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Monetary Policy and Commodity Terms of Trade Shocks

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ABSTRACT

The commodity terms of trade shocks are important to explain the macroeconomic fluctuations of oil-exporting countries. Oil price shocks are the main source of terms of trade variability in oil-exporting countries. Given the significant effects of terms of trade fluctuations on domestic macroeconomic variables, understanding the transmission and propagation of terms of trade fluctuations is crucial in the design and conduct of macroeconomic policies in oil-exporting countries. An appropriate monetary policy can help to stabilize these shocks. This study evaluates three alternative monetary policy regimes' responses to commodity terms of trade shock and export sector productivity shock using a New Keynesian Dynamic Stochastic General Equilibrium (DSGE) model. The model is calibrated to the Iran economy. This study aims at investigating the dynamic effects of commodity terms of trade shocks and evaluating the performance and the stabilization properties of various simple monetary policy rules for oil-dependent economies. Three alternative monetary policy rules have been considered: CPI inflation targeting (CIT) rule, non-traded inflation targeting (NTIT) rule, and exchange rate targeting (ET) rule. The comparison of responses under different monetary policy regimes shows that CPI inflation targeting is superior to the NTIT and ET targeting when commodity terms of trade shock happen. For export productivity shock, the performance of the CIT rule is better than other examining monetary policy rules. Also, the real exchange rate, which is defined as a function of commodity terms of trade and productivity differentials, makes it possible to examine the role of export productivity shock on macroeconomic variations and test the existence of Balassa- Samuelson effect. Under the export sector productivity shock, exported output increases while non-traded output decreases, possibly reflecting the symptoms of the Dutch disease. On the other hand, the dynamic responses of selected macroeconomic variables suggest the presence of the Balassa-Samuelson effect where an increase in productivity in the traded sector appreciates the real exchange rate and increases the prices of non-tradable goods through wage equalizations. Overall, when the economy is experiencing commodity terms of trade shocks or exported productivity shocks, CPI inflation targeting is relatively better than exchange rate targeting and non-traded inflation targeting in macroeconomic stabilization.

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1- Introduction

The commodity terms of trade shocks are regarded as a major source of economic fluctuations. These shocks roughly account for half of the fluctuation in aggregate output (Kose & Riezman, 2001; Mendoza, 1995), and play a very important role in inducing business cycles in factors of production as they account for more than 86% of investment and 80% of lobar supply fluctuations (Kose & Riezman, 2001). Coudert et al. (2015) have found a positive relationship between the real exchange rate and the country`s terms of trade for whole commodity exporters, be they advanced, intermediate or low-income countries. Also, they have shown that improved terms of trade cause a Dutch disease problem on the long run if commodity exporter countries do not adequately redistribute rents across sectors. These shocks are more volatile in developing countries because primary commodities constitute a significant component of the exports in developing countries (Cashin, McDermott, & Pattillo, 2004; De Gregorio & Wolf, 1994) so, fluctuations in world commodity prices have the potential to explain a large share of movements in their terms of trade (Cashin, Céspedes, & Sahay, 2004).

Broda (2004) and Chia & Alba (2005) have examined the effects of terms of trade shocks on important macroeconomic variables under alternative exchange rate regimes and they found that flexible exchange rate regimes adjust real shocks more effectively than fixed regimes. This result is in favor of Friedman`s (1953) hypothesis. Devereux, lane & Xu (2004) and Hove, Touna Mama & Tchana Tchana (2015) have compared alternative monetary policy rules in emerging market economics that experience commodity terms of trade shocks. Hove et al. (2015) have found that commodity terms of trade shocks have less impact on most macroeconomic variables under CPI inflation targeting. However, Devereux et al. (2004) have shown the degree of exchange rate pass-through is very important for the assessment of monetary policy. Allegret & Bebkhodja (2015) investigate the dynamic effect of external shocks under alternative monetary rules in an oil economy using Bayesian approach, the DSGE

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model based on the features of the Algerian economy. They have found that the core inflation monetary rule performs relatively better to stabilize both output and inflation.

A large part of the variability of the terms of trade is associated with extreme movements in oil prices (Backus & Crucini, 2000) and commodity price volatilities influence both exchange rates and the terms of trade of commodity exporters (Bergholt, 2014). Iran has the fifth largest oil reserves and the second largest gas reserves in the world. Oil exports account for a high percentage of export earnings and finance a significant portion of government spending in This country. However, some researches have studied the macroeconomic performance of alternative monetary policy regimes in Iran. They often have evaluated the role of monetary policy in adjusting shocks, such as oil price shocks, oil income shocks and productivity shocks (see Rabee Hamedani & Pedram, (2013); Bahrami & Ghoreishi, (2011)). Although these shocks are important, it is necessary to analyze commodity terms of trade shocks in oil exporting economies like Iran.

