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Effects of Oil Price Shocks on Agricultural Sector Using Dynamic Stochastic General Equilibrium Model

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ABSTRACT

This study aimed to develop a multi-sector Dynamic Stochastic General Equilibrium (Large DSGE) model for Iran's economy. In this model, economy was divided into three sectors: Agriculture, non-agriculture, and oil. Imports and exports were also included in the model. In order to adapt the model with Iran's economic conditions, price stickiness in agriculture and non-agriculture were included. Then, the impact of rising oil prices on agricultural sector was examined. To calculate the required coefficients, 1971-2012 data was gathered and Bayesian method was used. The results showed the negative impacts of rising oil prices on agriculture as well as the negative effects of Dutch Disease.

Keywords: Agriculture, Bayesian, DSGE, Multi-sector, Oil prices, Stickiness.

INTRODUCTION

Agriculture is very critical because it provides food security, creates jobs, increases non-oil exports, prevents rural immigration, etc. On the other hand, due to high oil share in Iran's economy, the effects of turbulent oil revenues on real sectors have always been significant. In this context, oil boom (higher oil prices) has different effects on the growth of tradeables and non-tradeables. In this situation, a significant gap is created between the factors' prices and price indices in different sectors, so that tradeables (such as agriculture and industry) are weakened and non-tradeables (such as construction) are strengthened. This is called de-agriculturalization. Meanwhile, the effects of higher oil prices on the growth of tradeables, including agriculture, have been analyzed in various patterns and models (econometric models and computable general equilibrium models). Since 1970s, econometric models have faced Lucas critique. In his critique of econometric models, Lucas (1976) says that if a certain relationship between two economic variables has been estimated econometrically, policy-makers, in formulating a policy for the future, cannot rely on that relationship to persist once a policy aiming to exploit the relationship is adopted (Ericsson and Irons, 1995). On the other hand, computable general equilibrium models are not so compatible with Iran's economic conditions due to lack of stickiness of prices and wages, as well as neutrality of money.

There are numerous studies on the effects of higher oil prices on agriculture such as Pasban (2004), Bakhtiari and Haghi (2001), Bahrami and Farshchi (2011), and Yazdani and Sherafatmand (2011). These studies show that higher oil prices have negative effects on agriculture. Manzoor *et al.* (2011)

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use the computable general equilibrium model to simulate the effects of higher oil revenues on Iran's economy. The results show that this shock increases activities in non-tradeables and decreases activities in tradeables (including agriculture). According to Stijns (2003), Dutch disease in developing countries leads to de-agriculturalization. Olusi and Olagunju (2005) show that Dutch disease shifts the labor force in agriculture to non-tradeables.

Domestic and foreign studies have used DSGE model but they have not considered agriculture specifically and have not addressed the effects of oil revenues on the sector. Walker (2013) formulates the DSGE model for low-income countries in which agriculture plays a dominant role; but is only theoretical, aiming to analyze the shocks of climate and import prices of fertilizers. This study aimed to use the Dynamic Stochastic General Equilibrium (DSGE) model to address the effects of higher oil prices on agricultural variables (production, imports, exports, inflation, and consumption), by using time series data for 1971-2012.

MATERIALS AND METHODS

The primary structure of this model is based on Resende *et al*. (2010) and Balke *et al*. (2010). The following changes, however, are made: Households are divided into two groups (urban and rural); agriculture and oil sectors, as well as the Government and the Central Bank are introduced into the model; imported agricultural commodity subsidies are included, energy is introduced into the agricultural and non-agricultural production function, fertilizer and subsidies for fertilizer are included in the agricultural production function.

The DSGE model is the result of interactions among three blocks: Demand (households), supply (firms), and monetary authorities (the Government and the Central Bank). The equations of these blocks originate from microeconomic principles. These interactions lead to a clearing among the said blocks in each period, and ultimately to a general equilibrium. What follows is a description of these three blocks.

Households

Each household maximizes its lifetime utility through choosing Consumption (Ct), Investment (It), public Bonds (Bt), capital stack (Kt), real money holdings, using the following utility function:

$$\max E_t \sum_{t=0}^{\infty} \beta^t \left[\frac{\left(C_{u,t+i}\right)^{1-\sigma_c}}{1-\sigma_c} + \frac{\gamma}{1-b}\left(\frac{M_{u,t+i}}{P_{t+i}}\right)^{1-b} - \frac{1}{1+\sigma_{lu}}\left(L_{u,t+i}\right)^{1+\sigma_l} \right] \quad (1)$$

Where,

β stands for the discount factor, σ_c for the inverse of intertemporal elasticity of substitution, σ_l 6t for the inverse of elasticity of work effort with respect to the real wage, b for the inverse of elasticity of money holdings with respect to the interest rate, *Lt+i* for Labor force, Ct+i for total household Consumption, and Mt for the Monetary base. This optimization will be achieved with an eye to two limitations: Budget line and capital accumulation.

$$C_{u,t} + I_{u,t} + \frac{M_{u,t}}{P_t} + \frac{B_{u,t}}{P_t} + T_{u,t} = \frac{W_{u,t}}{P_t} L_{u,t} + R_t K_{u,t-1} + \frac{D_{o,t}}{P_t} + \frac{M_{u,t-1}}{P_t} + \left(1+r_{t-1}\right)\frac{B_{u,t-1}}{P_t} \quad (2)$$

$$K_{u,t+1} = I_{u,t} + \left(1-\delta_u\right) K_{u,t} \quad (3)$$

Where

$\mathbf{D}_{o,t}$ is the Distributed profit of firms, P_t is the aggregate Price index, $B_{u,t}$ is the quantity of one-period nominally riskless discount Bonds, r_t is the net actual return of bonds, $T_{u,t}$ is the households' Tax, $\mathbf{W}_{u,t}$ is the nominal Wage, R_t is the real Rate of capital, and δ_u is the capital depreciation.

Consumer utility optimization results in the following equations.

$$C_{u,t}^{-\sigma_c} = (1+r_t)\beta\left(\frac{E_t C_{u,t+1}^{-\sigma_c}}{\pi_{t+1}}\right) \quad (4)$$

The above equation shows the allocation of consumption between periods. In addition, it shows the relationship between consumption, discount rate, and interest rate.

$$m_{u,t}^{-b} = \left(\frac{r_t}{1+r_t}\right) C_{u,t}^{-\sigma_c} \quad (5)$$

Based on Equation (5), real money holding is positively related to consumption and negatively related to interest rate.

$$L_{u,t}^{\sigma_{lu}} = W_{u,t} C_{u,t}^{-\sigma_c} \quad (6)$$

Equation (6) shows the positive relation between wage and consumption.

$$-\lambda_t + \beta E_t \lambda_{t+}(1+r_t)\left(\frac{P_t}{P_{t-1}}\right) = 0 \quad (7)$$

Equation (7) shows that real interest rate gap will depend on inflation and nominal interest rates (Fisher Equation).

