}$ is the log-deviation of variable X from its steady state $(\hat{x} = \log X - \log \bar{X})$, the definition and the corresponding log-linearized version of consumer equations are given by:

$$\varpi \bar{m}^{-b}\left(1-b\hat{m}\right) = \left(\frac{\bar{r}}{1+\bar{r}}\right) \bar{G}^{\gamma} \left(\bar{C}\bar{G}^{\gamma}\right)^{-\sigma} \left(1-\hat{r}_t - \sigma \hat{c}_t + \gamma\left(1-\sigma\right)\hat{g}_t\right)$$

$$\hat{m}_t = \frac{\sigma}{b}\hat{c}_t + \frac{\gamma\left(\sigma-1\right)}{b}\hat{g}_t - \frac{1}{b}\hat{r}_t \quad (15)$$

$$\chi \frac{\bar{L}^{\eta}}{\bar{G}^{\gamma}\left(\bar{C}\bar{G}^{\gamma}\right)^{-\sigma}} \left(1+\eta \hat{l}_t + \sigma \hat{c}_t + \gamma\left(\sigma-1\right)\hat{g}_t\right) = \bar{w}\left(1+w_t\right)$$

$$\hat{w}_t = \eta \hat{l}_t + \sigma \hat{c}_t + \gamma\left(\sigma-1\right)\hat{g}_t \quad (16)$$

$$\beta \frac{\bar{G}^{\gamma}\left(\bar{C}\bar{G}^{\gamma}\right)^{-\sigma}}{\bar{\pi}} E_t\left(1-\sigma\hat{c}_{t+1} + \gamma\left(1-\sigma\right)\hat{g}_{t+1} - \hat{\pi}_{t+1}\right)$$
$$= \frac{\bar{G}^{\gamma}\left(\bar{C}\bar{G}^{\gamma}\right)^{-\sigma}}{\bar{\pi}} \left(1-\sigma\hat{c}_t + \gamma\left(1-\sigma\right)\hat{g}_t - \hat{r}_t\right)$$

$$\hat{c}_t = \hat{c}_{t+1} - \frac{1}{\sigma}\left[\hat{r}_t - \hat{\pi}_{t+1} - \gamma\left(\sigma-1\right)\left(\hat{g}_{t+1} - \hat{g}_t\right)\right] \quad (17)$$

$$\bar{R}\left(1+\hat{r}_t\right) + \left(1-\delta\right) = \frac{1+\bar{r}}{\bar{\pi}} E_t\left(r_t - \pi_{t+1}\right)$$

2.2. Final Goods Producer

Final good producer firms purchase intermediate goods from monopolistic competitive firms, repackage them as Dixit-Stieglitz aggregator and sell in perfectly competitive market. Where is total production of final goods, is j^{th} firm production, and is mark-up of varied price over time.

$$Y_t = \left(\int_0^1 \left(Y_t^j\right)^{\frac{1}{\lambda_{N,t}^p}} dj\right)^{1+\lambda_t^p} \quad (19)$$

$$\log\left(\lambda_t^p - \bar{\lambda}^p\right) = \rho^p \left(\log \lambda_{t-1}^p - \bar{\lambda}^p\right) + u_t^p \quad (20)$$

In the Equation 20, $\bar{\lambda}^p$ is the steady state value of λ_t^p. This equation implies a cost-push shock to inflation equation.

The final good producer profit maximization yields the demand function of intermediate good as follows:

$$Y_t^j = \left(\frac{P_t^j}{P_t}\right)^{\frac{-\left(1+\lambda_t^p\right)}{\lambda_t^p}} Y_t, \quad \forall j \in [0,1] \quad (21)$$

Also, according to Equations 19 and 21, internal producer price index can be achieved by the following equation:

$$P_t = \left(\int_0^1 \left(P_t^j\right)^{\frac{-1}{\lambda_{N,t}^p}} dj\right)^{-\lambda_t^p} \quad (22)$$

2.2.1. Intermediate goods producer

A continuum of intermediate goods' producers acts in a monopolistic competition market ($j \in [0,1]$). They provide their capital and labor from a perfect competition market and the production function is as follows:

$$Y_t^j = A_t\left(\tilde{K}_{t-1}^j\right)^{\alpha}\left(L_t^j\right)^{1-\alpha}\left(K_{t-1}^g\right)^{\alpha_g} - \Phi^j \quad (23)$$

Where $\alpha \in (0,1)$ is the share of private capital in the production and $\alpha_g \in (0,1)$ is capital share of public sector in the production. $\tilde{K}_{t-1}^j = z_t K_{t-1}^j$ is effective capital stock of private sector (operation). K_{t-1}^g is capital stock of the government assumed effective as augmented on the production of intermediate goods. $A_t = \rho^a \log A_{t-1} + u_t^a$ is technology shock, the same in all firms. Φ^j is fixed cost to ensure zero profit under steady state.

