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Fiscal Shocks, Economic Growth, and Income Inequality in Iran: A DSGE Model Analysis with Emphasis on Human Capital

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Abstract

This study examines how tax shocks, government spending shocks, and government bond interest rate shocks impact economic growth and income inequality in Iran, emphasizing human capital as a mediating factor. We develop a New Keynesian DSGE model, incorporating households, firms, the foreign trade, the oil sector, the central bank, and the government. Using Bayesian methods and annual data from 2004 to 2023, we estimate model parameters to capture economic dynamics robustly. The results indicate that economic growth and income inequality are inversely related. Specifically, tax increases, spending cuts, and higher bond interest rates hinder growth, reduce human capital accumulation, and exacerbate inequality—highlighting the need for targeted fiscal reforms. To address these challenges, we propose three policy recommendations: First, broadening the tax base by enhancing compliance and formalizing the informal sector, rather than raising tax rates. Second, improving the efficiency of public spending by reallocating resources to high-impact sectors and replacing blanket subsidies with targeted cash transfers. Third, reducing reliance on high-interest bonds and shifting toward public-private partnerships (PPPs). By integrating these shocks into a DSGE model for Iran's growth-inequality nexus, this study provides novel insights, underscoring the overlooked role of human capital in shaping economic outcomes.

Highlights

- Studying fiscal policy transmission mechanisms in Iran's economy and analyzing their impact on economic growth and income inequality.
- Developing a DSGE model incorporating human capital dynamics.
- Emphasis on Human Capital

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1. Introduction

Economic growth and equitable income distribution are core macroeconomic objectives for any country. Striking a balance between them is crucial, as imbalanced policies may undermine both economic stability and social cohesion. Excessive focus on growth without equitable distribution reduces aggregate demand—due to the higher marginal propensity to save among high-income groups. Conversely, neglecting growth to prioritize redistribution may deter investment, spur capital flight, and shrink the tax base needed to fund social programs.

Although Iranian policymakers acknowledge the need to balance these objectives, structural barriers hinder their simultaneous achievement. A key challenge is the soaring operating deficit, which expanded by 742% between 2015 and 2022 (Central Bank of Iran, Figure 1). This sharp increase stems from several factors, primarily the lack of a fiscal consolidation strategy. Additionally, declining oil revenues—driven by price volatility and international sanctions on the oil sector—have exacerbated the situation. As a result, the share of oil revenues in the total government budget plummeted from 33% in 2015 to just 6.60% in 2020 (Statistical Center of Iran). Despite efforts to boost domestic revenues through taxation, tax income remains low, reaching just 39% of total government revenue (Statistical Center of Iran, Figure 2).

These structural constraints have weakened the government's fiscal capacity, limiting its ability to expand public expenditure on income redistribution programs. As a result, the proportion of individuals living below the poverty line increased from 0.2% of the total population in 2013 to 0.5% in 2022 (World Bank). Furthermore, household expenditure analysis highlights a widening inequality gap, as the share of the poorest 20% declined from 6.63% in 2011 to 6% in 2023, while the share of the wealthiest 20% rose from 44.98% to 47% (Statistical Center of Iran).

Financial shocks reshape the dynamic between economic growth and income inequality through distinct transmission channels. On one hand, they affect economic growth by altering productive capacity and investment patterns. On the other hand, they modify income distribution through changes in household earnings and human capital accumulation pathways. Therefore, the use of inappropriate financial policies may reduce economic growth and lead to increased income inequality.

Empirical studies investigating this relationship in Iran have yielded contradictory findings. Some researchers support the notion of an inverse relationship, suggesting that higher economic growth enhances income distribution (Hoseini et al., 2021; Rezaghoizadeh, 2017; Mousavi Jahromi et al., 2015; Sadeghi et al., 2009). Others, however, argue that economic growth increases inequality (Ghobaishavi et al., 2023; Kazerooni et al., 2020; Radfar et al., 2020; Hassanvand & Khochiani, 2018; Farzanegan & Krieger, 2017; Motameni, 2015; Jani, 2012; Mortazavi et al., 2011). This empirical discrepancy stems from the bidirectional causality between growth and inequality—a

methodological challenge that partial-equilibrium regression frameworks inadequately address (Mu et al., 2022).

This study fills a critical gap in the literature through several methodological and analytical innovations. First, it represents one of the few studies employing a DSGE model to investigate the interplay between economic growth and income distribution inequality in the Iranian context, whereas most prior research has relied on partial equilibrium models or traditional econometric approaches. Second, it incorporates human capital as a key mediating factor in the growth-inequality nexus—a dimension overlooked in previous literature despite its theoretical and empirical relevance. Third, it offers a comprehensive analysis of three fiscal shocks (taxation, government spending, and government bond interest rates), providing a holistic perspective on fiscal policy dynamics in an oil-dependent economy like Iran.

These contributions collectively tackle our central research question: How do fiscal shocks alter the dynamic between economic growth and income inequality in Iran, particularly through their effects on human capital accumulation?

To address this, the article proceeds as follows: Section 2 reviews the theoretical framework linking economic growth and income inequality, synthesizing key empirical studies. Section 3 presents the DSGE model's structure, tailored to Iran's resource-dependent economy. Section 4 employs Bayesian estimation to derive the model's structural parameters, while also computing key economic ratios. It also evaluates the model's fit and accuracy. Furthermore, it utilizes impulse response functions (IRFs) to examine the effects of tax shocks, government spending shocks, and government bond interest rate shocks on economic growth and income inequality, highlighting human capital as a transmission channel.

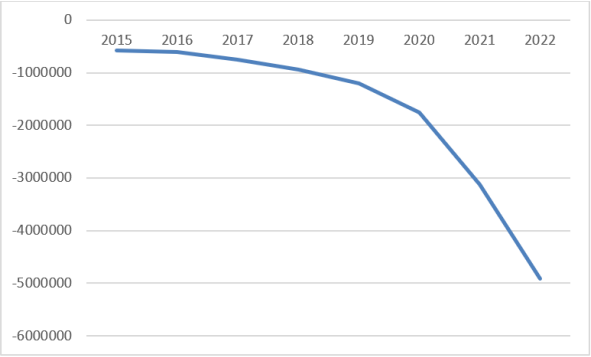

Figure 1. Operating Balance (Billion Rials)
Source: *Central Bank of Iran*

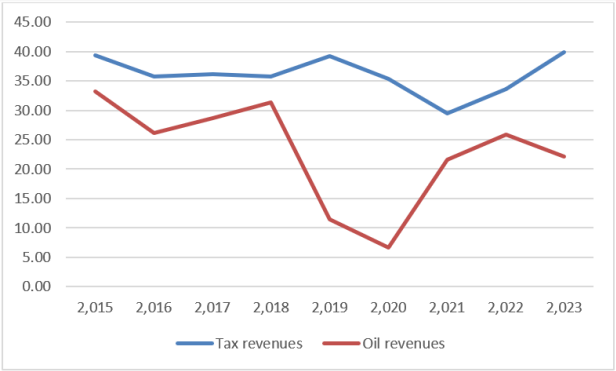

Figure 2. Share of Oil and Tax Revenues from the Total Government Budget %
Source: *Central Bank of Iran*

2. Literature Review

The Kuznets hypothesis was the first systematic attempt to analyze the nexus between economic growth and inequality in income distribution. In his seminal work, Kuznets (1955) examined data from Germany, the United Kingdom, and the United States. He found that inequality initially increased, reached a peak, and subsequently declined as economic development progressed (Hoseini et al., 2021). This pattern revealed an inverted U-shaped link between growth and inequality. During the initial phases of development, only a small segment of the population shifted to the modern sector, widening the wage gap between traditional and modern industries. However, as the economy advanced, workforce skills improved and wages rose, leading to a gradual decrease in income inequality (Radfar et al., 2020).