In this paper, a multi-sector DSGE set-up based on Hove et al. (2015), Monacelli (2005) and Cashin et al. (2004) has been developed for the economy of Iran. This study aims at investigating the dynamic effects of commodity terms of trade shocks and evaluating the performance and the stabilization properties of various simple monetary policy rules for oil-dependent economies. Three alternative monetary policy rules have been considered: CPI inflation targeting (CIT) rule, non-traded inflation targeting (NTIT) rule and exchange rate targeting (ET) rule. The rest of the paper is organized as follows: section 2 lays out the model while section 3 describes the calibration of parameters and solution of the model. Section 4 analyzes the results. Section 5 is the conclusions and suggestions.

2- A small open economy model

In this study, the model has been developed based on Hove et al. (2015), Monacelli (2005) and Cashin et al. (2004) for the economy of Iran. This theoretical framework characterizes a small open oil exporting economy by two domestic sectors: traded sector and non-traded sector. In non-traded sector, prices are sticky according to Calvo`s (1983). There is one external sector which is the rest of the world. Also, incomplete exchange rate pass-through is introduced via nominal rigidities on import prices. This model has developed to evaluate the response of different monetary policy regimes to commodity terms of trade shocks and export productivity shocks.

2-1- The consumer`s problem

Following Hove et al (2015), Representative household in the home country are assumed to maximize the following utility function:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1+\psi}}{1-\sigma} - \eta \frac{L_t^{1+\psi}}{1+\psi} \right) \qquad (1)$$

Subject to the following budget constraint:

$$P_t C_t \leq W_t L_t + \prod_t + D_t - E_t(Q_{t+1} D_{t+1}) + T_t \qquad (2)$$

E_0 denotes the conditional expectation on information available at date t=0, β is the inter temporal discount factor, with $0 < \beta < 1$. C_t denotes composite consumption in period t, L_t denotes labor supply. $\sigma > 0$ is the inverse of the elasticity of substitution between consumption and labor and $\psi > 0$ is the inverse of wage elasticity of labour.

In the budget constraint, W_t is the nominal wage, P_t is the consumer price index, and Π_t are real profits for the home consumer.D_t is the portfolio of assets. D_{t+1} is the nominal payoff of period $t+1$ of the portfolio held at the end of time t, $Q_{t+1}$is the stochastic discount factor, and T_t are lump-sum taxes.

The aggregate consumption index (C_t) is a composite of non-tradable (C_{Nt}) and tradable (C_{Tt}) goods witch takes the constant elasticity of substitution (CES) function of the form:

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(3) $$C_t = \left[\alpha^{\frac{1}{\rho}} C_{Nt}^{\frac{\rho-1}{\rho}} + (1-\alpha)^{\frac{1}{\rho}} C_{Tt}^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}$$

where ρ is elasticity of substitution between the tradable and non-tradable goods, and α is share of non-tradable goods in the consumption basket at home. In this context, the consumer price index that corresponds to the previous specification is given by:

(4) $$\mathrm{P_t} = \left(\alpha \mathrm{P}_{\mathrm{Nt}}^{1-\rho} + (1-\alpha)\mathrm{P}_{\mathrm{Tt}}^{1-\rho}\right)^{\frac{1}{1-\rho}}$$

where, all prices are for goods sold in the home country, in home currency for tradable and non-tradable goods.

Households allocate aggregate expenditure based on the following demand functions:

(5) $$C_{Nt} = \alpha \left(\frac{P_{Nt}}{P_t}\right)^{-\rho} C_t$$

(6) $$C_{Tt} = (1-\alpha) \left(\frac{P_{Tt}}{P_t}\right)^{-\rho} C_t$$

The demand for domestic non-tradable goods and imports is given by:

(7) $$Y_{Nt}^{D} = C_{Nt} + G_t$$

(8) $$Y_{Tt}^{D} = C_{Tt}$$

It is assumed that the government only demands domestically non-tradable goods, such that:

(9) $$G_t = G_{Nt}$$

Government spending is exogenously determined and exhibits persistent variation. In particular, it follows an AR(1) process in log-linearized terms:

(10) $$g_t = \rho_g g_{t-1} + \epsilon_{gt}$$

where g_t is the amount spent by the government and ϵ_{gt} is distributed normally with mean 0 and variance σ_g^2. Lowercase letters are used to denote the log-linearized of their uppercase counterparts.

