

The Impact of Fiscal Policy on Macroeconomic Variables: New Evidence from a DSGE Model

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Abstract

The purpose of this article is to analyze the macroeconomic impacts of fiscal policy in Iran using a new-Keynesian Dynamic Stochastic General Equilibrium (DSGE) model. The model takes into account distortionary taxations on wage, dividend, and consumption, while government expenditures are broken down into consumption of goods and services, and investment. The model is calibrated for Iran based on the estimated parameters by Bayesian method. To do so, a data set from 1981 to 2016 is used. The impulse response functions illustrate that an increase in consumption tax rate has a larger impact on the contraction of the economy than wage tax rate whereas the expansionary effects of government investment is much larger than government consumption expenditures.

Keywords: Fiscal policy, DSGE model, Distortionary taxation, Iran.

JEL Classification: E32, E62, D58.

1. Introduction

The role of fiscal policy in stabilizing the economy has been one of the most extensively discussed issues by both academics and policy-makers. Fiscal policy was at the heart of the tax discussion of Ramsey (1927) and macroeconomic analysis of Keynes (1936). Following these works was a path-breaking analysis on the optimal tax rule by Mirrlees (1971). A renewed emphasis on this issue has recently been observed in the US and European Monetary Union due to the recession of 2008 and the needs for designing fiscal stimulus plans and ensuing fiscal consolidation.

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Despite this emphasis, we know surprisingly very little about the effects of fiscal policy on economic activity (Perotti, 2001). From a theoretical point of view, the sign and magnitude of the impact of discretionary fiscal policy on aggregate demand depend on a number of key assumptions, with different models offering often opposite conclusions (de Castro and de Cos, 2008).

In practical terms, there are a lot of works studying different aspects of fiscal policy and its impacts on the economy. However, this empirical evidence does not provide a common picture. In particular, although most of the recent literature, based either on structural macro models (like Dynamic Stochastic General Equilibrium models) or on VAR analysis, shows positive short-term output multipliers stemming from public expenditure increases and tax cuts, the estimated magnitude and duration of these effects is very disperse (see de Castro and de Cos, 2008 and Henry et al., 2004 for more discussion). There is even some evidence of negative fiscal multipliers for some OECD countries in the post-1980 period (Perotti, 2004).

This paper aims at providing evidence for the case of Iran on the effects of exogenous fiscal policy shocks on key macroeconomic variables within a DSGE framework. The DSGE models developed in order to assess the dynamics impacts of shocks arising from the demand or supply side of the economy or fiscal and monetary policies (Bhattarai and Trzeciakiewicz, 2012). These models provide a reliable tool for evaluating alternative policy measures. For this reason, fiscal policy analysis in DSGE models has gained momentum recently. The applications of such models include the assessment of temporary versus permanent fiscal stimulus, the assessment of structural changes in public tax and spending policy, the analysis of fiscal multipliers and the role of private demand as well as fiscal policy's interaction with monetary policy (Stähler and Thomas, 2011).

Relevant studies include Gali and Monacelli (2008), who analyze optimal fiscal and monetary policy in a currency union; Forni et al. (2009), who estimate the effects of fiscal policy in the Euro area; Iwata (2009), who models fiscal policy in Japanese economy in order to study how the fiscal authority's financing behavior affects dynamic responses to a government spending shocks; Colciago et al. (2009), who assess the role of automatic stabilizers in a monetary union; Leeper et al. (2010), who assess dynamics of fiscal financing in the united states; Stähler and

Thomas (2011), who simulate fiscal policy in a two-country monetary union structure; Bhattarai and Trzeciakiewicz (2012), who analyze several policy measures in the UK economy; and Christiano et al. (2009), Cogan et al. (2009), Hall (2009), and Zubairy (2010), all of which analyze fiscal multipliers.

Also, there are a wide set of studies in Iran which use DSGE framework to model the economy. Motavaseli et al. (2010), Moshiri et al. (2011), Komijani and Tavakolian (2012), and Daliri and Mehragan (2015) are among these researches. Despite this fairly large body of literature on DSGE modelling in Iran, few of these studies analyze the impacts of fiscal policy shocks in the country. The DSGE model presented in this paper contributes to the literature in two important ways. First, it presents a model for fiscal policy in Iran, which includes the interaction between fiscal and monetary policies in Iran. Second, it covers five important fiscal policy instruments including three distortionary taxes (tax on the consumption, wage, and dividend), government consumption expenditure, and government investment expenditure.

This paper is organized as follows. Section 2 describes in detail the model and assumptions regarding policies. Section 3 sketches the techniques used to solve and simulate the model, describes the data and priors, and explains macroeconomic effects of fiscal policy instruments in the model. Finally, section 4 summarizes the results.

2. The Model

The model consists of three main sectors: households, firms, and fiscal-monetary authority. It is supposed that households and firms are optimizing agents; households maximize their lifetime utility functions subject to inter-temporal budget constraint, and firms maximize their inter-temporal profits. Due to the important role of oil sector in Iran's economy, it is assumed that total product consists of non-oil and oil products. While oil sector is supposed to follow an autoregressive exogenous stochastic process, non-oil sector is modeled similar to Smets and Wouters (2003, 2007). There are two types of firms in the non-oil sector: perfectly competitive final-good firm and monopolistically competitive intermediate-good firms. Intermediate-good firms set prices similarly to the mechanism presented in Calvo (1983). The final-good firm combines intermediate goods and produces final goods. Finally, with regard to Iran's

context, it is assumed that government is the fiscal and monetary policymaker, as central bank in Iran has a very low level of independence.

To capture the research's goals, five fiscal instruments are included in the model: consumption tax, wage tax, dividend tax, government consumption expenditure, and government investment expenditure.

2-1. Households

Lifetime utility of the i^{th} household is a separable function of its consumption $c_t(i)$, labor $L_t(i)$, and real money $m_t(i) = \frac{M_t(i)}{P_t}$ given by

$$E_t \sum_{t=0}^{\infty} \beta^t \left[\frac{c_t(i)^{1-\sigma_c}}{1-\sigma_c} - \frac{L_t(i)^{1+\sigma_L}}{1+\sigma_L} + \frac{m_t(i)^{1-\sigma_m}}{1-\sigma_m} \right] \quad (1)$$

where E_t is the expectation operator, $\beta \in (0,1)$ is the discount factor, σ_c denotes the inverse elasticity of substitution, σ_L is the inverse elasticity of work effort with respect to real wages, and σ_m is the inverse elasticity of real money with respect to interest rate, and $\sigma_c, \sigma_L, \sigma_m > 0$.

Household i faces a flow budget constraint (expressed in real terms) as follows

$$c_t(i) + I_t(i) + m_t(i) + b_t(i) + or_t = (1 - \tau_t^w)w_t(i)L_t(i) + r_t^k K_{t-1}(i) + \frac{m_{t-1}(i)}{\pi_t} + (1 + r_{t-1})\frac{b_{t-1}(i)}{\pi_t} + (1 - \tau_t^D)D_t(i) \quad (2)$$

This constraint guarantees that household's income and expenditure are equal. Household's income includes net labor income $(1 - \tau_t^w)w_t(i)L_t(i)$, net income from dividends distributed by firms to households $(1 - \tau_t^D)D_t(i)$ (by assumption, households are the firms' owners), the income from renting capital services to firms $r_t^k K_{t-1}(i)$, and the income from bondholding $r_{t-1} \frac{b_{t-1}(i)}{\pi_t}$ (where r_{t-1} denotes the real interest rate on the one-period bond). π_t is the gross inflation rate, $\pi_t = \frac{P_t}{P_{t-1}}$, where P_t is the consumer price index. The fiscal authority issues one period maturity bonds $b_t = \frac{B_t}{P_t}$ and levies taxes on labor income τ_t^w , dividends τ_t^D , and consumption τ_t^c . Consumption tax makes a gap between the producer price index \tilde{P}_t and the consumers price index $P_t = (1 + \tau_t^c)\tilde{P}_t$. Finally, as the model is closed (export and import aren't included in the model), it is assumed that households buy oil instead of foreigners. Therefore, household i spends its income for consumption (non-oil and oil products), investment $I_t(i)$, bondholding b_t , and taxes, and also hold real money $m_t(i)$.