The Lagrange function obtained cost minimizing of intermediate goods producer firm is as follows:

$$\min_{\left\{\tilde{K}_{t-1}^j, L_t^j\right\}} \frac{W_t}{P_t} L_t^j + R_t^k \tilde{K}_{t-1}^j + \varsigma_t\left[\bar{Y}_t^j - A_t\left(\tilde{K}_{t-1}^j\right)^{\alpha}\left(L_t^j\right)^{1-\alpha}\left(K_{t-1}^g\right)^{\alpha_g}\right] \quad (24)$$

Lagrange ς_t is interpreted as real marginal cost of j^{th} intermediate goods. Through solving the above problem, the optimal ratio of capital to labor is obtained as the following equation:

$$\frac{\tilde{K}_{t-1}^j}{L_t^j} = \frac{\alpha}{(1-\alpha)}\frac{W_t}{P_t}\frac{1}{R_t^k}$$

By substituting the above equation in FOCs, real marginal cost is obtained as the following equation:

$$mc_t = \frac{1}{A_t}\left(\frac{1}{\alpha}\right)^{\alpha}\left(\frac{1}{1-\alpha}\right)^{1-\alpha}\left(\frac{W_t}{P_t}\right)^{1-\alpha}\left(R_t^k\right)^{\alpha}\left(\frac{1}{K_t^g}\right)^{\alpha_g} \quad (25)$$

The log-linearized form is as the following equation:

$$\widehat{mc}_t = \alpha \hat{R}_t^k + (1-\alpha)\hat{w}_t - \alpha_g \hat{K}_{t-1}^g - \hat{A}_t \quad (26)$$

Calvo (1983) type price setting behavior is assumed, as in each period only (1-θ)% of intermediate goods producer set prices optimally while (θ_N)% firms adjust prices according to last year inflation as follows:

$$P_{t+1}^j = (\pi_t)^{\tau} P_t^j \quad (27)$$

Where $\pi_t = \frac{P_t}{P_{t-1}}$ is inflation rate of gross non-traded goods and τ is price indexing degree. In each period, the firms that are able to set their price optimally they try to maximize their expected discounted profit as follows:

$$\max_{P_t^j} E_t \sum_{k=0}^{\infty} (\beta\theta)^k \frac{\lambda_{t+k}}{\lambda_t}\left[\prod_{s=1}^{k}(\pi_{t+s-1})^{\tau_N}\frac{P_t^j}{P_{t+k}} - MC_{t+k}\right]Y_{t+k}^j$$

$$s.t.\ \ Y_t^j = \left(\frac{P_t^j}{P_t}\right)^{\frac{-\left(1+\lambda_t^p\right)}{\lambda_t^p}} Y_t \quad (28)$$

Then, first order conditions of the above problem are as follows to determine the optimal price P_t^* for (1-θ) percent of the firms that are able to adjust their price:

$$E_t \sum_{k=0}^{\infty} (\beta\theta)^k \frac{\lambda_{t+k}}{\lambda_{t+k}^p}\left[\prod_{s=1}^{k}\frac{(\pi_{t+s-1})^{\tau_N}}{\pi_{t+s}}\right]^{\frac{-1}{\lambda_{t+k}^p}} \frac{P_t^*}{P_t} Y_{t+k} =$$

$$\sum_{k=0}^{\infty} (\beta\theta)^k \lambda_{t+k} \frac{1+\lambda_{t+k}^p}{\lambda_{t+k}^p}\left[\prod_{s=1}^{k}\frac{(\pi_{t+s-1})^{\tau_N}}{\pi_{t+s}}\right]^{-\frac{1+\lambda_{t+k}^p}{\lambda_{t+k}^p}} MC_{t+k}Y_{t+k} \quad (29)$$

Therefore, domestic price level can be defined as follows:

$$(P_t)^{\frac{-1}{\lambda_t^p}} = \theta\left[(\pi_{t-1})^{\tau} P_{t-1}\right]^{\frac{-1}{\lambda_t^p}} + (1-\theta)\left(P_t^*\right)^{\frac{-1}{\lambda_t^p}} \quad (30)$$

With the maximization of the problem (29) and combine it with the price index for domestic production, new Keynesian Phillips curve is obtained that explains the dynamics of inflation rate in domestic goods' production sector. According to the study of Rudebusch (2002), new Keynesian Phillips curve equation is estimated as hybrid for Iran's economy where both future and past inflation is considered that its log-linearized form is as follows:

$$\hat{\pi}_t = \frac{\beta}{1+\beta\tau}E_t\hat{\pi}_{t+1} + \frac{\tau}{1+\beta\tau}\hat{\pi}_{t-1} + \frac{1}{1+\beta\tau}\frac{(1-\beta\theta)(1-\theta)}{\theta}\widehat{mc}_t + \hat{\lambda}_t^p \quad (31)$$

2.3. Foreign Sector

Foreign sector consists of importing and exporting firms. It is assumed that these two types of firms have pricing power through branding and differentiating.

2.3.1. Importing firms

Import sector consists of a large number of firms that purchase homogeneous goods and turn them to distinctive consumer goods (through branding). This distinctive consumer goods are sold to domestic households by including nominal rigidity. Each of the importing firm is subject to price stickiness through an indexation variant of the Calvo (1983) model. Thus, in each period $(1-\theta_F)$ percent of importing firms are allowed to reoptimize their prices θ_F% of the other importer adjusts its price through the indexation scheme as follows:

$$P_{F,t+1}^j = \left(\pi_{F,t}\right)^{\tau_F} P_{F,t}^j \quad (32)$$

Where, τ_F is the indexation parameter and $\pi_{F,t} = \frac{P_{F,t}}{P_{F,t-1}}$ is gross inflation of imported goods.

