

Assessing the Macroeconomic and Welfare Effects of Government Spending Shocks under Two Banking Systems Via the DSGE Approach

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Abstract:

The aim of this research was to examine the macroeconomic and welfare effects of shocks to government consumption expenditure and government investment expenditure under fractional reserve banking and full reserve banking in the Iranian economy. To this end, two New Keynesian dynamic stochastic general equilibrium (DSGE) models were developed, and the behavior of the economy under the two banking regimes was analyzed in a comparative framework. Model parameters were calibrated and estimated using quarterly data for the Iranian economy from 1991 to 2023, using the Bayesian estimation method. The impulse response function analysis indicates that the effects of government fiscal shocks depend critically on the type of banking. Under fractional reserve banking, positive shocks to government consumption and investment expenditures increase output and money supply through the credit channel and endogenous money creation. However, the associated rise in the real interest rate constrains private consumption in the short run and generates more persistent inflationary pressures. In contrast, under full reserve banking, the elimination of bank-based money creation and the direct control of money supply dampen monetary and inflationary fluctuations. As a result, both consumption and output increase, while macroeconomic variables return more rapidly to their steady-state paths. Moreover, the results show that government investment expenditure shocks generate more persistent and less volatile effects on real economic activity than government consumption expenditure shocks. To assess welfare implications, a welfare loss function based on inflation volatility and the output gap was specified, and welfare losses under optimal monetary policy were computed under the two types of banking. The results showed that welfare losses are significantly lower under full reserve banking. In both models, policy configurations that assign a relatively lower weight to output gap stabilization compared to inflation stabilization are welfare superior. Overall, the results suggest that a stronger focus on inflation control by the central bank—particularly within a full reserve banking framework—can reduce macroeconomic volatility and enhance economic stability and welfare.

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1. Introduction and Literature review

A coherent relation between the real sector and the monetary sector is the primary condition for efficient performance in any economic system. A stable and durable equilibrium in economics is obtained when the two sectors, with their interconnected relations, make conditions ready for achieving equilibrium. In the conventional monetary system, which is based on the principle of fractional reserve banking, and the matured difference between depositability and lending, there appears credit money which is created from nothing (Phillips, 1992). The creation of money in the framework of fractional reserve banking has caused instability in the equilibrium of the economy and has resulted in financial and economic crises. Statistics show that debt or created money in the banking system is growing at a rate faster than the real gross domestic production in almost every country, and this has led researchers to pay close attention to bank-related issues, their amendments and stabilization.

Evidence indicates that the function of fractional reserve banking, even after the financial crisis of 1930, worsened financial instability in the economic system. Such a disorder is widely attributed to a lack of attention to the dual roles of banks, both as a payment system and a financial intermediary system, that guide savings to investment (Dimand, 1993). During the 1980s, bank failures became a common phenomenon before economic crises, in a manner that bank loans went through a cycle that ultimately led to bank failures and loss of big loans (Al-Jarhi, 2004). There are signs that fractional reserve banking may limit the central bank's ability to supply money, while at the same time it provides banks with too much power and incentive to create money (Borhani et al. (2019); Sigurjonsson (2015)).

The adoption of full reserve banking, also known as one-hundred percent money, is the most difficult reform in the monetary system of any nation. Banks and governments usually resist this kind of reform, and they have done so in the past. In full reserve banking, there is the separation of debt obligations and money from each other, meaning that money cannot be created by a bank as demand deposits. Furthermore, money would not be affected by debt-related fluctuations. The full reserve banking (FuRB) system has been adopted by the Hamburg Bank (1619), the Amsterdam Bank (1609), the Postal System, and also by other full reserve institutions of depository function which limited commerce to pure-secure transfer and depository purposes (Grace, 2022).