Furthermore, the trickle-down theory offers another perspective on the growth- inequality nexus. This theory argues that reducing capital tax rates can stimulate economic growth, ultimately benefiting all individuals—not just those receiving tax reductions. Additionally, it suggests that increased credit demand from wealthy individuals drives interest rates higher, enabling lower-income lenders to accumulate wealth (Matsuyama, 2000).

Human capital theory also sheds light on the interconnection between economic growth and income inequality. It classifies human capital into two types: initial human capital, determined by years of formal education, and accumulated human capital, developed through learning by doing. Mu et al. (2022) argue that the positive correlation between initial and accumulated human capital fosters a long-term positive association between economic growth and income inequality. This occurs because workers with higher initial human capital acquire skills more efficiently over time, leading not only to faster wage growth for them but also contributing to broader economic development. However, workers with lower initial human capital often face barriers to skill acquisition, which exacerbates the wage gap between skilled and unskilled labor. Moreover,

human capital theory suggests that reduced income inequality expands educational opportunities, allowing more individuals to invest in skill development. This creates a virtuous cycle where enhanced human capital drives growth and narrows inequality (Heidari & Hassanzadeh, 2017).

Numerous studies have explored the nexus between economic growth and inequality in income distribution in Iran, employing various statistical and quantitative methods across different time periods. However, the findings have been contradictory, with some studies indicating a direct relationship between the two variables, while others suggesting an inverse one.

For instance, Ghobaishavi et al. (2023) analyzed the dynamic interplay between economic growth and income inequality in rural areas of Iran using spatial panel data from 2011 to 2019. Their results revealed a U-shaped pattern, contradicting the inverted U-shaped curve proposed by Kuznets. In contrast, Hoseini et al. (2021) examined how democracy, as a political factor, influenced the growth-inequality nexus in Iran from 1971 to 2018, using an autoregressive-distributed lag (ARDL) model. While their findings confirmed Kuznets' hypothesis within the Iranian economy, they also indicated that democracy weakened the inverse effect of economic growth on inequality.

Similarly, Kazerooni et al. (2020) applied an ARDL model to test both Thomas Piketty's and Kuznets' hypotheses in Iran from 1975 to 2015. Their results validated Piketty's but contradicted Kuznets' hypothesis. Meanwhile, Radfar et al. (2020) explored the interplay between employment, economic growth, and income inequality in Iran from 1989 to 2016, using a vector autoregressive (VAR) model. Their results highlighted a positive correlation, emphasizing the unequal distribution of economic gains. Hassanvand & Khochiani (2018) also applied wavelet coherence analysis to assess economic growth and income inequality in Iran from 1969 to 2016, revealing a direct relationship between the two variables.

Moreover, Ashrafi et al. (2018) studied the effect of economic growth on inequality in income distribution in Iran over the period 1978–2016, using an ARDL model. The results revealed a long-term inverse nexus between the two variables. Rezaghoizadeh (2017) also investigated the interaction among economic growth, income inequality, and tourism in Iran from 1971 to 2012, using the generalized method of moments (GMM). Their findings supported the existence of Kuznets' inverted U-curve in Iran.

Additionally, Samadi et al. (2015) conducted a spatial analysis of income inequality and economic growth in Iran's 28 provinces from 2001 to 2011. To achieve this goal, they used a geographically weighted regression (GWR) model. The results showed that the nexus between the two variables was negative. Mousavi-Jahromi et al. (2015) also employed an ARDL model to examine how various economic factors influenced income inequality in Iran from 1984 to 2011. Their findings confirmed that the correlation between economic growth and income distribution aligned with Kuznets' hypothesis.

Motameni (2015) analyzed the nexus between economic growth and income distribution inequality in Iran from 1971 to 2013, using GARCH and EGARCH models. The findings pointed to a long-term relationship, showing that greater volatility in economic growth contributed to rising income inequality. Jani (2012) Jani2012 also examined the interaction between economic growth and income inequality, using an error correction model (ECM) from 1974 to 2007. Their results showed that economic growth tended to increase income inequality. Additionally, Mortazavi et al. (2011) tested Kuznets' hypothesis across Iran's urban and rural areas from 2000 to 2007, using panel data. Their findings revealed an N-shaped relationship between the two variables in urban areas, while rural areas exhibited an inverse N-shaped pattern.

Furthermore, Akbarian & Famkar (2010) examined the growth-inequality nexus in Iran from 1974 to 2005, considering government spending on education as a mediating factor. Using a simultaneous equations model (SEM) and a two-stage least squares method, they found that income inequality was inversely related to economic growth. In addition, Sadeghi et al. (2009) analyzed the impact of economic growth on income inequality using average data from three periods across 50 developing and developed countries, including Iran. Their findings indicated that higher economic growth reduced income inequality.

3. The Study Model

This model draws inspiration from the works of Nasiri et al. (2023), Khiabani & Amiri (2012), Mu et al. (2022), and Mu & Yan (2021), highlighting its relevance to Iran's economic realities. The framework, designed for an open economy, integrates key economic agents—households, firms, the foreign sector, the oil sector, the government, and the central bank. The study uses a DSGE model to explore the impact of various exogenous shocks on the nexus between economic growth and inequality in income distribution, with particular emphasis on human capital as a transmission mechanism. These shocks include fluctuations in tax revenues, government spending, and government bond interest rates.

3.1. Households

Households aim to maximize expected utility while considering the budget constraint, the capital accumulation equation, and the production function of human capital. The economy consists of similar households with unlimited lifespans. Following the model of Mu & Yan (2021), we use the following instantaneous utility function:

$$U_t^i = \varepsilon_t^C \frac{1}{1-\Omega_c}(C_t)^{1-\Omega_c}(L_t^m)^{\Omega_L} \quad (1)$$

Here, Ω_c is the household's relative risk aversion coefficient, Ω_L is the inverse elasticity of labor supply with respect to the real wage, C_t is the consumption, L_t^m is the total labor supply, and ε_t^C is the preference shock.