The physical capital accumulation law is

$$K_t(i) = (1 - \delta_k)K_{t-1}(i) + I_t(i) \quad (3)$$

where δ_k is the depreciation rate of private capital, $\delta_k \in (0,1)$. Households maximize the utility function subject to equations (2) and (3) with respect to $c_t(i)$, $L_t(i)$, $b_t(i)$, $K_t(i)$, $I_t(i)$, and the two Lagrangian multipliers, λ_t , and Q_t respectively. In the symmetric equilibrium, labor supply, money demand, Euler equation, and Fisher equation are obtained from the corresponding first order conditions as follows

$$\frac{L_t^{\sigma_L}}{c_t^{-\sigma_c}} = (1 - \tau_t^w)W_t \quad (4)$$

$$m_t^{-\sigma_m} = c_t^{-\sigma_c} \left[1 - \frac{1}{1+r_t} \right] \quad (5)$$

$$c_t^{-\sigma_c} = \beta(1 + r_t)E_t \frac{c_{t+1}^{-\sigma_c}}{\pi_{t+1}} \quad (6)$$

$$(1 + r_t) = E_t \pi_{t+1} [r_{t+1}^k + (1 - \delta_k)] \quad (7)$$

2-2. Firms

Regarding oil sector is an important part of the economy, it is assumed that the total product (Y_t^T) is the sum of oil (or_t) and non-oil (Y_t) products as follows

$$Y_t^T = or_t + Y_t \quad (8)$$

Since oil products mostly depend on the oil reserves and don't change substantially due to the increase in labor and capital, this sector is modeled as an autoregressive exogenous stochastic process of the form¹

$$\widehat{or}_t = \rho_{or} \widehat{or}_{t-1} + \varepsilon_t^{or} \quad (9)$$

where ε_t^{or} is an i.i.d. normally distributed error, $\varepsilon_t^{or} \sim N(0, \sigma_A^2)$. Non-oil sector is modeled as producing firms. There are two types of firms in this sector: perfectly competitive final-good firm and monopolistically competitive intermediate-good firms indexed by $j \in [0,1]$. The final-good firm produces the final good Y_t by using the differentiated intermediate goods $y_t(j)$ produced by the firm j .

2-2-1. Final-good firm

The competitive final-good producing firm purchases differentiated goods $y_t(j)$ from intermediate-good producers and combines them into one single good Y_t using the following bundler technology

¹ The hats above variables denote log-deviations from steady state.

$$Y_t = \left[\int_0^1 y_t(j)^{\frac{\theta-1}{\theta}} dj \right]^{\frac{\theta}{\theta-1}} \quad (10)$$

where $\theta > 1$ denotes the elasticity of substitution of differentiated intermediate goods. Final-good firm maximizes its profit as follows

$$\max_{y_t(j)} \pi_t = \tilde{P}_t \left[\int_0^1 y_t(j)^{\frac{\theta-1}{\theta}} dj \right]^{\frac{\theta}{\theta-1}} - \int_0^1 \tilde{P}_t(j) y_t(j) dj \quad (11)$$

where $\tilde{P}_t(j)$ is the price of the intermediate good $y_t(j)$. The first-order condition results in the demand function for intermediate goods

$$y_t(j) = \left(\frac{\tilde{P}_t(j)}{\tilde{P}_t} \right)^{-\theta} Y_t \quad (12)$$

Putting equation 12 into the bundler technology of the final-good firm with zero profit condition gives the price index as follows

$$\tilde{P}_t = \left[\int_0^1 \tilde{P}_t(j)^{1-\theta} dj \right]^{\frac{1}{1-\theta}} \quad (13)$$

2-2-2. Intermediate-good firms

Following Stähler and Thomas (2011), each monopolistic intermediate-good firm indexed by $j \in [0,1]$ produces its differentiated output using the following Cobb-Douglas technology

$$y_t(j) = A_t K_{t-1}(j)^\alpha L_t(j)^{1-\alpha} (K_{t-1}^G)^\gamma \quad (14)$$

where $\alpha \in [0,1]$ is the elasticity of output with respect to private capital, $L_t(j)$ denotes the labor input, $K_{t-1}(j)$ is the capital stock available in period t and A_t is technology shock which denotes total factor productivity (TFP). It is assumed that A_t follows a first-order autoregressive process

$$\hat{A}_t = \rho_A \hat{A}_{t-1} + \varepsilon_t^A \quad (15)$$

where ε_t^A is an i.i.d. normally distributed error, $\varepsilon_t^A \sim N(0, \sigma_A^2)$. Also, K_{t-1}^G is the public capital stock available in period t , which is determined by the government. It is assumed that public capital enhances productivity. The parameter $\gamma \in [0,1]$ shows how public capital affects private production (see Leeper et al., 2010 for more discussion).

Intermediate-good firms obtain labor and private capital in perfectly competitive factor markets at real (CPI-deflated) prices w_t and r_t^k , respectively. These firms face the following cost minimization problem

$$\min_{L_t(j), K_{t-1}(j)} \Xi_t(j) = w_t L_t(j) + r_t^k K_{t-1}(j) \quad (16)$$

$$St: \quad y_t(j) = A_t K_{t-1}(j)^\alpha L_t(j)^{1-\alpha} (K_{t-1}^G)^y$$

Cost minimization subject to the production technology yields labor and capital demands as follows

$$w_t = (1 - \alpha) m c_t \frac{y_t(j)}{L_t(j)} \quad (17)$$

$$r_t^k = \alpha m c_t \frac{y_t(j)}{K_{t-1}(j)} \quad (18)$$

where $m c_t$ is the real (CPI-deflated) marginal cost, which is common to all intermediate-good firms. Putting equations 17 and 18 in equation 14 gives marginal cost as follows

$$m c_t = \frac{1}{A_t (K_{t-1}^G)^y} \left(\frac{w_t}{1 - \alpha} \right)^{1-\alpha} \left(\frac{r_t^k}{\alpha} \right)^\alpha \quad (19)$$

From the combination of inputs' demands (equations 17 and 18), the wage rental ratio is obtained as follows

$$\frac{L_t(j)}{K_{t-1}(j)} = \frac{1 - \alpha}{\alpha} \frac{r_t^k}{w_t} \quad (20)$$

Real profit of each intermediate-good firms D_t is defined as the difference between total real revenue TR_t and total real expenditure TC_t . Total revenue of the firm j is equal to producer price index \tilde{P}_t multiplied by firm's total products $y_t(j)$, so

$$\frac{TR_t(j)}{P_t} = \frac{\tilde{P}_t y_t(j)}{\tilde{P}_t (1 + \tau_t^c)} = \frac{y_t(j)}{1 + \tau_t^c} \quad (21)$$

