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RESEARCH PAPER

Inflow and Outflow of Oil Revenues: Scenarios for National Development Fund of Iran (NDFI)

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Abstract
Resource-rich developing countries are forced by economic fluctuations due to international commodity price movement. One way to reduce the volatility adverse effects is to establish institutions such as Sovereign Wealth Fund. However, the way this fund is managed is important. Iran, as a resource-rich developing country, suffers from economic fluctuations. To manage resource revenues, National Development Fund (NDF) has been established. In this paper, using DSGE model, we examined different scenarios for managing fund resources. A scenario, without any stabilizer Fund and two different scenarios for National Development Fund. In the second scenario, NDF has a role like the one in Sixth Development Plan. In the third scenario, all oil revenues are deposited to NDF and a part of the fund as much as interest rate in the OECD countries plus 70% of long-run oil revenues invested in the economy. The Results indicated that the management of oil revenues by the Fund, in which the inflow of oil revenues into the economy follows the commitment, is an appropriate policy to reduce the economic fluctuations in Iran.
Keywords: Economic Fluctuations, Fiscal Policy, DSGE, Iranian Economy, Macroeconomics, National Development Fund (NDF), Oil Revenue.
JEL Classification: E32, E37, E13, E6, Q33.

Introduction

Fluctuations in GDP growth have an adverse effect on economic growth by increasing uncertainty for economic agents. Hence, economic stability is a prerequisite for policymakers in achieving sustainable growth.

The conditions of oil-rich countries indicate that most of them have been among the most fluctuating economies in the last 30 years (Hojjati Najafabadi, 2015). Volatility in global prices of natural resources is the main reason for economic fluctuations in resource-rich countries. Iran, as an oil-exporting country, has suffered from oil price volatility in the world economy. However, the experience of Norway for example has been different in this regard. Norway managed to achieve the desired growth and avoid fluctuations by proper management of oil revenues.

Accordingly, the resource curse or blessing depends more on the institutional structures and the government than the resources themselves. An institution for this purpose is the Sovereign Wealth Fund. Nevertheless, the experience of oil-rich economies in recent years has shown that it is not enough to establish such FUNDS, but the proper management of these Funds has a big role to play.

This paper examines three scenarios for managing the NDF in Iran, by using a DSGE

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model. The remainder of this paper is organized as follows. Section 2 provides a literature review of the subject matter. Section 3 explains the methodology, addressing household, firm, oil revenues, external sector, NDF scenarios, and first-order conditions. Finally, Section 4 concludes the paper.

Literature Review

Economic growth is dealt with in the long term, while economic fluctuation is a concern in the short-term macroeconomics. Therefore, to better understand this phenomenon, we need to focus our perspective on the short term (Stiglitz and Walsh, 2006: 637). Generally, we can observe the long-term growth rate of the economy, but it hides the fact that the production of goods and services do not have steady growth (Mankiw, 2015: 281).

The real effect of fluctuations on production can be seen from both the supply of and demand for capital. Bernanke (1983), Pindyck (1993), and Dixit and Pindyck (1994) argued that if irreversibility in the investment occurred, economic fluctuations contributed to the decline of investment. In addition, Killian (2009) examined the effect of delayed purchases on demand due to uncertainty.

Lucas (1988) found that the trend of long-term growth in developed countries was less fluctuating than that in developing countries. Today, it is clearer for economists that poor developing countries experience more fluctuations than developed countries. Yet, the question is why, and if it clarifies the causes for fluctuations.

Acemoglu et al. (2003) studied the weakness of institutions and introduced disruptive policies as the main reason for economic fluctuations. They referred to a source of difference in fluctuations as institutional. In addition, they examined other macroeconomic variables as intermediaries for the effect of the institutions on fluctuations. According to them, fluctuations and other economic issues are signs of profound institutional weaknesses. Acemoglu et al. (2004) indicated that countries with poor institutions suffered from more fluctuations. Economies that have weak institutions not only cannot benefit from economic opportunities but also suffer from political

tensions. Economic instability is the result of institutions' weakness, economic crises, exchange-rate turbulence, and systemic risk in the banking system, and political crises.

Commodity price fluctuations attenuate long-term growth and derail the country from the development trend. Deaton (1999) argued that what clarified fluctuations in per capita growth was the volatility in the price of export commodities such as oil, coffee, and cereals, and the resulting shocks. A statistical survey of Sub-Saharan African countries revealed that in most of these countries, an export commodity accounted for more than a third of total exports. This indicates the dependence of the country's foreign exchange revenues on exports. Hence, the trend of economic growth in these countries also depends on the supply of and demand for this commodity.

Lane and Tornell (1996) found that resource-rich countries suffered more from rent-seeking than non-resource-rich economies. Torvik (2002) elaborated the challenge of rising natural resource revenues in the resource-rich countries that is the competition for capturing the rent of these proceeds. This reduces the number of entrepreneurs who lead efficient enterprises.

To understand this phenomenon, Eifert et al. (2002) estimated a model that included not only exploration, extraction, and export of oil but also oil proceeds which affected policymakers' decisions and extractive industries. In a case study, they explored the trend of establishing social and economic institutions in successful and non-successful oil economies (Norway, Saudi Arabia, and other Persian Gulf countries, Nigeria, Indonesia, and Chad). They found that government size led to non-flexibility in many oil-rich countries upon oil

shocks. It prevents them from overcoming shocks by reducing expenditures. While Norway's S.W.F. has led it to succeed in dealing with shocks and to reduce the disturbing effect of fluctuations.

Pieschacón (2009) studied the effect of rising oil prices in the Mexican economy between 1980 and 2005 and found that oil price shock heightened the temporary rise in government purchases, the production of tradable and non-tradable goods, and private consumption. In addition, it increased the real exchange rate temporarily.

Oil revenue shock is a major source of fluctuations in oil-rich developing countries, including Iran, which is heavily dependent on these revenues. The volatility of oil prices and consequently oil revenues give rise to business cycles in these countries. In addition, it has also an adverse effect on investment, consumption, distribution of income, and other macroeconomic variables. On the other hand, since volatility emanates from international markets, and it is external to the domestic economy, it could be almost unpredictable and wide-ranging (Filis et al., 2011). So the countries face uncertainty in economic activity.

Dutch disease also happens due to volatility in resource revenues. Kutan and Wyzan (2005) refer to Dutch disease as the movement of economic resources from the tradable to the non-tradable sector. It happens due to rising oil revenues and stimulating the demand side of the economy. Auty (2001) showed that structural changes in resource-rich countries made the tradable sector smaller than the non-tradable sector, which was a determining factor in creating a resource curse.

The volatility of foreign exchange revenues, by stimulating import, will increase the non-tradable goods[1] in the abundance of these revenues, and then decelerate when these revenues decline.

Sachs and Warner (1997) showed that a consequence of increased resource revenues in resource-dependent economies was the decline of a tradable sector of the economy. They referred to this issue as the most important reason for the slow growth.

Another effect of economic fluctuation is in household consumption. In macro-consumption theories, risk-averse households seek to reduce the variability of their consumption, and the policymakers reduce the effect of the fluctuations on the households. A review of oil-rich countries in ranking the consumer fluctuations indicate that most of these countries have been among the most fluctuating ones in the last 30 years. Yet, the presence of countries such as Norway among countries with low consumption variability questions the acceptance of this statement (Hojjati Najafabadi, 2015).

