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# The Effects of Oil Revenue Allocation between Accumulation and Current Use on Macroeconomic Responses to External and Internal Shocks in a Small Oil-exporting Economy

**Bulat Mukhamediyev[1], Azimzhan Khitakhunov[2], Zhansaya Temerbulatova[3], Aliya Mukhamediyeva[3]*, Aidana Sabikenova[1]**

[1]Al-Farabi Kazakh National University, Almaty, Kazakhstan, [2]Central Asian Policy Studies, Almaty, Kazakhstan, [3]Almaty Management University, Almaty, Kazakhstan. *Email: aliya.mukhamediyeva@gmail.com

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**ABSTRACT**

All economies face risks of potential shocks, including oil-exporting countries. However, they can influence their impacts by changing the distribution of oil export revenues. However, the impact of different strategies for using rent income on the stability of macroeconomic indicators in the face of external and domestic shocks has been little studied. This study, using a dynamic general equilibrium (DSGE) model, examines the impact of the distribution of oil revenues between accumulation and current expenditure on the macroeconomic responses of a small oil-exporting economy to external and domestic shocks. Within this model, the study identified how different distributions of oil revenues affect the responses of economic indicators such as GDP, consumption, inflation, interest rates, real effective exchange rates, and net exports. The effects of shocks to the global oil price, total factor productivity, labor preferences, external demand for oil, and output in the rest of the world were considered. Although even small changes in the distribution of oil revenues can influence the responses of macroeconomic indicators to shocks, conclusions about the significance of differences between responses were drawn based on their estimated 90% confidence intervals. The results of this study can be considered by policymakers in oil-exporting countries.

**Keywords:** Oil Revenue, External Shocks, Impulse Response Functions, DSGE Model, Confidence Intervals
**JEL Classifications**: E21, C68

## 1. INTRODUCTION

Resource-dependent economies, especially oil-exporting countries, are highly vulnerable to both external and internal shocks that can disrupt macroeconomic stability. Fluctuations in global oil prices, changes in external demand, and domestic productivity disturbances often cause pronounced volatility in key macroeconomic indicators such as output, inflation, and exchange rates. These vulnerabilities make the design of effective fiscal and stabilization policies crucial for maintaining sustainable economic growth.

The allocation of oil revenues between accumulation in sovereign wealth funds and current fiscal expenditures plays a central role in mitigating or amplifying the effects of such shocks. When revenues are saved, they can serve as a buffer against external volatility and contribute to long-term intergenerational equity. In contrast, prioritizing current expenditures can stimulate short-term economic activity and improve welfare, but at the cost of increased fiscal exposure to commodity price cycles. Despite a large body of literature examining the resource curse, Dutch disease, and fiscal policy in resource-rich economies, there remains limited research on how different allocation strategies of oil rents influence macroeconomic responses to various external and domestic shocks within a unified analytical framework.

The purpose of this study is to assess how alternative distributions of oil revenues between accumulation and current use affect the macroeconomic dynamics of a small oil-exporting economy when exposed to external and internal shocks. The analysis is conducted within a dynamic stochastic general equilibrium (DSGE) framework, which enables the consistent evaluation of transmission mechanisms and policy responses. This approach contributes to the understanding of how fiscal design can enhance resilience and stability in economies dependent on exhaustible resources.

The remainder of this paper is structured as follows. Section 2 provides a review of the theoretical and empirical literature on oil revenue management and fiscal stabilization in resource-based economies. Section 3 describes the methodological framework and model specification. Section 4 presents the simulation results and discussion. Section 5 concludes with key policy implications.

## 2. LITERATURE REVIEW

Oil-exporting countries have a dilemma between spending oil revenues for current necessities or saving them for future generations. This issue has no easy solution due to unstable nature of oil revenues caused by economic and other shocks. Fluctuations in oil prices remain surprising despite improved understanding of resource market dynamics. Oil price shocks have implications for key macroeconomic indicators and vary across industries and plants. For economists it is important to determine their duration and dynamics (Baumeister and Kilian, 2016) as the volatility and persistence of oil price shocks is not constant over time (Omotosho and Yang, 2024). In general, increases in oil prices can cause recessions, accelerate inflation, reduce productivity and lower economic growth (Barsky and Kilian, 2004). However, for oil-exporting countries higher prices are associated with higher economic growth and improvements in welfare for national economies and transformation of local economies (Caselli and Michaels, 2013; Newell and Raimi, 2015; Cust and Poelhekke, 2015).

Country experiences show different results in terms of spending and saving tradeoffs. An example of Iran demonstrates that both oil fund savings and physical investments lead to a higher economic growth. However, while physical investments lead to higher economic growth in medium run, financial investment contribute to higher economic growth in longer term (Barkhordar and Saboohi, 2013). Sayadi and Khosroshahi (2020) based on the example of Iran show an importance of investigation of the response of key macroeconomic variables to the oil revenue shocks for an appropriate fiscal rule design using a New Keynesian DSGE approach. According to the findings of the study, a positive oil revenue shock causes an increase in both public and private productions with the former substantially exceeding the latter. The authors conclude that oil funds provide more appropriate oil revenues management, meet the development goals, and can preserve future generations' interests. According to Breisinger et al. (2010) study on Ghana, macroeconomic stability and economic growth require an allocation of oil revenues to both productivity-enhancing investments and an oil fund.

There are countries that experience lack of effects of oil revenues on macroeconomic indicators. For example, the case of Nigeria shows that oil revenue allocation has no significant long-run effect on the country's sustainable economic growth due to institutional problems (Samuel and Kouhy, 2025).