Regarding the inputs demands, total real expenditure is given by the following

$$\frac{TC_t(j)}{P_t} = \Xi_t(j) = m c_t y_t(j) \quad (22)$$

Therefore, real profit of the firm j is

$$D_t(j) = \frac{y_t(j)}{1 + \tau_t^c} - m c_t y_t(j) \quad (23)$$

2-2-3. Price setting

In addition to minimizing costs, intermediate-good firms face price setting and its adjustments. It is assumed that intermediate goods' prices aren't flexible. The mechanism presented in Calvo (1983) is used for modelling price rigidity in this paper. Each period, a randomly chosen fraction $\omega \in [0,1)$ of firms cannot re-optimize their price but the others can. A firm with the chance to re-optimize its price in period t chooses the new price $\tilde{P}_t^*(j)$ in a way that maximizes

$$\max_{\tilde{P}_t(j)} E_t \sum_{s=0}^{\infty} (\beta\omega)^s \frac{\lambda_{t+s}}{\lambda_t} \{ [\frac{\tilde{P}_t(j)}{P_{t+s}} - mc_{t+s}] y_{t+s}(j) \} \quad (24)$$

subject to the demand function for intermediate goods (equation 12). The optimizing firm knows the probability ω^s that the price it chooses in this period will still be in effect s periods in the future. In addition, λ_t is the Lagrangian multiplier on household's budget constraint and is exogenous for firms. Therefore, $(\beta\omega)^s \frac{\lambda_{t+s}}{\lambda_t}$ shows a discount factor of the future of firms. All firms re-optimizing their prices in period t set new prices equal to \tilde{P}_t^* . After replacing \tilde{P}_t^* instead of $\tilde{P}_t(j)$, first order condition for optimal price would be

$$E_t \sum_{s=0}^{\infty} (\beta\omega)^s \frac{\lambda_{t+s}}{\lambda_t} \left[\frac{(1-\theta)}{(1+\tau_{t+s}^c)} \left(\frac{\tilde{P}_t^*}{\tilde{P}_{t+s}} \right)^{-\theta} + \theta mc_{t+s} \left(\frac{\tilde{P}_t^*}{\tilde{P}_{t+s}} \right)^{-\theta-1} \right] \left(\frac{1}{\tilde{P}_{t+s}} \right) Y_{t+s} = 0 \quad (25)$$

In case that all firms are allowed to re-optimize their prices, the above condition reduces to $\tilde{P}_t = \frac{\theta}{\theta-1} (1 + \tau_{t+s}^c) mc_t$, which shows that the optimized price is equal to a markup over the marginal costs. Taking into consideration equation 13, aggregate price index is expressed as

$$\tilde{P}_t = [(1-\omega)\tilde{P}_t^{*1-\theta} + \omega\tilde{P}_{t-1}^{*1-\theta}]^{\frac{1}{1-\theta}} \quad (26)$$

Combining equations 25 and 26 gives the producer price index equation named Hybrid New Keynesian Phillips Curve (HNKPC). The log-linearized form of this equation is as follows

$$\hat{\tilde{\pi}}_t = \kappa \left(\hat{m}c_t + \frac{\bar{\tau}^c}{1 + \bar{\tau}^c} \hat{\tau}_t^c \right) + \beta E_t \hat{\tilde{\pi}}_{t+1}, \quad \kappa = \frac{(1-\omega\beta)(1-\omega)}{\omega} \quad (27)$$

2-3. Fiscal-monetary authority

Many researches have confirmed low independence level of Iran's central bank and the dominance of fiscal policies in the country (for example, see Moshiri et al., 2011 and Komijani and Tavakolian, 2012). Therefore, it is assumed that government is responsible for fiscal and monetary policies in this paper. Government seeks to balance its budget

and central bank behaves in a way that government can keep budget balance. Total government expenditure include consumption expenditure c_t^G and investment expenditure I_t^G . Government finances its expenditure by collecting taxes (consumption tax, wage tax, and dividend tax) and selling oil. Suppose GE_t and GR_t are total real expenditure and total real income of government respectively, then

$$GE_t = c_t^G + I_t^G \quad (28)$$

$$GR_t = \frac{\tau_t^c c_t}{1+\tau_t^c} + \tau_t^w w_t L_t + \tau_t^D D_t + or_t \quad (29)$$

Government income from consumption tax is equal to $\tau_t^c \beta_t C_t$ (as τ_t^c is levied on the producer value of goods), so the real consumption tax revenue equals $\frac{\tau_t^c \beta_t C_t}{(1+\tau_t^c)\beta_t} = \frac{\tau_t^c c_t}{1+\tau_t^c}$. It is obvious from the definitions that the whole government revenues and expenditures aren't covered in the model. We exclude some items that are of minor importance and that are hard to consistently implement into the model. Also, the model doesn't cover taxes on imports, because it is a closed model. However, the revenue side covers about 77% of tax revenues and taking into consideration oil revenues, the model captures 70% of total government revenues in 2015.

As government has experienced budget deficits in most years of the considered period, the model must capture this item. To do so, real budget deficit BD_t is defined as the difference between total government expenditure and total government revenue, so

$$BD_t = GE_t - GR_t \quad (30)$$

Government finances its deficit through borrowing from private sector (by issuing participation bonds b_t) and central bank (by seigniorage m_t). Also, it has to pay interest and principal payments on the bonds it issued in $t-1$. As a result, budget deficit defines as

$$BD_t = b_t - (1 + r_{t-1}) \frac{b_{t-1}}{\pi_t} + (m_t - \frac{m_{t-1}}{\pi_t}) \quad (31)$$

Here, m_t can be defined as the net government debt to the central bank.¹ If total government debt tl_t^G defines as the sum of government borrowing

¹ According to the central bank's balance sheet, central bank liabilities are equal to its assets, which equals the base money. Hence, currency in circulation plus government and banks deposits in central bank (as its liabilities) is equal to foreign reserves plus loans extended to government and banks (as its assets). Suppose all banks of Iran are government-owned, so we can add banks' deposit and debt to the government account. Therefore, currency in circulation equals foreign reserves plus net government debt to central bank (defined as the difference between government deposit and its debt). Since our model is closed, we cannot add foreign reserves in the model, and so currency in circulation equals net government debt to central bank.

from private sector and central bank ($tl_t^G = b_t + m_t$), equation 31 can be re-write in the following way

$$\hat{t}l_t^G = \frac{\hat{t}l_{t-1}^G}{\pi_t} + r_{t-1} \frac{b_{t-1}}{\pi_t} + BD_t \quad (32)$$

Equation 32 is the debt accumulation equation which shows that government debt in each period is a result of the accumulation of fiscal deficits over the previous periods. Generally, controlling government debt is a key driver for fiscal policies. This has been considered for modelling fiscal rules in the most important studies in this area (for example, see Forni et al., 2009; Iwata, 2009; and Leeper et al., 2010).