The eradication of fractional reserve banking is regarded as an essential condition for founding a stable banking system. Fractional reserve banking involves debt money, the eradication of which comes to support FuRB. This circumstance was postulated by Maurice Allais (1999), Murray Rothbard (1962), Ludwig von Mises (1953), Irving Fisher (1936), Frederick Soddy (1934), authors of the Chicago Plan (1933), Amasa Walker (1873), Charles H. Carroll (1850s), William

Gouge (1833), and David Hume (1752), to name several economists. Their important contribution was the proposition of a two-tier banking system:

- i. FuRB, exclusively for payments and depository processes
- ii. Achieving financial intermediation through investment banking and making investments from savings

There are several reasons why full reserve banking has been suggested. It enables the avoidance of (i) recurrent bank failures and loss on the depositors' side; (ii) a large contraction and/or expansion of money supply that contribute to crashes, speculative bubbles, grave recessions, and decreases in employment and output; (iii) the unfair redistribution of wealth through unreal credit that benefits speculators and borrowers; (iv) debt money that was excessively expensive to utilize, because interest should be waged on debt-money contracts when there is a failure of interest payment. It is also because interest should be waged on outstanding debt. In fact, fractional reserve banking has caused numerous banks to become bankrupt, while incurring large amounts of financial loss on depositors, or on tax payers via bailouts and schemes that make deposit-insurance subsidized. Thus, it has been in the intention of many authors to separate money deposits from debt obligations and lending. Separating them in this way meant to cut off links that money supply had with debt, in order to avoid inter-connected fluctuations of debt and money, as well as to assure that banks lend and hold true savings, instead of issuing unreal credit. In this way, there should be no creation or destruction of money through debt contraction and/or expansion by the credit multiplier (Demeulemeester, 2024).

With fractional reserve banking, many banks have become bankrupt as a result of deposit insurance and financing schemes that caused financial loss for tax payers and depositors. Thus, many authors have considered necessary the separation of money deposit from loan obligations and debt. Separating them was a prerequisite to disband money supply from debt, in order to avoid their fluctuation relationship with each other. The separation also aimed at ensuring that banks have real savings, lend money, and refrain from issuing unreal credit. Money creation and/or destruction is recommended to be avoided from happening by increasing debt and through constriction by the money multiplier (Dixhoorn, 2013). There is a relation between fractional reserve banking and debt-based money. In terms of defining the concepts, to create money, the government actually finances a bank. Where fractional reserve banking was used, debt money caused nations to deteriorate in economy, moving them from prosperity to recession (Juglar, 1862) and dismantling the gold standard.

Thus, to make reforms in the fractional reserve banking system, the full reserve banking (FuRB) system was suggested by economists. Under FuRB, it is not allowed to create private money. Nowadays, this actually means that banks can no longer create new money as bank deposits through bank lending. This is

synonymous with the condition that either a commodity (e.g. gold) or governmental money (i.e. government securities, cash and central bank reserves) would have to back each deposit. FuRB is tasked with the aim to separate the financing system from the payments system, while also aiming to sever the relation between credit policy and monetary policy.

Whereas the discussion on full reserve banking started from the suggestion of David Ricardo (1823), full reserve banking was first introduced by leading economists in the Chicago Plan (1933) after the Great Depression (1930). In order of appearance through time, regarding the FuRB suggestions, the standard on pure commodity appeared initially (e.g. Ricardo 1824; Mises 1912; Hayek 1937; Rothbard 1962; Huerta de Soto 2009), and was attributed to as early as David Ricardo. According to FuRB, money in its totality, bank deposits included, should be supported by value-based commodities, e.g. gold (in the entire variety of types),¹ which is characteristic of the Austrian school.

Within the frame of a sovereign monetary system (e.g. from as early as Soddy 1926 to most recent as Wolf 2014a; 2014b), the central bank maintains demand deposits in entirety. Deposit banks are able to provide loans, exclusively, through encouraging depositors to deposit their savings or by utilizing their own capital. Associations are recognized among Sovereign money, ecological economics, New Economics Foundation, and Positive Money.

As a matter of the Chicago Plan (e.g. from as early as Knight et al. (1933) to as recent as Prescott and Wessel 2016), deposit banks cannot provide anything other than payments services, and are not eligible to make loans, as linked with the ‘old’ Chicago school. Deposited currency proposals (e.g. from as early as Tobin 1985 to as recent as Grace 2022) state that only some specific deposits can be managed by the full-reserve requirement, whereas no guarantee can be made for other deposits (i.e. those that are not fully backed). Individuals are free to select their preference of which deposit type to hold. Deposited currency can occur in several examples, such as central bank accounts for the general public and Postal saving systems.