Besides Norway, there are other countries that successfully manage their resource revenues. For example, Chile designed a stable fiscal policy that is based on a simple idea of saving during periods of high copper prices and using those accumulated resources during a global economic crisis. This approach helped to smooth public investment and social expenditures (Céspedes et al., 2014). Here it is worth mentioning that both Norway (Government Pension Fund Global) and Chile (Economic and Social Stabilization Fund) refer to sovereign wealth funds (SWF) for investment and saving purposes. James et al. (2022) draw several important theoretical conclusions regarding the functioning of SWF. They note the need to adapt the capabilities of SWF to the level of development of the country. Countries that have received significant revenues may face constraints. These constraints can be microeconomic (a lack of domestic talent) and macroeconomic (imbalances in monetary and fiscal policies). Kitano and Takaku (2023) apply a DSGE model with a focus on SWF. The review section of the article provides a significant list of studies on these funds and estimates using DSGE models. The overall conclusion of these studies is that SWF can contribute to macroeconomic stability and improve welfare. The authors note that sovereign wealth funds can help stabilize the economies of commodity-exporting countries facing sharp fluctuations in commodity prices.

Many countries show unsuccessful experience of using natural resource revenues for the development and saving purposes (Van der Ploeg and Venables, 2012). Technical difficulty of handling time-limited resource revenues and inefficient governance that is unable to resist short-run spending pressures and lack of commitment to long-run investment and growth strategies explain the failure of many resource-abundant countries. These shortages make the process of transforming subsoil assets into human and physical capital problematic (Venables, 2016). Hence, explaining country differences in managing oil and other resource revenues remain challenging. However, there is consensus that successful management requires strong institutions and appropriate incentives of elites (Savoia and Sen, 2021).

This study tests the hypotheses:

$H_1$. A higher share of current use of oil revenues strengthens the responses of macroeconomic indicators to external and domestic shocks.

$H_2$. A higher share of current use of oil revenues weakens the responses of macroeconomic indicators to external and domestic shocks.

## 3. MATERIALS AND METHODS

A small open economy interacts with the rest of the world, which consists of a large number of small open economies. They share similar preferences, technologies, and market structure. Following (Galí and Monacelli, 2005; Calvo, 1983), we assume that each country is populated by many households. Since further attention will focus on the behavior of a single economy in country H and its interaction with the global economy, we will consider the following.

In the country's economy, households, represented by a representative household, offer their labor to the market in exchange for a variety of final goods. Firms, operating under monopolistic competition and with nominal price rigidity, produce goods. Monetary authorities implement monetary policy in the country. This study is a continuation of the work (Mukhamediyev, 2014). Below is a brief description of the model, which is well suited for the purpose of the study.

### 3.1. Household Behavior

A representative household seeks to maximize the discounted utility that results from the consumption of final goods and labor costs:

$$max\mathbb{E}_0\sum_{t=0}^{\infty}\beta^t\left[\frac{C_t^{1-\sigma}-1}{1-\sigma}-\vartheta_t\frac{L_t^{1+\varphi}}{1+\varphi}\right] \quad (1)$$

Under balance constraints

$$P_tC_t+\mathbb{E}_t\left[Q_{t,t+1}D_{t+1}\right]\le D_t+W_tL_t+\pi_t+\pi_{ot},\ t=0,1,\ldots \quad (2)$$

The variables used here are: consumption ($C_t$), labor supply ($L_t$), intertemporal discount factor ($\beta$), the inverse of the elasticity of intertemporal substitution of consumption ($\sigma$), the inverse of the wage elasticity of labor supply ($\varphi$), preference shock variable ($\vartheta_t$), which affects labor supply, the consumer price index ($P_t$), discounted value of dividends on securities ($Q_{t,t+1}D_{t+1}$) at the end of the period $t$, nominal wage rate ($W_t$), profit $\pi_t$, $\pi_{ot}$, obtained from the production of final goods and oil, respectively, $\mathbb{E}_t$ represents the operator of rational expectations taking into account all information available in period $t$.

First-order autoregressive process $ln\vartheta_t = \rho_\vartheta\, ln\vartheta_{t-1} + \varepsilon_{\vartheta t}$, $\varepsilon_{\vartheta t}\sim i.i.d.(0,\sigma_\vartheta^2)$, describes the behavior of the labor supply shock variable. In an open economy, the population can consume both domestically produced and imported goods. The composite consumption index is formed on the basis of the consumption index of domestic goods $C_{Ht}$ and the consumption index of imported goods $C_{Ft}$:

$$C_t=\left[(1-\alpha)^{\frac{1}{\kappa}}C_{Ht}^{\frac{\kappa-1}{\kappa}}+\alpha^{\frac{1}{\kappa}}C_{Ft}^{\frac{\kappa-1}{\kappa}}\right]^{\frac{\kappa}{\kappa-1}}$$

The parameter $\alpha\in[0,1]$ reflects the degree of openness of the economy, with its higher value indicating a greater degree of openness of the economy. The parameter κ determines the degree of substitutability between the two groups of goods.

Necessary conditions for first-order optimality for problem (1)-(2) taking into account that $Q_{t,t+1}=\frac{1}{1+i_t}$, where $i_t$ – interest rate, lead to equations that define the optimal distribution of consumption and labor. These equations, after log-linearization, are written as

$$c_t=\frac{1}{\sigma}\left(\rho-i_t+\mathbb{E}_t\pi_{t+1}\right)+\mathbb{E}_tc_{t+1} \quad (3)$$

$$w_t-p_t=\sigma c_t+\varphi l_t+\xi_t \quad (4)$$

In them, the logarithms of the quantities represented by capital letters in the previous formulas are designated by the corresponding small letters, with the exception of the inflation rate, for which

$$\pi_{t+1}=P_{t+1}/P_t-1\approx\ln(P_{t+1}/P_t)=p_{t+1}-p_t$$

This is the inflation rate based on the consumer price index ($P_t$), meaning it reflects price changes for both domestic and imported goods. Equation (3), known as the Euler equation, contains expectations for future values of the inflation and consumption variables.