Exchange rate volatility due to oil revenue shocks, in turn, can affect other economic variables and act as an intermediary channel for transferring the fluctuations into the economy. Sachs and Warner (2001) concluded that in a resource-rich economy, there was a tendency to overvalue the exchange rate, which led to reducing non-oil exports. Yet, the results based on the resource curse and its impact are not universal. The experience of countries like Norway that managed to benefit from resource revenues, while avoiding its curse, did not allow the generalization of the resource curse.

Auti (2001) stated that while many countries suffered from the resources curse, this was not the case for other countries. Thus, cursing resources cannot be considered as an iron rule. He referred to Dutch disease as a result of structural and institutional constraints to curb the distribution of resource revenues in the form of economic rents. Gylfason (2001) pointed out

1. Non-tradable goods are goods that, for some reason such as non-portability, cannot enter into international transactions, such as housing and services. Yet, some services can be considered tradable. Since non-tradable sector products cannot be traded in international markets, they have mostly a distributive role in the economy. For this reason, non-tradable products play a smaller role in the long-term growth than the tradable products. The development of tradable sector can lead to an increase in the size of the economy by reducing imports as well as increasing exports.

that the quality of institutions managing the resources, and not the resources per se, made this curse happen.

Brunnschweiler and Bulte (2008) examined the resource course over the period 1960–2004 by using a panel and introduced a resource dependency index. They indicated that resource dependency rather than resource abundance led to a decline in growth.

Nevertheless, developing countries have indicated a different performance in this regard. Many studies showed that developing countries tended to use procyclical policies, and did not able to implement counter-cyclical policies to reduce fluctuations caused by shocks.

Lopez et al. (2019) indicated that as government spending increased with revenue shock from exporting goods, tax revenues decreased. They found that using various financial support instruments could reduce the fluctuation of macroeconomic variables.

Mohaddes and Raissi (2017) examined the effects of international commodity price volatility on the per capita output of exporting countries. They found that, despite the positive effect of price increases, its effects through decreasing capital accumulation and factor efficiency had a negative impact on economic growth. The results also suggested that forward-looking solutions such as National Wealth Funds, especially in countries with good institutional and governance indicators, could mitigate these negative effects. These Funds can be established either in the long run as a national wealth Fund or as a stabilization Fund in the short run to cope with revenue shocks caused by price fluctuations.

Resources-rich Countries can also use these Funds to accumulate physical and human capital and improve the status of areas such as property rights and human capital.

Behboudi (2009) indicated that built-in mechanisms and institutions are needed to avoid exogenous shocks of oil prices. The institutions such as Sovereign Wealth Funds or stabilization funds were established to invest resource revenues globally in a variety of real and financial assets. In some cases, government budget surplus or other reserved funds are transferred to these institutions too (Butt et al., 2008).

The stabilization funds manage volatile revenue and make them sustainable revenue to reduce economic fluctuations. These funds stabilize the economy by saving revenues in the upturn and investing in the downturn.

Youssef et al. (2018) explored that National Wealth Funds play an important role against pro-cyclical fiscal policies and were also effective in maintaining fiscal balance. Therefore, it is recommended that developing countries utilize this instrument for stabilizing fiscal policies. Accordingly, the financial discipline under these Funds will play an important role in the efficiency of the institution, and therefore recommend that various long-term factors be considered in establishing these Funds and that the relevant laws be formulated and adopted.

Ammar et al. (2018) examined the performance of resource-rich countries that established National Wealth Funds in dealing with Dutch Disease. The results indicated that these Funds reduced the adverse effects of Dutch disease by managing foreign exchange resources and investing them abroad.

Van der Ploeg (2019), while referring to National Wealth Funds, which have a significant role in managing resource revenue, emphasizes the need to revise some policies. First, to counteract fluctuations and price reductions, prudential instruments need built-in Funds. Second, given the limited access to financial markets for some resource-rich countries, it is necessary to use these revenues to offset capital expenditure and invest domestically. Third, given the wage stickiness, these revenues could be used to increase consumption and reduce unemployment. Fourth, by stabilizing the exchange rate, it would signal to foreign investors and gradually increase capital attraction. Fifth, with the short-term horizon, the effects of shocks to the private sector and the exchange rate volatility will cause instability. Finally, he suggests that where nominal wage stickiness exists, the Taylor rule for nominal exchange rate control could be used.

Cherif and Hasanov (2013) examined the fiscal policy of oil-rich countries by using the 2000s data and optimizing intertemporal consumption. Results indicated that the tradable sector played a key role in the dynamics of investment and savings. The productivity of investment in the tradable sector in countries with a shortage of capital and high volatility in oil revenues is low. So, the establishment of a Sovereign Wealth Fund is necessary as a buffer to reduce the adverse effects of oil revenue volatility. When domestic productivity is high, savings in the Sovereign Wealth Fund will be as a buffer, and make investment flow more stable inside the country. In addition, oil revenues expenses should be conservative and marginal propensity to consumption need to be less than one while there are permanent shocks.

Eldredge (2019) explored how National Wealth Funds may cope with the vulnerabilities of open economies in international markets. By examining 48 National Wealth Funds established between 1950 and 2012, he concludes that medium-size economies with a high degree of openness have established such funds because they are a form of insurance against uncertainty and international market fluctuations that are the main source of vulnerability.

Sayadi et al. (2017) studied the impact of oil revenue shocks, productivity, and money growth rates on the Iranian economy. Results, in line with their previous research (Sayadi et al., 2016), confirmed that oil revenue shocks gave rise to increased consumption, and government spending and inflation rate reduced in the short-term, although in the mid-term, the inflation increased. Because of increased oil revenues, the NDF increases financing of private sector projects that could strengthen the private sector production, but due to the economic structure of Iran, rising oil revenues have had little effect on growth and also promotion of non-oil products. Their findings also indicated that by reducing the inefficiency in government investment, oil revenues can strengthen private sector activity.

Rahbar and Salimi (2016) studied the effect of government financial discipline and NDF on reducing Dutch disease in the Iranian economy. To this end, they used DSGE model for a small open economy in which firms were divided into tradable and non-tradable sectors and then studied the effects of oil shocks on macroeconomic variables. Results indicated high stable inflation, the growth of the non-tradable sector, and the decline of the exchange rate. In the next scenario, they assessed the effect of restricting the government's access to oil revenues and depositing to the NDF to reduce the adverse effects of oil shocks. Results confirmed that reducing the government's share of oil revenues could reduce the inflation rate and also the effects of Dutch disease.

Zamanzadeh et al. (2014) studied the mechanism of Dutch disease emerging in the Iranian economy by using DSGE model. They found that in the short-term, a positive oil shock increased the relative price of non-tradable goods to the price of tradable goods; thereby non-tradable sector expands relatively. In addition, since an important part of the positive effect of oil shocks on the production of the non-tradable sector is offset by reducing the production of the tradable sector, a positive oil shock does not have a strong effect on non-oil production.

Barkhordar and Saboohi (2013) assessed alternative scenarios for allocating oil revenues in Iran, using a recursive dynamic CGE model. To this end, they studied the trade-off between consumption, investment, and savings of oil revenues in Iran by simulating and comparing two scenarios: investment in the domestic economy and investment in foreign assets (saving in the NDF). They found that either saving oil revenues in oil funds or physical investment in the domestic economy led to higher economic growth than the base scenario (government expenditure), and thus oil fund's long-term scenario has a greater effect on economic growth.