With regard to the related studies and the economic theories, it is assumed that taxes are affected mostly by output \hat{Y}_t^T (GDP) and total government debt $\hat{t}l_{t-1}^G$. Therefore, consumption tax, wage tax, and dividend tax follow the bellow rules.

$$\hat{t}_t^c = \rho_{\tau^c} \hat{t}_{t-1}^c + (1 - \rho_{\tau^c}) \eta_{\tau^c, t} \hat{t}l_{t-1}^G + (1 - \rho_{\tau^c}) \eta_{\tau^c, Y} \hat{Y}_t^T + \varepsilon_t^{\tau^c} \quad (33)$$

$$\hat{t}_t^w = \rho_{\tau^w} \hat{t}_{t-1}^w + (1 - \rho_{\tau^w}) \eta_{\tau^w, t} \hat{t}l_{t-1}^G + (1 - \rho_{\tau^w}) \eta_{\tau^w, Y} \hat{Y}_t^T + \varepsilon_t^{\tau^w} \quad (34)$$

$$\hat{t}_t^D = \rho_{\tau^D} \hat{t}_{t-1}^D + (1 - \rho_{\tau^D}) \eta_{\tau^D, t} \hat{t}l_{t-1}^G + (1 - \rho_{\tau^D}) \eta_{\tau^D, Y} \hat{Y}_t^T + \varepsilon_t^{\tau^D} \quad (35)$$

where $\varepsilon_t^{\tau^c}$, $\varepsilon_t^{\tau^w}$, and $\varepsilon_t^{\tau^D}$ are i.i.d. normally distributed errors as $\varepsilon_t^{\tau^G}$. The above equations represent positively responds to output and government debt. Also, government consumption and investment expenditures are supposed to follow the feedback rules that respond to output and government debt as follows

$$\hat{l}_t^G = \rho_{I^G} \hat{l}_{t-1}^G - (1 - \rho_{I^G}) \eta_{I^G, t} \hat{t}l_{t-1}^G + (1 - \rho_{I^G}) \eta_{I^G, Y} \hat{Y}_t^T + \varepsilon_t^{I^G} \quad (36)$$

$$\hat{c}_t^G = \rho_{c^G} \hat{c}_{t-1}^G - (1 - \rho_{c^G}) \eta_{c^G, t} \hat{t}l_{t-1}^G + (1 - \rho_{c^G}) \eta_{c^G, Y} \hat{Y}_t^T + \varepsilon_t^{c^G} \quad (37)$$

where $\varepsilon_t^{I^G}$ and $\varepsilon_t^{c^G}$ are i.i.d. normally distributed errors. Theoretically, government expenditures are expected to decrease with increasing government debt, and so, $\hat{t}l_{t-1}^G$ has negative coefficients in equations 36 and 37. Also, positive coefficients of \hat{Y}_t^T imply that government expenditures are not counter-cyclical. Although one of the most important tasks of fiscal policy is to stabilize economy through countercyclical movements during the booms and recessions, evidences show a reverse function for government expenditures in Iran (for example, see Samadi and Oujimehr, 2011; Ghasemi and Mohajeri, 2015; and Zarei, 2015). For this reason, it is

supposed that government consumption and investment expenditures respond positively to the output.

Given government investment, the stock of public physical capital evolves as follows

$$K_t^G = (1 - \delta_K^G)K_{t-1}^G + I_t^G \quad (38)$$

where the public capital stock depreciates at rate δ_K^G (which may potentially be different from the private sector depreciation rate).

Following Motavaseli et al. (2010) and Komijani and Tavakolian (2012), government is assumed to follow McCallum rule for monetary policy, so the money is supplied as

$$\vartheta_t = \frac{M_t}{M_{t-1}} \quad (39)$$

where ϑ_t is the growth rate of money. Defining $m_t = \frac{M_t}{P_t}$, we obtain

$$\vartheta_t = \frac{\pi_t m_t}{m_{t-1}} \quad (40)$$

It is assumed that monetary growth rule is as follows

$$\hat{\vartheta}_t = \rho_m \hat{\vartheta}_{t-1} + \varepsilon_t^m \quad (41)$$

where ρ_m is to capture the persistence of the money growth and ε_t^m is a money supply shock.

2-4. Aggregation and market clearing

The final goods market is in equilibrium when the aggregate supply equals the aggregate public and private demands for consumption and investment. Equilibrium in the goods market can be derived by the sum of households and government budget constraints as follows

$$\frac{c_t}{1+\tau_c^G} + I_t + c_t^G + I_t^G = w_t L_t + r_t^k K_{t-1} + D_t = Y_t^T \quad (42)$$

The labor market is in equilibrium when the total labor supplied by households is equal to the total labor demanded by the intermediate-good firms at a real wage rate of w_t , and the capital market is in equilibrium when the capital demanded by intermediate-good firms equals the capital supplied by households at a real rental rate r_t^k .

3. The Simulation Results

First order conditions are log-linearized around the steady state and the model is solved using linear techniques. The model is simulated using

Dynare 4.5.0 software for Matlab, which is now a standard software in simulating DSGE models. The log-linearized form of the model is reported in the appendix.

3-1. "Data" and erase "and prior distribution"

It is necessary to set priors as initial information for simulation. The calibration strategy for model's ratios and parameters is to, first, set key steady-state ratios equal to their real world counterparts using available data. Data is derived from the Statistical Centre of Iran for the period from 1981 to 2016. In the first calibration strategy, we calibrated the model's steady-state ratios based on observed data, using the average amount of variables during the period. With Regard to the tax rates, we calculated them as average effective tax rates, dividing the government revenues from a specific kind of taxes by its corresponding base. The model's ratios are summarized in Table 1.

Table 1. Steady-state ratios in the model

| Steady-state of | Symbol | Value |
|--|-------------------------------|--------|
| effective tax rate on wage | $\bar{\tau}^W$ | 0.04 |
| effective tax rate on consumption | $\bar{\tau}^C$ | 0.0149 |
| effective tax rate on dividend | $\bar{\tau}^D$ | 0.138 |
| consumption to GDP ratio | $\frac{\bar{c}}{\bar{Y}_t}$ | 0.515 |
| private investment to GDP ratio | $\frac{\bar{I}}{\bar{Y}_t}$ | 0.244 |
| government consumption to GDP ratio | $\frac{\bar{c}^G}{\bar{Y}_t}$ | 0.146 |
| government investment to GDP ratio | $\frac{\bar{I}^G}{\bar{Y}_t}$ | 0.095 |
| total government expenditure to budget deficit ratio | $\frac{\bar{GE}}{\bar{BD}}$ | 2.107 |
| total government revenue to budget deficit ratio | $\frac{\bar{GR}}{\bar{BD}}$ | 1.107 |
| government consumption to total government expenditure ratio | $\frac{\bar{c}^G}{\bar{GE}}$ | 0.41 |
| government investment to total government expenditure ratio | $\frac{\bar{I}^G}{\bar{GE}}$ | 0.39 |
| divided to total government revenue ratio | $\frac{\bar{D}}{\bar{GR}}$ | 0.8 |
| consumption to total government revenue ratio | $\frac{\bar{c}}{\bar{GR}}$ | 4.1 |

| | | |
|---|-----------------------------|-------|
| labor income to total government revenue ratio | $\frac{\bar{w}L}{\bar{GR}}$ | 0.1 |
| oil revenue to total government revenue ratio | $\frac{or}{\bar{GR}}$ | 0.6 |
| government borrowing from private sector to total government debt ratio | $\frac{b}{\bar{tl}^G}$ | 0.969 |
| budget deficit to total government debt ratio | $\frac{BD}{\bar{tl}^G}$ | 0.868 |
| seigniorage to total government debt ratio | $\frac{m}{\bar{tl}^G}$ | 0.031 |
| oil production to GDP ratio | $\frac{or}{\bar{Y}_t^T}$ | 0.134 |
| non-oil production to GDP ratio | $\frac{y}{\bar{Y}_t^T}$ | 0.866 |
| public capital depreciation rate** | δ_k^G | 0.022 |
| private capital depreciation rate** | δ_k | 0.014 |

Source: research results

* Steady-state ratios are calculated based on the data (means of data series in 1981- 2016).