Narrow banking proposals (e.g. from as early as Kareken (1986) to as recent as Stiglitz (2016)), limit the assets of banks to ‘safe’ by applying several standards. Less limiting proposals, however, do not count as FRB. Accordingly, these proposals enable the issuance of assets, such as mortgages, by private banks.

In limited purpose banking which was mentioned by Kotlikoff (2010), Cochrane (2014) and Pollock (1993), banks become unleveraged mutual funds, so that the liabilities of banks become limited to equity, meaning that investors create all risks, whereas the banks do not create risk. Fisher (1935) and Jackson and Dyson (2012) probably provided the most valuable and precise proposals for FuRB. They contributed to the Chicago Plan and sovereign money versions of FuRB,

¹ For this reason, FRB is used as a comprehensive term, instead of public money.

respectively. The Chicago Plan was almost adopted at the time of the Great Depression, but nowadays the most widespread type of FuRB appears to be sovereign money.

Statistical data show that in recent years of the Iranian economy, despite its growth in variables, e.g. money supply, the real sector of Iran's economy has not benefited much from this growth. It shows a separation between the real sector and the monetary sector, which is due to the performance of banks. Of course, one of the most essential fundamentals of the financial system, especially in developing countries, is the banking system. According to statistics and information published by the Central Bank, the share of the banking system in the economy of Iran from 2019 to 2021 was 79, 81 and 82%, respectively, which validates the predominance of the banking system in the financial system of Iran's economy. In such a situation, investment decisions of public and private firms and consumption decisions of households will be strongly influenced by the conditions of the country's banking system due to the bank-centered financial system.

Considering the said issues, the main purpose of this article is, firstly, to design two Dynamic Stochastic General Equilibrium (DSGE) models for fractional reserve banking and full reserve banking for the Iranian economy. Subsequently, the macroeconomic and welfare effects of financial shocks stemming from government expenditures are assessed using these models. This article is organized into five sections. After the introduction and review of literature, the models are introduced in the second section. In the third section, there is the calibration and evaluation of the model. In the fourth section, there is the experimental results and analysis of impulse response function. In the final section, conclusions and recommendations for policy are presented.

2. Model

In the following, we specify two DSGE models for the Iranian economy in terms of fractional reserve and full reserve banking.

2-1. Model under fractional reserve banking

To be pertinent and efficient, the current article employs a model that evaluates realities within the Iranian economy and examines how the monetary sector interacts with real sectors of the Iranian economy. The model is inspired by Geraly et al (2010), Benes, and Kumhof (2014) whereby a stochastic dynamic general-equilibrium model is used. In the following, the assumptions and characteristics of each section are explained.

2-1-1. Household

A country's economy is usually regarded as a system that consists of many households, of which the ω percent represents patient households and the $(1-\omega)$ percent represents impatient households. The representative household gains

desirability from the consumption of goods (c_t) and the maintenance of real monetary assets (x_t), whereas its desirability decreases with the supply of labor (h_t). A present value of the acquired benefits exists by the representative household during its lifetime (Relation 1):

$$U_t^i = E_t \sum_{\tau=0}^{\infty} \beta^{\tau} \left\{ \frac{(c_t^i)^{1-\sigma_c}}{1-\sigma_c} + \psi_x \log \left(\frac{x_t^i}{p_t} \right) - \frac{(h_t^i)^{1-\sigma_h}}{1-\sigma_h} \right\} \quad i = P, I \quad (1)$$

In relation 1, β represents the discount factor, σ_c represents the inverse elasticity of substitution among periods of consumption, σ_h is the inverse-elasticity of labor supply relative to real wages, p_t is the general level of prices according to consumer-price index, ψ_x is the interest-elasticity of demand for monetary assets as stated by Agenor et al. (2014), x_t is the combined index of monetary assets which resemble the geometric average of the holding currency ($M_t^{c,u}$) and deposits of all sorts in the banking system (D_t). In real terms, they are expressed in Equation (2):

$$x_t = (m_t^c)^{\mu} (d_t)^{1-\mu}, \quad \mu \in (0,1) \quad (2)$$

Each household serves the purpose of maximizing the present value of expected utility which can be subject to budget constraints by optimally selecting decision variables.