### 3.2. Behavior of Firms

Monopolistically competitive firms in country H produce final goods and are indexed $i\in[0, 1]$. Each firm $i$ uses a technology described by the production function

$$Y_{it}=A_t min\left\{N_{it},\frac{1}{\zeta}O_{it}\right\}$$

Where $Y_{it}$ is the output of final goods by firm $i$, $O_{it}$ is the amount of oil used as an energy source, $A_t$ is the total factor productivity, reflecting the impact of scientific and technological progress, $N_{it}$ is the number of workers employed by this firm, and the coefficient $\zeta$ specifies the fixed proportions of production factors. The value of $A_t$ varies in accordance with the autoregressive process AR(1) of the following form:

$$ln\ A_t=\rho_a ln\mathrm{A}_{t-1}+\varepsilon_{at},\ \varepsilon_{at}\sim i.i.d.\left(0,\sigma_a^2\right).$$

Since the firm does not incur excess costs, the equations $Y_{it}=A_tN_{it}$, $O_{it}=\zeta N_{it}$ will hold. According to the approach of Calvo (1983), the firm changes the price of its product in each period with probability $1-\theta$ and keeps it constant with probability $\theta$.

The probability of price stability over $k$ periods is equal to $\theta^k$. The firm's present value must be taken into account, taking into account the stochastic discount factor $Q_{t,t+k}$. Therefore, the firm setting the price in period t determines the optimal price $\bar{P}$ by solving the following optimization problem:

$$\max_{\bar{P}_t}\left\{\sum_{k=0}^{\infty}\theta^k\mathbb{E}_t\left[Q_{t,t+k}\left(\bar{P}_tY_{it+k|t}-TC_{it+k|t}^n(Y_{it+k|t})\right)\right]\right\}$$

In term of market clearing

$$Y_{it+k|t}=\left(\frac{\bar{P}_t}{P_{t+k}}\right)^{-\varepsilon}C_{t+k}$$

Here, $Y_{it+k|t}$ is the output of the firm in period $t+k$, which last changed its price $P_t$ in period $t$, $TC_{it+k|t}^n(Y_{it+k|t})$ is the firm's total nominal costs in period $t+k$, ε is the elasticity of substitution between bundles of goods produced in country H.

Taking into account the stochastic discount factor, the firm's problem has the form:

$$\max_{\bar{P}_t}\left\{\sum_{k=0}^{\infty}\theta^k\mathbb{E}_t\left[\beta^k\frac{C_{t+k}^{-\sigma}P_t}{C_t^{-\sigma}P_{t+k}}\left(\bar{P}_t\left(\frac{\bar{P}_t}{P_{t+k}}\right)^{-\varepsilon}C_{t+k} - TC_{it+k|t}^n\left(\left(\frac{\bar{P}_t}{P_{t+k}}\right)^{-\varepsilon}C_{t+k}\right)\right)\right]\right\}=0$$

Based on the necessary conditions of first-order optimality, the optimal price that the firm should set in period $t$ is determined:

$$\bar{P}_t=\frac{\varepsilon}{\varepsilon-1}\frac{\mathbb{E}_t\sum_{k=0}^{\infty}\beta^k\theta^k C_{t+k}^{1-\sigma}P_{t+k}^{\varepsilon}MC_{t+k|t}^r}{\mathbb{E}_t\sum_{k=0}^{\infty}\beta^k\theta^k C_{t+k}^{1-\sigma}P_{t+k}^{\varepsilon-1}} \tag{5}$$

Here, $MC_{t+k|t}^r = MC_{t+k|t}^n / P_t$ is the real marginal cost of a firm in period $t+k$, that last changed its price in period $t$. In the case of flexible prices, $\theta = 0$, therefore

$$\bar{P}_t=\frac{\varepsilon}{\varepsilon-1}MC_{t|t}^r$$

The DSGE model is constructed in the form of equations for deviations of variables from their steady state. In the steady state, $\bar{P}_t = P_t = P, Y_{it+k|t} = Y_{it|t}, Q_{t,t+k} = \beta^k$, as well as real marginal costs

$$MC_{t+k|t}^r = MC_{t|t}^r = \frac{\varepsilon-1}{\varepsilon} \equiv MC^r.$$

By expanding into a first-order Taylor series and going over to the logarithms of the variables, formula (5) is transformed to the form

$$\bar{p}_t = m + (1-\theta\beta)\sum_{k=0}^{\infty}\beta^k\theta^k\left[mc_{t+k|t}^r + p_{t+k}\right], \tag{6}$$

where designated $m = -mc^r$.

## 3.3. The Oil Sector

*In country H*. An oil-producing firm maximizes profits at a given wage rate $W_t$ and world oil price $P_{ot}$:

$$\max_{N_{ot}}\left[P_{ot}O_{st} - W_t N_{ot}\right] \tag{7}$$

given that

$$O_{st} = A_{ot}N_{ot}^{\mu},\ 0<\mu<1 \tag{8}$$

The coefficient $A_{ot}$ reflects the impact of technological progress in the oil sector, with $ln\ A_{ot} = \rho_{ao} ln A_{ot-1} + \varepsilon_{aot}$, $\varepsilon_{aot} \sim i.i.d.(0, \sigma_{ao}^2)$. $N_{ot}$ is the number of people employed in oil production, and $O_{st}$ represents the total supply of oil for domestic consumption and export.

By writing down the necessary first-order optimality conditions, we obtain the dependence of the number of people employed in the oil sector ($N_{ot}$) and the volume of oil supply ($O_{st}$) on the price of oil ($P_{ot}$) nd the wage rate ($W_t$), respectively, in log-linearized form:

$$n_{ot} = \ln N_{ot} = \frac{1}{1-\mu}\left(\ln\mu + p_{ot} + a_{ot} - w_t\right),$$

$$o_{st} = \ln O_{st} = \frac{\mu}{1-\mu}\left(\ln\mu + p_{ot} + \frac{1}{\mu}a_{ot} - w_t\right)$$

It can be seen that the volume of oil production, as well as the number of people employed in its production, are positively dependent on the world price of oil and negatively dependent on the wage rate in the country's economy.