The first order conditions of the household`s optimization problem are given by:

(11) $$C_t^{\sigma}\eta L_t^{\psi} = \frac{W_t}{P_t}$$

(12) $$\beta R_t E_t\left(\left(\frac{C_{t+1}}{C_t}\right)^{-\sigma}\left(\frac{P_t}{P_{t+1}}\right)\right) = 1$$

2-2- Firms

2-2-2- Domestic firms

Following Hove et al (2015), There are two sectors in the domestic economy; the traded sector and non-traded sector. It is assumed that the domestic traded sector only produces oil which are all exported. Firms in the traded sector operate under perfect competition and use the following linear technology:

(13) $$Y_{Xt} = A_{Xt}L_{Xt}$$

where A_{Xt} is a productivity variable and L_{Xt} is labor in the commodity export sector. A_{Xt} follows an AR(1) process such that in logarithms, it is:

(14) $$\ln A_{Xt} = \rho_x \ln A_{Xt-1} + \epsilon_{Xt}$$

where $\epsilon_{Xt} \sim N(0.1)$ and ρ_x is the autocorrelation coefficient showing the persistence parameter of lobar productivity in the oil export sector. Cost minimization in the commodity export gives the following marginal cost:

(15) $$MC_{Xt}^{R} = \frac{W_t}{A_{Xt}P_{Xt}}$$

where MC_{Xt}^{R} is the real marginal cost in the oil export sector, W_t is the wage rate and P_{Xt} is the oil price. Firms in the non-traded sector face monopolistic competition and produce differentiated non-traded goods using the linear production technology:

(16) $$Y_{Nt} = A_{Nt} L_{Nt}$$

where A_{Nt} is a productivity variable for non-traded goods and L_{Nt} is labor in the non-traded sector. A_{Nt} follows an AR(1) process such that in logarithms, it is:

(17) $$\ln A_{Nt} = \rho_N \ln A_{Nt-1} + \epsilon_{Nt}$$

where $\epsilon_{Nt} \sim N(0.1)$ and ρ_N is the autocorrelation coefficient showing the persistence parameter of lobar productivity in the non-traded sector. Cost minimization in the non-traded sector gives the following marginal cost:

(18) $$MC_{Nt}^{R} = \frac{W_t}{A_{Nt} P_{Nt}}$$

where MC_{Nt}^{R} is the real marginal cost in the non-traded sector and P_{Nt} is the price of non-traded goods. Because of perfect competition in the traded sector, the price of tradeable goods can be expressed as a function of wages and productivity only. Also the price of non-traded goods can be expressed as a function of wages, productivity and marginal costs:

(19) $$P_{Nt} = \frac{W_t}{A_{Nt} MC_{Nt}^{R}}$$

(20) $$P_{Xt} = \frac{W_t}{A_{Xt}}$$

Using E.q. (19) and (20), the price of non-traded goods can be written as function of the oil price and the relative productivities between tradable and non-tradable sectors.

(21) $$P_{Nt} = \frac{A_{Xt}}{A_{Nt} MC_{Nt}^{R}} P_{Xt}$$

2-2-3- Foreign firms

Following Cashin et al.(2004) and Hove et al.(2015), the foreign economy is assumed to be contained of three different sectors that is the non-tradable sector, intermediate sector, and final good sector. Firms in all sectors are perfectly competitive. Since the labor is movement across sectors, the wage is equated across sectors, firms in non-tradable sector produce differentiated goods under a linear production function that is given by:

(22) $$Y^*_{Nt} = A^*_{Nt} L^*_{Nt}$$

where A^*_{Nt} is a productivity variable for non-traded goods and L^*_{Nt} is labor in the foreign non-traded sector. A^*_{Nt} follows an AR(1) process such that in logarithms, it is:

(23) $$\ln A^*_{Nt} = \rho_{N^*_t} \ln A^*_{N_{t-1}} + \epsilon^*_{N_t}$$

where $\epsilon^*_{N_t} \sim N(0.1)$. Firms in the foreign intermediate sector also operate under a linear production function:

(24) $$Y^*_{It} = A^*_I L^*_{It}$$

where A^*_I is a productivity variable for intermediate goods and L^*_{It} is labor in the foreign intermediate sector. A^*_I follows an AR(1) process such that in logarithms, it is:

(25) $$\ln A^*_{I_t} = \rho_{A^*_{It}} \ln A_{I^*_{t-1}} + \epsilon^*_{I_t}$$

where $\epsilon^*_{I_t} \sim N(0.1)$. As before, the price of foreign non-traded goods is defined as:

(26) $$P^*_{Nt} = \frac{A^*_{It}}{A^*_{Nt}} P^*_{It}$$

where P^*_{It} is the price of intermediate inputs. There is a continuum of final good variety producers. Firms in foreign traded sector produce traded final goods using oil which is exported by domestic economy (Y^*_{Xt}) and foreign intermediate good produced in the rest of the world (Y^*_{It}) through the following technology:

(27) $$Y^*_{Tt} = \vartheta (Y^*_{It})^{\nu} (Y^*_{Xt})^{1-\nu}$$

the price of foreign traded goods is defined as:

(28) $$\mathrm{P}^*_{\mathrm{Tt}} = (P^*_{It})^{\nu} (\mathrm{P}^*_{\mathrm{Xt}})^{1-\nu}$$

Foreign consumer price index is:

(29) $$P_t^* = {P_{Nt}^*}^{\alpha^*} {P_{Tt}^*}^{1-\alpha^*}$$

2-3- Pass through and deviations from PPP

Based on empirical evidence such as Shajari et al (2015), pass through is assumed to be incomplete in model. Following Monacelli (2005), under the assumption of incomplete pass-through, the Law Of One Price (LOP) does not hold. This means that the price of any imported goods in the market of small open economy is not equal to price of the identical good in the world market in terms of domestic currency. In other words, the economy is identified by deviation of the world price from the domestic currency price of imports as follows:

(30) $$P_{Tt} \neq \frac{P_{Tt}^*}{\varepsilon_t}$$

where ε_t is the nominal exchange rate, P_{Tt}^* is price of foreign country in the terms of its own currency. From above expression the LOP gap is defined as follows in log-linearized form:

(31) $$\psi_t = p_{Tt}^* - e_t - p_{Tt}$$

2-4- Real exchange rate, commodity terms of trade and Pass through

As Hove et al (2015), Real exchange rate is defined as the ratio of domestic prices in foreign currency to the foreign prices:

(32) $$\mathbb{Q}_t = \frac{\varepsilon_t P_t}{P_t^*}$$

The Law Of One Price is assumed to hold for exports such that:

(33) $$P_{Xt} = \frac{P_{Xt}^*}{\varepsilon_t}$$

Following Hove et al (2015) and monacelli (2005), From equation (32) and after some algebra, the following version of the real exchange rate can be derived:

(34) $$\mathbb{Q}_t = \left(\frac{A_{Xt}}{A_{It}^*}\frac{A_{Nt}^*}{A_{Nt}}\frac{P_{Xt}^*}{P_{It}^*}\right)^{\alpha} \left(\frac{1}{MC_{Nt}^R}\right)^{\alpha} \left(\frac{1}{\psi_t}\right)^{1-\alpha}$$

Commodity terms of trade is defined as the relative price of commodity exported in terms of intermediate foreign inputs.

(35) $$F_t = \frac{P^*_{Xt}}{P^*_{It}}$$

Substituting equation (35) into the real exchange rate equation gives:

(36) $$\mathbb{Q}_t = \left(\frac{A_{Xt}}{A^*_{It}}\frac{A^*_{Nt}}{A_{Nt}}F_t\right)^{\alpha}\left(\frac{1}{MC^R_{Nt}}\right)^{\alpha}\left(\frac{1}{\psi_t}\right)^{1-\alpha}$$

This is a version of real exchange rate which is function of productivity differential between the export and import sectors, productivity differential between domestic and foreign non-traded sectors, terms of trade, LOP gap and marginal costs.

2-5- Incomplete pass through and imports pricing

As Monacelli (2005), imported good firms follow Calvo (1983) staggered price setting where they adjust their prices only with some probability. That is at period t, $1 - \theta_\psi$ firms set prices optimally and θ_ψ keep prices unchanged, where $\theta_\psi \in (0.1)$ is the degree of nominal rigidity.

The import price index is defined as follows:

(37) $$P_{Tt} = \left\{(1-\theta_\psi)P^{new}_{Tt}{}^{1-\varepsilon} + \theta_\psi P_{Tt-1}{}^{1-\varepsilon}\right\}^{\frac{1}{1-\varepsilon}}$$

where P^{new}_{Tt} is price level of an optimizing firm. By log-linearizing equation (37) and Further computations lead to an aggregate supply curve equation for the import goods where$\lambda_\Psi = \frac{(1-\theta_\psi)(1-\theta_\psi\beta)}{\theta_\psi}$:

(38) $$\Pi_{Tt} = \beta E_t \Pi_{Tt+1} + \lambda_{\psi t}\psi_{Tt}$$

2-6- International risk sharing and uncovered interest parity

As Gali and Monacelli (2005) complete securities markets are assumed, so a first order condition analogous to (12) must also hold for the representative household in any other country:

(39) $$\beta E_t\left(\frac{C_{t+1}}{C_t}\right)^{-\sigma}\left(\frac{P_t}{P_{t+1}}\right) = \beta E_t\left(\frac{C^*_{t+1}}{C^*_t}\right)^{-\sigma}\left(\frac{\varepsilon_t P^*_t}{\varepsilon_{t+1}P^*_{t+1}}\right)$$

Under the assumption of complete international markets, the uncovered interest parity condition can be derived:

(40) $$E_t Q_{T+1}\left(R_t - R_t^* \frac{\varepsilon_{t+1}}{\varepsilon_t}\right) = 0$$

2-7- Domestic price setting

As Hove et al (2015) non-traded good firms follow Calvo`s (1983) staggered price setting where they adjust their prices only with some probability. That is at period t, $1-\theta_N$ firms set prices optimally and θ_N keep prices unchanged, where $\theta_N \in (0.1)$ is the degree of nominal rigidity. The aggregate price level of domestically produced non-traded goods (P_{Nt}) evolves according to:

(41) $$P_{Nt} = \theta_N P_{Nt-1} + (1-\theta_N) P_{Nt}^*$$

where P_{Nt}^* is an index for the prices newly set in period t.