Haghighi et al. (2012) argued that according to Islamic teachings, the 'natural resource conservation rule' should be considered in the exploitation of natural resources. They concluded that it was not right to allocate non-renewable resources to consumption and estimated oil and gas exploitation accordingly by using a dynamic CGE model. Results

suggested that the higher was the rate of oil and gas revenue savings, the more the welfare declined in the early years, but welfare grew in the long-term. Non-oil exports would also grow.

Hosseinzadeh et al. (2018) studied the role of the NDF for reducing economic fluctuations in Iran by three scenarios using DSGE model: first, government allocate total oil revenues, second, a portion of the oil revenues is allocated to NDF, and third, government deposits total oil revenues in the fund, and rely only on tax revenues. Results indicate that oil revenues have a significant effect on economic growth and consumption in all scenarios. However, the second and third scenarios in the short term have led to lower consumption, investment, and economic growth. Yet, in the long term, they have a positive effect on these variables. Results of the third scenario suggested that government reliance on tax revenues, customs duties, and investment through the NDF's foreign exchange reserves would increase economic growth, consumption, and investment.

It should be noted that the contribution of our study is that two scenarios on the inflow and outflow of oil revenue to the fund will be examined, while this is not the case in other studies like Hosseinzadeh Yousef Abadi et al. (2018).

Methodology

We examined different scenarios for the NDF, using a DSGE model to find the most appropriate scenario that reduces the economic fluctuations. In all scenarios, NDF, in addition to making buffer stock and absorbing external volatility for the oil revenue, plays the role of sustainable earning.

DSGE model is based on real business cycles. This means that firms are in perfect competition and prices are flexible. Furthermore, money is neutral in the model. We also developed the basic model of Ebrahimian and Madenizadeh (2018), which is calibrated for the Iranian economy as the core of the model. Dutch disease and the movement of resources between tradable and non-tradable sectors are inserted in the model as conducted by Zifak et al. (2016), Seyed Momeni (2016), and Zamanzadeh et al. (2015).

The model consists of four main sections: households, enterprises, NDF, and oil. Enterprises include two types of business, which produce tradable and non-tradable goods. Foreign exchange revenue from oil export is deposited in the NDF. To simplify, we assume that the fund's share of oil revenues is equal to the average investment profits in OECD countries.

Household

The Representative Household seeks to maximize its utility subject to its budget line. The household life is assumed unlimited, and in each period, the optimal decision is made on consumption, saving, and supply of labor.

Given the underdeveloped financial system of the Iranian economy in providing loans to the bank customers, the friction of holding money at the beginning of each period as much as the nominal amount of goods and services exchangeable to money during the period could be the main cause of demand for money for the Iranian households. Also, given some statistical evidence regarding the real volume of money in the Iranian economy in the 1980s, economic entities have made available money at the beginning of each season, almost as much money for the season ahead. At the same time, calibration of alternative models of money demand for utility, such as the MIU model, requires data on the equilibrium interest rate and observes its effect on the short-term behavior of money circulation velocity, which cannot be achieved due to the unavailability of such data.

The utility function of the household has been specified based on Ebrahimian and Madenizadeh (2018). The household consumes C_t during each period, and spends l_t for leisure. Normalizing the hours available to each household as 1, and assuming each household decide between leisure and work, the supply of household labor is as: $L_t = 1 - l_t$.

$$max\, U = maxE \sum_{t=0}^{\infty} \beta^t \left[\frac{\left(C_t {l_t}^{\nu}\right)^{1-\sigma} - 1}{1-\sigma}\right] \quad (1)$$

β∈ (0, 1) is the discount factor, σ is the reversal of intertemporal substitution elasticity of consumption has been calculated for Iran in Ebrahimian and Madenizadeh, (2018), Seyed Momeni (2016), Rahmati et al. (2016), and ν is a reversal of labor elasticity.

The household maximizes its utility according to Equation 1. The utility function is rewritten as Equation 2:

$$\max U = maxE \sum_{t=0}^{\infty} \beta^t (\ln C_t + \nu \ln(1 - L_t)) \quad (2)$$

Equation 3 is the budget constraints or household resources constraint in which p_t is the general level of prices, namely the price of final goods. The households consume part of their income in each period by consuming the final goods and investing the rest. In each period, households supply $L_t$of labor and save I_t to invest and earn a real wage equal to w_t, and receives a rent r_t per unit of capital accumulated from the past, the sum of them forms the income of households from the supply of labor and capital.

Moreover, foreign exchange earnings from oil export are available to households from NDF.

$$s.t.: \quad p_t C_t + p_t I_t \leq p_t w_t L_t + p_t r_t K_t + F_t(YO_t * s_t) \quad (3)$$

Household capital accumulation during each period is defined as Equation 4, which is also called the Capital Movement.

$$I_t = k_{t+1} - (1 - \delta)K_t \quad (4)$$

Where δ is the depreciation rate. Capital is freely mobile across sectors.

Combining Equations 3 and 4, and assuming that for utility maximization, all income spend on consumption and savings, and the inequality constraint is removed, we can re-write the budget line again as Equation 5:

$$s.t.: \quad p_t c_t + p_t k_{t+1} = p_t(1 - \delta + r_t)k_t + p_t w_t L_t + F_t(YO_t * s_t) \quad (5)$$

Firms

To assess the impact of investing in oil revenue, firms' activities are classified into four categories: final products, non-tradable goods, tradable goods, and exports.

Final Product Firms

The final product Y_t consumed by households is a combination of tradable goods $y_{T,t}$ and non-tradable goods $Y_{N,t}$. The production function of final products is a constant elasticity of substitution (CES). The final product firm, by maximizing its profits according to the production function, derives demand for tradable and non-tradable goods. In the maximization

process, γ_c is the share of tradable goods, and θ_c is the elasticity of substitution between tradable and non-tradable goods. $P_{T,t}$ is the price of tradable goods, and $P_{N,t}$ denotes the wholesale price of non-tradable goods.

$$\max P_t Y_t - \left[P_{N,t} y_{N,t} + P_{T,t} Y_{Ti,t}\right] \tag{6}$$

$$\text{s.t.:} Y_t = \left[\gamma_c^{\frac{1}{\theta_c}} \left(Y_{Ti,t}\right)^{\frac{\theta_c - 1}{\theta_c}} + (1-\gamma_c)^{\frac{1}{\theta_c}} \left(Y_{N,t}\right)^{\frac{\theta_c - 1}{\theta_c}}\right]^{\frac{\theta_c}{\theta_c - 1}} \tag{7}$$

Non-Tradable Goods

The production function of non-tradable goods is Cobb-Douglas, in which the factors of production are labor and capital. A_N is the productivity of non-tradable sectors, k_N is non-tradable sector capital, and L_N is the labor employed in the non-tradable sector. By maximizing the profit function, the producer derives the demand for capital and labor. The parameter α_n is the share of capital in the production of the non-tradable sector.