## 3.4. Inflation, Terms of Trade, and International Risk Sharing

Log-linearization of the consumer price index relative to steady state, for which $P_H = P_F = P$, allows to relate terms of trade to inflation indicators. Using the first-order Taylor series expansion of $P_t$ relative to steady state, we obtain the logarithm of the consumer price index:

From the formula for the consumer price index $p_t = (1-\alpha)p_{Ht} + \alpha p_{Ft}$ and terms of trade $s_t = p_{Ft} - p_{Ht}$ in logarithmic form for the consumer price index,

$$p_t = p_{Ht} + \alpha s_t \tag{9}$$

This formula shows the relationship between the consumer price index and the domestic price index. This easily derives the relationship between the CPI inflation rate and the domestic producer price inflation rate for country H:

$$\pi_t = \pi_{Ht} + \alpha\Delta s_t \tag{10}$$

Assuming that the law of one price holds and using log-linearization about the steady state, the effective nominal exchange rate ($e_t$) can be given by:

$$p_{Ft} = e_t + p_t^* \tag{11}$$

Also, the effective real exchange rate ($q_t$) can be linearly expressed in terms of trade ($s_t$):

$$q_t = (1-\alpha)s_t \tag{12}$$

In this case, the parameter cannot be equal to one, since this would mean that only imported goods are consumed in country H. Under the assumption of perfect securities markets and the relationship (12) between the real exchange rate and the terms of trade, we have

$$c_t = c_t^* + \frac{1}{\sigma}s_t \tag{13}$$

where $c_t^*$ is the world consumption index.

Households can invest by purchasing both domestic securities $B_t$, and foreign securities $B_t^*$. In this case, the budget constraint must be satisfied.

$$P_t C_t + Q_{t,t+1} B_{t+1} + Q^*_{t,t+1} E_{t+1} B^*_{t+1} \le B_t + E_t B^*_t + W_t L_t + T_t,\ t = 0,1,\ldots$$

Transfers are denoted by $T_t$. From the optimality conditions for $B_t, B^*_t$ after log-linearization, we obtain an equation that links the interest rate $i_t$ in the country with the world interest rate $i^*_t$:

$$i_t = i^*_t + \mathbb{E}_t \Delta e_{t+1} \tag{14}$$

### 3.5. Equilibrium in the Economy

Clearing the market for good i in country H means that the total supply of this good is equal to its consumption in the country and in the rest of the world. By means of transformations and log-linearization, we can obtain the formula derived in (Galí and Monacelli, 2005) $y_t = c_t + \alpha\eta s_t + \alpha\left(\kappa - \frac{1}{\sigma}\right) q_t$. Substituting $q_t = (1-\alpha)s_t$ from (12) and, denoting $\omega = \sigma\eta + (1-\alpha)(\sigma\kappa-1)$, for country H we obtain

$$y_t = c_t + \frac{\alpha\omega}{\sigma} s_t \tag{15}$$

The real income of an oil-producing country is the sum of the income received from the production of goods by firms and the income $Y_{ot}$ from the sale of oil abroad. Let $\delta$ is the share of oil income used for current consumption in country H. The remaining share 1-$\delta$ of oil income is accumulated in a special fund. Then the total income for current consumption

$$Y_{ct} = Y_t + \delta Y_{ot} = \left( \int_0^1 Y_{it}^{\frac{\varepsilon-1}{\varepsilon}} di \right)^{\frac{\varepsilon}{\varepsilon-1}} + \delta \frac{P_{ot} O^*_t}{P_t}$$

Therefore, equality (15) is replaced by

$$y_{ct} = c_t + \frac{\alpha\omega}{\sigma} s_t \tag{16}$$

Where $y_{ct} = g_Y + \psi_Y y_t + (1-\psi_Y) y_{ot}$, $0 < \psi_Y < 1$, and using it, get

$$y_{ct} = y^*_t + \frac{1}{\sigma_\alpha} s_t, \sigma_\alpha = \frac{\sigma}{1-\alpha+\alpha\omega} \tag{17}$$

After substituting $c_t$ from (13) into the Euler equation, we obtain the equation of the dynamic curve IS:

$$y_{ct} = \mathbb{E}_t y_{ct+1} - \frac{1}{\sigma}\left(i_t - \mathbb{E}_t \pi_{t+1} - \rho\right) - \frac{\alpha\omega}{\sigma} \mathbb{E}_t \Delta s_{t+1} \tag{18}$$

It can be written in another form by replacing the inflation rate based on the consumer price index with the inflation rate based on the producer price index in country H:

$$y_{ct} = \mathbb{E}_t y_{ct+1} - \frac{1}{\sigma}\left(i_t - \mathbb{E}_t \pi_{Ht+1} - \rho\right) - \frac{\alpha(\omega-1)}{\sigma} \mathbb{E}_t \Delta s_{t+1} \tag{19}$$

The firm's real marginal costs $MC^r_t = \frac{W_t + \zeta P_{ot}}{A_t P_{Ht}}$. From here, they can be represented in logarithmic form:

$$mc^r_t = g_W + \psi_W w_t + (1-\psi_W) p_{ot} - p_{Ht} - a_t, 0 < \psi_W < 1$$

As for a closed economy, the equation is valid

$$\pi_{Ht} = \beta \mathbb{E}_t \pi_{Ht+1} + \lambda \hat{mc}^r_t \tag{20}$$

where $\lambda = \frac{(1-\beta\theta)(1-\theta)}{\theta}$, $\hat{mc}^r_t = mc^r_t - mc^r$, and $mc^r$ – marginal costs in the steady state. Let τ is the subsidies per unit of output. Then the marginal costs are:

$$MC^r_t = (1-\tau)\frac{W_t + \zeta P_{ot}}{A_t P_{Ht}}$$

Taking into account the optimality condition in the oil sector and the necessary optimality conditions in the household problem, the real marginal costs in logarithmic form are:

$$mc^r_t = g_W + \ln(1-\tau) + \psi_W\left(\sigma c_t + \varphi l_t + \xi_t\right) + \psi_W \alpha s_t + \left(1-\psi_W\right)$$
$$\left(\sigma c_t + \varphi l_t + \xi_t + \alpha s_t - \ln\mu - a_{ot} - (\mu-1) n_{ot}\right) - a_t. \tag{21}$$