Utility function of rural households is the same as urban ones, but rural households do not participate in capital and asset markets. So, their budget constraints will be different. Like urban households, rural ones keep money. Their utility function, budget line, and capital stock are as follows:

$$max\, E_t \sum_{t=0}^{\infty} \beta^t \left[\frac{\left(C_{r,t+i}^{1-\sigma_c}\right)}{1-\sigma_c} + \frac{\gamma}{1-b}\left(\frac{M_{r,t+i}^{1-b}}{P_t}\right) - \frac{1}{1+\sigma_{lu}}\left(L_{r,t+i}^{1+\sigma_l}\right)\right] \quad (8)$$

$$C_{r,t} + I_{r,t} + \frac{M_{r,t}}{P_t} + T_{r,t} = \frac{W_{r,t}}{P_t} L_{r,t} + R_t K_{r,t-1} + \frac{D_{a,t}}{P_t} + \frac{M_{r,t-1}}{P_t} \quad (9)$$

$$K_{r,t+1} = I_{r,t} + (1-\delta_r) K_{r,t} \quad (10)$$

Optimizing the utility function of rural household yields:

$$C_{r,t}^{-\sigma_c} = (1+r_t)^{E_t C_{r,t+1}^{-\sigma_c}} \Big/ \pi_{t+1} \quad (11)$$

$$\left(m_{r,t}^{-b}\right) = \left(\frac{r_t}{1+r_t}\right) C_{r,t}^{-\sigma_c} \quad (12)$$

$$L_{r,t}^{\sigma_{lr}} = w_t(r) C_{r,t}^{-\sigma_c} \quad (13)$$

Urban and Rural Consumption Basket

Households make decisions at two stages. At stage one, households choose a combination of goods in a way which minimizes the costs. At stage two, their target is to choose an optimal quantity of consumption, labor supply, and financial assets (including money). Agricultural and non-agricultural baskets for both households are assumed to be the same. CES function is used to combine the two baskets:

$$C_t = \left[(1-\gamma)^{\frac{1}{\eta}}\left(C_{a,t}\right)^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}}\left(C_{o,t}\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} \quad (14)$$

Where,

$\eta >$ 0 is the elasticity of substitution between goods, $C_{a,t}$ is the agricultural goods, and $C_{o,t}$ is the non-agricultural goods.

Agricultural and non-agricultural goods are also a combination of domestic and imported goods:

$$C_{o,t} = \left[(1-\gamma_o)^{\frac{1}{\eta_o}}\left(C_{o,t}^d\right)^{\frac{\eta_o-1}{\eta_o}} + (\gamma_o)^{\frac{1}{\eta_o}}\left(C_{o,t}^m\right)^{\frac{\eta_o-1}{\eta_o}}\right]^{\frac{\eta_o}{\eta_o-1}} \quad (15)$$

$$C_{a,t} = \left[(1-\gamma_a)^{\frac{1}{\eta_a}}\left(C_{a,t}^d\right)^{\frac{\eta_a-1}{\eta_a}} + (\gamma_a)^{\frac{1}{\eta_a}}\left(C_{a,t}^m\right)^{\frac{\eta_a-1}{\eta_a}}\right]^{\frac{\eta_a}{\eta_a-1}} \quad (16)$$

Where, $C_{o,t}^d$ and $C_{o,t}^m$ stand for the domestic and imported non-agricultural goods, $C_{a,t}^d$ and $C_{a,t}^m$ indicate the domestic and imported agricultural goods. Consumers choose agricultural and non-agricultural commodities in such a way as to minimize the costs. So, at this stage, the target is also to set a proper combination of agricultural and non-agricultural goods and then an optimal mix of the domestic and imported goods. Considering this optimization, we will have:

$$C_{a,t} = (1-\gamma)\left(\frac{\mathbf{P}^c_{a,t}}{\mathbf{P}^c_t}\right)^{-\eta} \mathbf{C}_t \tag{17}$$

$$C_{o,t} = \gamma\left(\frac{\mathbf{P}^c_{o,t}}{\mathbf{P}^c_t}\right)^{-\eta} C_t \tag{18}$$

If Equations (17) and (18) are used in Equation (14), the consumer price index will be:

$$\mathbf{P}^c_t = \left[(1-\gamma)\left(\mathbf{P}^c_{a,t}\right)^{1-\eta} + \gamma\left(\mathbf{P}^c_{o,t}\right)^{1-\eta}\right]^{\frac{1}{1-\eta}} \tag{19}$$

Non-agriculturals are a combination of domestic and imported goods and demand for them should be calculated. Hence, a mix of domestic and imported non-agricultural will be:

$$C^d_{o,t} = (1-\gamma_o)\left(\frac{P^{cd}_{o,t}}{\mathbf{P}^c_{o,t}}\right)^{-\eta_o} C_{o,t} \tag{20}$$

$$C^m_{o,t} = \gamma_o\left(\frac{P^{im}_{o,t}}{\mathbf{P}^c_{o,t}}\right)^{-\eta_o} C_{o,t} \tag{21}$$

Since we have imports and exports in the model (and in turn, the exchange rate), DSGE model will be open and the prices of imported goods will be:

$$P^{im}_{o,t} = P^m_{o,t} * \mathrm{ex}_t \tag{22}$$

Where,

$p^{im}_{o,t}$ stands for the Prices of imported goods in local currency (Rials), $p^m_{o,t}$ indicates the Prices of imported goods in dollar, and ex_t denotes the nominal exchange rate. The import price can be defined as the [AR(1)]:

$$\log(P^m_{o,t}) = \rho_{mo,t}\log(P^m_{o,t-1}) + \left(1-\rho_{mo,t}\right)\log(P^m_o) + \varepsilon^m_{o,t} \tag{23}$$

Where,

$\rho_{mo,t}$ is the coefficient of auto regression process for import prices.

The next step is to set the non-agricultural prices. To do so, we enter (20) and (21) in (14).

$$\mathbf{P}^c_{o,t} = \left[(1-\gamma_o)\left(P^{cd}_{o,t}\right)^{1-\eta_o} + \gamma_o\left(P^{im}_{o,t}\right)^{1-\eta_o}\right]^{\frac{1}{1-\eta_o}} \tag{24}$$

If the same process is used for agriculturals (domestic and imported), domestic demand, import demand and the price combination of agriculturals will be:

$$C^d_{a,t} = (1-\gamma_a)\left(\frac{P^{cd}_{a,t}}{\mathbf{P}^c_{a,t}}\right)^{-\eta_a} C_{a,t} \tag{25}$$

$$C^m_{a,t} = \gamma_a\left(\frac{P^{im}_{a,t}}{\mathbf{P}^c_{a,t}}\right)^{-\eta_a} C_{a,t} \tag{26}$$

$$\mathbf{P}^c_{a,t} = \left[(1-\gamma_a)\left(P^{cd}_{a,t}\right)^{1-\eta_a} + \gamma_a\left(P^{im}_{a,t}\right)^{1-\eta_a}\right]^{\frac{1}{1-\eta_a}} \tag{27}$$

Now it's time to set the domestic prices of imported agriculturals. Since imported agriculturals receive subsidies, (γ_m) in the below function indicates the subsidy rate:

$$\mathbf{P}^{im}_{a,t} = \left(P^m_{a,t} * \mathrm{ex}_t\right)^{1-\gamma_m} \quad and \quad 0 \prec \gamma_m \prec 1 \tag{28}$$

Meanwhile, $P^m_{a,t}$ can be defined as AR(1) process:

$$\log(P^m_{a,t}) = \rho_{ma,t}\log(P^m_{a,t-1}) + \left(1-\rho_{ma,t}\right)\log(P^m_a) + \varepsilon^m_{a,t}$$

Where,

$\rho_{ma,t}$ is the coefficient of AR(1) for prices of imported agriculturals.

Firms

The production block in this paper is similar to that in new Keynesian literature. Production is created by two sectors: agriculture and non-agriculture.