** Public and private capital depreciation rates are derived from Komijani and Tavakolian (2012) calculated based on Iran's data.

Then, we set the model's structural parameters by (a) reproducing the mentioned steady-state ratios, (b) using estimated parameters from Bayesian method, and (c) following recent literature. The details of priors are presented in Table 2.

Table 2. Priors of model's parameters

| Parameter | | Prior | |
|--|----------------------|--------|-----------------------------|
| Definition | Symbol | Mean | Reference |
| Inverse elasticity of labor with respect to real wages | σ_L | 2.22 | Komijani &Tavakolian (2012) |
| Inverse elasticity of substitution | σ_C | 1.52 | Komijani &Tavakolian (2012) |
| Discount factor | β | 0.96 | Komijani &Tavakolian (2012) |
| Private capital share in production | α | 0.43 | Tavakolian (2015) |
| Public capital influence in production | γ | 0.19 | Komijani &Tavakolian (2012) |
| Autoregressive coefficient of technology shock | ρ_A | 0.84 | Komijani &Tavakolian (2012) |
| Degree of price indexation | ω | 0.58 | Komijani &Tavakolian (2012) |
| Elasticity of substitution of intermediate goods | θ | 4.33 | Authors calculation |
| Inverse elasticity of real money with respect to interest rate | σ_m | 2.24 | Komijani &Tavakolian (2012) |
| Autoregressive coefficient of monetary growth shock | ρ_m | 0.56 | Komijani &Tavakolian (2012) |
| Wage tax rate debt coefficient | $\eta_{\tau^w,tl}^G$ | 0.0043 | Authors' calculation |
| Consumption tax rate debt coefficient | $\eta_{\tau^c,tl}^G$ | 0.4175 | Author's calculation |
| Dividend tax rate debt coefficient | $\eta_{\tau^d,tl}^G$ | 0.1747 | Authors' calculation |

| | | | |
|--|-------------------|--------|----------------------|
| Government consumption debt coefficient | $\eta_{c,t c}$ | 0.0852 | Author's calculation |
| Government investment debt coefficient | $\eta_{i,t c}$ | 0.1129 | Authors' calculation |
| Government investment output coefficient | $\eta_{i,c,y}$ | 0.5149 | Author's calculation |
| Government consumption output coefficient | $\eta_{c,c,y}$ | 0.4702 | Authors' calculation |
| Consumption tax rate output coefficient | $\eta_{\tau^c,y}$ | 0.4904 | Author's calculation |
| Wage tax rate output coefficient | $\eta_{\tau^w,y}$ | 0.5737 | Authors' calculation |
| Divided tax rate output coefficient | $\eta_{\tau^D,y}$ | 0.4696 | Author's calculation |
| Autoregressive coefficient of government investment shock | $\rho_{i,c}$ | 0.5 | Authors' calculation |
| Autoregressive coefficient of government consumption shock | $\rho_{c,c}$ | 0.4803 | Author's calculation |
| Autoregressive coefficient of consumption tax rate shock | ρ_{τ^c} | 0.4854 | Authors' calculation |
| Autoregressive coefficient of wage tax rate shock | ρ_{τ^w} | 0.4998 | Author's calculation |
| Autoregressive coefficient of dividend tax rate shock | ρ_{τ^D} | 0.4887 | Authors' calculation |
| Autoregressive coefficient of oil revenue shock | ρ_{or} | 0.427 | Tavakolian (2016) |
| Standard deviation of oil revenue shock | σ_{or} | 0.01 | selected |
| Standard deviation of technology shock | σ_a | 0.01 | selected |
| Standard deviation of monetary growth shock | σ_m | 0.01 | selected |
| Standard deviation of government investment shock | $\sigma_{i,c}$ | 0.01 | selected |
| Standard deviation of government consumption shock | $\sigma_{c,c}$ | 0.01 | selected |
| Standard deviation of consumption tax rate shock | σ_{τ^c} | 0.01 | selected |
| Standard deviation of wage tax rate shock | σ_{τ^w} | 0.01 | selected |
| Standard deviation of dividend tax rate shock | σ_{τ^D} | 0.01 | selected |

Source: research results

3-2. Macroeconomic effects of fiscal policy instruments

This section presents impulse response functions of the fiscal policy shocks to investigate macroeconomic effects of government fiscal instruments.¹ On each graph presenting the impulse response, the horizontal axis shows time in quarters, and the vertical axis denotes the percentage deviation from the steady state.

3-2-1. Macroeconomic effects of consumption tax

Figure 1 represents the impulse response functions to a one standard deviation consumption tax shock. As it is seen, an increase in the consumption tax rate results in an increase in prices. Consequently, the consumption of households decreases. Furthermore, inflation induces a decrease in the real rate of return and real wages, the decreasing rate of the first is more though. Hence, capital to labor ratio is expected to rise.

¹ For the impulse response functions, we always use a one-standard deviation shock, equals 0.01 which can be found in Table 2.

Lower demand for goods, induced by the consumption tax rise, causes firms decrease output by decreasing demands for labor and capital.

The real tax revenue rises but its increase is significantly smaller than 1%: the increase of consumption taxes induces a substantial decrease in wage tax and dividend tax bases. However, budget deficit and, hence, government debts decrease.

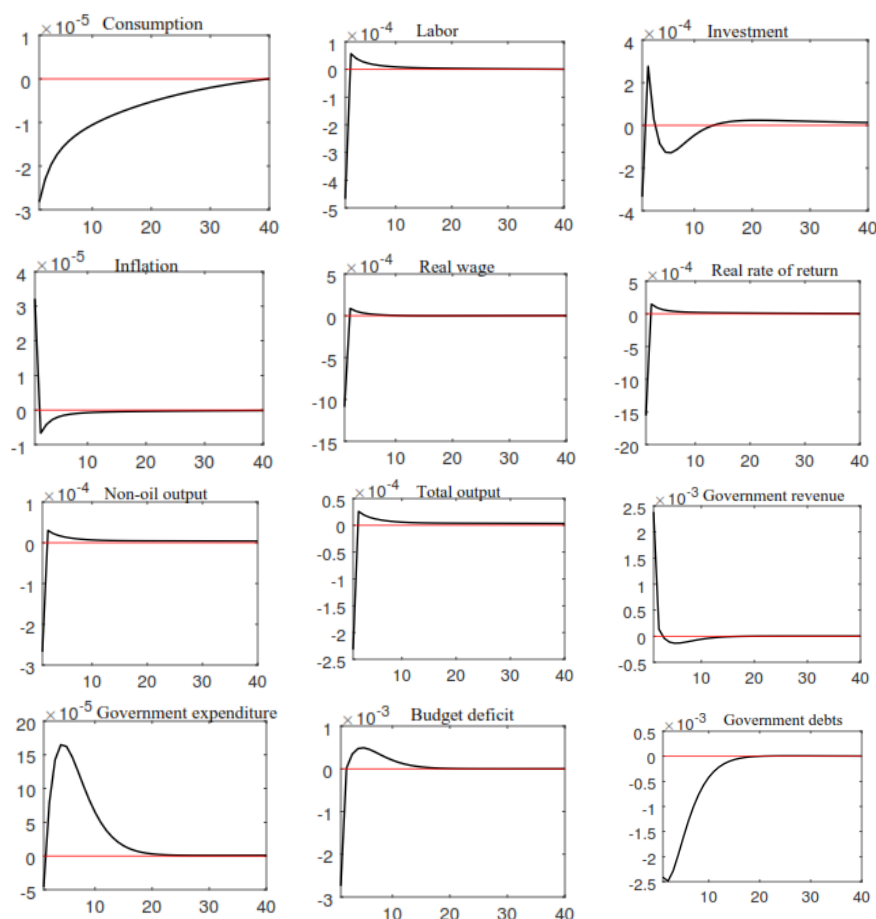


Figure 1. Responses to a one standard deviation consumption tax shock

3-2-2. Macroeconomic effects of dividend tax

In this research, dividend tax is assumed to be imposed on the dividends distributed by firms to households. In other words, this kind of tax is supposed to impose after distributing dividends to households (when

they receive dividends), so it isn't surprising if dividend tax doesn't decrease firms' output.¹ The impulse response functions to a one standard deviation dividend tax shock is shown in Figure 2.