2-1-1-1. Patient Household

In a given period, the representative patient household manifests private consumption (c_t^P), holding currency ($m_t^{c,P}$), surplus revenue from labor supply ($w_t h_t^P$), while it spends on investment (i_t), makes deposits (d_t^P) in banks and credit institutions, and benefits from their returns. In other words, in terms of the net real-tax payment ($\bar{T}_t^P$), there are capital gains from rental income and real distributed profits of firms (π_t^m). Thus, the real household budget constraint and the capital accumulation process are expressed as Equations (3) and (4).

$$c_t^P + \mathcal{P}_{It} i_t + m_t^{c,P} + d_t^P = w_t h_t^P + r_{k,t} k_{t-1} + (1 + r_{d,t-1}) \frac{d_{t-1}^P}{\pi_t} + \frac{m_{t-1}^{c,P}}{\pi_t} + \pi_t^m - \bar{T}_t^P \quad (3)$$

$$k_t = (1 - \delta_k) k_{t-1} + \left(1 - S \left(\frac{i_t}{i_{t-1}} \right) \right) i_t \quad (4)$$

Where $\mathcal{P}_{It} = \frac{P_{It}}{P_t}$ represents the price-index ratio of investment goods against the price-index of consumer goods, which can be expressed as follows:

$$\frac{\mathcal{P}_{It}}{\mathcal{P}_{It-1}} = \frac{\pi_{It}}{\pi_t} \quad (5)$$

$\pi_{1t} = \frac{p_{1t}}{p_{1,t-1}}$ is inflation of investment goods and $\pi_t = \frac{p_t}{p_{t-1}}$ is the inflation of domestic consumer goods.

With reference to the two constraints in equations (3) and (4), the household aims at maximizing the present value of utility. the first order circumstances comprise the demand for real money balance, the consumption Euler, labor supply, investment Euler, and capital pricing dynamics.

2-1-1-2. Impatient Households

Unlike patient households, impatient households cannot participate in financial markets; consequently, their consumption equals their current income. Impatient households have no usual source of income other than labor-supply (wage). Therefore, the general assumption is that they alleviate the pressure of their consumption expenditure by obtaining a loan from a bank. In this regard, the maximum loan is based on a ratio (proportion) of household income (ltv^I) whose real value is expressed as Equation (6).

$$l_t^I = ltv^I (w_t h_t^I) \quad (6)$$

Similar to the impatient household itself, the present value of utility that describes the impatient household is expressed as Equation (1). In a given period, the impatient household spends its income on the consumption of goods and the holding of currency. It also spends revenues partly on repaying debts of the past period ($r_{h,t-1}$). Since there is usually a lack of bank deposits by these households, Equation (7) is used for describing their real composite monetary assets index (x_t).

$$x_t = m_t^c \quad (7)$$

Thus, Equation (8) can be used for determining the budget constraint of the household in real terms and in light of the net real-paid tax ($\tilde{J}_t^I$).

$$c_t^I + m_t^{c,I} + (1 + r_{h,t-1}) \frac{l_t^h}{\pi_t} = w_t h_t^I + \frac{m_{t-1}^{c,I}}{\pi_t} + l_t^h - \tilde{J}_t^I \quad (8)$$

Households usually aim at maximizing the present value of the expected utility (1) subject to the budget constraint (8) and loan-limitation (6), by optimally selecting decision variables.

In making a summation of supply and demand of the two households groups, Equation (9) is used for determining consumption expenditures, demand for community money and labor supply.

$$\Gamma_t = \Gamma_t^p + \Gamma_t^I \quad \Gamma = c, n, m^c \quad (9)$$

2-1-2. Final producing firm

Supposing that there is a representative firm that buys a chain of distinct goods and incomplete substitutes supplied by intermediate firms, it may combine these goods based on a Dixit-Stiglitz aggregator and, thus, supply the final product ($\mathcal{Y}_t$)

according to Equation (10). In this Equation, θ is the constant substitution elasticity of intermediate goods.