The household's budget constraint ensures balance between income and expenditures. On the income side, the household earns wages W_t from supplying

labor L_t^I, rental earnings R_t^k from leasing capital K_{t-1}^I to the production sector, interest income R_{t-1}^{bg} from holding government bonds B_{t-1}, and dividend income DIV_t^I. On the expenditure side, the household allocates resources to consumption C_t, investment I_t, taxes T_t, capital adjustment costs $R.K_{t-1}^m$, and government bonds purchases B_t.

$$C_t + I_t + T_t + R.K_{t-1}^m + \frac{B_t}{\varepsilon_t^{bg}.R_t^{bg}} = \frac{B_{t-1}}{\pi_t} + W_t L_t^I H_{t-1} + R_t^k K_{t-1}^I + DIV_t^I \quad (2)$$

Here, ε_t^{bg} is the government bond interest rate shock.

$$K_t^m = (1-\delta_k)K_{t-1}^m + [1 - S\left(\frac{I_t}{I_{t-1}}\right)]\, I_t \quad (3)$$

$$H_t = (K_{t-1}^h)^{\Psi_{hc}}(L_t^h H_{t-1})^{1-\Psi_h} + (1-\delta_h)H_{t-1} \quad (4)$$

The household's lifetime utility is discounted by the factor $\beta\epsilon(0,1)$. Equation (2) gives the budget constraint. Equation (3) describes capital accumulation, where δ_k is the depreciation rate, and $S\left(\frac{I_t}{I_{t-1}}\right)$ is a convex adjustment cost function satisfying $S(1) = S'(1) = 0$.

Equation (4) represents human capital production, where K_{t-1}^h and L_t^h are capital and labor allocated to human capital production, respectively. In addition, δ_h is the depreciation rate of human capital, and Ψ_{hc} is the capital's share in human capital production.

Following Khiabani & Amiri (2012), the total consumption consists of both domestic and imported goods, represented by the following equation:

$$C_t = [(1-\alpha_c)^{\frac{1}{\eta^c}}.(C_t^D)^{\frac{\eta^c-1}{\eta^c}} + (\alpha_c)^{\frac{1}{\eta^c}}.(C_t^F)^{\frac{\eta^c-1}{\eta^c}}]^{\frac{\eta^c}{1-\eta^c}} \quad (5)$$

Here, C_t^D is the domestic goods consumption, C_t^F is the imported goods consumption, α_c is the share of imported goods in the total consumption, and η^c is the elasticity of substitution between domestic and imported goods.

The nexus between domestic and imported goods prices and their respective consumption levels is given by:

$$P_t^D.C_t^D + P_t^F.C_t^F = P_t^{\eta^c}.C_t \quad (6)$$

Here, P_t^D is the domestic goods price index, P_t^F is the imported goods price index, and $P_t^{\eta^c}$ is the aggregate price index.

The aggregate price index is defined as:

$$P_t^{\eta^c} = [(1-\alpha_c).(P_t^D)^{1-\eta^c} + (\alpha_c).(P_t^F)^{1-\eta^c}]^{\frac{1}{1-\eta^c}} \quad (7)$$

The optimal allocation of domestic and imported goods within consumer expenditure is determined as follows:

$$C_t^D = (1-\alpha_c).(\frac{P_t^D}{P_t^{\eta^c}})^{-\eta^c}.C_t \quad (8)$$

$$C_t^F = (\alpha_c).(\frac{P_t^F}{P_t^{\eta^c}})^{-\eta^c}.C_t \quad (9)$$

Upon constructing the Lagrangian function (equation 10) and deriving the first-order conditions, we obtain equations (11) and (12).

$$\boldsymbol{l_c} = \varepsilon_t^C \frac{1}{1-\theta_c}(C_t)^{1-\theta_c}(L_t^m)^{\theta_L} + \lambda \left[-C_t - I_t - T_t - R_t.K_{t-1}^m - \frac{B_t}{\varepsilon_t^{bg}.R_t^{bg}} + \frac{B_{t-1}}{\pi_t} + W_t L_t^I H_{t-1} + R_t^k K_{t-1}^I + DIV_t^I\right] + \lambda^k[-K_t^m + (1-\delta_k)K_{t-1}^m + [1 - S\left(\frac{I_t}{I_{t-1}}\right)] I_t] + \lambda^h[-H_t + (K_{t-1}^h)^{\Psi_h}(L_t^h H_{t-1})^{1-\Psi_h} + (1-\delta_h)H_{t-1}] \quad (10)$$

$$\varepsilon_t^C (C_t)^{-\Omega_c}(L_t^m)^{\Omega_L} = \frac{\pi_{t+1}}{\beta^t.\varepsilon_t^{bg}.R_t^{bg}} \quad (11)$$

$$\frac{1}{-\beta^t.R_{t+1} + \beta^t(1-\delta_k)} = \frac{\pi_{t+1}}{\beta^t.\varepsilon_t^{bg}.R_t^{bg}} \quad (12)$$

3.2. Firms

3.2.1. Intermediate goods sector

Each firm employs the following production technology to produce the intermediate good:

$$Y_{j,t}^I = \varepsilon_t^a[\Psi_k(K_{j,t}^I)^{1-\gamma} + \Psi_{pg}(PG_{j,t})^{1-\gamma} + (1 - \Psi_k - \Psi_{pg})(L_{j,t}^I H_{t-1})^{1-\gamma}]^{\frac{1}{1-\gamma}} \quad (13)$$

Here, $K_{j,t}^I$, $PG_{j,t}$, $L_{j,t}^I$, and H_{t-1} are capital, public goods, labor, and human capital allocated to intermediate goods production, respectively. Additionally, $\varepsilon_t^a$is the firm's productivity shock, Ψ_k is the share of capital, Ψ_{pg} is the share of public goods, and γ is the substitution elasticity between production inputs.

The dividend equation for each firm is as follows:

$$DIV_{j,t}^I = Y_{j,t}^I - R_t^k K_{j,t}^I - R_t^{pg} PG_{j,t} - W_t L_{j,t}^I \quad (14)$$

Here, R_t^{pg} represents the return on public goods.

The optimization problem for the intermediate goods producer can be formulated as follows:

$$Min: \left[R_t^k K_{j,t}^I + R_t^{pg} PG_{j,t} + W_t L_{j,t}^I\right] - \Lambda_t[\varepsilon_t^a[\Psi_k(K_{j,t}^I)^{1-\gamma} + \Psi_{pg}(PG_{j,t})^{1-\gamma} + \left(1 - \Psi_k - \Psi_{pg}\right).(L_{j,t}^I H_{t-1})^{1-\gamma}]^{\frac{1}{1-\gamma}} - Y_{j,t}^I] \quad (15)$$

To derive the firm's demand for production inputs, we solve the relevant equations, yielding the following relationships:

$$\frac{R_t^k}{\varepsilon_t^a.[Y_{j,t}^I]^{\frac{1}{1-\gamma}-1}.\Psi_k(K_{j,t}^I)^{-\gamma}} = \frac{R_t^{pg}}{\varepsilon_t^a.[Y_{j,t}^I]^{\frac{1}{1-\gamma}-1}.\Psi_{pg}(PG_{j,t})^{-\gamma}} \quad (16)$$

$$mc_t = \frac{W_t}{\varepsilon_t^a.[Y_{j,t}^I]^{\frac{1}{1-\gamma}-1}(1-\Psi_k-\Psi_{pg})(H_{t-1})^{1-\gamma}(L_{j,t}^I)^{-\gamma}} \quad (17)$$