Imported goods' price index is calculated by the following equation:

$$P_{F,t} = \left(\int_0^1 \left(P_{F,t}^j\right)^{\frac{-1}{\lambda_{F,t}^p}}\right)^{-\lambda_{F,t}^p} \quad (33)$$

Where $\lambda^{p}_{F,t}$ is the markup shock process is given in log-linearized as follows:

$$\hat{\lambda}^{p}_{F,t} = \rho^{p}_{M}\hat{\lambda}^{p}_{F,t-1} + \hat{u}^{p}_{F,t} \tag{34}$$

The aggregate imported goods is a continuous combination $j\in[0,1]$ of distinctive imported goods that can be expressed as:

$$C_{F,t} = \left(\int_0^1 \left(C^{j}_{F,t}\right)^{\frac{1}{\lambda^{p}_{F,t}}}\right)^{1+\lambda^{p}_{F,t}} \tag{35}$$

Imported consumer goods' demand function can be written as follows:

$$C^{j}_{F,t} = \left(\frac{P^{j}_{F,t}}{P_{F,t}}\right)^{-\frac{1+\lambda^{p}_{F,t}}{\lambda^{p}_{F,t}}} C_{F,t} \tag{36}$$

Similar to producers of intermediate goods, importing firms maximize their expected discounted profit flow due to limitations of price stickiness and Calvo (1983) method that finally log-linearized form of hybrid Keynesian Phillips curve is obtained for imported goods as follows:

$$\hat{\pi}_{F,t} = \frac{\beta}{1+\beta\tau_F}E_t\hat{\pi}_{F,t+1} + \frac{\tau_F}{1+\beta\tau_F}\hat{\pi}_{F,t-1} + \frac{1}{1+\beta\tau_F}\frac{(1-\beta\theta_F)(1-\theta_F)}{\theta_F}\widehat{mc}_{F,t} + \hat{\lambda}^{p}_{F,t} \tag{37}$$

That in the above equation $\widehat{mc}_{F,t} = \hat{p}^{fr}_t + \hat{e}_t - \hat{p}_{F,t}$ is real marginal cost of importing firms.

2.3.2. Exporting firms

Each domestic firm sells its own products both in the domestic and foreign markets. It is assumed that the demand for export goods is the same as the demand for domestic products. Hence, the demand for export goods is considered as the following equation:

$$EX_t = \left(\frac{P_{E,t}}{P^{f}_t}\right)^{-\eta_f} C^{fr}_t \tag{38}$$

Where η_f is elasticity of substitution between domestic exports and foreign goods in foreign sector and C^{fr}_t is consumption of rest of the world. Since Iran's economy is small compared to the world, so the world economy is closed to Iran's economy. Hence, it is assumed that $C^{fr}_t = Y^{fr}_t$ as a result of export demand function for the production of the country is obtained as follows:

$$EX_t = \left(\frac{P_{E,t}}{P^{f}_t}\right)^{-\eta_f} Y^{fr}_t \tag{39}$$

Also, because the share of Iran's export is partial to the world production, it is assumed that in exported goods' market single price law is applied, hence Iran's exported goods in the foreign market are the price taker and the price index of exported goods is defined as follows:

$$P_{E,t} = \frac{P_{H,t}}{e_t} \tag{40}$$

Where $P_{H,t}$ is trad-able goods price index domestic-produced and e_t is nominal exchange rate.

Also, foreign inflation and production is assumed as exogenous and follow AR(1) process as:

$$\pi^{fr}_t = \rho_{\pi^{fr}}\log\pi^{fr}_{t-1} + \varepsilon^{\pi^{fr}}_t,\quad \varepsilon^{\pi^{fr}}_t \approx iid.N\left(0,\sigma^2_{\pi^{fr}}\right) \tag{41}$$

$$y^{fr}_t = \rho_{y^{fr}}\log y^{fr}_{t-1} + \varepsilon^{y^{fr}}_t,\quad \varepsilon^{y^{fr}}_t \approx iid.N\left(0,\sigma^2_{y^{fr}}\right) \tag{42}$$

2.4. The Government and Central Bank

Because of the lack of independence of the Central Bank and financial control of the government in Iran, the government and Central Bank cannot be modeled as two distinct parts and the two parts should be considered in a framework. Here it is assumed that the government purpose is to balance its budget. In this regard, the Central Bank acts in a manner that the government achieves its main goal. In addition to the government help, the Central Bank through monetary policy-making tries to achieve its main goals including maintaining price consistency, exchange rate consistency and economic growth.