$$\max \prod_t = P_{N,t} \cdot Y_{N,t} - r_t k_{N,t} - w_t L_{N,t} \tag{8}$$

$$\text{s.t.: } Y_{N,t} = A_N k_N^{\alpha_n} L_N^{1-\alpha_n} \tag{9}$$

Tradable Goods

The tradable final products $Y_{T,t}$ supplied to domestic consumption is a combination of the domestic tradable goods $Y_{Th,t}$and the imported goods $Y_{TF,t}$. The firms by maximizing the profit of the production function, which is a CES, derive the demand for domestic tradable goods and imports. γ_h is the share of domestic tradable in the final tradable goods, and θ_h is the elasticity of substitution between domestic and foreign tradable goods. In Equation 10, $p_{TF,t} = s_t p^*_{TF,t}$, where $p^*_{TF,t}$is the price of tradable goods in foreign currency, and s_t is the nominal exchange rate.

$$\max p_{T,t} Y_{T,t} - \left[P_{Th,t} Y_{Th,t} + P_{TF,t} Y_{TF,t}\right] \tag{10}$$

$$\text{s.t.:} Y_t = \left[\gamma_h^{\frac{1}{\theta_h}} \left(Y_{Th,t}\right)^{\frac{\theta_h - 1}{\theta_h}} + (1-\gamma_h)^{\frac{1}{\theta_h}} \left(Y_{TF,t}\right)^{\frac{\theta_h - 1}{\theta_h}}\right]^{\frac{\theta_h}{\theta_h - 1}} \tag{11}$$

A part of the domestic tradable goods consumed at a rate of $Y_{Ti,t}$ in which its share in the final products domestically derives from optimization of final products firm based on Equation 6 and subject to constraint 7. What remains from domestic tradable products will be exported.

Export

In Iran, export goods is a combination of domestic tradable goods and import goods demanded by other countries. The export price in foreign currency affects non-oil exports and is equal to $P_{T,t}/s_t$. The demand function is constant elasticity function for foreigners, presented in Equation 12:

$$Y_{Tx,t} = A_{x,t} * \left({}^{P_{T,t}}/_{S_t}\right)^{\theta_x} \quad (12)$$

Where $A_{x,t}$is an exogenous parameter, and a function of the economic conditions of other countries, which can simulate the condition of a business boom as a shock. θ_x is the price elasticity of demand.

Domestic Tradable Firms

The firm that produces tradable goods also seeks to maximize profits and uses the same production function, another Cobb-Douglas as the firm in the non-tradable sectors which uses labor and capital. $y_{Th,t}$ is domestic tradable output, $A_{T,t}$ is the productivity of the tradable goods, $k_{T,t}$is the capital of tradable goods, and $L_{T,t}$ is the labor employed in this sector. By maximizing its profit function, the producer derives the demand for capital and labor. α_t is the share of capital in the production of domestic tradable goods.

$$\max \prod_t = p_{Th,t} \cdot y_{T,t} - r_t k_{T,t} - w_t L_{T,t} \quad (13)$$

$$\text{s.t.: } y_{Th,t} = A_{T,t} k_{T,t}^{\alpha_t} L_{T,t}^{1-\alpha_t} \quad (14)$$

Oil Revenue

To model oil revenues, we use AR (1) model as indicated in Equation 15. YO_{ss} is the stable level of oil revenues that, according to available estimates, amount to about 13% of aggregate product, and amounts to about 30% of tradable goods. ρ_{YO} is the coefficient for the duration of oil shocks, which is the duration of the shock from the beginning to the disappearance.

$$\ln(\mathrm{YO}_t) = (1 - \rho_{YO}) * \ln(\mathrm{YO}_{ss}) + \rho_{YO} \ln(\mathrm{YO}_{t-1}) + \varepsilon_{YO} \quad \varepsilon_{YO} \sim N(0, \sigma_{YO}^2) \quad (15)$$

National Development Fund

In the model, the only source of income flow for the NDF is a share of oil revenues. It is assumed that oil revenues are deposited in the Fund and, on the contrary, a share of oil revenues plus a fixed percentage of Fund assets is equal to the average rate of profit on foreign deposits invested by the Fund in the economy. Given this, the fund absorbs some of the oil revenues shocks and acts as a buffer. We examined scenarios for the type of inflow and outflow of the National Development Fund to find a scenario that can reduce economic fluctuation, therefore the Fund function appears in the model as in Equation 16.

$$F_{t+1} = \left(1 - r_f\right) \cdot F_t + YO_t - IOR_t \quad (16)$$

where r_f is the average rate of interest on deposits abroad, $f(or_t)$ is the amount of inflow of foreign exchange earnings from oil revenues deposited in the fund, and IOR_t is a share of oil revenues that the NDF invest.

External Sector

In the external sector, it is assumed that in addition to oil exports, there are export of tradable goods and import im_t. Therefore, the Current Account (C.A.) indicated in Equation 17 is as

follows:

$$CA = r_f * F_t + IOR_t + Y_{Tx,t} * \left(P_{T,t}/s_t\right) - im_t \quad (17)$$

$$im_t = y_{TF,t} \quad (18)$$

National Development Fund Scenarios

We examine three scenarios for inflow and outflow of oil revenues to the fund. The flows affect the equilibrium of the external sector of the economy, and also the exchange rate. In the following scenarios, only the equations for the fund and external balance are presented.

Scenario I: Lack of National Development Fund

In this scenario, the fund has no role to play, and foreign exchange earnings from oil revenues are allocated to the government. Therefore, the external balance will be as the Equation 19:

$$CA = YO_t + Y_{Tx,t} * \left(P_{T,t}/s_t\right) - im_t \quad (19)$$

Scenario II: Deposit of 30% of Oil Revenue to the Fund

In this scenario, based on the regulation of the Sixth Development Plan, 30% of the foreign exchange earnings from the oil revenue in each period will be deposited in the fund, and the remaining 70% would be allocated to the government. In addition to 70% of the oil revenues, a percentage of the assets of the fund r_f will be invested in the economy that plays as a buffer to absorb oil shocks. In Equation 20, Ω represents the fund's share of oil revenues, which can be assigned in this scenario. Accordingly, three equations on oil revenues, the fund, and the external balance are as follows:

$$IOR_t = (1 - \Omega) * YO_t + r_f * F_t \quad (20)$$

$$F_{t+1} = \left(1 - r_f\right)F_t + YO_t - IOR_t \quad (21)$$

$$CA = IOR_t + Y_{Tx,t} * \left(P_{T,t}/s_t\right) - im_t \quad (22)$$

Scenario III: Investing a Stable Flow of Oil Revenues in the Economy by the Fund

In this scenario, a steady share of the long-term flow of foreign exchange earnings from oil revenues in each period will be a revenue for the government, and the remaining will be deposited with the fund. In addition, a part of the fund r_f is invested in the country. Accordingly, the equations will be as follows:

$$IOR_t = (1 - \Omega) * \mathrm{YO}_{ss} + r_f * F_t \quad (23)$$

$$F_{t+1} = \left(1 - r_f\right)F_t + YO_t - IOR_t \quad (24)$$

$$CA = IOR_t + Y_{Tx,t} * \left(P_{T,t}/s_t\right) - im_t \quad (25)$$

First Order Conditions

The equations for the model are as follows:

$$\frac{1}{C_t} = \beta E_t \left[\frac{1}{C_{t+1}}\left(r_{t+1} + (1-\delta)\right)\frac{p_t}{p_{t+1}}\right] \quad (26)$$