3.2.2. Final goods sector

A representative firm purchases $Y_{j,t}^I$ units of intermediate goods at the nominal price $P_{j,t}$ to produce Y_t units of the final good. In other words, this firm converts a set of differentiated intermediate goods $Y_{j,t}^I$ into Y_t using the following production function:

$$Y_t = [\int_0^1 (Y_{j,t}^I)^{\frac{1}{1+\lambda_P}} dj]^{1+\lambda_P} \quad (18)$$

The firm maximizes its profit function subject to the production constraint, as follows:

$$Max: \prod_t = P_t^D.Y_t - \int_0^1 P_{j,t}Y_{j,t}^I d_j \quad (19)$$

By constructing the Lagrangian function and differentiating it with respect to $Y_{j,t}^I$, then setting the derivative equal to zero, we obtain the following relationship:

$$Y_{j,t}^I = (\frac{P_{j,t}}{P_t^D})^{-\frac{1+\lambda_P}{\lambda_P}} Y_t \quad (20)$$

We assume that $-\frac{1+\lambda_P}{\lambda_P} = \lambda_P$. Consequently, the standard Dixit-Stiglitz curve for the intermediate good takes the following form:

$$Y_{j,t}^I = (\frac{P_{j,t}}{P_t^D})^{\lambda_P} Y_t \quad (21)$$

Here, λ_P represents the price markup.

Given that profits are zero under perfect competition, the profit of the representative firm will also be zero. Therefore, the profit equation is given by:

$$\prod_t = P_t^D Y_t - \int_0^1 P_{j,t}Y_{j,t}^I d_j = 0 \quad (22)$$

As a result, the following relationship holds:

$$P_t^D = [\int_0^1 (P_{j,t})^{-\frac{1}{\lambda_P}} dj]^{-\lambda_P} \quad (23)$$

According to Calvo (1983), the profit function is expressed as follows:

$$Max\ E_t \sum_{s=0}^{\infty} (\beta\xi_P)^s \left[\frac{P_{j,(t+s)}}{P_{t+s}}.Y_{j,t}^I - mc_{t+s}.Y_{j,t}^I\right] \quad (24)$$

Here, ξ_P represents the fraction of firms that are unable to adjust their prices.

By differentiating with respect to P^* and setting the derivative equal to zero, the Phillips curve is as follows:

$$P^* = \frac{\lambda_P mc_{t+s}}{(1+\lambda_P)} P_t^D \quad (25)$$

3.3. Foreign trade sector

According to Yarbrough & Yarbrough (2006), export volume is determined by the Constant Elasticity of Substitution (CES) function, formulated as follows:

$$EX_t = (\frac{P_t^X}{PR_t^*})^{-\eta^f} . Y_t^* \quad (26)$$

Here, Y_t^* is the aggregate demand in foreign countries, P_t^X is the price index for exported goods, and PR_t^* is the consumer price index in foreign countries. η^f is the foreign elasticity of substitution, which indicates the ability of foreign consumers to switch between domestic and imported products.

Similarly, the import volume equation is formulated as follows:

$$IM_t = (\frac{P_t^F}{P_t^D})^{-\eta^c} . Y_t \quad (27)$$

Here, Y_t is the country's aggregate demand, P_t^F is the price index for imported goods, and P_t^D is the consumer price index in the country. η^c is the domestic elasticity of substitution, which indicates the ability of domestic consumers to switch between domestic and imported products.

3.4. Oil sector

The oil sector is the cornerstone of the Iranian economy, making its accurate representation crucial in developing DSGE models for the country. According to Khiabani & Amiri (2012) and Nakhli, et al. (2020). oil revenues in rials are calculated using the following formula:

$$OR_t = re_t . P_t^o . Y_t^o \quad (28)$$

Here, P_t^o is the oil price, Y_t^o is the oil production, and re_t is the real exchange rate. Both the oil price and the oil production follow first-order autoregressive processes (AR(1)), specified as follows:

$$logP_t^{oil} = \rho_{P^{oil}} logP_{t-1}^{oil} + \varepsilon_t^{P^{Oil}}, \varepsilon_t^{P^{Oil}} : N(0, \sigma_{Po}^2) \quad (29)$$

$$logY_t^{oil} = \rho_{Y^{oil}} logY_{t-1}^{oil} + \varepsilon_t^{Y^{Oil}}, \varepsilon_t^{Y^{Oil}} : N(0, \sigma_{Yo}^2) \quad (30)$$

Here, $\rho_{P^{oil}}$ is the coefficient of the autoregressive process for oil prices, while $\rho_{Y^{oil}}$ is the coefficient of the autoregressive process for oil production.

3.5. Government

The government aims to maximize its capacity to provide public goods. The production function follows the specification of Mu et al. (2022):

$$PG_t = (G_t \varepsilon_t^g)^{\Psi_g} (L_t^{pg} H_{t-1})^{1-\Psi_g} \quad (31)$$

Here, L_t^{pg} is the labor used in the production of public goods, G_t is the government expenditures, ε_t^g is the government spending shock, and Ψ_g is the share of government spending in the production of public goods.

The government finances its activities by collecting taxes T_t, issuing bonds B_t, borrowing GD_t from the central bank*, earning oil revenues OR_t, and setting R_t^{pg} as the rental rate for public goods. Accordingly, the government's budget constraint can be expressed as follows:

$$\varepsilon^t T_t + \frac{B_t}{R_t^{bg}} + (GD_t - \frac{GD_{t-1}}{\pi_t}) + R_t^{pg} PG_t + OR_t = \frac{B_{t-1}}{\pi_t} + G_t \varepsilon_t^g + W_t H_{t-1} L_t^{pg} \quad (32)$$

Here, π_t is the inflation, and $\varepsilon^t$is the tax shock. The public goods rental rate, R_t^{pg}, is defined by:

$$R_t^{pg} = \frac{G_t + W_t L_t^{pg} H_{t-1}}{Y_t} \quad (33)$$

The government's optimization problem is formulated as:

$$Max: E_t \sum_{t=0}^{\infty} \beta^t \{R_t^{pg} PG_t\} - \mathfrak{X}_t \left[\varepsilon^t T_t + \frac{B_t}{R_t^{bg}} + (GD_t - \frac{GD_{t-1}}{\pi_t}) + R_t^{pg} PG_t + OR_t - \frac{BG_{t-1}}{\pi_t} - G_t \varepsilon_t^g - W_t H_{t-1} L_t^{pg}\right] - \mathfrak{K}_t [PG_t - (G_t \varepsilon_t^g)^{\Psi_g} (L_t^{pg} H_{t-1})^{1-\Psi_g}] \quad (34)$$

After performing differentiation and rearrangement, we obtain the following relationship:

$$L_t^{pg} = \frac{G_t \, (\varepsilon_t^g)^{\Psi_g} (1 - \Psi_g)}{\Psi_g . W_t H_{t-1}} \quad (35)$$

3.6. Central bank

The monetary base (M_t), a key indicator of the central bank's financial position, is fundamental to monetary policy implementation. As specified in Equation (36), it comprises three components: net foreign assets (FR_t), net government liabilities to the central bank (GD_t), and banking sector liabilities to the central bank (BD_t).

$$M_t = GD_t + FR_t + BD_t \quad (36)$$

The growth rate of the monetary base is defined by:

$$RM_t = \left(\frac{M_t}{M_{t-1}}\right) . \pi_t \quad (37)$$

* The variable GD was added to the government's budget constraint based on Nasiri et al. (2023).