Final Good Firms

There is a chain of firms which produce various goods in monopolistic manner and have market power for price-setting. Agricultural and non-agricultural production builds total production (Yt) whose constituents are determined by CES function:

$$Y_t = \left[(1-\omega_N)^{\frac{1}{v}} Y_{a,t}^{\frac{v-1}{v}} + \omega_N^{\frac{1}{v}} Y_{o,t}^{\frac{v-1}{v}} \right]^{\frac{v}{v-1}} \quad (30)$$

Where,

ω_N stands for the share of non-agriculturals in final goods and v indicates the elasticity of substitution of agriculturals and non-agriculturals. If P_t^p is the final products' Prices, producers choose the final products $Y_{a,t}$ and $Y_{o,t}$ in a way that maximizes the profit function. So demand for agriculturals and non-agriculturals will be obtained:

$$Y_{a,t} = (1-\omega_N)\left(\frac{P_{a,t}^p}{P_t^p}\right)^{-v} Y_t \quad (31)$$

$$Y_{o,t} = \omega_N \left(\frac{P_{o,t}^p}{P_t^p}\right)^{-v} Y_t \quad (32)$$

Meanwhile, if (31) and (32) are used, the final product prices, i.e. producer price index, will be:

$$P_t^p = \left[(1-\omega_N)(P_{a,t}^p)^{1-v} + \omega_N (P_{o,t}^p)^{1-v} \right]^{\frac{1}{1-v}} \quad (33)$$

Non-Agricultural Firms

It is assumed that there is a final good producing firm which purchases $Y_{o,jt}$ units of intermediate good $\theta_o \in (1,\infty)$, at the nominal price $P_{o,jt}^p$ from monopolistic competitive firms, in order to produce $Y_{o,t}$ units of the final good using a technology with constant return to scale:

$$Y_{o,t} = \left[\int_0^1 (Y_{o,jt})^{\frac{\theta_o-1}{\theta_o}} dj \right]^{\frac{\theta_o}{\theta_o-1}} \quad (34)$$

Where,

$\theta_o \in (1,\infty)$ stands for the elasticity of substitution of intermediate goods. The demand for intermediate inputs of sector j will be obtained through optimizing the producers' profit:

$$Y_{o,jt} = \left(\frac{P_{o,jt}^p}{P_{o,t}^p}\right)^{-\theta_o} Y_{o,t} \quad (35)$$

Non-agricultural producer price will be obtained by:

$$P_{o,t}^p = \left(\int_0^1 (P_{o,jt}^p)^{1-\theta_o} dj \right)^{\frac{1}{1-\theta_o}} \quad 36$$

Here, it is assumed that $Y_{o,t}$ is a combination of imported ($Y_{o,t}^m$) and domestic ($Y_{o,t}^d$) goods. The constituents of which are determined by CES function:

$$Y_{o,t} = \left[(1-\omega_o)^{\frac{1}{\eta_o}} (Y_{o,t}^d)^{\frac{\eta_o-1}{\eta_o}} + (\omega_o)^{\frac{1}{\eta_o}} (Y_{o,t}^m)^{\frac{\eta_o-1}{\eta_o}} \right]^{\frac{\eta_o}{\eta_o-1}} \quad (37)$$

Where,

η_o stands for the elasticity of substitution of domestic and imported goods and ω_o indicates the import share in non-agricultural sector supply.

If $P_{o,t}^{im}$, $P_{o,t}^{pd}$ and $P_{o,t}^p$ are the Prices of imported goods, domestic goods and non-agricultural goods respectively, the firm chooses $Y_{o,t}^m$ and $Y_{o,t}^d$ in a way which maximizes its profit. This maximization yields the below function for domestic and imported goods:

$$Y_{o,t}^d = (1-\omega_o)\left(\frac{P_{o,t}^{pd}}{P_{o,t}^p}\right)^{-\eta_o} Y_{o,t} \quad 38$$

$$Y^{m}_{o,t} = (\boldsymbol{\omega}_o)^{\frac{1}{\mu_o}} \left(\frac{P^{im}_{o,t}}{P^{p}_{o,t}}\right)^{-\eta_o} Y_{o,t} \qquad 39$$

Now, if (۳۷) and (۳۸) replace (۳۵), the equation of non-agricultural producer price will be obtained.

$$P^{p}_{o,t} = \left[(1-\boldsymbol{\omega}_o)(P^{pd}_{o,t})^{1-\eta_o} + (\boldsymbol{\omega}_o)(P^{m}_{o,t})^{1-\eta_o}\right]^{\frac{1}{1-\eta_o}} \qquad (40)$$

In the next step, the intermediate good $\boldsymbol{Y}_{o,jt}$ will be produced using Cobb-Douglas function. The firm j produces the intermediate good $\boldsymbol{Y}_{o,jt}$ using capital $\boldsymbol{K}_{o,t}$, labor $\boldsymbol{L}_{o,t}$ and energy $\boldsymbol{E}_{o,t}$. That is:

$$\boldsymbol{Y}^{d}_{o,jt} = \boldsymbol{A}_{o,t}\left(\boldsymbol{K}_{o,jt}\right)^{\alpha_o}\left(\boldsymbol{L}_{o,jt}\right)^{l_o}\left(\boldsymbol{E}_{o,jt}\right)^{\alpha_1} \qquad (41)$$

α_o, l_0 and α_1 are the elasticity of non-agricultural production to capital, labor and energy. $\boldsymbol{A}_{o,t}$ stands for the technological impulse which follows the AR(1):

$$\boldsymbol{logA}_{o,t} = \boldsymbol{\rho}_{Ao}\boldsymbol{log}\left(A_{o,t-1}\right) + (1-\boldsymbol{\rho}_{Ao})\boldsymbol{log}\left(A_o\right) + \varepsilon_{o,t} \qquad (42)$$

Where,

$\boldsymbol{A}_o$ is greater than zero and $\boldsymbol{\rho}_{Ao}$ stands for the technological coefficient.

Here, producers perform two tasks. Firstly, they minimize the costs by choosing optimal amounts of inputs. If the cost function is minimized, the following equation will be obtained (marginal cost function):

$$\phi_{o,t} = \left(\frac{W_{o,t}}{l_o}\right)^{l_o}\left(\frac{R_t}{\alpha_o}\right)^{\alpha_o}\left(\frac{P_{e,t}}{\alpha_1}\right)^{\alpha_1} \qquad (43)$$

Secondly, they maximize their profit by choosing the commodity prices. Here the price stickiness (Calvo price-setting) enters the model. (ω) percent of firms do not adjust their prices (they add a given percent of previous inflation to the current price $P^{d}_{o,t} = \pi_{o,t-1}P^{d}_{o,t-1}$.) and $(1-\omega)$ percent of firms adjust their prices $\left(P^{*d}_{o,jt}\right)$.

Mathematically, one can express this profit maximization problem as:

$$\boldsymbol{D}_{o,t} = \boldsymbol{E}_t\sum_{i=0}^{\infty}\boldsymbol{\omega}^{o}_{i}\left(\boldsymbol{\Delta}_{i,t+i}\right)^{o}\left[\left(\frac{P^{*d}_{o,jt}}{P^{d}_{o,t+i}}\right)\boldsymbol{Y}^{d}_{o,jt+i} - \boldsymbol{\phi}_{o,t+i}\boldsymbol{Y}^{d}_{o,jt+i}\right] \qquad (44)$$

s.t.

$$\boldsymbol{Y}^{d}_{o,jt} = \left(\frac{\left(P^{*pd}_{o,jt}\right)}{P^{pd}_{o,t}}\right)^{-\theta_o}\boldsymbol{Y}^{d}_{o,t}$$

Note that the appropriate discount factor in (۴۲) is given by $\left(\boldsymbol{\Delta}_{i,t+i}\right)^{o} = \boldsymbol{\beta}^{i}\left(\frac{\boldsymbol{Y}^{d}_{o,t+i}}{\boldsymbol{Y}^{d}_{o,t}}\right)^{-\sigma_o}$, since firms have to take into account the future demand elasticity when setting prices (Menz and Vogel, 2009).