$$y_t = \left(\int_0^1 y_{jt}^{\left(\frac{\theta-1}{\theta}\right)} d_j \right)^{\frac{\theta}{\theta-1}} \quad \theta > 1 \quad (10)$$

The final producer maximizes profits according to Equation (11).

$$\text{Max}_{y_{jt}}: p_t y_t - \int_0^1 P_{jt} y_{jt} d_j \quad (11)$$

By imposing the zero profit condition, pertinent values can be determined for the demand function of a product (made by each intermediary firm) and the price-index of the final goods, according to Equation (12) and (13).

$$y_{jt} = \left(\frac{P_{jt}}{P_t} \right)^{-\theta} y_t \quad (12)$$

$$P_t = \left(\int_0^1 P_{jt}^{1-\theta} d_j \right)^{\frac{1}{1-\theta}} \quad (13)$$

Where P_{jt} represents variety j in its price (defined at time t) and P_t represents a price-index.

2-1-3. Intermediate good producing firm

In this part, a chain of monopolistic competitive firms exists. Each firm is indexed within the range of $[0 - 1]$ where $j \in [0 - 1]$. Each of these firms uses input of labor and capital to produce distinct intermediate goods.

$$y_{jt} = a_t h_{jt}^{1-\alpha} k_{jt}^{\alpha} \quad (14)$$

Where (h_{jt}) indicates the number of working hours, the productivity shock (a_t) can follow an AR (1) process.

$$a_t = \rho_a a_{t-1} + (1 - \rho_a) \bar{a} + \varepsilon_{a,t}, \quad \varepsilon_{a,t} \approx N(0, \sigma_{\varepsilon_{a,t}}), \quad \rho_a \in (0,1), \quad \alpha \in (0,1) \quad (15)$$

From the beginning of each period, it is assumed that each firm (j) obtains a loan (l_t^m) from a bank and finances a proportion (ltv^m) of the cost of capital and labor. Thus, the amount of loan is expressed in Equation (16).

$$L_{jt}^m \leq ltv^m (r_t^k K_{jt} + w_t h_{jt}) \quad (16)$$

The loan repayment rate is r_{jt}^l at the end of the period.

The optimization process of firms occurs in two steps. In the first step, a firm that produces a type of intermediate goods (j) has a certain amount of production and aims at minimizing its total costs. In this process, it minimizes its total cost and determines the amount of demand for the production input, loan and marginal cost at each level of output.

In the second step, there is the issue of price readjustments. According to Calvo (1983), price rigidity states that v % of firms are unable to realign with a new price and, thus, maintain their original price through the period. In contrast, $1 - v$

% of the firms can determine optimal prices (i.e. readjust) according to demand for the goods. Therefore, a firm that finds the opportunity to change its price faces the issue in Equation (17) and (18).

$$\frac{Max}{p_t^d(i)} E_t \sum_{k=0}^{\infty} (\beta_p \gamma)^k \frac{\lambda_{t+k}}{\lambda_t} \left[\frac{p_t^d(i)}{p_{t+k}^d} - mc_{t+k} \right] y_{t+k}(i) \quad (17)$$

$$S.T. \quad y_t(i) = \left(\frac{p_t^d(i)}{p_t^d} \right)^{-\theta} y_t \quad (18)$$

If firms determine $P_t^{*,d}$ as the price and have the opportunity to readjust the price at time t, the first order condition is determined by Equation (19).

$$\frac{P_t^{*,d}}{p_t^d} = \left(\frac{\theta}{\theta-1} \right) \frac{E_t \sum_{k=0}^{\infty} (\beta_p \gamma)^k \lambda_{p,t+k} y_{t+k} mc_{t+k} \left(\frac{p_{t+k}^d(i)}{p_t^d} \right)^{\frac{\theta}{\theta-1}}}{E_t \sum_{k=0}^{\infty} (\beta_p \gamma)^k \lambda_{p,t+k} y_{t+k} \left(\frac{p_{t+k}^d}{p_t^d} \right)^{\frac{\theta}{\theta-1}}} \quad (19)$$

Given the fact that all re-optimizing retailers encounter a symmetric problem, there is a way to express the aggregate PPI (P_t^d) as a weighted geometric mean value of “previous” and “readjusted” prices:

P_t^d represents the weighted average of the prices set by the ratio (γ) of firms that have readjusted their prices in the past. Also, it represents the ratio ($1-\gamma$) of firms that have readjusted their prices at time t. Thus, the price index of the domestic producer P_t^d can be written as Equation (20):

$$P_t^d = \left[(1-\gamma)(P_t^{*,d})^{1-\theta} + \gamma(P_{t-1}^d)^{1-\theta} \right]^{\frac{1}{1-\theta}} \quad (20)$$

By combining Equations (19) and (20), the Phillips curve is obtained which has a logarithmic linear form in display through Equation (21).

$$\hat{\pi}_t^d = \frac{1}{1+\beta} E_t \hat{\pi}_{t+1}^d + \frac{(1-\beta\gamma)(1-\gamma)}{\gamma} \hat{m}\hat{c}_t \quad (21)$$

2-1-4. Bank

The bank exists as a representative that has the role of a mediator of financial funds and aggregates household deposit resources (d_t). After distributing precautionary and legal reserves in portions of rr_t to the central bank, it grants the rest to households and firms as consumption loans (l_t^h) and production loans (l_t^m), respectively.

In the Iranian economy, financial imbalances in the banking network include unbalanced balance sheets due to the accumulation of frozen and imaginary assets in a bank's balance sheets, as well as income and expenditure imbalances due to high interest payments to depositors and cash flow imbalance. These lead to a cumulative reliance of banks on central bank resources through overdrafts

and central bank credit lines. The result has been macroeconomic repercussions and negative effects that happen through an increase in the monetary base and liquidity, which ultimately lead to an increase in inflation.

Therefore, since some banks are currently over-investing in fixed assets and have a lack of turnover in conditions of recession, they are facing limited lending. It is assumed that a percentage of assets (ϕ_t) is non-cash based on the macroeconomic conditions according to the following equation. Due to its lack of turnover, it is accompanied by a decrease in the lending power of banks. In this regard, (u_t^ϕ) is the shock on the freezing of assets.

$$\phi_t = \left(\frac{\phi_{t-1}}{\sigma}\right)^{\rho_\phi} \left(\frac{y_t}{y}\right)^{\psi_y^\phi} \left(\frac{q_t}{q}\right)^{\psi_q^\phi} e^{\varepsilon_t^\phi}, \quad \varepsilon_t^\phi \sim N(0, \sigma_\phi^2) \quad (22)$$

Under these circumstances, banks may provide some of their resources after acquiring them from the central bank (d_t^c) when they face a shortage of resources in providing loans. Banks are also required to comply with the minimum capital adequacy ratio (car) announced by the central bank. If the ratio is violated, the bank will incur adjustment costs (κ). According to these assumptions, the cash flow, a bank's balance sheets and a bank's profits take the form of equations (24), (25) and (26) according to a study by Angelini et al. (2014). Banks should maintain part of the people's deposits as legal reserves in the central bank, so if the legal reserve rate of banks in the current period is equal to (rr_t), then:

$$RR_t = rr_t d_t \quad (23)$$

Accordingly, (RR_t) is equal to the total legal deposit of banks in the central bank.

$$l_t^m + l_t^h + \phi_t = (1 - rr_t) d_t + K_t^B + d_t^c \quad (24)$$

$$\pi_{B,t} = R_{m,t} L_{m,t} + R_{h,t} L_{h,t} - R_{d,t} D_t - R_{c,t} d_t^c - \frac{\kappa}{2} \left(\frac{k_t^B}{l_t^m} - \overline{car} \right)^2 K_t^B - \frac{\kappa}{2} \left(\frac{k_t^B}{l_t^h} - \overline{car} \right)^2 K_t^B \quad (25)$$

$$L_t = l_t^m + l_t^h \quad (26)$$

Also, according to a study by Gerali et al. (2010), it is assumed that the capital formation of the banking sector is expressed in equation (27):

$$K_t^B = (1 - \delta_{KB}) K_{t-1}^B + \pi_t^B \quad (27)$$

By maximizing the bank's interest according to the balance sheet, the behavior of interest rates and loans is determined.