Net foreign assets (FR_t) in Iran are primarily driven by oil export revenues. As specified in Equation (38):

$$FR_t = re_t.OR_t + \frac{FR_{t-1}}{\pi_t} \quad (38)$$

The Taylor rule is expressed as follows:

$$i_t = r^* + \pi_t + \alpha(\pi_t - \pi^*) + b(Y_t - Y^*) \quad (39)$$

This rule explains how the nominal interest rate (i_t) adjusts in response to deviations in inflation from its target π^* and output from its potential level Y^*. Here, α is the inflation responsiveness coefficient, b is the output gap responsiveness coefficient, and r^* is the long-term equilibrium real interest rate.

3.7. Income Inequality

To measure income inequality, we use the Thiel index, following the methodology of the Central Bank of Iran. Its formula is as follows:

$$THEIL = \frac{1}{N}\sum_{i=1}^{N}\frac{y_i}{\bar{y}}\ln\left(\frac{y_i}{\bar{y}}\right) \quad (40)$$

Here, N is the total number of households. y_i is the income of the household (i), and $\bar{y}$ is the total income of all households.

3.8. Clearing conditions

The market equilibrium equations show that total output and oil revenues equal the sum of consumption, investment, government spending, net exports, and capital adjustment costs. Gross Domestic Product (GDP) is the sum of total output and oil revenues. Total capital includes capital used in human capital production and intermediate goods production. Additionally, total labor force consists of labor employed in human capital production, intermediate goods production, and public goods production.

$$Y_t + OR_t = (\varepsilon^C C_t) + I_t + G_t + EX - IM + R_t.K_{t-1}^m \quad (41)$$

$$GDP_t = Y_t + OR_t \quad (42)$$

$$K_{t-1}^m = K_t^h + K_t^I \quad (43)$$

$$\varepsilon^L L_{t-1}^m = L_t^h + L_t^I + L_t^{pg} \quad (44)$$

After estimating the model parameters and calculating the key ratios, we can determine the steady-state values for all variables. Using MATLAB and Dynare, the model is then solved as a system of nonlinear equations.

4. Empirical Results

4.1. Parameter Estimation and Ratio Calculation

This study employed a Bayesian framework to estimate structural parameters using annual macroeconomic data from 2004 to 2023. The data, sourced from the Central Bank of Iran and the Iranian Statistical Center, included key variables such as GDP, private consumption, government expenditures, capital stock, public goods production, and human capital accumulation. All time series were log-transformed and detrended using a Hodrick-Prescott filter. The results are presented in Table (1).

Additionally, key economic ratios were derived from these time series data. These included the ratios of consumption, capital, government expenditures, and oil production to total output, as well as the ratios of public goods to government expenditures and human capital to labor. The results are presented in Table (2) of Appendix (1).

The public goods-to-government spending ratio reflects how much a government allocates to essential services—such as education, and healthcare—relative to its total budget. Similarly, the human capital-to-labor ratio assesses workforce skills, education, and training levels.

Table 1. The results of estimating the parameters using Bayesian Analysis

Parameter	Prior Mean	Posterior Mean	Prior PDF	Posterior Standard Deviation
Ω_c	0.590	0.5908	Gamma	0.0500
Ω_L	2.170	2.1714	Gamma	0.0500
β	0.960	0.9599	Beta	0.0100
δ_k	0.042	0.0418	Beta	0.0100
δ_h	0.035	0.0350	Beta	0.0200
λ_P	0.300	0.2890	Beta	0.0800
Ψ_k	0.412	0.4105	Beta	0.0700
Ψ_{pg}	0.030	0.0343	Beta	0.0150
γ	0.930	0.9401	Gamma	0.1000
Ψ_g	0.400	0.4154	Gamma	0.1000
re_t	0.032	0.0317	Norm	0.0200
θ	0.270	0.2752	Norm	0.0500
n	0.010	0.0099	Beta	0.0050
t	0.180	0.1800	Beta	0.0200
a	0.694	0.6918	Norm	0.2000
b	0.500	0.5005	Norm	0.1000
η^f	1.560	1.5606	Gamma	0.5000
η^c	3.000	3.0061	Gamma	0.5000
ρ_a	0.720	0.7211	Beta	0.1000
$\rho_{P^{Oil}}$	0.700	0.7003	Beta	0.1000
$\rho_{Y^{Oil}}$	0.800	0.7988	Beta	0.1000
ρ_g	0.690	0.6910	Beta	0.1000
ρ_t	0.590	0.7824	Beta	0.1000
ρ_{bg}	0.557	0.5571	Beta	0.1000

***Source**: Research finding*

We assessed the robustness of our results using Markov Chain Monte Carlo (MCMC) diagnostics. Convergence requires two conditions: (1) between-chain variance approaching zero, indicating chain homogeneity, and (2) stable within-chain variance as iterations increase, demonstrating sampling efficiency. Figure (3) illustrates these diagnostics through two traces: the blue line represents the Gelman-Rubin statistic, which combines within- and between-chain variance, while the red line tracks within-chain variance. Meeting both convergence criteria confirmed the reliability of our parameter estimates.

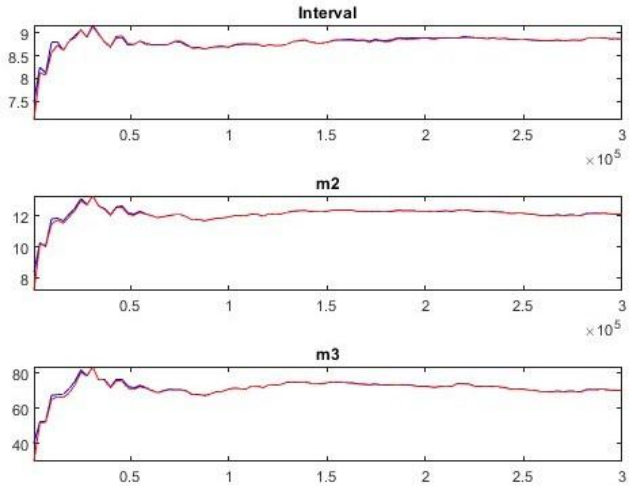

Figure 3. MCMC Diagnostics of the Model
Source: *Research finding*

4.2. Evaluation of model fitness

To evaluate the accuracy of the model, we compared the moments derived from the simulated model with the moments generated by real-world data. The real-world data consists of time series for output, capital stock, private consumption, and government expenditures during the period from 2004 to 2023. These results are presented in Table (2).