In the present model, the government expenditures are classified as current and development expenditures that the government is trying to balance the expenditures through tax earnings from households, sell bonds and earnings from the sale of the oil. In case of balancing the budget through the three types of income sources, seignior age by the government will not happen and the Central Bank is able to apply its monetary policy without taking into account the limitations of the government budget. But if despite these three sources of income, a deficit occurs, the government through borrowing from the Central Bank (or withdrawals from their deposits at the Central Bank) will finance its budget deficit, meaning financial domination. Since the exchange sale obtained from oil revenues of the government is reflected in high powered money, so what is reflected in the government budget constraint as monetary base changes is the combination of oil revenues and the withdrawal of government deposits at the Central Bank. With this description, the government budget constraint is obtained as the following equation:

$$G_t + R_t\frac{B_{t-1}}{P_t} = \frac{\omega e_t o_t}{P_t} + T_t + \frac{B_t}{P_t} + \frac{(DC_t - DC_{t-1})}{P_t} \tag{43}$$

Where DC_t is net public sector debt to the Central Bank, G_t is the government expenditures, T_t is the government tax earnings, o_t is oil export earnings and ω is the government's share of oil earnings. Right side of the equation is budget income sources and its left side is budget expenditure.

Since oil price is determined in global markets as exogenous and Iran's export share is also determined through OPEC, hence exchange earnings from oil export are exogenous and it is assumed it follows AR(1) process as the following equation:

$$\log(o_t) = (1-\rho_o)\bar{o} + \rho_o \log(o_{t-1}) + \varepsilon_t^o \tag{44}$$

The government tax earnings is a function of national earnings as the following equation:

$$\log(T_t) = \rho_{tax} \log(Y_{t-1}) + \varepsilon_t^T \tag{45}$$

The government expenditures include two types of current GC_t and development GI_t expenditures.

$$G_t=GC_t+GI_t \tag{46}$$

It is assumed that the government current expenditures follow AR(1) process as follows:

$$\log(GC_t) = (1-\rho_{GC})\bar{G}C + \rho_{GC} \log(GC_{t-1}) + \varepsilon_t^{GC} \tag{47}$$

Since after reducing oil revenues, the government reduces its development expenditures and the government current expenditures are less affected, for the government development expenditures AR(1) process is assumed as the following equation:

$$\log(GI_t) = (1-\rho_{GI})\bar{G}I + \rho_{GI} \log(GI_{t-1}) + \varepsilon_t^{GI} + \varepsilon_t^{oil} \tag{48}$$

The government development expenditures play a role in forming the government capital and it follows as:

$$K_t^g = (1-\delta_g)K_{t-1}^g + GI_t \tag{49}$$

High powered money is defined as:

$$M_t=DC_t+e_t.FR_t \tag{50}$$

Where DC_t is net public sector debt to the Central Bank (domestic credit) and FR_t is net foreign assets of the Central Bank. By dividing both sides of the above equation in prices' level, real high powered money is obtained:

$$m_t = dc_t + \frac{e_t.FR_t}{P_t} \tag{51}$$

A change in net foreign assets of the Central Bank (In foreign currency) follows the following equation:

$$FR_t - FR_{t-1} = \varpi_{fr}\left(\omega.o_t + P_{E,t}.EX_t - \frac{1}{e_t}P_{F,t}.IM_t\right) \tag{52}$$

Where $IM_t=C_{F,t}$ is the imported consumer goods and ϖ_{fr} is the exchange sold to the Central Bank. Assuming $B_t^f = R_t^f B_{t-1}^f$, the above equation represents the balance of payments.

So far, new Keynesian model adjusted for Iranian economy is almost completed and only requires a monetary policy response function to establish general equilibrium in the economy. We assume that monetary policy tool available to the Central Bank is money growth rate. It is the best assumption that could explain the behavior of monetary policy in Iranian economy. Also, it is assumed that monetary policy response function is in a way that the money growth rate responds to both goals of the Central Bank, i.e., reduce the exchange rate deviation from the potential exchange rate and the inflation deviation from targeted inflation and minimizes both deviations. Monetary policy response function in log-linearized form is defined as follows:

$$\widehat{mg}_t = \rho_{mg}\widehat{mg}_{t-1} + \lambda_\pi(\hat{\pi}_t - \hat{\pi}_t^*) + \lambda_y\hat{y}_t + \lambda_{RER}\widehat{rer}_t + \varepsilon_t^{mg} \tag{53}$$

Where $\widehat{mg}_t = \hat{m}_t - \hat{m}_{t-1} + \hat{\pi}_t$ is money growth deviation from its steady state, $\hat{y}_t$ is the production gap, $\hat{\pi}_t$ is inflation deviation from its steady state in the period t, $\hat{\pi}_t^*$ is inflation target deviation from the target value in period t and $\widehat{rer}_t$ is real exchange rate gap in its steady state.

However, as mentioned in the introduction, in Iran in spite of inflation targeting in development programs, no explicit and declared targeting is made to the people by the Central Bank but policymakers always try to follow an implicit target, so, here in the response function introduced, we assume that the implicit targeted inflation is an unobservable variable that is only available to policymakers and other economic agents are not aware of that. It is assumed that the implicit targeted inflation follows AR(1) process as follows where the model coefficient ρ_{π^*} is close to 1, so conditional mathematical expectation of inflation target in the period t is very close to mathematical expectation of inflation target in the past period. Because monetary authority tries to keep the inflation target constant over time, but sometimes fail to achieve this goal.

$$\hat{\pi}_t^* = \rho_{\pi^*}\hat{\pi}_{t-1}^* + \varepsilon_t^{\pi^*}\ ,\ \ \varepsilon_t^{\pi^*} \approx iid.N(0,\sigma_{\pi^*}^2) \tag{54}$$

It should be noted though introduced monetary response function is a kind of policy-making rule, but introducing implicit targeted inflation in the model reduces its ruling degree and it is tried to consider policymakers' discretion.