(42) $$\pi_{Nt} = \lambda_N mc_{Nt} + \beta E_t\{\pi_{Nt+1}\}$$

where $\lambda_N = \frac{(1-\theta_N)(1-\beta\theta_N)}{\theta_N}$.

2-8- Monetary policy rules

Monetary policy is conducted with generalized Taylor rule.

(43) $$R_t = R_{t-1}^{\rho_r}\left\{\left(\frac{Y_t}{\bar{\bar{Y}}}\right)^{\omega_1}\left(\frac{\Pi_t}{\bar{\bar{\Pi}}}\right)^{\omega_2}\left(\frac{\Pi_{Nt}}{\bar{\bar{\Pi}}_N}\right)^{\omega_3}\left(\frac{\varepsilon_t/\varepsilon_{t-1}}{\bar{\varepsilon}}\right)^{\omega_4}\right\}^{1-\rho_r}$$

2-9- Equilibrium

The good market clearing condition in domestic economy requires for all t that domestic output equals a weighted average of traded and non-traded output:

(44) $$y_t = \alpha y_{Nt} + (1-\alpha) y_{Xt}$$

That domestic non-traded output consists of private consumption and government spending:

(45) $$y_{Nt} = y_{Nt}^D = c_{Nt} + g_t$$

And the domestic traded output is equal to consumption of traded goods:

(46) $$y_{Tt} = y_{Tt}^{D} = c_{Tt}$$

Also, the market clearing condition in foreign economy is a weighted average of traded and non-traded output:

(47) $$y_t^* = \alpha^* y_{Nt}^* + (1 - \alpha^*) y_{Tt^*}$$

(48) $$r_t^* = \rho_r r_{t-1}^* + \epsilon_{t.r^*}$$

3- Calibration and solution

The model is solved numerically and the parameter choices for the model are summarized in Table 1. The model is calibrated to match the key features of the Iran economy using data for period 1991: Q1 to 2017: Q1. The series of Oil production and Non-oil production are obtained from the "Statistical Centre of Iran" The series of Interest rate and oil price are obtained from the "Central Bank of Iran". The series of production in foreign intermediate sector and foreign intermediate good price are obtained from the "Archival Federal Reserve Economic Data"[1]. Other parameters were obtained from previous studies on the Iran economy and business cycle literature in the world. The benchmark parameter choices for the model are described in Table 1. Following Fotros, Tvakolian and Maabodi (2014), Elasticity of substitution between traded and non-traded goods ρ is set at 3.4. Following Tavakolian and Afzali Abarghoie (2016), the subjective discount factor β and the share of non-traded goods in consumption α are set as 0.96 and 0.8, respectively. The inverse of the elasticity of substitution between consumption and labor σ is set at 1.57, Following Komijani and Tavakolian (2012). As Manzoor and Taghipour (2015) stickiness parameter in the non-traded sector θ_N, stickiness parameter in the import sector θ_Ψ and Elasticity of substitution between traded and non-traded goods in foreign ρ^* are set as 0.2488, 0.2, 3.5 respectively. Following Rabanal &Tuesta (2013) persistence parameter for foreign interest rate ρ_r^* and persistence parameter of lobar productivity in foreign non-traded sector ρ_{Nt}^* are set as 0.88 and 0.75 respectively. Following Hove et al. (2015), share of non-traded goods in

[1] The date of US is considered as an alternative for foreign sector data

consumption in foreign country $\boldsymbol{\alpha}^*$ is set at 0.8. AR(1) processes are fitted for interest rate in Iran, oil price, lobar productivity in intermediate sector and intermediate good price in U.S. (as proxy for world) using quarterly, HP-filtered data over the sample period between 1991:Q1 to 2017:Q1, Which are estimated as follows:

(49) $$p_{xt}^* = 0.69965 p_{xt-1}^* + \varepsilon_{xt}^*$$

(50) $$a_{It}^* = 0.870763 a_{It-1}^* + \varepsilon_{It}$$

(51) $$r_t = 0.702393 r_{t-1} + \varepsilon_{rt}$$

Tabel 1. Calibration of the model
Source: Research results

Parameter	Definition and Description	Value
$\boldsymbol{\alpha}$	share of non-traded goods in consumption	0.8
$\boldsymbol{\rho}$	Elasticity of substitution between traded and non-traded goods	3.4
$\boldsymbol{\beta}$	subjective discount factor	0.96
$\boldsymbol{\theta_N}$	stickiness parameter in the non-traded sector	0.2488
$\boldsymbol{\theta_\Psi}$	stickiness parameter in the import sector	0.2
$\boldsymbol{\sigma}$	inverse of the elasticity of substitution between consumption and labor	1.57
$\boldsymbol{\rho_r}$	smoothing parameter for Taylor rule	0.7
$\boldsymbol{\rho_r^*}$	persistence parameter for foreign interest rate	0.88
$\boldsymbol{\rho_{A_I}^*}$	persistence parameter of lobar productivity in intermediate sector	0.8
$\boldsymbol{\rho_{xt}^*}$	persistence parameter of oil price	0.6
$\boldsymbol{\alpha}^*$	share of non-traded goods in consumption in foreign country	0.8
$\boldsymbol{\rho}^*$	Elasticity of substitution between traded and non-traded goods in foreign	3.5
$\boldsymbol{\rho_{Nt}^*}$	persistence parameter of lobar productivity in foreign non-traded sector	0.75

4- Results

This section analyzes the dynamic properties of the models when the economy is exposed to the commodity terms of trade shocks and productivity shocks in the export sector under the following alternative monetary policy rules. Following Hove et al. (2015), these monetary policy rules are assessed based on the degree to which they minimize the volatility of selected macroeconomic variables as reflected by their impulse response functions.

4-1- Impulse response analysis

4-1-2- Commodity terms of trade shocks

Figure 1 presents impulse responses of selected macroeconomic variables to the commodity terms of trade shock that have received the most attention in the literature. The figure shows that the commodity terms of trade shock decreases production in traded sector under three alternative monetary policies. However, NTIT rule exhibits the largest fall. An increase in terms of trade that is an increase in the relative price of oil in terms of foreign intermediate goods declines foreign output in response to higher oil price as an input to production becomes costlier. So, global oil demand decreases which results in a deduction oil production. Although, reducing demand for oil may be due to the fact that rising oil prices make shale oil more affordable. The income effect of commodity terms of trade shock also increases production in non-traded sector, with the strongest response being experienced under NTIT rule. The possible explanation is that oil income expending increases the demand for traded and non-traded sectors. Since the price of traded sector is determined in international markets, extra demand for traded goods is provided with extra import. So prices in non-traded sector increase more than prices in traded sector, which move resources from traded sector to non-traded sector. Finally, the output and labor supply in non-traded sector increase and this leads to an increase in employment aggregate. Total output as weight average of traded and non-traded output increases in all regimes, which is in line with those reported by Hove et al. (2015). The largest volatilities in total output are under NTIT and the smallest is under CIT. The commodity terms of trade shock generate a wealth effect which increases the demand and prices of imported and non-traded goods. Higher prices cause consumption deduction under CIT and NTIT rules, while the increase in domestic prices leads to an increase in imported consumption and thus increases consumption aggregate under ET rule. The largest volatility in consumption is under CIT and the smallest is under ET. Although the movement of production resources to the non-traded sector acts to rise in non-traded production, the demand is higher than production so excess demand leads a rise of inflation in this sector under three alternative monetary policy rules. Most fluctuations of non-traded inflation occur under the NTIT rule and the least fluctuations happen under the CIT rule. Since based on calibration, 80% of CPI inflation is formed by non-traded inflation, the increase in non-traded inflation induces an appreciation of the CPI inflation and CPI inflation follows a pattern of non-traded inflation. The commodity terms of trade shock provides an initial decline of real exchange rate in all regimes. The immediate response of real exchange rate is larger under NTIT and ET rules but smaller under CIT rule. In addition, the commodity terms of trade shock triggers to decrease oil incomes and exchange reserves of the central bank. As a result, the nominal exchange rate depreciates under three alternative regimes. In reaction to inflation and production, the nominal interest rate increases as contractive monetary policy. Increasing interest rate reduces investment, output and inflation. Finally, they return to equilibrium. Generally, the dynamic adjustment of most variables shows that CIT rule is superior to NTIT and ET rules because it generally exhibits small responses of most variables in terms of trade shock.