The above optimization leads to new Keynesian Phillips curve:

$$\boldsymbol{\pi}_{o,t} = \tilde{\boldsymbol{\kappa}}^{o}\hat{\phi}_{o,t} + \frac{\beta}{1+\beta}\boldsymbol{E}_t\boldsymbol{\pi}_{o,t+1} + \frac{1}{1+\beta}\boldsymbol{\pi}_{o,t\text{-}1} \qquad (45)$$

$$\tilde{\boldsymbol{\kappa}}^{o} = \frac{(1-\boldsymbol{\omega}^{o}_{i})(1-\boldsymbol{\omega}^{o}_{i}\beta)}{\boldsymbol{\omega}^{o}_{i}} \qquad (46)$$

According to Equation (۴5) inflation is a function of marginal cost, inflation of past and expected inflation:

Agricultural Firms

Agricultural products are either domestically consumed or exported. In addition, part of country's annual need will be met through imports. Hence, the mixed goods of this sector encompass domestic production ($\boldsymbol{Y}^{d}_{a,t}$), imports ($\boldsymbol{Y}^{m}_{a,t}$) and exports ($\boldsymbol{Y}^{ex}_{a,t}$).

$$\boldsymbol{Y}_{a,t} = \left[(1-\boldsymbol{\omega}_a)^{\frac{1}{\mu_a}}\left(\boldsymbol{Y}^{d}_{a,t}\right)^{\frac{\mu_a-1}{\mu_a}} + (\boldsymbol{\omega}_a)^{\frac{1}{\mu_a}}\left(\boldsymbol{Y}^{m}_{a,t}\right)^{\frac{\mu_a-1}{\mu_a}}\right]^{\frac{\mu_a}{\mu_a-1}} \qquad (46)$$

Where,

μ_a stands for the elasticity of substitution of imported and domestic goods. $\boldsymbol{\omega}_a$

indicates the import share in supply. If $P^{m}_{a,t}$, $P^{pd}_{a,t}$ and $P^{p}_{a,t}$ are the import, domestic, and producer Prices of agriculturals, respectively, the firm chooses $Y^{m}_{a,t}$ and $Y^{d}_{a,t}$ in a way which maximizes its profit. This maximization yields the below function for domestic and imported goods:

$$Y^{d}_{a,t} = (1-\omega_a)\left(\frac{P^{pd}_{a,t}}{P^{p}_{a,t}}\right)^{-\eta_a} Y_{a,t} \tag{47}$$

$$Y^{m}_{a,t} = (\omega_a)^{\frac{1}{\eta_a}}\left(\frac{P^{m}_{t}}{P^{p}_{a,t}}\right)^{-\eta_a} Y_{a,t} \tag{48}$$

Now if (47) and (48) are put in (45) prices of agriculturals will be:

$$P^{p}_{a,t} = \left[(1-\omega_a)\left(P^{pd}_{a,t}\right)^{1-\eta_a} + (\omega_a)\left(P^{m}_{a,t}\right)^{1-\eta_a}\right]^{\frac{1}{1-\eta_a}} \tag{49}$$

The firm combines distinct domestic goods using technology constant return to scale:

$$Y^{d}_{a,t} = \left(\int_0^1 Y^{d}_{a,jt}{}^{\frac{\theta_a-1}{\theta_a}} d_j\right)^{\frac{\theta_a}{\theta_a-1}} \tag{50}$$

Where,

θ_a stands for the elasticity of substitution of intermediate goods. The demand for intermediate inputs of sector j will be obtained through optimizing the producers' profit:

$$Y^{d}_{a,jt} = \left(\frac{P^{pd}_{a,jt}}{P^{pd}_{a,t}}\right)^{-\theta_a} Y^{d}_{a,t} \tag{51}$$

Agricultural producer price will be obtained by:

$$P^{pd}_{a,t} = \left(\int_0^1 \left(P^{pd}_{a,jt}\right)^{\theta_a-1} d_j\right)^{\frac{1}{1-\theta_a}} \tag{52}$$

Now, the next problem arises: How $Y^{d}_{a,jt}$ will be produced? Following the literature in this paper, we use Cobb-Douglas function:

$$Y^{d}_{a,jt} = A_{a,t}\left(K_{a,jt}\right)^{\alpha_d}\left(L_{a,jt}\right)^{\gamma_d}\left(E_{a,jt}\right)^{\alpha_2} \tag{53}$$

Where,

$L_{a,t}$ stands for Labor, $K_{a,t}$ for capital stock, and $E_{a,t}$ for Energy. α_d, γ_d and α_2 indicate the capital, labor, and energy elasticity, respectively.

Energy in agricultural production is different from that in non-agricultural production. In the above function, the energy used in agriculture consists of energy of oil products and that of chemical and fertilizers and pesticides/herbicides which will be addressed later. $A_{a,t}$ indicates productivity impulse which is determined exogenously and follows the AR(1):

$$logA_{a,t} = \rho_a log\left(A_{a,t-1}\right) + (1-\rho_a) log\left(A_a\right) + \varepsilon_{a,t} \tag{54}$$

Here, producers perform two tasks. Firstly, they minimize the costs by choosing optimal amounts of inputs. If the cost function is minimized, the following equation will be obtained (marginal cost function):

$$\phi_{a,t} = \left(\frac{w_{a,t}}{\gamma_a}\right)^{\gamma_a}\left(\frac{R_t}{\alpha_a}\right)^{\alpha_a}\left(\frac{P_{e,t}}{\alpha_2}\right)^{\alpha_2} \tag{55}$$

Secondly, they maximize the profit by choosing the commodity prices. Calvo price stickiness is also introduced here. New Keynesian Phillips curve is as follows:

$$\pi_{a,t} = \tilde{\kappa}^{a}\hat{\phi}_{a,t} + \frac{\beta}{1+\beta}E_t\pi_{a,t+1} + \frac{1}{1+\beta}\pi_{a,t-1} \tag{56}$$

Energy Combination in Agriculture

The CES function combines the energy of oil products and that of chemical fertilizer:

$$E_{a,t} = \left[(1-\alpha_e)^{\frac{1}{\theta_e}}\left(E^{d}_{a,t}\right)^{\frac{\theta_e-1}{\theta_e}} + (\alpha_e)^{\frac{1}{\theta_e}}\left(E^{f}_{a,t}\right)^{\frac{\theta_e-1}{\theta_e}}\right]^{\frac{\theta_e}{\theta_e-1}} \tag{57}$$

Where,

$E_{a,t}$ stands for the Energy used in agriculture, $E^{d}_{a,t}$ for the Energy obtained from oil products, $E_{a,t}^{f}$ for the Energy obtained from chemical fertilizers and pesticides/herbicides, and α_e for $E_{a,t}^{f}$ share in total energy. Since chemical fertilizers and pesticides/herbicides are supplied both domestically and through importation, their CES function can be written as:

$$E_{a,t}^{f}=\left[\left(1-\alpha_f\right)^{\frac{1}{\theta_f}}\left(E_{a,t}^{fd}\right)^{\frac{\theta_f-1}{\theta_f}}+\left(\alpha_f\right)^{\frac{1}{\theta_f}}\left(E_{a,t}^{fm}\right)^{\frac{\theta_f-1}{\theta_f}}\right]^{\frac{\theta_f}{\theta_f-1}} \quad (58)$$