The Central Bank to manage the exchange rate and maintain a managed floating exchange rate regime tries to make the policy of exchange through an exchange policy rule (exchange response function). The Central Bank with the exchange policy-making try to achieve two goals. First, it tries to maintain economic competitiveness and for this purpose it considers the difference between domestic and foreign inflation e.g. when domestic inflation rate is increased to foreign rate, the Central Bank tries to reduce the value of Rls. against foreign exchange, i.e., the exchange rate is increased. The second objective of the Central Bank is to keep its foreign reserves at a desirable level. When exchange reserves of the Central Bank are increased, the exchange rate is reduced through more exchange supply in the exchange market. But, when reserves of the Central Bank are not sufficient, the Central Bank cannot keep the exchange rate constant. Here the rule of exchange policy is as follows:

$$\Delta\hat{e}_t = k_0\Delta\hat{e}_{t-1} + k_1(\hat{\pi}_t - \hat{\pi}_t^*) + k_2(r\hat{e}r_t + \hat{fr}_t - \hat{m}_t) + \varepsilon_t^{\Delta e} \tag{55}$$

2.5. The Aggregate Resource Constraint

The aggregate resource constraint is:

$$Y_t = C_t + IT_t + GC_t + \psi(z_t)K_{t-1} + e_t\left(\frac{P_{E,t}EX_t + o_t}{P_t}\right) - \left(\frac{P_{F,t}IM_t}{P_t}\right) \tag{56}$$

$IT_t = I_t + GI_t$

$Y_t = Y_{no,t} + Y_{o,t}$

3. ESTIMATING THE MODEL PARAMETERS

To estimate the model parameters, Bayesian method is used where initial values of parameters are known as initial information. If initial information are complete and accurate, Bayesian method is calibrated. But if the information of prior distribution is totally inaccurate and wrong, Bayesian method will be based on maximum likelihood. In borderline, Bayesian method is a combination of both calibration and maximum likelihood.

The data used in this study are seasonally adjusted data for the period 1981-2014, including real gross domestic product at constant prices of 1997, the CPI, producer price index, the real incomes of oil, real government expenditures, real current and development expenditures of the government, the rate of informal nominal exchange growth and money growth rate. All data have been extracted from time series of database of the Central Bank of Iran. For variables such as inflation and the rate of money supply growth according to the definition of New Keynesian growth rate, the variable ratio during the period t to $t-1$ has been used.

To calculate the log-linearized values of the variables (deviation from steady state of variables) using Hodrick-Prescott filter with λ=677 components of log data cycle have been extracted.

It is necessary to calibrate parameters and indicators as a share or with no need to estimate before estimate the parameters of the model. The parameters are obtained through values of variables' steady state and average ratio data is considered as values of steady state and there is no need to estimate it. Steady state parameters are reported in Table 1.

For Bayesian estimation of the model parameters, prior distribution, mean and standard deviation of parameters should be determined. Then, posterior distributions and related posterior statistics for the parameters of the DSGE model are computed by Metropolis-hastings Markov chain Monte Carlo (MCMC) sampling algorithm implemented in Dynare toolbox for MATLAB. In Table 2, prior and posterior mean and distribution of the model parameters are reported that Posterior mean values show the model parameters' estimation using Bayesian method.

To examine the accuracy of estimates, of MCMC and the diagnostic test of Brooks and Gelman (1988) were applied. The results of the diagnostic test show that intra and inter sample variance has been converged to a fixed value that reflects estimates' accuracy of the model parameters using Bayesian method (Figure 1).

It is common to the literature to assessing the simulation performance of the DSGE model, the moments of the data (after employing filter of Hodrick Prescot) from those generated by the model compared which has done and presented in Table 3.

Table 1: Stable conditions' parameters

Parameter	Value	Parameter	Value
Private sector capital depreciation rate	$\frac{\bar{I}}{\bar{K}} = 0.0139$	The ratio of current expenditures to aggregate government expenditures	$\frac{\overline{GC}}{\bar{G}} = 0.73$
The ratio of consumption to GDP	$\frac{\bar{C}}{\bar{Y}} = 0.53$	The ratio of development expenditures to aggregate government expenditures	$\frac{\overline{GI}}{\bar{G}} = 0.27$
The ratio of aggregate investment (private and government) to output	$\frac{\overline{IT}}{\bar{Y}} = 0.321$	The ratio of oil exports to net foreign assets of the Central Bank	$\frac{\overline{IOL}}{\overline{FR}} = 1.68$
The ratio of government consumption expenditure to output	$\frac{\overline{GC}}{\bar{Y}} = 0.123$	The ratio of non-oil exports to net foreign assets of the Central Bank	$\frac{\bar{X}}{\overline{FR}} = 0.51$
The ratio of imports to output	$\frac{\overline{IM}}{\bar{Y}} = 0.234$	The ratio of imports to net foreign assets of the Central Bank	$\frac{\overline{IM}}{\overline{FR}} = 1.28$
The ratio of non-oil exports to output	$\frac{\bar{X}}{\bar{Y}} = 0.08$	The ratio of net public sector and banks debt to monetary base	$\frac{\overline{DC}}{\bar{M}} = 0.49$
The ratio of oil exports to output	$\frac{\overline{OIL}}{\bar{Y}} = 0.2$	The ratio of net foreign assets of the Central Bank to monetary base	$\frac{\overline{FR}}{\bar{M}} = 0.51$