Table 2. Comparison of means, standard deviations, and autocorrelation coefficients between real-world data and the simulated model output

Variable	Description	Mean		Std		Autocorr	
		Real data	Simulated data	Real data	Simulated data	Real data	Simulated data
C	Consumption	0.4423	0.4366	0.3350	0.2754	0.6532	0.5998
Y	Output	1	0.9923	۰٫۷۱۳۲	0.6259	0.7467	0.6987
K^m	Capital stock	0.2865	0.2679	0.2100	0.1690	0.5621	0.4969
G	Government spending	0.1532	0.1488	0.1450	0.0978	0.7124	0.6524

Source**:** *Research finding*

As shown in the tables above, comparing the means, standard deviations, and autocorrelation coefficients of real-world data with the simulated model output confirmed that the model accurately represents Iran's economic dynamics.

4.3. Impulse Response Functions

This section examines the impact of various external shocks on the nexus between economic growth and inequality in income distribution. In particular, it focuses on three types of shocks: positive tax shocks, negative government spending shocks, and positive government bond interest rate shocks.

Figure (4) illustrates that a positive tax shock reduces both human capital and GDP, while the income inequality index (THEIL) rises, indicating a widening income gap. These findings reinforce the argument that a positive tax shock induces an inverse nexus between economic growth and income inequality.

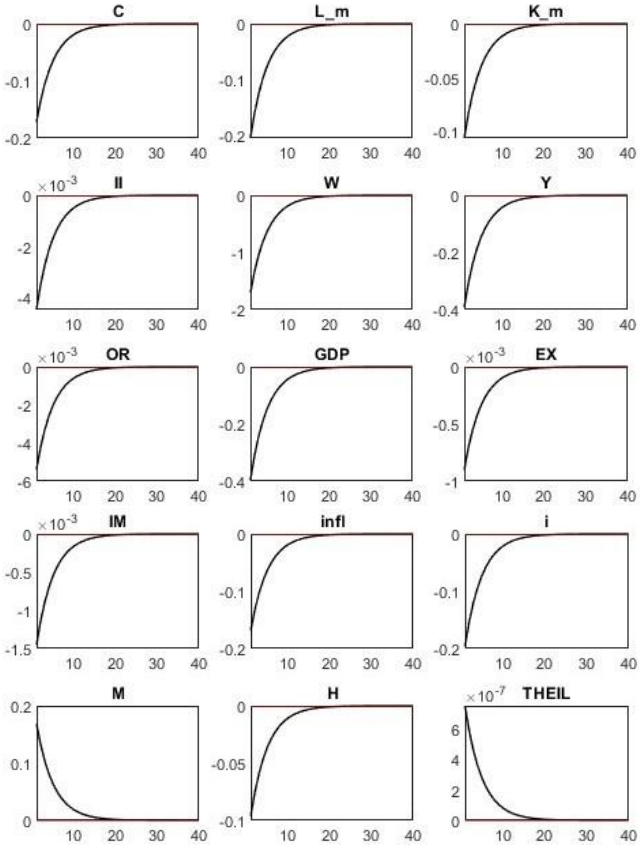

Figure 4. Impulse Response Functions (IRFs) of Economic Variables—Consumption, Labor Supply, Capital, Investment, Wages, Non-Oil Output, Oil Revenues, GDP, Exports, Imports, Inflation, Interest Rate, Money Supply, Human Capital, and Income Inequality—following a Positive Tax Shock

Source: *Research finding*

A positive tax shock reduces households' disposable income, weakening their purchasing power and decreasing consumption (C). The substitution effect further induces individuals to reduce labor hours ($\boldsymbol{L^m}$), exacerbating the economic downturn. As consumption falls, firms face declining sales, prompting them to cut investment (I) due to both higher tax burdens and reduced profits. These constrained profit margins force companies to implement cost-cutting measures, including layoffs and wage reductions (W), which deepen the economic contraction. Consequently, both non-oil output (Y) and oil revenues (OR)

decline—the latter due to weaker demand for petroleum products—resulting in an overall GDP decline.

In addition, a positive tax shock simultaneously dampens both exports (EX) and imports (IM) through interconnected mechanisms. On the export side, higher income and corporate taxes elevate production costs, reducing the competitiveness of domestic goods in global markets. Additionally, constrained financial resources limit firms' investments in research and development (R&D), weakening product quality and long-term competitiveness. Regarding imports, the tax shock impacts two key areas: first, by reducing disposable income, it curtails household demand for imported goods, particularly luxury and durable items. Second, declining aggregate demand and shrinking corporate profits lower businesses' need for intermediate and capital goods, such as raw materials and machinery, further contracting import volumes. Collectively, these dynamics intensify economic pressures, reinforcing the slowdown in trade activity.

Furthermore, declining wages and economic stagnation hinder human capital accumulation (H) by limiting individuals' ability to invest in education, healthcare, and vocational training. This, in turn, exacerbates income inequality (THEIL). Individuals with lower human capital struggle to find employment, while those with higher human capital remain more adaptable to economic shifts.

A positive tax shock also reduces inflation (infl), mainly because higher taxes weaken aggregate demand—households have less to spend, and businesses earn lower profits. To counter this slowdown, the central bank cuts the interest rate (i), encouraging borrowing and investment. This boosts the money supply (M) as banks lend more, which helps stabilize the economy and prevent a deeper downturn. Finally, convergence path analysis indicates that, after the shock, the variables gradually return to their steady states, suggesting a long-run adjustment process.

Figure (5) shows the impulse response functions (IRFs) for key economic variables following a negative government spending shock. Research findings reveal that a reduction in government spending lowers both human capital and GDP while increasing income inequality (THEIL). These results suggest that negative government spending shocks foster an inverse nexus between economic growth and income inequality.

Economic sanctions on Iran often force the government to reduce public expenditure (G), limiting the provision of public goods (PG). Since the government is the largest employer in the country, this fiscal contraction directly lowers public-sector wages (W). As a result, wage reductions in the public sector put downward pressure on private-sector wages through labor market spillovers.

Lower wages reduce labor supply ($\boldsymbol{L^m}$) and household consumption (C), while firms cut investment (I) in response to falling demand. This simultaneous decline in consumption and investment contracts non-oil output (Y), reducing domestic demand for petroleum products and consequently depressing oil revenues (OR). This shock not only shrinks GDP but also erodes the tax base,

triggering a significant drop in government tax revenues (T).