$$w_t l_t = \nu C_t \quad (27)$$

$$l_t = 1 - L_t \quad (28)$$

$$Y_{Ti,t} = \gamma_c \left(P_{T,t}\right)^{-\theta_c} Y_t \quad (29)$$

$$Y_{N,t} = (1-\gamma_c)\left(p_{N,t}\right)^{-\theta_c} Y_t \quad (30)$$

$$P_t = \left[\gamma_c \left(P_{T,t}\right)^{1-\theta_c} + (1-\gamma_c)\left(P_{N,t}\right)^{1-\theta_c}\right]^{\frac{1}{1-\theta_c}} \quad (31)$$

$$Y_{N,t} = A_N k_N^{\alpha_n} L_N^{1-\alpha_n} \quad (32)$$

$$\alpha_n P_{N,t} Y_{N,t} = r_t k_{N,t} \quad (33)$$

$$(1-\alpha_n) P_{N,t} Y_{N,t} = w_t L_{N,t} \quad (34)$$

$$Y_{Th,t} = \gamma_h \left(\frac{P_{Th,t}}{P_{T,t}}\right)^{-\theta_h} y_{T,t} \quad (35)$$

$$Y_{TF,t} = (1-\gamma_h)\left(\frac{s_t}{P_{T,t}}\right)^{-\theta_h} Y_{T,t} \quad (36)$$

$$P_{T,t} = \left[\gamma_h \left(P_{Th,t}\right)^{(1-\theta_h)} + (1-\gamma_h)(s_t)^{1-\theta_h}\right]^{\frac{1}{1-\theta_h}} \quad (37)$$

$$y_{Th,t} = A_{T,t} k_{T,t}^{\alpha_t} L_{T,t}^{1-\alpha_t} \quad (38)$$

$$\alpha_t p_{Th,t} y_{Th,t} = r_t k_{N,t} \quad (39)$$

$$(1-\alpha_t) p_{Th,t} y_{Th,t} = w_t L_{T,t} \quad (40)$$

$$Y_{Tx,t} = A_{x,t} * \left({}^{P_{T,t}}/_{s_t}\right)^{-\theta_x} \quad (41)$$

$$L_t = L_{T,t} + L_{N,t} \quad (42)$$

$$k_t = k_{T,t} + k_{N,t} \quad (43)$$

$$I_t = k_{t+1} - (1-\delta) K_t \quad (44)$$

$$Y_{T,t} = Y_{Tx,t} + Y_{Ti,t} \quad (45)$$

$$Or_t + r_{f,t}F_{t-1} + Y_{Tx,t}(P_{T,t}/s_t) = y_{TF,t} \quad (46)$$

$$Or_t + r_{f,t}F_{t-1} + Y_{Tx,t}(P_{T,t}/s_t) = (1-\gamma_h)\left(\frac{s_t}{P_{T,t}}\right)^{-\theta_h} Y_{T,t} \quad (47)$$

$$Y_t = C_t + I_t \quad (48)$$

We also calibrated the parameters and the ratios of the macroeconomic variables based on the studies and data of the Iranian economy over the period 2004–2016.

The values for the calibrated parameters are illustrated in Table 1.

Table 1. Parameters Calibration

Parameter	Value	Source
β	0.987	Madanizadeh and Ebrahimian (2018)
ν	4.2	"
δ	0.0233	"
α_n	0.57	Momeni (2014)
α_t	0.66	"
γ_c	0.58	Research calculation
γ_h	0.48	"
θ_c	0.44	"
θ_h	0.68	"
θ_x	2.5	Madanizadeh and Ebrahimian (2018)
$A_{x,t}$	4.52	Research calculation
ρ_{YO}	0.71	Sayadi (2016)

Model Result

In this section, we examine the impact of positive and negative shocks on oil revenues.

A Positive Shock to Oil Revenues

The macroeconomic response to the positive shock of oil revenue is illustrated in the following figures.

The response of macroeconomic variables in the first scenario that oil revenues are allocated to the government is illustrated in Figure 1.

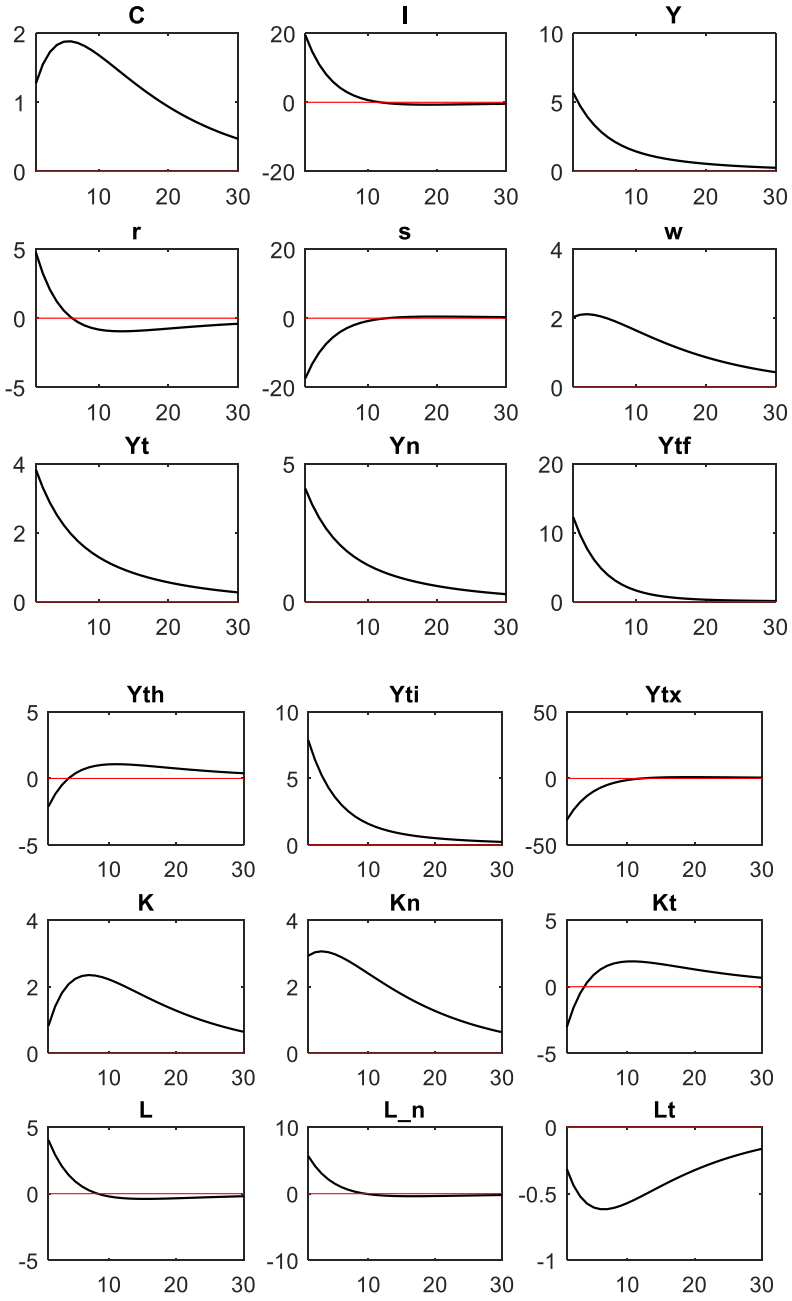

Figure 1. Impulse Response of Macroeconomic Variables for Positive Shocks of Oil Revenue in the Baseline Scenario
Source: Research finding.