Where,

$\left(E_{a,t}^{fd}\right)$ and $\left(E_{a,t}^{fm}\right)$ stand for the domestic and imported fertilizers and pesticides/herbicides, and θ_f for substitution elasticity between them. Meanwhile, agricultural firms choose the energy obtained from oil products and chemical fertilizers in a way which minimizes their costs. The consumption of domestic energy and chemical fertilizers will be as follows:

$$E_{a,t}^{f}=\left(1-\alpha_e\right)\left(\frac{P_{a,t}^{f}}{P_{e,t}}\right)^{-\theta_e}E_{a,t} \quad (59)$$

$$E_{a,t}^{d}=\alpha_e\left(\frac{P_{a,t}^{ed}}{P_{e,t}}\right)^{-\theta_e}E_{a,t} \quad (60)$$

Where,

$P_{a,t}^{f}$ stands for the chemical fertilizers' Prices and $P_{a,t}^{ed}$ for the domestic energy Prices,

The energy prices should be set. Since oil prices are considered to be exogenous, the relevant formula can be written as:

$$P_{e,t}=ex_tP_{\mathrm{pe},t} \quad (61)$$

Where,

$P_{e,t}$ indicates oil Prices which follows the AR(1):

$$\log(pp_{e,t})=\rho_{ppe}*\log(pp_{e,t-1})+(1-\rho_{ppe})\log(pp_e)+\varepsilon_t^{ppe} \quad (62)$$

Agricultural producers minimize

$$E_{a,t}^{f}=\left[\left(1-\alpha_f\right)^{\frac{1}{\theta_f}}\left(E_{a,t}^{fd}\right)^{\frac{\theta_f-1}{\theta_f}}+\left(\alpha_f\right)^{\frac{1}{\theta_f}}\left(E_{a,t}^{fm}\right)^{\frac{\theta_f-1}{\theta_f}}\right]^{\frac{\theta_f}{\theta_f-1}}$$

subject to budget constraint $P_{a,t}^{fd}E_{a,t}^{fd}+P_{a,t}^{fm}E_{a,t}^{fm}=P_{a,t}^{f}E_{a,t}^{f}$. The results provide domestic and import demands:

$$E_{a,t}^{fd}=\left(1-\alpha_f\right)\left(\frac{P_{a,t}^{fd}}{P_{a,t}^{f}}\right)^{-\theta_f}E_{a,t}^{f} \quad (63)$$

$$E_{a,t}^{fm}=\left(\alpha_f\right)\left(\frac{P_{a,t}^{fm}}{P_{a,t}^{f}}\right)^{-\theta_f}E_{a,t}^{f} \quad (64)$$

Now, the domestic prices of imported chemical fertilizers and pesticides/herbicides should be set. Since chemical fertilizers receive subsidies, the import price in local currency can be written as:

$$P_{a,t}^{fm}=\left(\mathrm{P}_{pe,t}*ex_t\right)^{1-\gamma_f} \qquad and \qquad 0\prec\gamma_f\prec 1 \quad (65)$$

Where,

$P_{a,t}^{fm}$ stands for import Prices in Rials, $\mathrm{P}_{\mathrm{pe},t}$ for oil Prices, and γ_f for the subsidy.

Agricultural Exporting Firm

All firms follow the unit prices in domestic and foreign markets (Obstfeld and Rogoff, 1995). Therefore, in accordance with the law of one price, exchange rate fluctuations will be transferred through export prices. Foreign demand for export is written as:

$$\boldsymbol{Y}_{a,t}^{x}=\left(\frac{\mathbf{P}_{a,t}^{p}}{P_t^{m}}\right)^{-\nu_x}\boldsymbol{Y}_{\mathrm{a},t}^{wx} \quad (66)$$

Where,

$\boldsymbol{P}_t^{m}$ stands for export Price in Rials, $\boldsymbol{Y}_{a,t}^{wx}$ for foreign production, and ν_x for export elasticity. $\boldsymbol{Y}_{a,t}^{wx}$ follows the AR(1):

$$\boldsymbol{log}\left(\boldsymbol{Y}_{\mathrm{a},t}^{wx}\right)=\left(1-\rho_y^{*}\right)\boldsymbol{log}\left(\bar{Y}^{wx}\right)+\left(\rho_y^{*}\right)\boldsymbol{log}\left(\boldsymbol{Y}_{\mathrm{a},t-1}^{wx}\right) \quad (67)$$

Oil sector

In this paper, we follow Balke *et al.* (2010) and assume that oil-producing firm produces crude oil using technology $Z_{p,t}$, Labor $(L_{p,t})$ and oil reserves $(X_{p,t})$:

$$Y_{p,t} = Z_{p,t}\left[\omega_p X_{p,t}^{1-\rho_p} + (1-\omega_p)L_{p,t}^{1-\rho_p}\right]^{\frac{1}{1-\rho_p}} \quad (68)$$

The evolution of oil reserves reflects both additions to reserves and the depletion due to production:

$$X_{p,t+1} = X_{p,t} + \Phi_g(I_{xt}/X_{p,t})X_{p,t} - Y_{p,t} \quad (69)$$

The exploration of oil reserves follows the following formula:

$$G_{p,t} = \Phi_p\left(\frac{I_{xt}}{X_p}\right)X_p \quad (70)$$

Where,

$I_{x,t}$ indicates Investment which is assumed to be a combination of public (I_{gt}) and private investments ($I_{op,t}$):

$$I_{x,t} = A_{Xt}^{I}\left[\omega_{ix} I_{gt}^{1-\rho_i} + (1-\omega_{ix})I_{\mathrm{op},t}^{1-\rho_i}\right]^{\frac{1}{1-\rho_i}} \quad (71)$$

Where, $\Phi_g^{'}(.) \succ o$ and $\Phi_g^{''}(.) \prec o$. Note that in the steady state, $G_{p,t} = Y_p$, $\Phi_g\left(\frac{G}{X}\right) = \frac{G}{X}$ and $\Phi_g^{'}\left(\frac{G}{X}\right) = 1$.

One can view reserves in our model as representing total capital in the oil producing sector, which reflects oil-production infrastructure (capital), as well as oil in the ground. The depletion of reserves, i.e. the depreciation of oil-producing capital, depends on how much oil is produced (Balke *et al.* (2010).

It is assumed that private and public investment follows the AR(1):

$$\boldsymbol{log}I_{op,t} = \boldsymbol{\rho}_{op}\boldsymbol{log}\left(I_{op,t-1}\right) + \left(1-\boldsymbol{\rho}_{op}\right)\boldsymbol{log}\left(\boldsymbol{I}_{op}\right) + \boldsymbol{\varepsilon}_{op,t} \quad (72)$$

$$\boldsymbol{log}I_{g,t} = \boldsymbol{\rho}_i\boldsymbol{log}\left(I_{\mathrm{g},t-1}\right) + \left(1-\boldsymbol{\rho}_i\right)\boldsymbol{log}\left(\boldsymbol{I}_g\right) + \boldsymbol{\varepsilon}_{\mathrm{i},t} \quad (73)$$

The amount of oil production and reserves is determined through the optimization of the representative agent's utility function in the oil-producing country, taking prices as given. Therefore, we have:

$$p_{pe,t} = p_{x,t} + mc_{p,t} \quad (74)$$

$$mc_{p,t} = \frac{w_{u,t}}{mp_{l,t}^{p}} = \frac{w_{\mathrm{u},t}}{(1-\omega_p)\left(\frac{L_{p,t}}{Y_{p,t}}\right)^{-\rho_p}} \quad (75)$$

Where, $(P_{pe,t})$ stands for oil Price, $(p_{x,t})$ for oil reserve Price, $(mc_{p,t})$ for cost of oil production in time t, w_p wage in oil sector and $mp_{l,t}^{p}$ marginal product of labor.