The main effect of an increase in dividend tax rate is a reduction of private consumption due to the decrease in households' disposable income. However, it doesn't decrease output as the raised government revenues results in (a) an increase in government expenditures which compensates the decrease of aggregated demand caused by lower levels of consumption, and (b) a raised public capital which increase the output of intermediate-good firms. However, it should be noticed that the total impact of dividend tax shock on output is low.

Also, the results show that dividend tax shock drives firms to demand more labor and capital, which results in higher levels of wage and rate of return. This makes marginal cost of production larger, and hence, inflation rate rises. After the increase in government revenues, and hence, government investment, the reallocation of private and public capitals (crowding-out effect) _from private to public capital_ decreases private investment in the next periods.

¹ An extension of this model would be reflecting dividend tax in firm's profit equation.

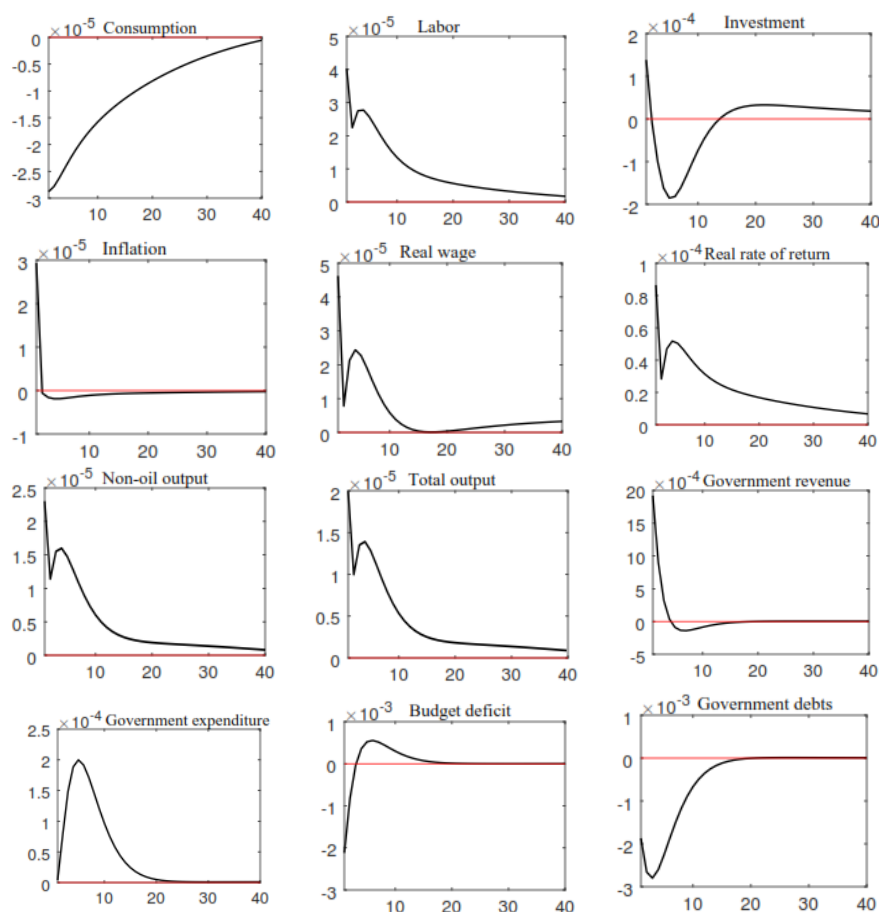


Figure 2. Responses to a one standard deviation dividend tax shock

3-2-3. Macroeconomic effects of wage tax

Figure 3 illustrates impulse response functions to a one standard deviation wage tax shock. The increase in wage tax rate leads to a descending shift of labor supply. On the other hand, it induces a decrease in household's disposable income and consumption. Aggregate demand decreases, and hence output and employment also fall. Real wages and inflation rises as results of decreased labor supply and lower aggregate demand. Similar to other kinds of taxes, wage tax shock increases real tax revenue, so decreases budget deficit and government debts.