As indicated in Figure 1, the added oil revenues in this scenario will be allocated totally to the government. It is expected to increase GDP, but this increase will be lower than what is expected.

With increasing oil revenues and hence foreign currency in the economy, the exchange rate appreciates, but the over-value of the national currency will reduce exports. Although the demand for tradable goods has increased as a result of enhanced production and rising income, the decline in exports along with the increase in demand for imported goods has led to a reduction in the production of domestic non-tradable goods. It happens simultaneously with a positive shock of oil, and the import will substitute the domestic production. In the model, there is no friction for the transfer of capital and labor. It takes at least five periods for domestic tradable goods to return to their original level. The labor force and capital follow the

same trend, and most of them move to the non-tradable sector that it can make a recession by possible frictions in a long period. It can reduce production capacity and foreign exchange earnings, which in turn will lead to worsening of recession in the absence of an oil boom.

By 20% positive oil revenue shock, consumption shocked by 1.5% and then will increase till about 2%, and then gradually returns to the equilibrium value. Investment, as a fluctuating variable, makes a significant increase first, but this increase is not sustainable and quickly returns to the equilibrium level. Responses of other variables can be seen in Figure 1.

For the second scenario, an annual percentage of current oil revenues is deposited into the fund. This scenario is illustrated in Figure 2.

For the second scenario, an annual percentage of current oil revenues is deposited into the fund. This scenario is illustrated in Figure 2.

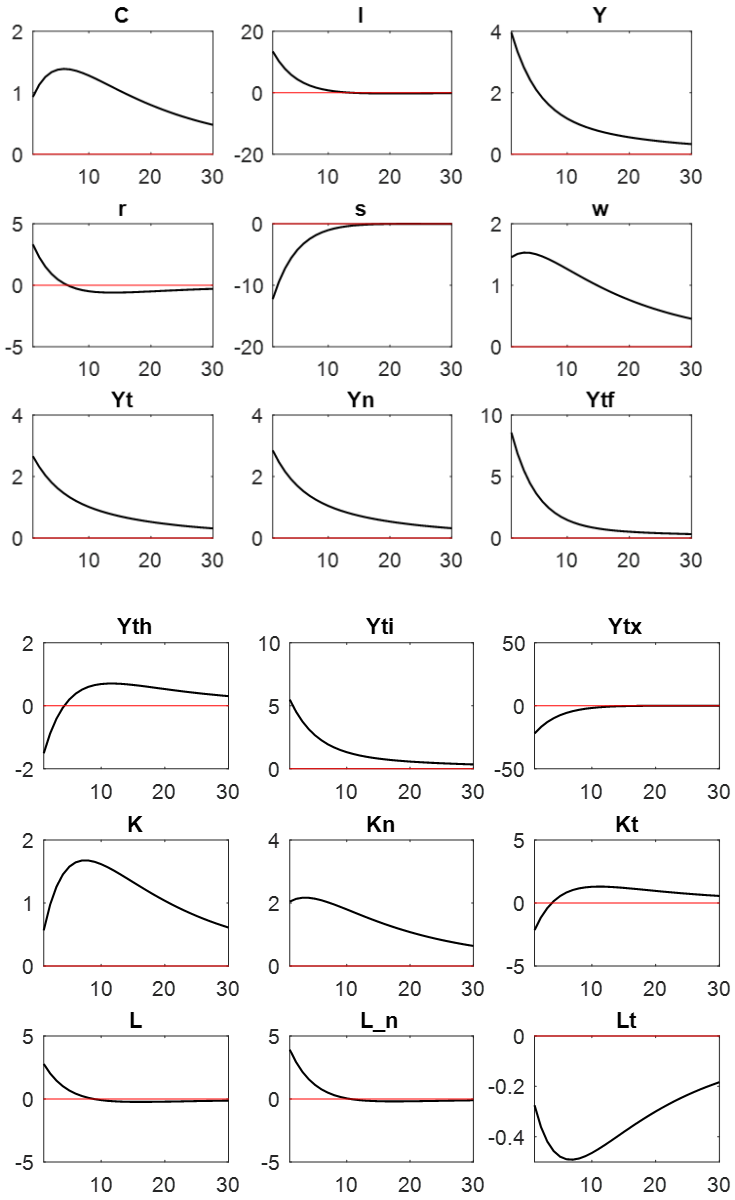

Figure 2. Impulse Response of Macroeconomic Variables for Positive Shock of Oil Revenues in the Second Scenario
Source: Research finding.

As illustrated in Figure 2, in this scenario, a part of the 20% positive oil shock has been absorbed by the fund and invest, but remains 70% of oil revenues for the government budget.

For this, the response of variables is almost the same as the baseline scenario, but the amount has slightly been adjusted.

In the third scenario, all oil revenues are deposited into the fund. The fund invests annually a certain amount of oil revenues: for example 70% along with a number of its previous assets.

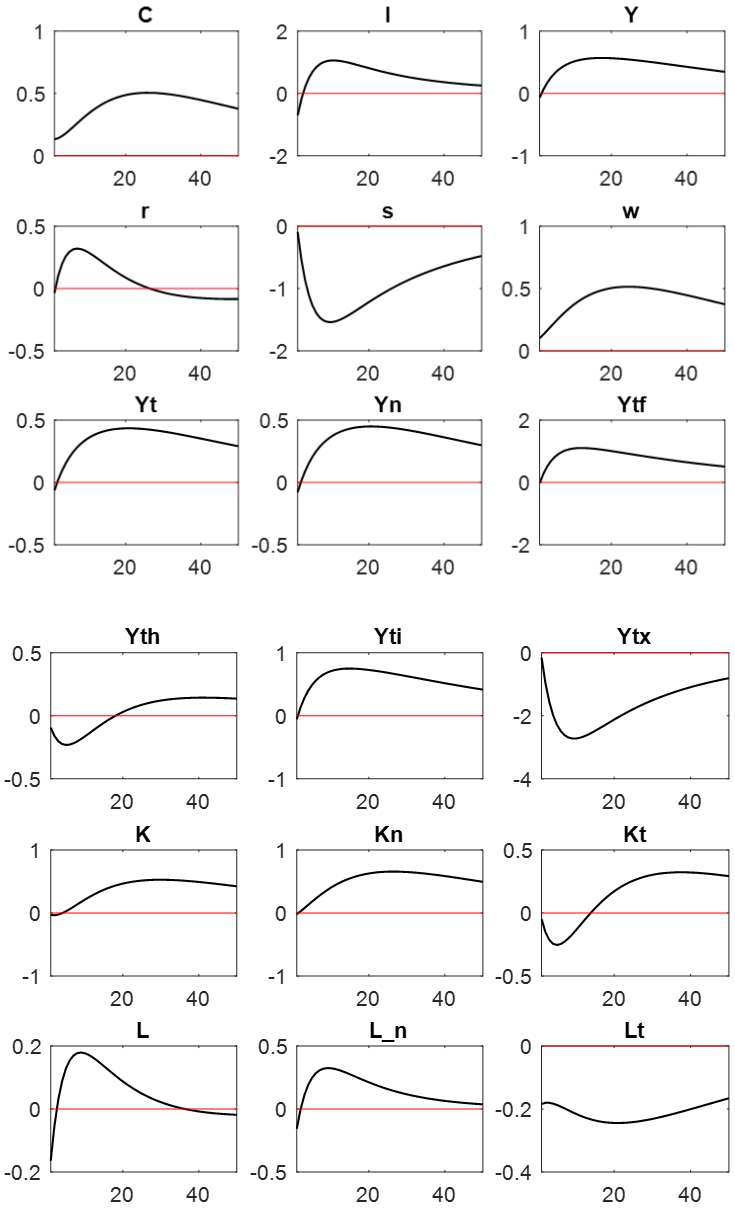

Figure 3. Impulse Response of Macroeconomic Variables for the Positive Shock of Oil Revenues in the Third Scenario
Source: Research finding.