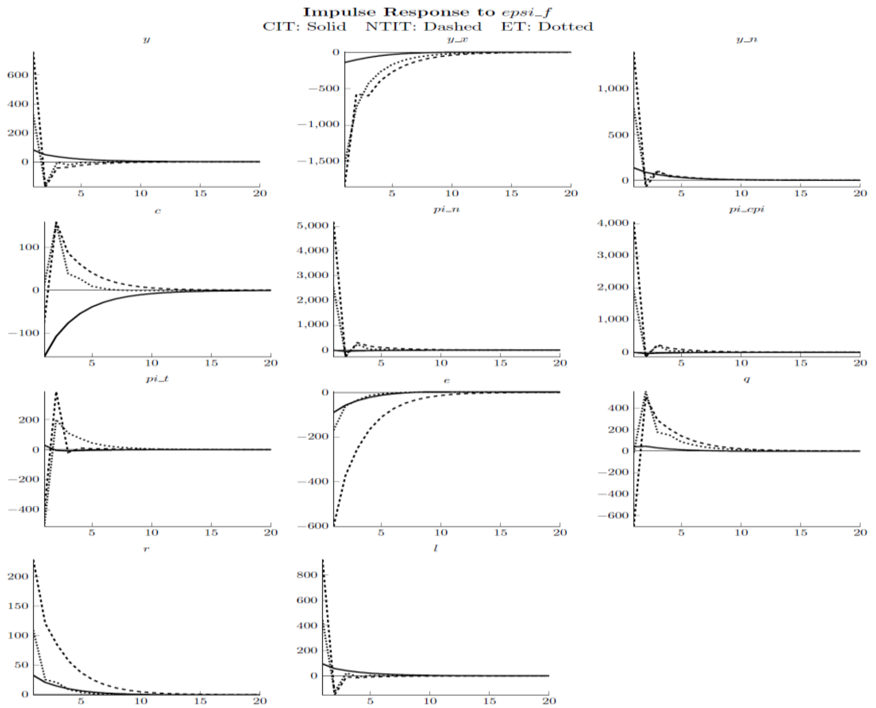

Figure 1. Impulse responses to commodity terms of trade shock
Source: Research results

4-1-3- Export productivity shocks

Figure 2 presents impulse responses to one standard deviation positive shock to export productivity. Based on research findings, the export productivity shock increases traded output under three alternative monetary policy rules. the export productivity shock decreases non-traded output and employment and increases consumption under three alternative rules. This case can be the result of the resources movement to the booming oil export sector, which can be the symptoms of the Dutch disease. An increase in consumption of imported good also leads to appreciates aggregate consumption and decreases employment. A Positive shock to export productivity improves productivity in non-traded sector, which leads to a fall in real marginal cost in non-traded sector. Based on this model, non-traded inflation is a function of next period`s expected inflation and real marginal cost in this sector, so real marginal cost deduction acts to fall non-traded inflation and CPI inflation. export sector productivity shock improvement and the consequent expansion in exported output induces an appreciation in export earnings that leads to increase nominal exchange rate. The export productivity shock appreciates real exchange rate under all rules, which shows the presence of the Balassa Samuelson effect. An increase in productivity in the commodity sector will tend to increase wages, which translate into an increase in the price of the non-traded good. As the relative price of the primary commodity is exogenously determined, the final effect will be an appreciation of the real exchange rate (Cashin, Céspedes, et al., 2004). Overall, the dynamic adjustment of most variables shows that CIT rule is superior to NTIT and ET rules because most of the selected variables are more stable under CIT rule. The good performance of inflation targeting is enhanced by its flexibility, credibility and the presence of flexible exchange rates which help to insulate the economy from shocks. Results of this study confirm Fridman`s (1953) discussion about merit of flexible exchange rate regime to nominal exchange rate regime under real shocks. Although, the efficient policy rule is dependent to kind of shock that hit the economy (Hove et al. (2015)), but a large number of empirical studies have found that CPI inflation targeting as superior policy rule under different shocks (Concalves and Salles (2008), Ball (1998), Svensoon (2000), Hove et al. (2015)).