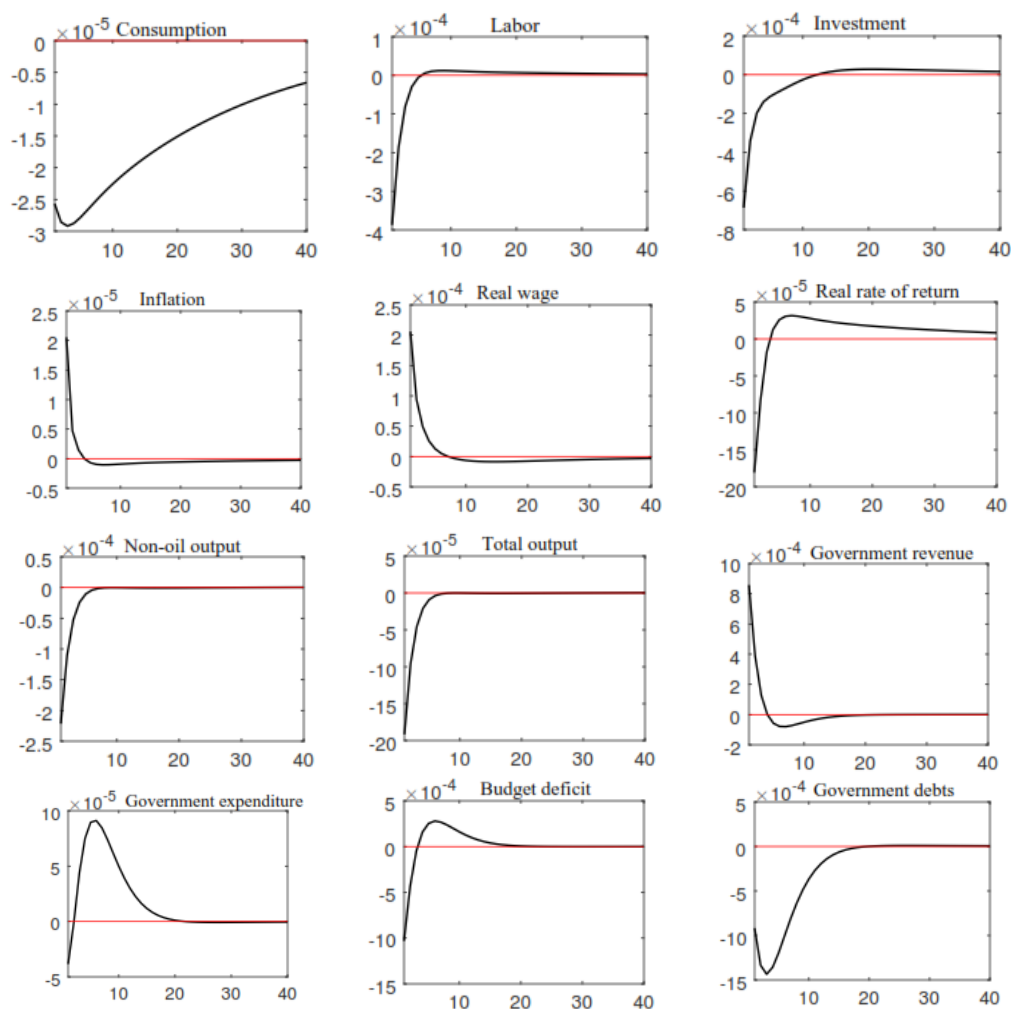


Figure 3. Responses to a one standard deviation wage tax shock

3-2-4. Macroeconomic effects of government consumption

Figure 4 shows the impulse responses with respect to a shock to real government consumption of goods and services. As it can be seen, higher level of government consumption increases output, because a positive government consumption shock means an increase in the government's demand for goods and services which, in turn, results in a raised aggregated demand.

Increased demand for goods brings about an increase in prices and encourages firms to rise output by increase in labor demand, which puts upward pressure on wages. As a result, employment and labor income increase, while investment drops due to the increase in the real rate of return.

Since all households in the model are forward-looking and optimizing households, the negative wealth effect generated by the higher levels of (current and future) taxes needed to finance the fiscal expansion leads to a negative response of private consumption to an increased government consumption. Furthermore, a positive government consumption shock increase budget deficit and government debt.

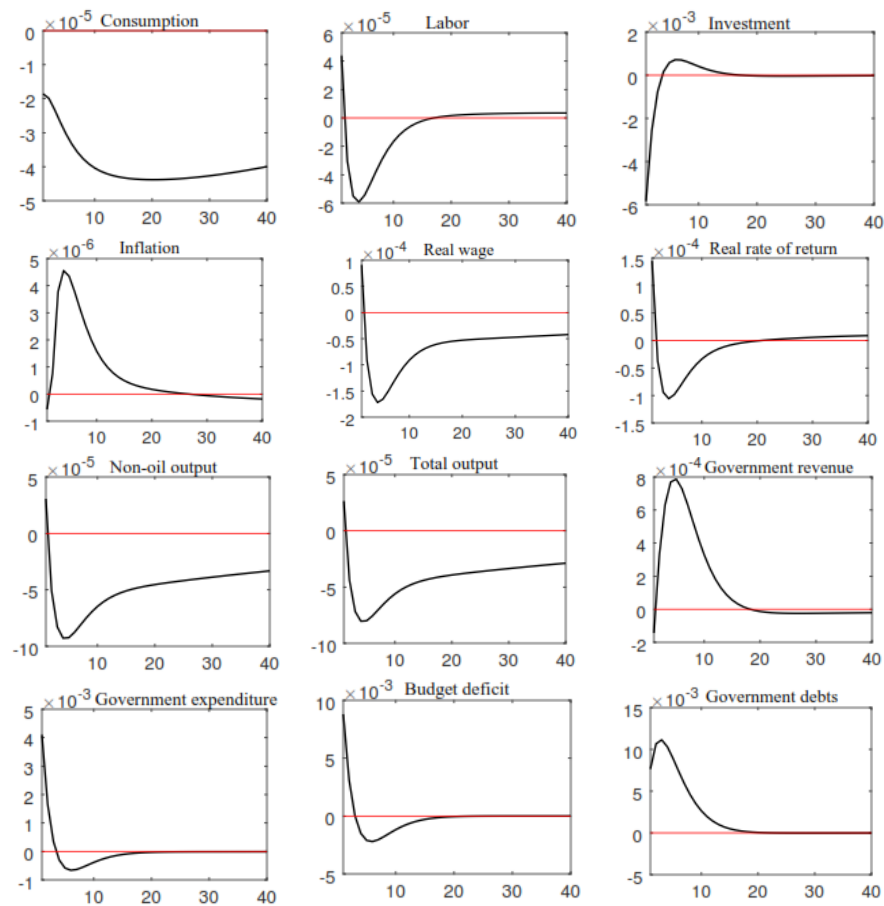


Figure 4. Responses to a one standard deviation government consumption shock

3-2-5. Macroeconomic effects of government investment

The impulse responses of the government investment shock can be seen in Figure 5. A comparison of Figures 4 and 5 demonstrates the main difference between the effects of the public investment and public consumption: government investment, apart from the increase in the aggregate demand, also leads to a continuous increase in public capital, which subsequently results in a long-lasting increase in output. This impact is lasting for a long time in a way that output will not return to the equilibrium level after 40 periods.

According to the results, a crowding-out effect is appeared after a government investment shock, which brings about a decrease in private capital utilization. Due to the positive response of supply side to public investment shock, inflation falls which, in turn, increases real rate of return and real wage.

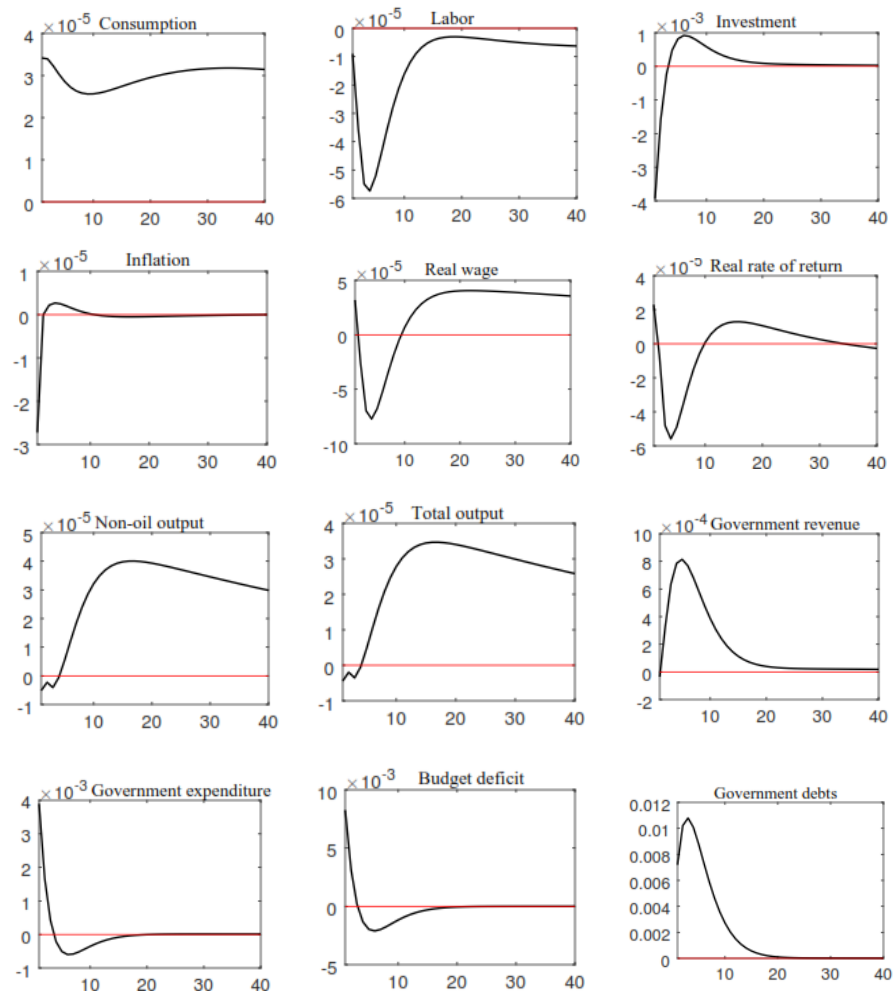


Figure 5. Responses to a one standard deviation government investment shock

4. Conclusion

This paper has presented new evidence regarding the macroeconomic effects of fiscal policy in Iran. To this end, a dynamic stochastic general equilibrium model has been developed and simulated. A data series from 1981 to 2016 has been used in the simulation.