As illustrated in Figure 3, in the third scenario, oil revenues transfer completely from a positive oil shock to the fund. In this way, by a stable inflow of foreign exchange of the fund to the economy, the exchange rate will be stable.

The economic growth resulting from these revenues takes place gradually, and although its increase is lower than two previous scenarios, it persists, and after 40 seasons, there remains a small number of its effects.

The fluctuations in consumption and investment are less than the previous two scenarios, and the effect of this revenue shock has increased them. It gradually reaches a peak, and then

declines.

This scenario devotes to stabilization and gradual adjustment of the exchange rate. By stabilization of foreign exchange earnings in this scenario, the exchange rate does not appreciate as a result of the positive shock to the foreign exchange earnings. Furthermore, the reduction in exports is not apparent as in the previous scenarios. In addition, stability of the exchange rate against other scenarios has led to control of the Dutch disease.

NDF by stabilizing the flow of foreign exchange into the economy, play as an anchor. Therefore, several variables grow less than what was expected.

By this scenario, we not only avoid the hasty use of these revenues, but also we provide a good opportunity for managing the resources.

A Negative Shock to Oil Revenues

Here, we study the immediate response of macroeconomic variables to the negative shocks of oil revenues. At first, the immediate response of the variables is examined in the baseline scenario (lack of funds).

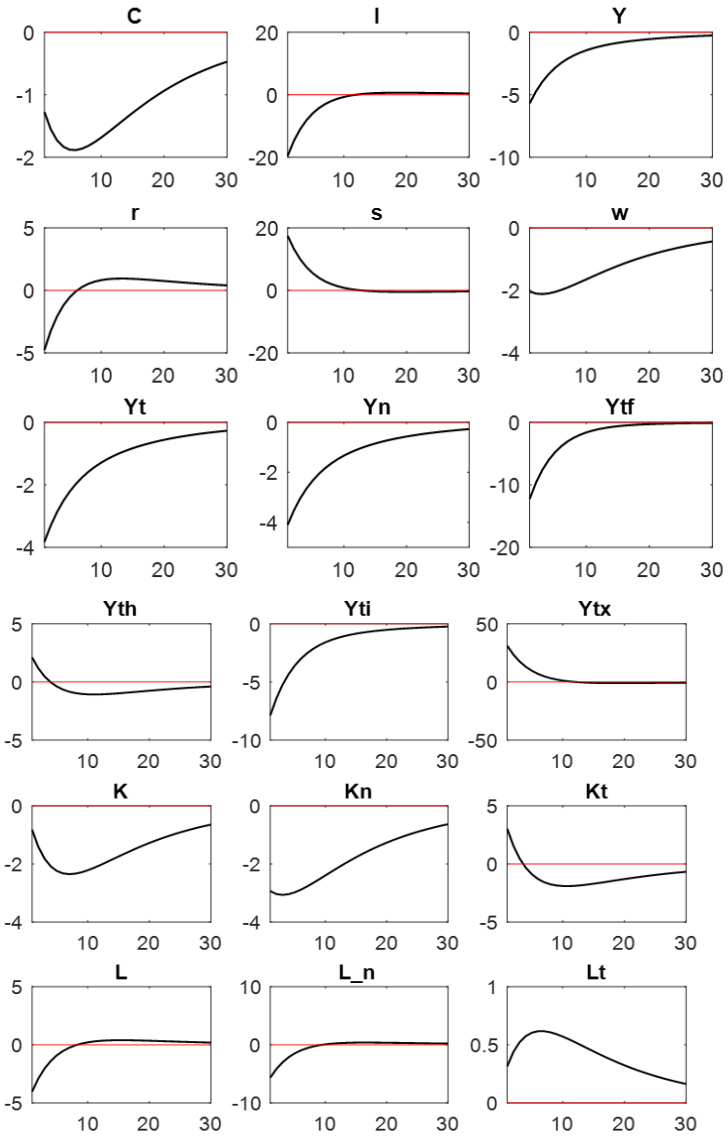

Figure 4. Impulse Response of Macroeconomic Variables for Negative Shocks of Oil Revenue in the Baseline Scenario

Source: Research finding.

As illustrated in Figure 4, in this scenario, oil revenue shock may improve macroeconomic performance. On the contrary, the negative shock may have adverse effects on oil-dependent countries.

The negative oil shock not only affects the aggregate product but also leads to the reduction of aggregate consumption and investment. The rise of the exchange rate leads to the reduction of imports. As a result, tradable goods are provided by domestic production, and therefore, the production is allocated to the tradable goods. In addition, with the decline of the aggregate product, non-tradable goods face a recession that may lead to the shift of these factors to the tradable sector.

These conditions can be considered for a post-oil boom, in which the frictions of the capital and labor markets are significant. In this case, the reduction in oil revenues in the baseline scenario, and the lack of stabilizing institutions, will lead to a deep economic recession.

This trend is true for the second scenario, and only a part of the effect of this shock may be offset by using the NDF's mechanism.

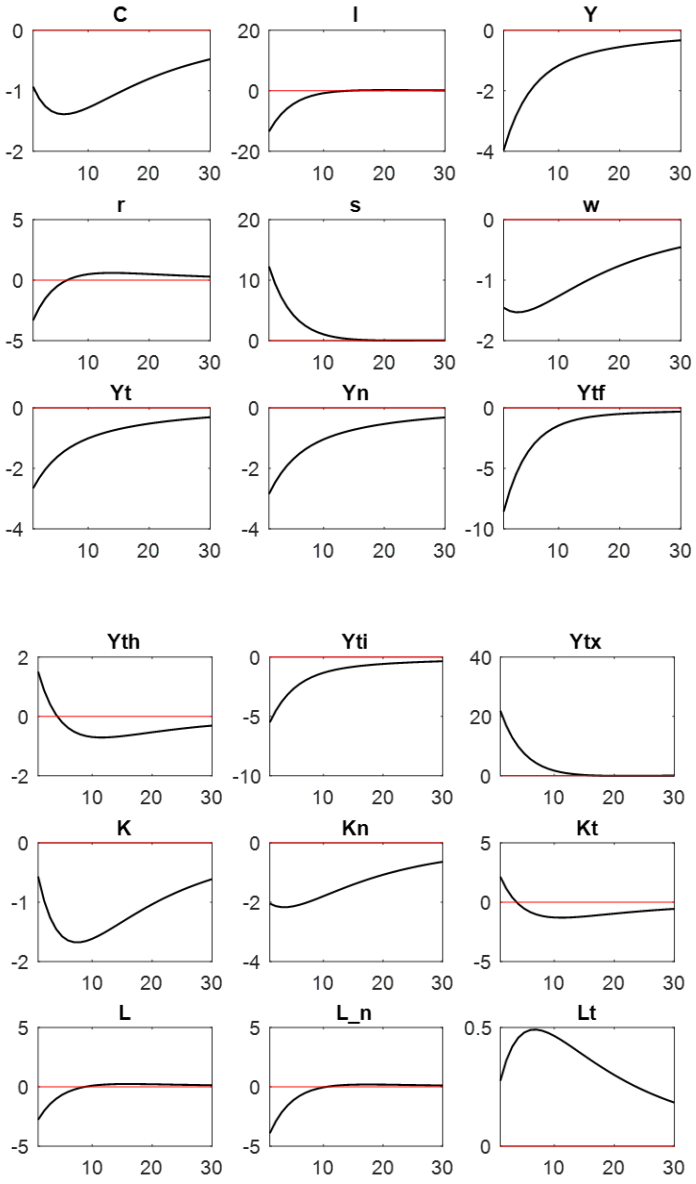

Figure 5. Impulse Response of Macroeconomic Variables for a Negative Shock of Oil Revenue in the Second Scenario
Source: Research finding.