In the oil production sector, the entire volume is divided between domestic consumption by domestic firms and exports abroad: $O_{st} = O_t + O^*_t$. Log-linearization relative to steady state leads to the formula

$$o_{st} = g_O + \psi_O o_t + (1-\psi_O) o^*_t, 0 < \psi_O < 1$$

From the production function for the oil sector it follows that $o_{st} = a_{ot} + \mu n_{ot}$ and $o_t = \ln\zeta + n_t$. Then

$$n_{ot} = \frac{1}{\mu}\left[g_O + \psi_O \ln\zeta + \psi_O y_t - \psi_O a_t + \left(1-\psi_O\right) o^*_t - a_{ot}\right]$$

Labor resources are also divided between firms producing final goods and the oil sector:

$$L_t = N_t + N_{ot}$$

$$l_t = g_N + \psi_N n_t + (1-\psi_N) n_{ot}, 0 < \psi_N < 1$$

The production of goods and oil, as well as production abroad, increases firms' marginal costs. Increased productivity in both the goods and oil sectors reduces marginal costs. We assume that domestic prices are correlated with global oil prices, i.e., their difference is described by a first-order autoregressive process:

$$p_{ot} - p_{Ht} = \rho_{po}(p_{ot} - p_{Ht}) + \varepsilon_{pot},$$

Where $\rho_{po}$ is a positive coefficient less than one, $\varepsilon_{POt}$ is a random variable "white noise".

Let $\tilde{y}_t = y_t - y^n_t$ denote the deviation of output under nominal price rigidity from output under flexible prices. Then, for the deviation of real marginal costs from their steady-state values,

$$\hat{mc}^r_t = \left[\sigma_\alpha \psi_Y + \varphi\psi_N + \varphi\left(1-\psi_N\right)\frac{1}{\mu}\psi_O + \left(1-\psi_W\right)\frac{1-\mu}{\mu}\psi_O\right]\tilde{y}_t \tag{22}$$

Substituting this into the right side of equation (20) yields the equation:

$$\pi_{Ht} = \beta \mathbb{E}_t \pi_{Ht+1} + \lambda_\alpha \tilde{y}_t \qquad (23)$$

Where is the coefficient

$$\lambda_\alpha = \lambda \left[ \sigma_\alpha \psi_Y + \varphi \psi_N + \varphi (1-\psi_N) \frac{1}{\mu} \psi_O + (1-\psi_W) \frac{1-\mu}{\mu} \psi_O \right]$$

This is the equation of the new Keynesian Phillips curve for the small open economy considered here.

Given the equality $\Delta s_{t+1} = \sigma_\alpha (\Delta y_{ct+1} - \Delta y^*_{t+1})$, from the equation of the dynamic IS curve, Euler's equation (19), we obtain

$$y_{ct} = \mathbb{E}_t y_{ct+1} - \frac{1}{\sigma_\alpha} (i_t - \mathbb{E}_t \pi_{Ht+1} - \rho) + \alpha(\omega - 1) \mathbb{E}_t \Delta y^*_{t+1}$$

By definition, the real interest rate $r_t = i_t - \mathbb{E}_t \pi_{Ht+1}$. Then this equation can be rewritten as

$$y_{ct} = \mathbb{E}_t y_{ct+1} - \frac{1}{\sigma_\alpha} (r_t - \rho) + \alpha(\omega - 1) \mathbb{E}_t \Delta y^*_{t+1}$$

and for flexible prices we get the same

$$y^n_{ct} = \mathbb{E}_t y^n_{ct+1} - \frac{1}{\sigma_\alpha} (r^n_t - \rho) + \alpha(\omega - 1) \mathbb{E}_t \Delta y^*_{t+1}$$

Subtracting this equality from the previous one, we have the equation

$$\tilde{y}_{ct} = \mathbb{E}_t \tilde{y}_{ct+1} - \frac{1}{\sigma_\alpha} (r_t - r^n_t)$$

Having solved this equation for $r^n_t$ and having performed the required transformations, we can find that $\tilde{y}_{ct} = \psi_Y \tilde{y}_t$. Then the equation of the dynamic curve IS can be written with respect to the variable $\tilde{y}_t$.

$$\tilde{y}_t = \mathbb{E}_t \tilde{y}_{t+1} - \frac{1}{\psi_Y \sigma_\alpha} (i_t - \mathbb{E}_t \pi_{Ht+1} - r^n_t) \qquad (24)$$

Another important component of the dynamic stochastic general equilibrium model is the monetary policy rule. In this model, we adhere to the well-known Taylor rule.

$$i_t = \rho + \varphi_\pi \pi_{Ht} + \varphi_y \tilde{y}_t + v_{mt}$$

Where $\varphi_\pi$, $\varphi_y$ are non−negative coefficients, and $v_{mt}$ is a random variable reflecting monetary policy shocks. Its dynamics are determined by a first-order autoregressive process.

$$v_t = \rho_{mt} v_{t-1} + \varepsilon_{mt},\ \varepsilon_{mt} \sim i.i.d.(0, \sigma^2_m) \qquad (25)$$

Thus, all the relations for the DSGE model, based on the equations of the New Keynesian Phillips curve, the dynamic IS curve, and the monetary policy rule (23)–(25), have been formed.

### 3.6. Confidence Interval Bounds

The estimated dynamic general equilibrium model allows us to obtain the responses of macroeconomic indicators to various external and domestic shocks. In accordance with the topic of the study, to identify the influence of the share of oil revenue use for current needs on the consequences of such shocks, it seems natural to compare the impulse response functions of the indicators at different levels of their use. However, although the graphs of the impulse response functions may differ, there is no reason to believe that the observed differences are statistically significant.