GDP: Gross domestic product

Table 2: The prior and posterior distribution of the model parameters

Parameter	Description	Type	Prior mean	Reference	Posterior mean
β	Mental intertemporal discount rate of household	Beta	0.968	Komijani and Tavakolian (2012)	0.967
γ	Elasticity of substitution between private and public consumption	Beta	0.192	Komijani and Tavakolian (2012)	0.182
σ_{oilr}	The standard deviation of oil revenues shock	Inv. Gamma	0.0427	Komijani and Tavakolian (2012)	0.46
σ_{mb}	The standard deviation of money supply shock	Inv. Gamma	0.0927	Komijani and Tavakolian (2012)	0.043
σ_{gc}	The standard deviation of current expenditures shock	Inv. Gamma	0.0917	Komijani and Tavakolian (2012)	0.76
σ_{GI}	The standard deviation of development expenditures shock	Inv. Gamma	0.2482	Komijani and Tavakolian (2012)	0.43
θ_E	Calvo price stickiness parameter in exported goods	Beta	0.5	Khiabani and Amiri (2014)	0.56
θ_1	Consumption elasticity of substitution between domestic and imported goods	Normal	1.05	Manzoor and Taghipour (2016)	1.067
η_f	Elasticity of substitution between exports and foreign goods	Normal	3.51	Manzoor and Taghipour (2016)	2.61
σ_C	Reverse intertemporal elasticity of substitution of consumption	Gamma	1.52	Manzoor and Taghipour (2016)	1.483
σ_L	Inverse elasticity of labor	Gamma	2.21	Manzoor and Taghipour (2016)	2.253
σ_M	Inverse elasticity of real money balances	Gamma	2.24	Manzoor and Taghipour (2016)	1.58
ρ^a	Auto-regressive coefficient of technology shock	Gamma	0.751	Manzoor and Taghipour (2016)	0.904
ρ_{oilr}	Auto-regressive coefficient of oil revenues shock	Beta	0.443	Manzoor and Taghipour (2016)	0.265
ρ_{gc}	Auto-regressive coefficient of current expenditures shock	Beta	0.899	Manzoor and Taghipour (2016)	0.552
ρ_{gi}	Auto-regressive coefficient of development expenditures shock	Beta	0.850	Manzoor and Taghipour (2016)	0.979
ρ_{mg}	Auto-regressive coefficient of money growth rate in monetary response function	Beta	0.305	Manzoor and Taghipour (2016)	0.901
$\rho_\pi*$	Auto-regressive coefficient of implicit inflation-target	Beta	0.80	Manzoor and Taghipour (2016)	0.42
λ_π	The sensitivity coefficient of Central Bank to inflation in monetary response function	Normal	−1.641	Manzoor and Taghipour (2016)	−1.42
λ_Y	The sensitivity coefficient of Central Bank to output in monetary response function	Normal	−1.626	Manzoor and Taghipour (2016)	−2.34
λ_{RER}	The sensitivity coefficient of Central Bank to exchange rate in monetary response function	Normal	0.684	Manzoor and Taghipour (2016)	0.69
K_0	The auto-regressive coefficient of exchange rate in exchange response function	Beta	0.875	Manzoor and Taghipour (2016)	0.94
K_1	The sensitivity coefficient of Central Bank to output in exchange response function	Normal	−1.9	Manzoor and Taghipour (2016)	−1.74
K_2	The sensitivity coefficient of Central Bank on the ratio of foreign reserves to the monetary base in exchange response function	Normal	−1.54	Manzoor and Taghipour (2016)	−1.37
α	Private capital's share of output	Beta	0.44	Manzoor and Taghipour (2016)	0.48
α_{Kg}	The share of the state capital of output	Beta	0.078	Manzoor and Taghipour (2016)	0.072
θ_p	Calvo price stickiness parameter in locally-produced goods	Beta	0.24	Manzoor and Taghipour (2016)	0.26
θ_M	Calvo price stickiness parameter in imported goods	Beta	0.05	Manzoor and Taghipour (2016)	0.09
τ	The price index calibration for domestically produced goods	Beta	0.52	Manzoor and Taghipour (2016)	0.75
τ_F	The price index calibration for imported goods	Beta	0.68	Manzoor and Taghipour (2016)	0.74
σ_a	The standard deviation of technology shock	Inv. Gamma	0.01	Manzoor and Taghipour (2016)	0.09

According to the Table 3 it is found that the designed model has relatively good fit and accuracy and ability to explain Iran's economy.

4. SIMULATION

In this section, the results of the model parameters' estimation are examined under three scenarios of not targeting policy-making, policy-making of targeting inflation and policy-making of targeting exchange rate (by changing parameters), the effect of a positive shock of oil revenues on macroeconomic variables, especially the trade sector.