As illustrated in Figure 5, the difference between the second and third scenarios is in the effect of oil shocks. For most macroeconomic variables, trends are the same.

Possibly, the positive features of the third scenario would be greater in response to a negative oil shock. This is where the mechanism of fund stagnation from negative oil shocks, by transferring the shock to the fund's reserves, acts as an automatic counter-cyclical fiscal policy.

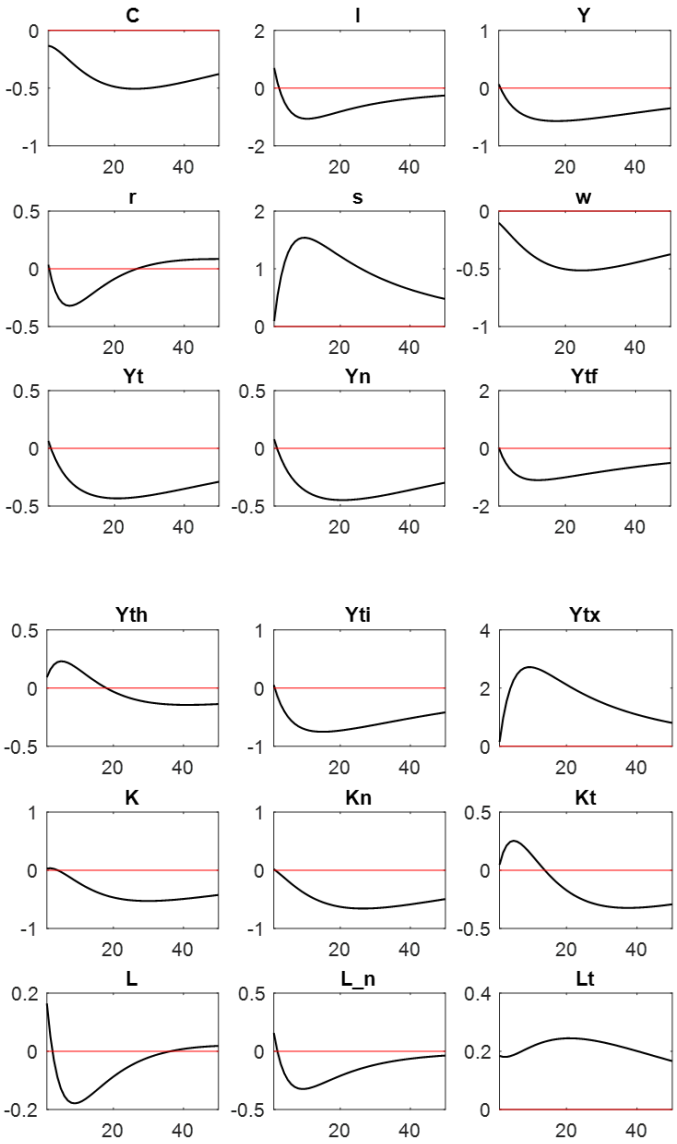

Figure 6. Impulse Response of Macroeconomic Variables for a Negative Oil Shock in the Third Scenario
Source: Research finding.

As illustrated in Figure 6, the mechanism of the fund in this scenario responds to the negative oil shock and reduces the stagnation for oil-dependent countries.

The Fund by stabilizing foreign exchange earnings avoids exchange rates volatility. Similarly, revenue stability prevents a sharp decline in GDP. Furthermore, adjusting negative shocks by the Fund minimizes volatility in consumption and investment. In addition, the exchange rate stabilization improves the production of domestic tradable goods rather than the other two scenarios.

In sum, as this scenario is coupled with macroeconomic policies, it can prevent a significant drop in non-tradable goods when a negative shock happens.

Conclusion

Global price fluctuations of natural resources including oil are a primary reason for economic fluctuations in resource-rich developing countries such as Iran. Rising oil prices and consequently oil revenues in Iran in the 1970s and 2000s have faced the Iranian economy with the Dutch disease in these two periods. The consequence of the disease was a significant

increase in the share of natural resources in national income compared to other sectors. Another consequence of the disease is the weakening of the tradable sector against the non-tradable sector, which is mainly due to the inflow of foreign exchange earnings from natural resource exports and leads to the national currency depreciation. On the other hand, abundant resources weaken the industrial sector as well as the replacement of non-tradable sectors, including services.

However, countries such as Norway were successful in dealing with natural resource revenues and they achieved the desired growth and development with the proper management of resources and avoid the fluctuations of these revenues. Based on these experiences, most economists today attribute the positive or negative effects of resources to the institutional structures and governance of resource-rich countries rather than to the resources.

They benefited from an institutional change in governance as well as strong independent institutions to manage natural resource revenue. They managed to avoid the adverse effect of fluctuations and to make optimal use of such revenues by Sovereign Wealth Fund (SWF). Although these Funds were initially established in Kuwait in the 1950s, the widespread use of these Funds happened mainly after the successful experience of Norway. SWF by managing the inflow of resource revenues, not only prevents the transfer of these fluctuations into the economy but also provides the basis for further growth by investing them properly.

We examined the role of the National Development Fund in the smoothing of economic fluctuations and also as a controlling body for the inflow of oil revenues into the Iranian economy. If the Fund manages to control the inflow of oil revenues into the economy, its impact on economic fluctuations could be explored by a DEGE model. Accordingly, in this study, we examined the role of the Fund in controlling the inflow and outflow of oil revenues by scenarios for the Fund.

The model is based on the real business cycle (RBC) theory. Given that the NDFI is an institution for economic stabilization, three scenarios for the inflow and outflow of oil revenue were considered.

In this article, we examined three scenarios on the inflow and outflow of oil revenue through National Development Fund by developing a DSGE model. In the first scenario which was designed without a stabilization Fund, oil shock directly hit the economy and make macroeconomic fluctuations. Under the second scenario, National Development Fund reduces oil revenue shocks by absorbing just a part of it.

The third scenario, in which all oil revenues are deposited to the National Development Fund and in exchange invest a part of the Fund assets plus a share of oil revenue, is the most effective policy in avoiding the volatility of oil revenues to the economy. Adherence to the rules such as the rule in the third scenario is very effective for improving economic stabilization in Iran's economy.

A difference between the scenarios of this study and Hosseinzadeh et al. (2018) is that, for them, total oil revenues deposited at the Development Fund and will lead to enhancing investment and economic growth in Iran. But for us, the Development Fund through fiscal policy stabilizes the economy.

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