The Government and the Central Bank

Since the Central Bank in Iran is not independent, the Government and the Central Bank should be modeled together. It is assumed that the Government's objective is to achieve a balanced budget. Thus, the Central Bank does its best to help the Government. The Central Bank also aims to stabilize prices and enhance economic growth (Komijani and Tavakolian, 2010). The Government budget constraint is as follows:

$$\boldsymbol{g_t} + (1+\boldsymbol{i}_{t-1})\frac{\boldsymbol{b}_{t-1}}{\pi_t} = \frac{ex_t * or_t}{\boldsymbol{P_t}} + \boldsymbol{T_t} + \boldsymbol{b}_t + \left(\frac{DC_t - DC_{t-1}}{\boldsymbol{P_t}}\right) \quad (76)$$

Where

g_t stands for the government expenditures, b_{t-1} for the previous period's bonds, $\boldsymbol{T_t}$ for households Tax, b_t for current period's bonds, $DC_t - DC_{t-1}$ for public net Debt to the Central Bank, and or_t for oil revenue. Public expenditure, including consumption and investment, are as follows:

$$\boldsymbol{g_t} = c_{gt} + I_{gt} \quad (77)$$

Government consumption follows the AR(1) process:

$$\boldsymbol{logc}_{\mathrm{g,t}} = \boldsymbol{\rho_g log}\left(c_{\boldsymbol{a,t}-1}\right) + \left(1-\boldsymbol{\rho_g}\right)\boldsymbol{log}\left(\boldsymbol{c}_g\right) + \boldsymbol{\varepsilon}_{g,t} \quad (78)$$

Meanwhile, monetary base and its growth can be written as:

$$\boldsymbol{M_t} = ex_t * FR_t + DC_t \quad (79)$$

$$\boldsymbol{M_t} - \boldsymbol{M_{t\text{-}1}} = \left(DC_t - DC_{t-1}\right) + \left(ex_t FR_t - ex_{t-1} FR_{t-1}\right) - RCB_t \quad (80)$$

Where,

$\boldsymbol{M_t}$ stands for Monetary base, DC_t for net Debt to the Central Bank, FR_t for the Central Bank's net Foreign assets, ex_t for formal exchange rate, $M_t - M_{t\text{-}1}$ for Monetary growth rate, RCB_t for the change in the Central Bank Reserves due to change in exchange rate. Meanwhile, foreign reserves will be defined as follows:

$$\boldsymbol{ex_t FR_t} = \boldsymbol{ex}_{t-1} FR_{t-1} + Y_t^x - Y_t^m \quad (81)$$

The Central Bank's foreign assets accumulation consists of foreign assets in the previous period (FR_{t-1}) plus exports ($ex_t or_t$ for oil and $Y_{a,t}^{ex}$ for agriculture) minus imports (including agriculture ($Y_{a,t}^m$), non-agriculture ($Y_{0,t}^m$).

In Iran's economy, it is assumed that money growth rate is a monetary policy instrument, because the interest rate is controlled. In addition, the policymakers enjoy great discretion in formulating monetary policy based on monetary growth rate, in order to achieve their policy objectives, namely, reducing the deviation of production from potential production and deviation of inflation from inflation target (Manzoor and Taghipour, 2015).

$$\dot{m}_t = \rho_m \dot{m}_t(\mathrm{t}-1) + \lambda^{\pi i}(\pi_t^c - \pi_t^{ta}) + \lambda^y (y_t - y) + \upsilon_t^m \quad (82)$$

Meanwhile, monetary growth rate will be defined by:

$$m_t^{\bullet} = \hat{m}_t - \hat{m}_{t-1} + \pi_t \quad (83)$$

Equation (82) assumes that inflation target (π_t^{ta}) follows the AR(1) process too.

$$\log(\pi_t^{ta}) = \rho_{\pi ta}\log(\pi_t^{ta}) + (1-\rho_{\pi ta})\log(\pi^{ta}) + \varepsilon_t^{\pi ta} \quad (84)$$

υ_t^m stands for the monetary impulse and is assumed to follow the AR(1) process:

$$\log(\upsilon_t^m) = \rho_\varepsilon \log(\upsilon_t^m) + (1-\rho_\varepsilon)\log(\upsilon^m) + \varepsilon_t^\upsilon \quad (85)$$

The Central Bank reacts to deviation of inflation rate from inflation target, deviation of *GDP* from the balance rate, and deviation of real exchange rate from balanced rate (Manzoor and Taghipour, 2015)

$$\frac{\Delta ex_t}{\Delta ex} = \left(\frac{\Delta ex_t}{\Delta ex}\right)^{\kappa_0}\left(\frac{\pi_t^c}{\pi_{o,t}^{im}}\right)^{\kappa_1}\left(\frac{\frac{FR_t}{M_t}}{\frac{FR}{M}}\right)^{\kappa_2}\varepsilon_t^{ex} \quad (86)$$

Where,

ex_t stands for the change in formal exchange rate, π_t^c for the consumer inflation rate, $\pi_{o,t}^{im}$ for foreign inflation rate, and $\frac{FR_t}{M_t}$ for the Central Bank's net Reserves-Money ratio. Based on actual exchange rate, Equation (90) will become:

$$\frac{\Delta ex_t}{\Delta ex} = \left(\frac{\Delta ex_{t-1}}{\Delta ex}\right)^{\kappa_0}\left(\frac{\pi_t^c}{\pi_{o,t}^{im}}\right)^{\kappa_1}\left(\frac{\frac{fr_t}{m_t}}{\frac{fr}{m}}\right)^{\kappa_2}\varepsilon_t^{ex} \quad (87)$$

Solving DSGE Model

The Data Used

Time series data for 1971-2012 for the following variables (at constant prices of 2011) is used to estimate the model: output gap, agricultural production, rural household consumption, agricultural investment, agricultural exports, agricultural imports, and inflation. Since the cyclic component of time series data is used in DSGE models, it is separated by Hodrick-Prescott filter (using

EVIEWS software and $\lambda = 100$). All variables in the model are defined as the logarithm deviation from their stable value. Inflation and money growth rate are obtained from the logarithm of the ratio of these variables to their prior values.

Steps of Estimation DSGE

DSGE models are formulated and estimated in six stages. In step 1 (methodology), we describe the model framework including defining the problem, model equations and its constraints. First-Order Conditions (FOCs) are obtained through optimization in step 2. The steady state model is extracted in step 3 (Table 1). In step 4, the first-order conditions and constraints must be log-linear.

In step 5 the model dynamics is resolved using Blanchard and Kahn method (1980). Differential equations are solved using Bayesian approach in step 6.

BVAR Estimation

As noted, the Bayesian approach is used to estimate the DSGE model. First, we must determine the prior distribution, mean and standard error of the parameters. Prior distribution of each parameter is selected based on its characteristics and desired distribution characteristics. For example, the Beta distribution is characterized by three parameters: mean standard error, and lower and upper bounds. Bayesian method commonly uses four distributions: Gamma, Normal, Beta and Inverse Gamma.

Bayesian methods are used to calculate the maximization of likelihood of observed variables (real variables) as well as the posterior distributions. Mode of posterior distribution and Hessian matrix are calculated using the Markov Chain Monte Carlo method (MCMC). Metropolis Hastings Sampling is used to draw the posterior distribution (Asgari *et al*., 2015). The Metropolis-Hastings sampling is used with 10 blocks and 1.5 million harvests per block. Results are shown in Table 2.