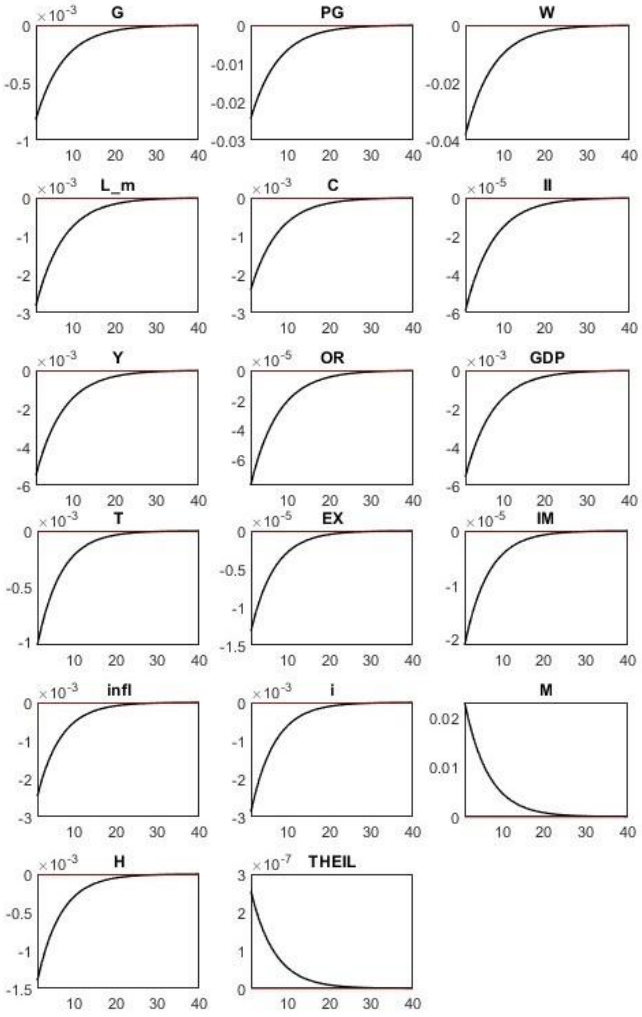

Figure 5. Impulse Response Functions (IRFs) of Economic Variables - Government Spending, Public Goods Production, Wages, Labor Supply, Consumption, Investment, Non-Oil Output, Oil Revenues, GDP, Tax Revenues, Exports, Imports, Inflation, Interest Rate, Money Supply, Human Capital, and Income Inequality - in Response to a Negative Government Spending Shock

Source: *Research Results*

The reduction in government spending also affects both exports (EX) and imports (IM). On the export side, lower public investment in infrastructure, transportation, and logistics raises operational costs for firms, weakening their ability to compete globally. Additionally, budget cuts in education and technology slow innovation, limiting firms' capacity to improve product quality and sustain

international competitiveness. Regarding imports, fiscal tightening indirectly impacts industries that rely on imported intermediate and capital goods, as shrinking corporate profits and declining investment lead firms to reduce their demand for production inputs. Simultaneously, diminished social transfers and subsidies lower household disposable income, further restricting demand for imported consumer goods.

Reduced government spending on public goods, subsidies, and social transfers undermines individuals' ability to accumulate human capital (H), which in turn exacerbates income inequality (THEIL). Limited access to education, healthcare, and vocational training disproportionately affects lower-income groups, reinforcing structural inequalities. Wealthier households, however, retain access to such resources, perpetuating intergenerational barriers to upward mobility and long-term poverty cycles.

Moreover, a negative government spending shock reduces inflation (infl). As economic growth weakens, the central bank tends to cut the interest rate (i) to stimulate private lending. Concurrently, the money supply (M) expands, as monetary authorities deploy expansionary tools—such as open market operations and reserve requirement reductions—to enhance systemic liquidity. This helps offset the fiscal shock's impact and revitalizes economic activity. Empirical analysis of convergence paths reveals that macroeconomic variables gradually revert to their steady-state levels post-shock, suggesting a self-correcting mechanism over the long term.

Figure (6) displays the impulse response functions (IRFs) of key economic variables following a positive government bond interest rate shock. The research findings indicate that this shock leads to a decline in both human capital and GDP, while increasing income inequality (THEIL). These results imply that positive government bond interest rate shocks can contribute to an inverse nexus between economic growth and income inequality.

Over several decades of economic sanctions, Iran has been forced to finance its fiscal deficit by issuing bonds with consistently high interest rates (sometimes reaching up to 25%). As the yields on these government debt instruments rise, the Central Bank is forced to increase its policy interest rate (i) to maintain financial stability. This is because when bond yields exceed the Central Bank's rate, depositors begin to withdraw funds from commercial banks in favor of purchasing higher-yielding government securities. Consequently, the higher policy rate reduces the demand for credit by both individuals and firms, contracting the money supply (M) through a reduction in bank lending. Moreover, the increased cost of borrowing, along with investors' preference for bonds over productive investment projects, leads to a significant decline in investment levels (I).

The decline in investment triggers widespread economic consequences. Firms reduce employment and wages (W), weakening household purchasing power and lowering consumption (C). As wages fall, working hours ($\boldsymbol{L^m}$) also decrease. Meanwhile, high government bond interest rates raise borrowing costs for consumers, further suppressing spending. The simultaneous decline in

consumption and investment contracts non-oil output (Y), reducing demand for petroleum products and shrinking oil revenues (OR)—ultimately leading to a contraction in GDP. This decline in aggregate demand also eases price pressures, resulting in lower inflation (infl).

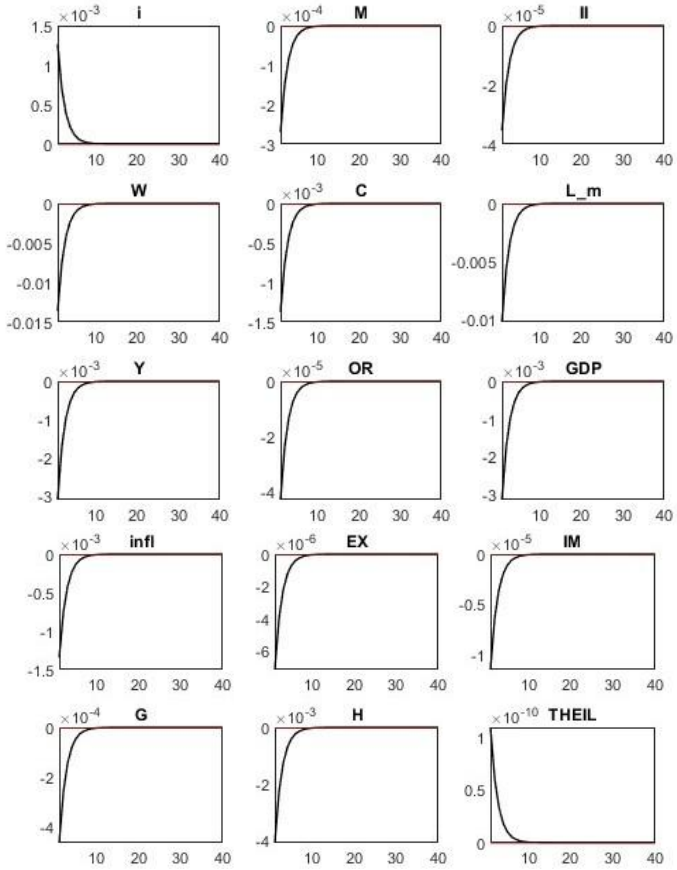

Figure 6. Impulse Response Functions (IRFs) of Economic Variables—Interest Rate, Money Supply, Investment, Wages, Consumption, Labour Supply, Non-Oil Output, Oil Revenues, GDP, Inflation, Exports, Imports, Government Spending, Human Capital, and Income Inequality—in Response to a Positive Government Bond Interest Rate Shock.