Therefore, the presented DSGE model was further developed in the MATLAB package to obtain the boundaries of 90% confidence intervals for each impulse response function. Only if the confidence interval regions for two different levels of current use of oil revenues do not intersect, at least in the first period, can we assume that there is a statistically significant difference in the responses of the indicator to a given shock.

For the shock under consideration, a large sample will be formed in MATLAB from the beta distribution of the autoregressive coefficient with N of its values, the probability density of which is a function

$$f(x;\alpha,\beta) = \frac{\Gamma(\alpha+\beta)}{\Gamma(\alpha)\Gamma(\beta)} x^{\alpha-1}(1-x)^\beta$$

Here Γ(z) is the gamma function:

$$\Gamma(z) = \int_0^\infty t^{z-1} e^{-t} dt$$

The parameters $\alpha, \beta$ of the beta distribution are selected based on the condition of equality of its mean and variation

$$E[X] = \frac{\alpha}{\alpha+\beta}, var(X) = \frac{\alpha\beta}{(\alpha+\beta)^2 (\alpha+\beta+1)}$$

Their corresponding values obtained during the DSGE model estimation process and their refinement using the Metropolis-Hasting algorithm.

N iterations are then performed in MATLAB, each estimating the DSGE model using a single element of the obtained sample from the beta distribution of the autoregressive coefficient for the corresponding shock. This procedure results in a sample of indicator values in each period, based on which the corresponding confidence interval is estimated.

For the time interval under consideration, the boundaries of the confidence intervals can be shown as curves, or the area between them can be shown as a colored fill.

### 3.7. Econometric Estimation of DSGE Model Parameters and Their Calibration

The parameters of the mathematically sound dynamic stochastic general equilibrium model were estimated using data from the economy of Kazakhstan. Various methods are used to estimate and calibrate the DSGE model parameters, such as econometric modeling, expert estimates, the use of estimates obtained in other studies, a Bayesian approach, and others.

The model presented in the previous section contains 48 parameters, but they are not independent. There are key parameters, which are used to calculate the remaining parameters in the program. Quarterly data for the Kazakhstan economy and the rest of the world from 2010 to 2024 were used to estimate the key parameters (Bureau of National Statistics of Kazakhstan, 2025; World Bank, 2025).

Bayesian estimation was used to refine the parameter estimates obtained during calibration for their consistency with actual data from the economy under study using the Metropolis-Hastings algorithm (Metropolis et al., 1953; Hastings, 1970). 500,000 iterations were performed. Figure 1 shows plots of the prior and posterior distributions for some parameters.

## 4. EMPIRICAL RESULTS AND DISCUSSION

When the National Fund was created in Kazakhstan, it was intended to accumulate the bulk of oil revenues and allocate only a relatively small portion for current economic use. However, subsequently, most of the oil revenues were withdrawn from the National Fund for current use, including to cover the budget deficit, which undoubtedly could have impacted the economy's vulnerability to external and internal shocks.

Below are graphs of the impulse return function (IRF) of macroeconomic indicators in response to an external shock (a positive oil price shock) and a domestic shock (a positive labor preference shock) with a 10% and 30% withdrawal of oil revenues from the National Fund, respectively, for current economic purposes. Confidence intervals for the corresponding responses are plotted, shown by the filled boundaries between the confidence intervals. These intervals allow one to judge the statistical significance of the difference in the indicator responses at these two levels of oil revenue use. In all cases, the shocks are isolated, that is, at the level of one standard error of the corresponding indicator. In all graphs, the value of the function on the vertical axis shows the magnitude of the variable's response to the specified shock in the first period. These responses then weaken in subsequent periods as the economy returns to equilibrium, approaching zero. The horizontal axis shows periods (quarters) from 1 to 10.

Figure 2 shows the responses of macroeconomic indicators to a global oil price shock for two levels of oil revenue use. A sharp increase in the global oil price leads to an increase in firms' production costs. Therefore, due to a decrease in oil use, the economy's output (y) decreases. At the same time, total income (yc) increases due to the inflow of funds from the National Fund, and the interest rate (i) also rises.

The increase in income in the economy contributes to increased consumption (c). The consumer price index (pi) and the domestic inflation rate (pih) increase.

The real effective exchange rate of the national currency (q) experiences a positive jump in both cases. There is an increase in the coefficient of technological progress (a) and net exports (nx) in both cases.

Note that the directions of the responses of all indicators to the global oil price shock are identical for both the 10% and 30% levels of oil revenue use. For all indicators considered, except net exports, the responses to the oil price shock are statistically different. Therefore, based on the relative positions of the