4.1. The Effect of Oil Revenues' Shock in the Basic State (Not Targeting Policy-making)

In the basic state, the results of estimating the model parameters are applied and the effects of government oil revenues' shock on important economic variables are examined through impulse response functions. The results of the main economic variables'

Table 3: Moments comparing real and simulated variables

Variable	Mean		SD		The correlation between real and simulated data	Co movement with output gap	
	Real	Simulated	Real	Simulated		Real	Simulated
Output	1.1	1.04	0.074	0.078	0.83	1	1
Inflation	1.02	1.25	0.12	0.13	0.76	0.24	0.26
Money	1.06	1.11	0.04	0.06	0.82	0.35	0.32
Government expenditures	1.07	1.02	0.21	0.19	0.78	0.19	0.23

SD: Standard deviation

response with an emphasis on trade state are shown in Figure 2. The mechanism of the effect of oil earnings is in such a way that increased oil export earnings increased the government costs. Since the major part of oil export earnings of the government is sold to the Central Bank, through which foreign reserves of the Central Bank and consequently high powered money are enhanced. Increased foreign exchange earnings and money supply of the country reduces the nominal and real exchange rate, then strengthening the national currency as nominal and real reduces export of domestic produced goods and increases import of consumer and intermediate goods. Also, it is observed that total production has been increased first due to increased oil production and then increased non-oil production due to increased governmental investment, but over time by increasing money supply and reducing exchange rate and export, non-oil and total production is reduced. With the increase in oil revenues, CPI has been reduced first due to reduced nominal exchange rate and increased import but over time and increased money supply, public price level has been increased. The results confirm Dutch disease followed by a shock of rise in oil export earnings in the country.

The Central Bank in order to reduce the negative impact of oil export earnings' shock can enforce appropriate monetary and exchange policy. Then, the effect of policy-making of targeting inflation and exchange rate on reducing the negative impact of oil shocks will be examined.

4.2. The Effect of Oil Earnings' Shock on Policy-making of Targeting Inflation Rate

In policy-making of inflation target, the Central Bank tries to keep the inflation rate close to the inflation target. In this state, among monetary and exchange policy-making response functions of the Central Bank, the inflation gap of the targeted inflation variable is the most important variable and other variables are less important. Here, it is assumed, the weight of other variables other than the inflation targeting is reduced to a tenth in monetary and exchange rate response functions of the Central Bank. The results of the effect of government oil earnings' shock on important economic variables with impulse response functions are shown in Figure 3. As seen, by policy-making of targeting the inflation rate again signs of Dutch disease followed by the shock of rise in oil export earnings are observed, but the intensity and duration of the negative impact of oil revenues' shock have been reduced; so that the policy has acted successfully to control the inflation and non-oil and total production has had less reduction and the effects of oil shocks on the variables have been faded quickly. Also, the reduction in export and increase in import of consumer and intermediate goods compared to not policy-making of targeting the inflation rate is less intensified.

Figure 1: Brooks and Gelman diagnostic multivariate test

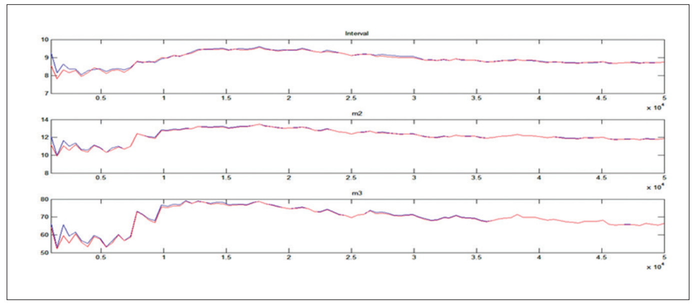


Figure 2: The main economic variables' response to the oil shock in the basic state

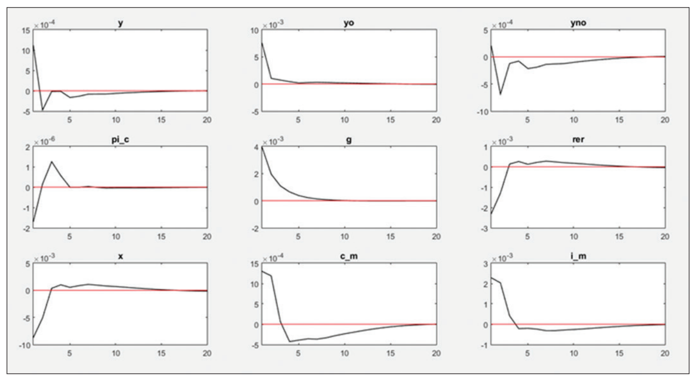
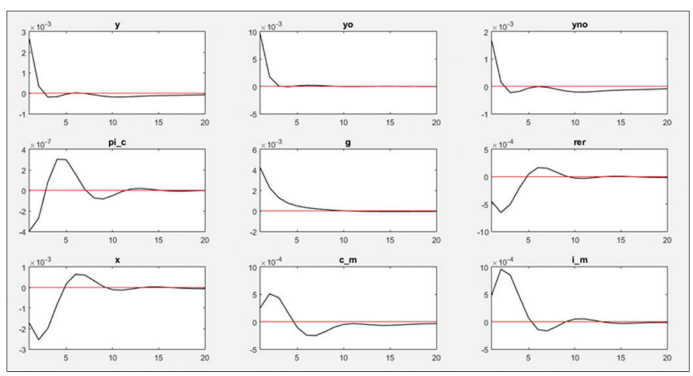