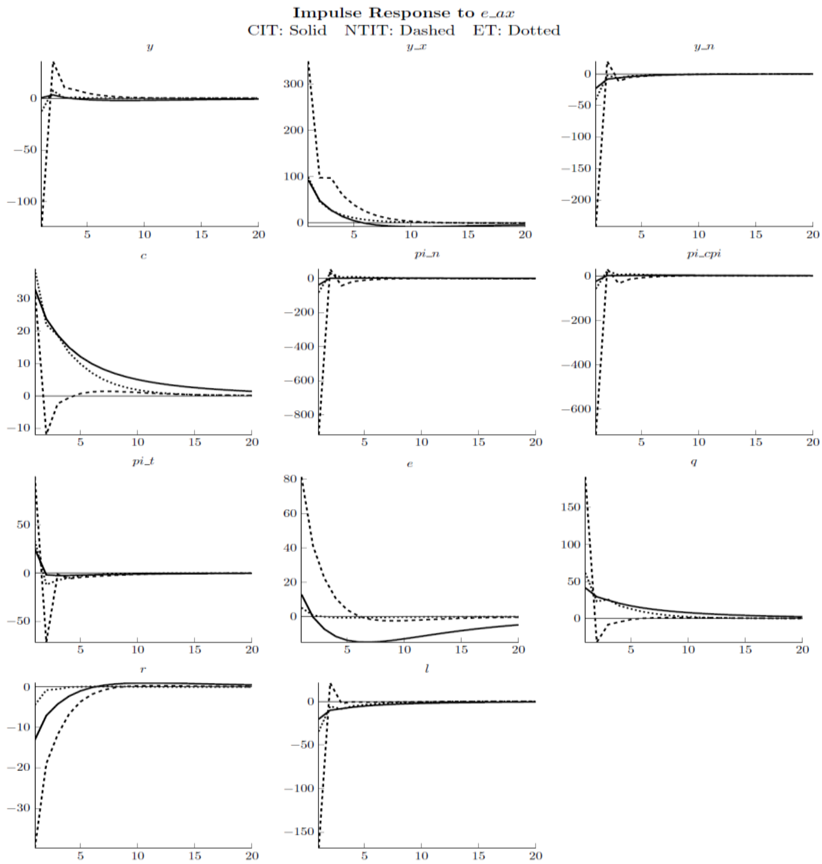

Figure 2. Impulse responses to an export sector productivity shock
Source: Research results

4-2- Volatility analysis of three alternative monetary policy rules

Tabel 2 compares the volatility of selected macroeconomic variables associated with alternative monetary policy rules. The results show that total output, non-traded output, exported output, labor supply, Real exchange rate, nominal exchange rate, CPI-inflation, non-traded inflation and interest rate induce the lowest volatility under CIT and highest under NTIT, this is consistent with Santacreu (2005), Devereux

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et al. (2006) and Hove et al. (2015) findings. Furthermore, consumption induces the lowest volatility under ET rule and highest under CIT rule. Generally, the volatility analysis confirms findings that were already evident from impulse responses, which CPI-inflation targeting outperforms other considered regimes.

Tabel 2. Standard Deviation of Macroeconomic variables
Source: Research results

Variable	**CIT**	**NTIT**	**ET**
total output	0.0538	0.3905	0.1823
non-traded output	0.0920	0.7091	0.3999
exported output	0.1006	1.0502	0.9001
labor supply	0.0634	0.4670	0.2299
Consumption	0.1092	0.1062	0.0809
real exchange rate	0.0359	0.4764	0.3046
nominal exchange rate	0.0587	0.3924	0.0921
non-traded inflation	0.0357	2.6054	1.2740
CPI-inflation	0.0294	2.0418	0.9683
interest rate	0.0216	0.1410	0.0571

Note: CIT is CPI inflation targeting, NTIT is non-traded inflation targeting and ET is exchange rate targeting. Bold values indicate the regime under which a volatility is lower.

4-3- Comparison of simulated data moments and real data moments

The moments of the calibrated model variables are compared with the moments of the identical variables in the real world. The degree of proximity to them is a good measure for fitting the model. **Tabel 3** compares the moments of some variables that shows the relative success of the model in simulating the realities of Iran's economy.

Tabel 3. Comparison of simulated data moments and real data moments
Source: Research results

Variable	The standard deviation of real data	The standard deviation of simulated data
Oil production	0.141527	0.1318
Non-oil production	0.14386	0.0927
Interest rate	0.079584	0.0295

5- Conclusions and suggestions

This essay focuses on the interaction of two characteristics of an oil exporting economy (oil dependence and vulnerability to terms of trade shocks) and their interactions with monetary policy and macroeconomic dynamics. the essay contributes to the literature by incorporating the oil sector and focusing on the commodity terms of trade shock in a multi-sector DSGE model, where incomplete exchange rate pass through is introduced via nominal rigidities on import prices. The analysis of the impulse response functions has shown that the CIT rule has had better performance than NTIT and ET rules in stabilizing the economy when it experiences the commodity terms of trade shocks or exported productivity shocks. So, the results generally suggest that the central bank can reduce macroeconomic volatility by targeting CPI inflation. performance of inflation targeting is enhanced by its flexibility, credibility and the presence of flexible exchange rates which help to insulate the economy from shocks. However, the increased flexibility of exchange rates in inflation targeting countries comes at the cost of higher exchange rate flexibility. This implies that inflation targeting in oil exporting economies need to pay attention to exchange rate fluctuations induced by commodity terms of trade shocks. Additionally, productivity shocks in export sector might provide problem of Dutch disease. improving this issue, policy makers should expend oil income for investment in non-traded sector instead of import of consuming goods, which are often cheap alternatives for domestic goods. It would be useful in future researches to examine how factors such as central bank independence, fiscal discipline and financial sector development do explain inflation target deviations from the target bands. Another interesting extension would be the incorporation of uncertainty of the commodity terms of trade shocks in the model. Uncertainty about the size and duration of the commodity terms of trade shock may affect the results since monetary policy responses may depend on whether the shock is temporary or permanent.

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