**Figure 1:** Prior and posterior distributions

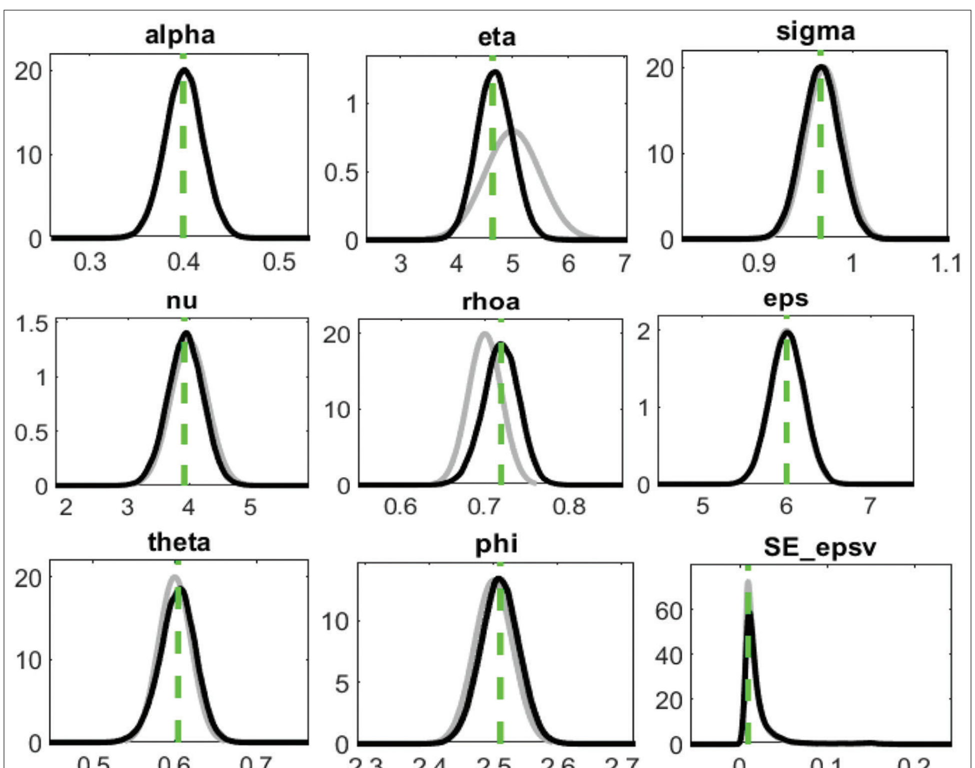
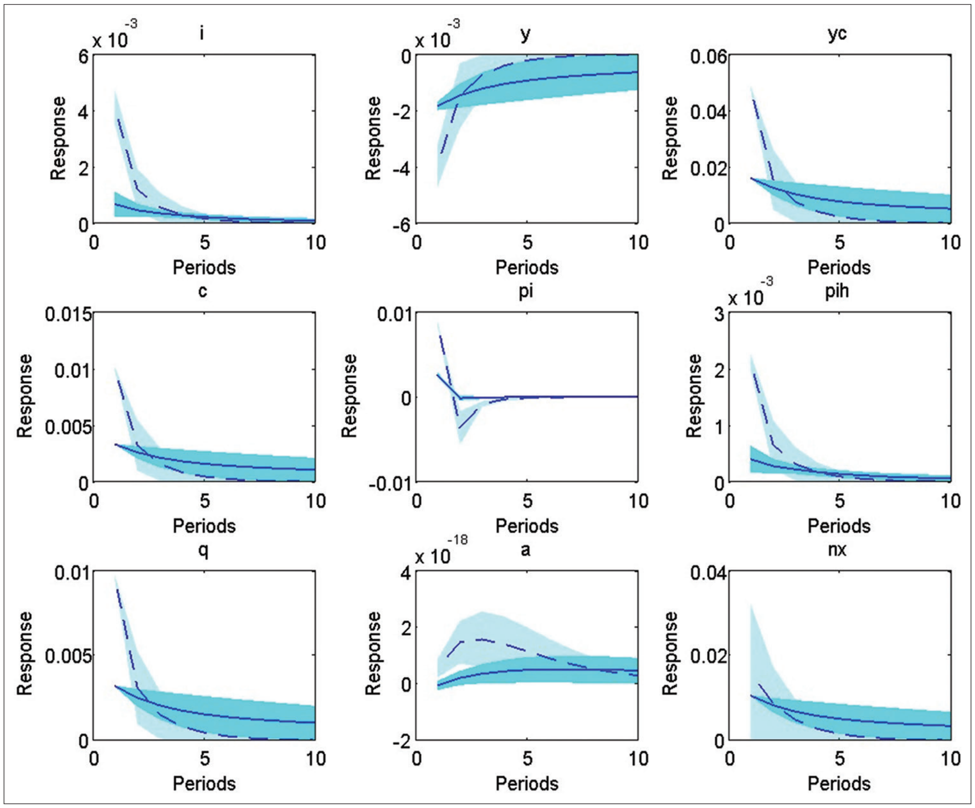


**Figure 2:** Graphs of the impulse response functions of the indicators for a positive oil price shock when using 10% (solid line) and 30% (dashed line) of oil revenues for current targets




confidence intervals, it can be concluded that with a higher share of oil revenues allocated to current use, the positive responses of the interest rate, total income, consumption, the CPI inflation rate, the domestic inflation rate, the technological progress coefficient (total factor productivity in logarithms), and the real effective exchange rate, as well as the negative response of output, are enhanced.

Figure 3 shows the impulse response function graphs of macroeconomic indicators to a positive labor preference shock for two cases: the first, when 10% of oil revenues are used, and the second, when 30% of oil revenues are used for current economic purposes. If the population begins to value leisure more than consumption, this will impact the economy.

Labor costs in the production of goods and services will decrease, and domestic oil consumption will decrease accordingly. This will reduce output (y) and oil production in the country, leading to a decrease in oil export revenues and total income (yc). As a result, consumption (c) will decrease.