Analyzing the impulse response functions of fiscal policy instruments shows the expected impacts of contractionary fiscal policies through the consumption tax and wage tax. However, leaving tax on the dividends distributed to the households decreases households' disposable income and consumption, while it doesn't affect firms' profits at the first time and increases output through a raised public capital. Also, comparing the impulse response functions of government investment and government consumption reveals that government investment induces a larger increase in output, which lasts for a long time.

While the model is rather general, the focus is restricted to a closed economy. Although this model is a good baseline for developing DSGE modelling of fiscal policy in Iran, it might still miss some effects coming from the external channel. However, this is a topic for future research. In addition, the way of introducing dividend tax rate into the model will be reviewed in the future research in order to be better able to picture relevant features of this policy.

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Appendix: Log-Linearized Form of Model

In addition to eight autoregressive rules which are represented in the log-linearized forms in the context (including \hat{l}_t^c , \hat{c}_t^c , $\hat{\tau}_t^c$, $\hat{\tau}_t^w$, $\hat{\tau}_t^D$, \hat{A}_t , $\hat{\sigma}_t$, and $\hat{\sigma}\hat{\tau}_t$), the log-linearized forms of 20 remaining equations are reported bellow.

| | |
|--|--|
| Labor supply | $\sigma_l \hat{L}_t + \sigma_c \hat{c}_t = -\frac{\tau^w}{1-\tau^w} \hat{\tau}_t^w + \hat{w}_t$ |
| Euler equation | $\hat{c}_t = E_t \hat{c}_{t+1} - \frac{1}{\sigma_c} [\hat{R}_t - E_t \hat{\pi}_{t+1}]$ |
| Fisher relation between real return on capital \hat{r}_{t+1}^k and real net interest rate on the one-period bond | $E_t \hat{r}_{t+1}^k = \frac{1}{1-\beta(1-\delta_k)} [\hat{R}_t - E_t \hat{\pi}_{t+1}]$ |
| Money demand | $\hat{m}_t = \frac{\delta_c}{\delta_m} \hat{c}_t - \frac{\beta}{(1-\beta)\delta_m} \hat{R}_t$ |
| Marginal cost | $\hat{m}\hat{c}_t = (1-\alpha)\hat{w}_t + \alpha\hat{r}_t^k - \hat{A}_t - \gamma\hat{K}_{t-1}^G$ |
| Labor demand | $\hat{L}_t = \hat{r}_t^k - \hat{w}_t + \hat{K}_{t-1}$ |
| New Keynesian Phillips Curve | $\hat{\pi}_t = \kappa \left(\hat{m}\hat{c}_t + \frac{\bar{\tau}^c}{1+\bar{\tau}^c} \hat{\tau}_t^c \right) + \beta E_t \hat{\pi}_{t+1}, \quad \kappa = \frac{(1-\omega\beta)(1-\omega)}{\omega}$ |
| Relation between consumer inflation π_t and producer inflation $\tilde{\pi}_t$ | $\hat{\pi}_t = \hat{\tilde{\pi}}_t + \frac{\bar{\tau}^c}{1+\bar{\tau}^c} (\hat{\tau}_t^c - \hat{\tau}_{t-1}^c)$ |
| Private sector production function | $\hat{y}_t = \hat{A}_t + \alpha\hat{K}_{t-1} + (1-\alpha)\hat{L}_t + \gamma\hat{K}_{t-1}^G$ |
| Total production | $\hat{Y}_t^T = \frac{y}{Y_t^T} \hat{y}_t + \frac{\sigma r}{Y_t^T} \hat{\sigma}\hat{\tau}_t$ |
| Firm dividend | $\hat{D}_t = \hat{y}_t - \frac{\theta\bar{\tau}^c}{1+\bar{\tau}^c} \hat{\tau}_t^c - (1-\theta)\hat{m}\hat{c}_t$ |
| Private capital accumulation | $\hat{K}_t = (1-\delta_k)\hat{K}_{t-1} + \delta_k\hat{I}_t$ |
| Public capital accumulation | $\hat{K}_t^G = (1-\delta_k^G)\hat{K}_{t-1}^G + \delta_k^G\hat{I}_t^G$ |
| Aggregate resource constraint | $\hat{Y}_t^T = \frac{c}{Y_t^T(1+\tau^c)} \hat{c}_t - \frac{\tau^c}{(1+\tau^c)^2} \frac{c}{Y_t^T} \hat{\tau}_t^c + \frac{f}{Y_t^T} \hat{l}_t + \frac{c^G}{Y_t^T} \hat{c}_t^G + \frac{f^G}{Y_t^T} \hat{l}_t^G$ |
| Government budget deficit | $\hat{B}\hat{D}_t = \frac{GE}{BD} \hat{G}\hat{E}_t - \frac{GR}{BD} \hat{G}\hat{R}_t$ |
| Total government revenue | $\hat{G}\hat{R}_t = \frac{\bar{\tau}^D}{GR} \hat{D}_t + \frac{\bar{\tau}^c}{1+\bar{\tau}^c} \frac{\bar{c}}{GR} \hat{c}_t + \frac{\bar{\tau}^c}{(1+\bar{\tau}^c)^2} \frac{\bar{c}}{GR} \hat{\tau}_t^c + \frac{\bar{\tau}^w \bar{w} \bar{L}}{GR} (\hat{\tau}_t^w + \hat{w}_t + \hat{L}_t) + \frac{\bar{\tau}^D \bar{D}}{GR} \hat{\tau}_t^D + \frac{\bar{\sigma} r}{GR} \hat{\sigma}\hat{\tau}_t$ |
| Total government expenditure | $\hat{G}\hat{E}_t = \frac{\bar{c}^G}{GE} \hat{c}_t^G + \frac{I^G}{GE} \hat{l}_t^G$ |

| | |
|------------------------------|---|
| Total government debt | $\hat{t}l_t^g = \frac{\bar{b}}{\bar{t}l^g} \hat{b}_t + \frac{\bar{m}}{\bar{t}l^g} \hat{m}_t$ |
| Government debt accumulation | $\hat{t}l_t^g = \hat{t}l_{t-1}^g + \frac{1}{\beta} \frac{\bar{b}}{\bar{t}l^g} \hat{R}_{t-1} + \frac{1-\beta}{\beta} \frac{\bar{b}}{\bar{t}l^g} \hat{b}_{t-1} - \frac{(\beta \bar{t}l^g + (1-\beta)\bar{b})}{\beta \bar{t}l^g} \hat{\pi}_t + \frac{\bar{B}\bar{D}}{\bar{t}l^g} \hat{B}\bar{D}_t$ |
| Monetary growth rate | $\hat{\vartheta}_t = \hat{m}_t - \hat{m}_{t-1} + \hat{\pi}_t$ |