Diagnostic tests such as Brooks-Gelman and acceptance rate indicate the desirability of the results. The acceptance rate of each block is in the range of 0.2-0.4. Also, the variances within the chains (blue curve) approach the variances between chains (red curve) and then converge.

DISCUSSION

In this paper, the effects of oil price shocks on macroeconomic variables in agriculture sector (production, consumption, imports, exports, employment and inflation) are studied. To do this, we examine Impulse Response Functions (IRFs) which show the dynamic behavior of variables over time. In fact, they provide an analysis of macroeconomic variables' responses to exogenous shocks.

Higher oil prices increase oil revenues which enhance the government's investment. Following the government's investment in agriculture, as expected, the agricultural production (ya) will increase by 0.14 percent in the short-run. In pursuit of agricultural production, demand for labor force will only increase 0.43 percent and, in turn, the wages of labor force will grow by 4.86 percent.

Higher oil prices increase oil revenues which, in turn, will reduce real exchange rate. Since the real exchange rate represents the competitiveness of an economy, lower real exchange rates reduce the prices of imported goods and increase their competitiveness in domestic markets, and finally increase imported goods.

As Figure 1 shows, higher oil prices negatively affect agriculture via lower exchange rates which, in turn, decrease agricultural exports (1.8 percent). As agricultural production and competitiveness decrease, imports of the same increase (0.94 percent). As agricultural imports increase and agricultural exports decrease, the supply of agricultural products goes up and cuts

Table 1. Calibrated parameters and ratios in the model**.**

Parameters	Values	Parameters	Values
Non-agricultural depreciation	0.081	Of net gov. debt to total money ratio	0.41
Agricultural depreciation	0.089	Of non-agri. labor share in the total labor	0.747
Agri. production share in total Prod.	0.1025	Oil labor share in the total labor	0.246
Non-agri. Import share in non-agri. production	0.475	Agri. labor share in the total labor	0.007
Agri. import share in agri. production	0.2923	Consumption share in *GDP*	0.55
Subsidy rate of agricultural products	0.1957	Investment share in *GDP*	0.35
Non-agri. production share in total Prod.	0.7422	Government expend. share in *GDP*	0.14
Fertilizers energy share in total use in Agri.	0.031	Export share in *GDP*	0.21
Fertilizer import share in total fertilizer use	0.25	Import share in *GDP*	0.25
Subsidy rate of fertilizer	0.5	Investment share in oil to total inv.	0.037
Gov. investment share in total investment in oil sector	0.7	Investment share in agri. to total inv.	0.042
Oil depreciation	0.079	Inv. in non-agri. share to total inv.	0.921
Steady state interest rate	1.21	Agri. cap. stock share in. total capital	0.04
Oil reserves share in oil production	0.8	Non-agri. cap. stock share in total capital	0.92
Subsidy rate of Energy	0.4	Oil cap. stock share in total capital	0.04
Non-agri. price index to *CPI* ratio	0.95	Marginal cost to the price of oil ratio	0.5
Agri. price index to *CPI* ratio	0.956	Oil price to reserves price ratio	6
Non-agri. domestic price index to *CPI* ratio	0.95	Oil reserves to oil production ratio	61.66
Non-agri. domestic price index to CPI ratio	0.92	Oil sector's labor share in oil production	0.63
Non-agri. Import price index to *CPI* ratio	0.721	Oil production to reserves ratio	0.016
Agri. import price index to Agri. Price index ratio	0.987	Oil investment to oil production ratio	7.38
Agri. production price index to *PPI* ratio	0.988	Private investment in to total inv.	0.3
Non-agri. production price index to PPI ratio	1.076	Oil inv. to oil reserves ratio	0.12
Domestic fertilizer price index to fertilizer price index ratio	0.96	Non-agri. consumption share to total cons.	0.654
Import fertilizer price index to fertilizer price index ratio	0.925	Agri. consumption share in total cons.	0.346
Oil extraction technology	0.1	Non-agri. energy use share in total energy	0.27
Gov. consumption share in Gov. expenditures	0.937	Agri. energy use share un total energy	0.06
Gov. investment share in Gov. expenditures	0.063	Oil exports share in total oil prod.	0.668
Export to nominal reserves ratio	2	Agricultural export share in total export	0.008
Import to nominal reserves ratio	1.5	Oil revenue share in *GDP*	0.205

Source: Research results.

inflation by 0.51 percent. According to Euler equation, lower inflation increases consumption by 2 percent. However, lower inflation is not stable and will increase again. A negative consequence of higher oil prices is their effect on private investment in agriculture. Due to expected higher capital efficiency in non-tradeables, private investment in this sector decreases by 20 percent.

Figure 1 also shows that the long-run effects of higher oil prices are lower agricultural production (2 percent) and exports (4 percent), lower employment (2 percent), lower private investment (5 percent), and higher imports (2.5 percent). Higher oil prices in Iran's economy during 2006-2010 and their effects on Iran's agriculture support our results.

CONCLUSIONS

Today, DSGE models are used to evaluate economic policies. In this study, within the framework of Keynesian economics, we developed a multi-sector DSGE model for Iranian economy. Formulation of a multi-sector DSGE model with an emphasis on agriculture is among the few works done in the world. Inclusion of agriculture, separation of urban and rural households,

Table 2. Prior and posterior distributions of parameters.