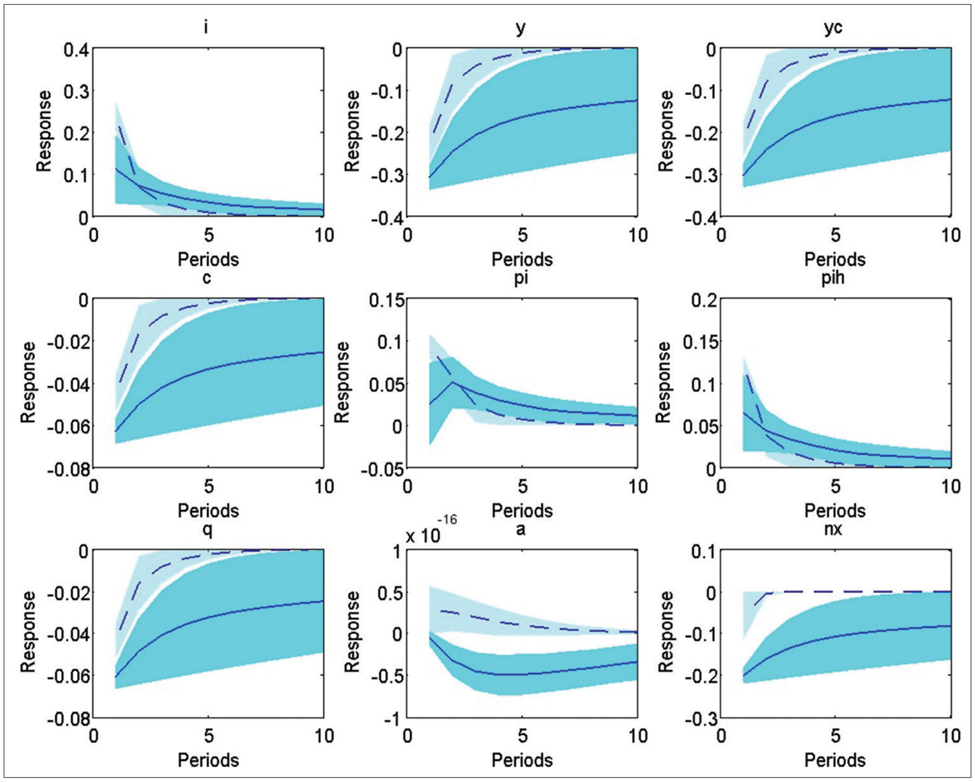
Inflation rates will increase for both the consumer price index (pi) and domestically produced goods (pih). Monetary authorities will respond to the increase in inflation by raising the interest rate (i). There will also be a real depreciation of the national currency (q). The country's net exports (nx) will decrease. A special situation arises for total factor productivity (a). In the first case, when 10% of oil revenues are allocated to current use in the economy, its response is negative, while in the second case, when 30% of oil revenues are currently used in the economy, its response is positive. This can be explained by the fact that, under conditions of labor shortages, firms strive to use them more efficiently and they have greater opportunities when more oil revenues enter the economy. The difference in the impact of oil revenues on the responses of macroeconomic indicators to a shock at two levels of oil revenue use can be confidently judged only if their confidence intervals do not overlap in at least one period. According to the relative positions of the confidence interval areas in Figure 3, as the share of oil revenues for current use increases from 10% to 30%, the responses of output, total consumption income, the real effective exchange rate, and net exports to a labor preference shock weaken, while the response of total factor productivity increases, ranging from negative to positive. For the interest rate, the CPI inflation rate, and the domestic inflation rate, the confidence interval areas overlap in all periods, and it is impossible to draw unambiguous conclusions about the impact of a labor preference shock on their responses with this change in the share of oil revenues used for current purposes in the economy.

An analysis of the responses of macroeconomic indicators to various types of shocks at different levels of oil revenue utilization allows us to assess how the distribution of these revenues between accumulation and current use affects the economy's resilience to external and internal disturbances.

### 4.1. Economic Response to an Oil Price Shock

The results of the analysis (Figure 2) show that in response to a positive oil price shock, economic output declines, while aggregate income, consumption, the real effective exchange rate of the tenge, consumer price index inflation, domestic goods inflation, the interest rate, and net exports all increase. Moreover, for all of

**Figure 3:** Graphs of the impulse response functions of indicators for a positive labor preference shock when using 10% (solid line) and 30% (dashed line) of oil revenues for current purposes




these indicators, with the exception of net exports, the confidence intervals for 10% and 30% oil revenue utilization levels do not intersect in the first period, indicating a statistically significant difference in their responses.

This fact allows us to conclude that the level of oil revenue utilization has a significant impact on the sensitivity of macroeconomic indicators to oil shocks. A higher level of current use (30%) amplifies the responses of variables to changes in oil prices, resulting in more pronounced fluctuations in inflation, interest rates, the real exchange rate, total factor productivity, and consumption, confirming hypothesis H1. Thus, an increase in the share of oil revenues allocated to current purposes increases the economy's dependence on external price conditions and increases its vulnerability to fluctuations in the global oil market. Conversely, a focus on accumulating a portion of oil revenues helps smooth out these fluctuations and forms the basis for long-term macroeconomic stability.

### 4.2. Economic Response to a Labor Preference Shock

The results of the analysis of the responses to a labor preference shock (Figure 3) indicate statistically significant differences between the 10% and 30% levels of oil revenue use for a number of key indicators – consumption, output, total income, the real effective exchange rate, and net exports. For these variables, the confidence intervals do not intersect in the first period, confirming the significance of the differences. A consistent pattern is observed: with higher levels of current use of oil revenues, the response of the real sector (output, exports, consumption) becomes less pronounced, and hypothesis $H_2$ is confirmed for them, whereas nominal indicators (inflation and the interest rate) react more strongly, and hypothesis $H_1$ holds true for them. This indicates that increasing current expenditures due to oil revenues reduces the economy's flexibility to internal behavioral shocks and increases inflation sensitivity, which in the long term can undermine macroeconomic stability.

## 5. CONCLUSION

Summarizing the results of the analysis for various types of shocks allows us to draw the following conclusions:

- A higher level of current use of oil revenues (30% or more) leads to a stronger response of macroeconomic indicators to external and internal disturbances. This is manifested in increased volatility of inflation, the exchange rate, interest rates, and consumption.
- Accumulating oil revenues (for example, through stabilization or sovereign wealth funds) helps smooth out temporary fluctuations, reducing the economy's sensitivity to oil and other shocks.
- With an increase in current use of oil revenues, the adaptability of the real sector weakens and inflationary effects increase, increasing overall macroeconomic vulnerability.
- Accumulation mechanisms provide a countercyclical effect, partially insulating domestic economic processes from external fluctuations and promoting long-term financial stability.

Therefore, a rational strategy for allocating oil revenues between accumulation and current use should provide for a predominance of the accumulation component. This helps reduce the economy's vulnerability to unfavourable external factors, ensure macroeconomic stability and create conditions for sustainable economic growth in the long term.

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