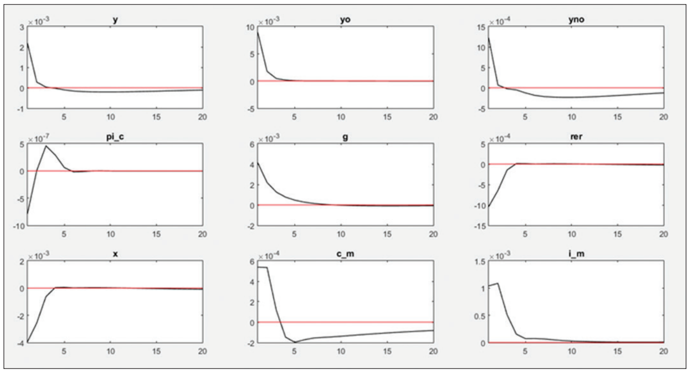
Figure 3: The main economic variables' response to the oil shock with inflation targeting policy



4.3. The Effects of Oil Revenues' Shock on Policy-making of Targeting Exchange Rate

At the state of policy-making of targeting the exchange rate, the Central Bank monetary considers the exchange rate control as

Figure 4: The main economic variables' response to the oil shock with exchange rate targeting policy



the most important of monetary and exchange policy-making response functions and other variables are less important. Here, it is assumed that among monetary and exchange policy-making response functions of the Central Bank, other variables' weight except for the exchange rate is reduced to one-tenth. The results of the effect of government oil revenues' shock on important economic variables with impulse response functions are shown in Figure 4. As seen, by policy-making of targeting the exchange rate again signs of Dutch disease followed by the shock of rise in oil export earnings are evident, but the intensity and duration of the negative impact of oil earnings' shock have been reduced so that the policy could reduce the intensity of real exchange rate reduction and its fluctuations. Non-oil and total production in this state to the basic state has had less reduction and the effects of oil shocks on the variables have been faded quickly. Also, the reduction in export and increase in import of consumer and intermediate goods compared to not policy-making of targeting the exchange rate is less intensified.

5. CONCLUSION

This study under the hypothesis that policies of targeting inflation and exchange rate will play an effective role in reducing and absorbing the negative impact of oil shocks on the country trade variables has examined the effect of policies of targeting inflation and exchange rate on foreign trade in Iran. For this purpose, a DSGE model was designed for a small open economy consisting of four parts: Households, firms, the government and monetary part and foreign trade. The paradigm used in the process of making the model because of characteristics such as imperfect competition, information asymmetry, taking into account the expectations and stickiness close to the true world, is Keynesian paradigm so it can explain the Iranian oil economy structure.

To test the research hypothesis, in three states of not making policy of targeting, policy-making of targeting inflation and finally policy-making of targeting exchange rate, a positive oil shock was applied to the model.

In basic state, as a result of positive oil shock, domestic -produced goods export was reduced and import of consumer and intermediate goods was increased. It was also observed that total production was first increased due to increased oil production and then increased non-oil production but over time by increasing money supply, reducing exchange rate and export, non-oil and total production was reduced. The CPI by increasing oil revenues was first reduced but over time and increasing money supply, price public level was increased, the results confirm Dutch disease followed by the shock of rise in oil export earnings in the country.

When making two policies of targeting inflation and exchange rate, the intensity and duration of adverse effects of oil revenue shock are reduced in a way that non-oil and total production is less reduced and oil shock effects on the variables are faded more quickly. Also, reduced export and increased import of consumer and intermediate goods compared to non-targeting policy have less intensity.

Finally, exchange rate targeting policy compared to inflation rate targeting policy could act more successfully to control real exchange rate fluctuations but inflation rate targeting policy could act better to deal with fluctuations and intensity of changes in inflation rate.

REFRENCES

Adolfson, M., Laséen, S., Lindé, J., Villani, M. (2007), Bayesian estimation of an open economy DSGE model with incomplete pass-through. Journal of International Economics, 72, 481-511.

Brooks, S.P., Gelman, A. (1988), Alternative methods for monitoring convergence of iterative simulations. Journal of Computational and Graphical Statistics, 7, 434-455.

Calvo, G.A. (1983), Staggered prices in a utility-maximizing framework. Journal of Monetary Economics, 12(3), 383-398.

Dixit, A.K., Stiglitz, J.E. (1977), Monopolistic competition and optimum product diversity. American Economic Review, 67(3), 297-308.

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

Mishkin, F.S. (1999), International experiences with different monetary policy regimes. Journal of Monetary Economics, 43(3), 579-605.

Rudebusch, G.D. (2002), Assessing nominal income rules for monetary policy with model and data uncertainty. The Economic Journal, 112(479), 402-432.

Khiabani, N., Amiri, H. (2014), The position of monetary and fiscal policies with emphasizing on oil sector with DSGE models (the case of Iran). Journal of Economics Research, 14(54), 133-173.

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

Taylor, J. (1993), Discretion versus policy rules in practice. Carnegie-Rochester Conference Series on Public Policy, 39, 195-214. Available from: http://www.cbi.ir.