Parameters	Prior distribution			Posterior distribution		
	Type	Mode	*SE*	Mean	Confidence interval	
Discount factor	Beta	0.98	0.01	0.945	1	0.8602
Inverse of the elast. of money	Gamma	1.3497	0.08	1.2842	1.3921	1.1716
Intertemporal elast. of subst.	Gamma	1.5209	0.08	1.5873	1.6735	1.5048
Inverse of the elasticity of work effort	Gamma	2.92	0.08	2.9411	3.0529	2.8313
Elast. of subst. between goods	Gamma	0.3	0.02	0.4479	0.5824	0.3267
Elast. of subst. home and foreign goods (Agri.)	Gamma	1.4	0.08	1.2695	1.3526	1.1892
Elast. of subst. home and foreign goods (Non-agri.)	Gamma	1.05	0.08	1.2474	1.3435	1.1503
Elast.of subst. agri. and non-agri.	Gamma	6	0.08	2.071	2.1616	1.9843
Fraction of non-agri. Firms not adjust price	Beta	0.2	0.03	0.1827	0.2117	0.1539
Capital elast. in non-agri. production	Gamma	0.59	0.05	0.3131	0.3712	0.2573
Labor elast. in non-agri. production	Gamma	0.16	0.02	0.7392	0.7966	0.6785
Energy elast. in non-agri. production	Gamma	0.47	0.05	0.5053	0.5605	0.4487
Fraction of agri. firms not adjust price	Beta	0.25	0.02	0.2106	0.2319	0.1916
Capital elast. in agri. production	Normal	0.647	0.05	0.9101	0.9737	0.8376
Labor elast. in agri. production	Normal	0.7708	0.05	0.3054	0.3326	0.2781
Energy elast. in agri. production	Normal	0.4365	0.05	0.2159	0.238	0.1935
Elast. of subst. between fertilizer and oil energy in agri.	Normal	-0.05	0.02	0.0014	0.0046	0
Elast. of subst. home and foreign goods (Fertilizer.)	Gamma	0.4	0.05	0.7745	0.8456	0.7054
Elast. of agri. export	Normal	3.3	0.08	3.1499	3.2504	3.047
Elast. of subst. labor and reserves in oil sector	Gamma	0.09	0.02	0.1575	0.1637	0.151
AR(1) coefficient (Agri. productivity)	Beta	0.9073	0.05	0.8291	0.9075	0.7528
AR(1) inflation coefficient (Monetary reaction function)	Beta	-0.9898	0.05	-0.9783	-0.9131	-1.0563
AR(1) production coefficient (Monetary reaction function)	Beta	-2.9672	0.05	-3.1949	-3.0997	-3.2907
AR(1) coefficient (Monetary shock)	Beta	0.72	0.05	0.7463	0.7991	0.6923
AR(1) coefficient (World production of agricultural)	Beta	0.8	0.05	0.8593	0.8899	0.8291
AR(1) coefficient (Net government debt)	Beta	0.9215	0.05	0.9913	0.9994	0.9834
AR (1) coefficient (Energy use in non-agri.)	Beta	0.6	0.05	0.6578	0.703	0.6156
AR(1) coefficient (Agri. import price)	Beta	0.85	0.05	0.7417	0.8239	0.6608
AR(1) coefficient (Non-agri. import price)	Beta	0.85	0.05	0.4276	0.4391	0.4188
AR (1) coefficient (Gov. consumption.)	Beta	0.5	0.05	0.5089	0.5607	0.4565
AR(1) coefficient (Non-agri. Productivity)	Beta	0.75	0.05	0.7875	0.844	0.7309
AR(1) coefficient (Oil price)	Beta	0.42	0.05	0.3613	0.4284	0.2969
AR(1) coefficient (Money demand)	Beta	0.2704	0.05	0.273	0.3328	0.2103
AR(1) coefficient (Oil revenue)	Beta	0.2773	0.05	0.1989	0.25	0.1442
AR(1) coefficient (Target inflation)	Beta	0.8912	0.05	0.9854	0.9945	0.9771
AR(1) coefficient (Gov. expenditure)	Beta	0.69	0.05	0.6952	0.7548	0.6371
AR(1) exchange rate coefficient (In the reaction function of Central Bank)	Beta	0.9	0.02	0.8792	0.9085	0.8514
AR(1) Inflation coefficient (Central Bank's reaction function)	Normal	-1.9	0.05	-1.8028	-1.7063	-1.8964
AR(1) foreign reserves coefficient (Central Bank's reaction function)	Normal	-1.55	0.05	-1.7161	-1.6209	-1.7985

Source: Research results.

inclusion of oil sector for analyzing the effects of Dutch disease, and reconsidering the economy for analyzing the effects of foreign shocks are among the innovations of this study.

The model consists of three sectors: agriculture, non-agriculture, and oil. It is used to investigate the oil price increases. One of the crucial factors that impact the real economy is the shocks of rising oil prices. They weaken real economy sectors and strengthen the non-tradable sectors.

In the short-run, increasing oil prices have negative impacts on agricultural production,

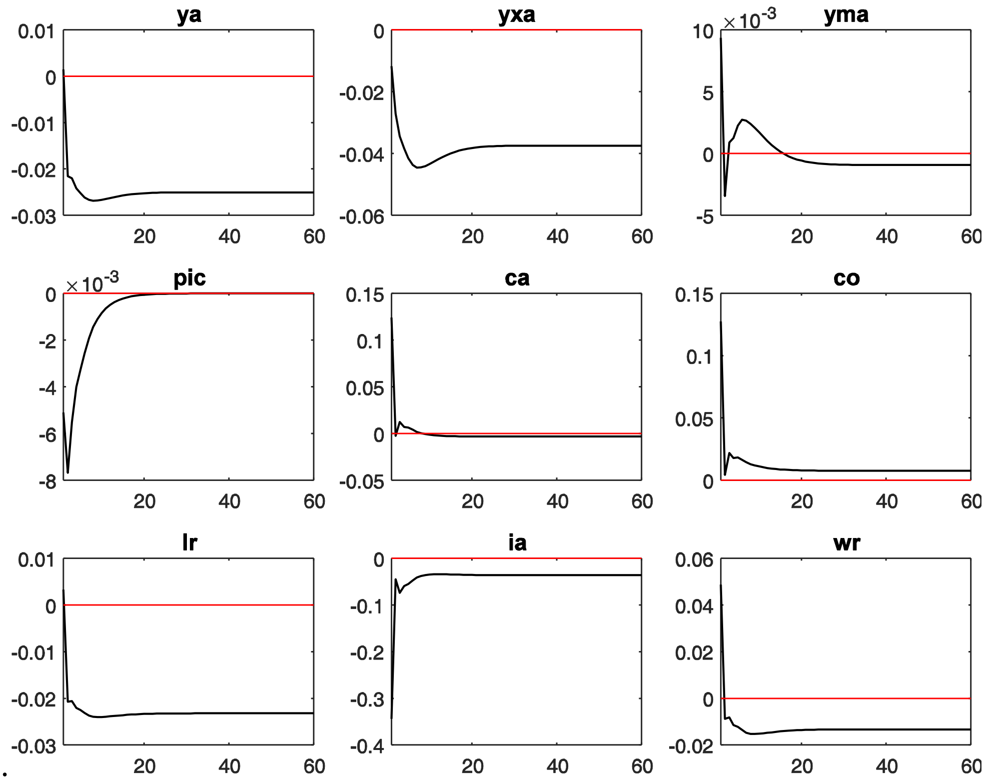

Figure 1. Impact of oil prices on macroeconomic variables in agriculture.

investment, consumption and exports. In response to the positive shocks in oil prices, agricultural imports will increase because the shocks reduce the competitiveness of agricultural production.

The results show the negative impacts of Dutch disease on tradable sectors, such as agriculture. Proper management of oil revenues is thus essential at the time of soaring oil prices. Unfortunately, the Iranian governments have not been able to properly manage the oil revenues.

Iran's monetary and financial policies are set with an eye to oil revenues. Higher foreign exchange revenues, resulting from oil sale and through higher foreign assets of the Central Bank, increase the monetary base which, in turn, will enhance liquidity and inflation. Meanwhile, an equivalent amount of foreign exchange earned through oil exports will enter the economy in the form of government expenditure. Therefore, financial policies, which are largely based on the government's expenditure, rely on the foreign exchange revenues earned because of higher oil prices. Interestingly, when positive shocks in oil prices occur, the government makes vast investments without paying attention to the median-term horizon of these revenues. If these revenues decrease, the projects cannot be completed. Considering the above statements, a sound management of foreign exchange revenues at the time of oil boom is necessary.

Please put the references in alphabetic order

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اثرات افزایش قیمت نفت بر متغیرهای کلان بخش کشاورزی با استفاده از مدل تعادل عمومی پویای تصادفی

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چکیده

در این مقاله مدل چندبخشی تعادل عمومی پویای تصادفی ایران تدوین شده است. در این مدل اقتصاد به سه بخش کشاورزی، غیرکشاورزی و نفت تفکیک شده است .به علاوه به دلیل ورود صادرات و واردات، مدل به صورت باز درآمده است .برای انطباق آن با اقتصاد ایران چسبندگی‌های قیمت نیز به مدل افزوده شده است .سپس آثار افزایش قیمت نفت بر بخش کشاورزی بررسی شد. برای اینکار از داده‌های سالانه ۹۱-۱۳۳۸ (به قیمت ثابت سال ۱۳۸۳) استفاده شد و مدل با روش بیزین برآورد گردید. نتایج نشان می‌دهند که افزایش قیمت نفت به شدت تاثیر منفی بر متغیرهای کلان بخش کشاورزی دارد و اثر بیماری هلندی بر بخش کشاورزی تایید می‌گردد.