Source: *Research Results.*

Higher interest rates on government bonds also reduce exports (EX) by increasing borrowing costs, limiting local firms' ability to expand production or improve export product quality. Similarly, imports (IM) decline as higher borrowing costs make it more costly for individuals and businesses to finance purchases of imported goods.

Moreover, a positive shock to government bond interest rates raises the debt

service-to-revenue ratio, pushing the government to cut overall expenditure (G) in an effort to rationalize spending. As a result, funding for energy subsidies, basic commodities, and essential public services—such as education and healthcare—declines. Simultaneously, lower wages (W) and restricted access to credit limit individuals' ability to invest in education and skill development. Together, these factors—reduced government spending, declining wages, and limited borrowing capacity—significantly hinder human capital accumulation (H), deepening income inequality (THEIL). Finally, convergence path analysis indicates that, following the shock, all variables gradually return to their steady states.

5. Conclusion and policy implications

This study examined the impact of various fiscal shocks on the nexus between economic growth and inequality in income distribution in Iran from 2004 to 2023, with a specific focus on human capital. The analysis focused on three key shocks: positive tax shocks, negative government spending shocks, and positive government bond interest rate shocks. To analyze these dynamics, we utilized a DSGE model based on the New Keynesian approach in an open economy. We applied Bayesian estimation methods to improve parameter accuracy and enhance the robustness of our results.

The results revealed an inverse nexus between economic growth and income inequality in Iran. Positive tax shocks reduced economic growth while increasing income inequality, as they decreased disposable income and weakened human capital accumulation. During economic downturns, inequality worsened further as firms cut wages and laid off workers. This made it particularly difficult for individuals with lower human capital to find new employment opportunities.

Moreover, negative government spending shocks and positive government bond interest rate shocks hindered economic growth and exacerbated income inequality. These fiscal constraints forced the government to cut subsidies, social transfers, and critical investments in education and healthcare. Consequently, access to quality education and healthcare became limited to affluent groups, trapping lower-income populations in a vicious cycle of poverty and unemployment.

The findings of this study are consistent with those of Hoseini et al. (2021), Hassanvand & Khochiani (2018), Ashrafi et al. (2018), Rezaghoizadeh (2017), Samadi et al. (2015), Mousavi-Jahromi et al. (2015), Akbarian & Famkar (2010), and Sadeghi et al. (2009). These studies indicated an inverse nexus between economic growth and inequality in income distribution, demonstrating that economic expansion contributed to a more equitable distribution of income. This effect is particularly strong when growth is supported by democratic governance, increased public spending, and investments in education.

Conversely, the findings of this study contradicted those of Ghobaishavi et al. (2023), Radfar et al. (2020), Kazerooni et al. (2020), Motameni (2015), and Jani (2012). These studies found that while economic growth increased overall wealth, it tended to benefit certain groups more than others, leading to wider

income inequality.

The findings of this study include several important recommendations for policymakers:

First, the government should focus on expanding the tax base rather than increasing tax rates. This can be achieved by combating tax evasion and integrating the informal sector into the formal economy. Strengthening tax monitoring mechanisms and employing advanced data collection and analysis technologies would enhance tax compliance, particularly among small and medium enterprises (SMEs). Empirical studies indicated that tax digitization, which simplifies tax reporting and payment processes, has significantly improved taxpayer compliance in countries such as Tajikistan, Senegal, and Peru (Nose & Mengistu, 2023). Additionally, the integration of the informal sector can be achieved through simplified registration programs for small businesses, along with temporary tax exemptions and incentives.These policy measures could strengthen the government's ability to increase public spending on education and healthcare. This, in turn, fosters human capital development, reduces inequality, and promotes sustainable economic growth.

Second, the government should focus on improving the efficiency of public spending rather than resorting to arbitrary budget cuts. This objective can be advanced through several concrete measures: a specialized committee of economic experts, private sector representatives, and civil society members should assess current programs and redirect resources to high-impact sectors like education and healthcare. Additionally, replacing in-kind subsidies with direct cash transfers would significantly reduce administrative burdens and logistical costs, as evidenced by international research on subsidy reforms (Young et al., 1999). Furthermore, implementing conditional cash transfer programs—similar to successful initiatives like Brazil's Bolsa Família and Mexico's Progresa—could offer immediate financial relief while encouraging long-term human capital development through encouraging school enrollment and regular healthcare visits (Cotto & Alfredo, 2018). Together, these targeted reforms would optimize fiscal efficiency while promoting equitable development and sustainable economic growth.

Third, the government should reduce reliance on high-interest government bonds and shift toward public-private partnerships (PPPs) for critical infrastructure projects. Evidence from India showed that well-designed PPPs delivered dual benefits: reducing fiscal pressure through private investment, while ensuring quality via performance-based contracts (Das, 2007). This shift can boost human capital development and reduce income inequality by improving access to quality infrastructure and public service.

This study yielded fresh insights into how financial shocks mediate the nexus between economic growth and income inequality in Iran, with particular emphasis on human capital dynamics. However, four methodological limitations warrant mention: First, it omitted the informal sector, a critical driver of Iran's economy that shapes both income distribution and growth patterns. Second, it excluded

non-Ricardian consumers, whose limited financial market access results in distinct shock-response behaviors. Third, it did not distinguish between initial human capital (proxied by formal education duration) and accumulated human capital (developed through experiential learning). Finally, it depended exclusively on the Theil Index, without supplementary inequality metrics.

Given these limitations, future studies should expand the scope of analysis to include the informal sector and incorporate non-Ricardian consumer behavior. Additionally, it is advisable to integrate initial human capital into the model alongside accumulated human capital to provide a more precise assessment of its role in economic development and income inequality reduction. Furthermore, we recommend using alternative indicators to analyze income inequality, such as decile-based analysis of household consumption expenditures. We also suggest examining additional shocks like oil and monetary shocks, given their critical importance to Iran's economy.

Author Contributions

Conceptualization, all authors; methodology all authors; formal analysis, all authors; resources, all authors; writing—original draft preparation, all authors; writing—review and editing, all authors. All authors have read and agreed to the published version of the manuscript.

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The authors declare no conflict of interest.

Data Availability Statement

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Appendix 1

Table 3. The results of calculating the key economic ratios

Ratio	Description	Value	source
$\frac{C}{Y}$	Consumption-to-output ratio	0.44236	Computing research
$\frac{K^m}{Y}$	Capital-to-output ratio	0.27583	Computing research
$\frac{G}{Y}$	Government-spending-to-output ratio	0.15880	Computing research

$\frac{Y^o}{Y}$	Oil-production-to-output ratio	0.43023	Computing research
$\frac{PG}{G}$	Public-goods-to-government spending ratio	0.53224	Computing research
$\frac{HC}{L^m}$	Human-capital-to-labor ratio	0.46890	Computing research

***Source*:** *Research finding*