2-1-5. Central bank

Real monetary base (MB_t) is the sum of real government-debt to the central bank (dg_t), real net foreign assets (fr_t) and the net debt of banks (d_t^c) which is shown in Equation (28).

$$mb_t = fr_t + dg_t + d_t^c \quad (28)$$

Where net foreign assets are equal to the accumulation of previous-period reserves and income from oil exports in Rials (Iranian currency).

$$fr_t = \frac{fr_{t-1}}{\pi_t} + \omega_g^{or} \text{ or} \quad (29)$$

The central bank is tasked with the role of creating monetary policies to control

monetary base growth, $rm b_t = \frac{mb_t \cdot \pi_t}{mb_{t-1}}$, and devaluation rate of domestic currency using specific tools. The central bank is usually expected to consider the inflation gap, the inflation rate as it deviates from its steady-state, and the output gap, as well as the deviance of GDP from its steady-state in calculating monetary-base growth, thereby shaping the monetary policy.

In the available literature on DSGE models, the Taylor rule of interest rates is used for monetary policymakers, but this cannot be possible in the Iranian economy because of interest-free banking which is a legal requirement. Therefore, the policy rule is based on the growth rate of the monetary base. Under these circumstances, it is assumed that the central bank aims at reducing the gap between production and inflation, by acting according to the following:

$$rm b_t = \frac{mb_t \cdot \pi_t}{mb_{t-1}} \quad (30)$$

$$rm b_t = \left(\frac{rm b_{t-1}}{rm b} \right)^{\rho_{rm b}} \left(\frac{y_t}{y} \right)^{\bar{\omega}_{rm b}^y} \left(\frac{\pi_t}{\pi} \right)^{\bar{\omega}_{rm b}^p} \varepsilon_t^{rm b} \quad (31)$$

$$\varepsilon_t^{rm b} = \rho_{rm b} \varepsilon_{t-1}^{rm b} + u_t^{rm b}, \quad u_t^{rm b} \sim N(0, \sigma_{rm b}^2) \quad (32)$$

Where $rm b$, π and μ are stable equilibrium growth rates, production and inflation, respectively. Where $\bar{\omega}_{rm b}^p$ and $\bar{\omega}_{rm b}^y$ are coefficients of inflation-gap and output-gap in monetary policymaking. The $\varepsilon_t^{rm b}$ shock results from the growth of the monetary base.

2-1-6. Government Budget Constraint

According to Manzoor and Taghipour (2016), it is assumed that the financial rule follows a structural deficit rule. The government tries to cover its expenditures through tax revenues from households (T_t), Rial revenues from oil sales (or_t)

and seigniorage from the central bank, $mb_t - \frac{mb_{t-1}}{\pi_t}$. Thus, the real government budget constraint is expressed in Equation (33):

$$g_t = \omega_g^{or} or_t + T_t + mb_t - \frac{mb_{t-1}}{\pi_t} \quad (33)$$

Government expenditures are comprised of two components: consumption expenditures and investment expenditures. Both are assumed to be affected by past conditions and by its stable amount, while also being influenced by changes in oil revenues as shown in Equation (34) and (35).

$$g_t^c = (1 - \rho_{gc})\bar{g}^c + \rho_{gc} g_{t-1}^c + \rho_{orc} or_t + u_t^{gc}, u_t^{gc} \sim N(0, \sigma_{gc}^2) \quad (34)$$

$$g_t^k = (1 - \rho_{gk})\bar{g}^k + \rho_{gk} g_{t-1}^k + \rho_{ork} or_t + u_t^{gk}, u_t^{gk} \sim N(0, \sigma_{gk}^2) \quad (35)$$

where τ is the tax revenue elasticity, the tax equation is as follows:

$$T_t = y_t^\tau \quad (36)$$

Given that the flow of oil production is more dependent on the nation's oil reserves, the added value of this sector is exogenous and cannot be modified simply by enhancements in capital and labor. Since the share of Iranian oil exports by OPEC and the oil prices are also determined exogenously in world markets, the Rial income from crude oil exports (or_t) follows an AR (1) process.

$$\log or_t = (1 - \rho_{or})\log \bar{or} + \rho_{or}\log or_{t-1} + \varepsilon_t^{or}, \varepsilon_t^{or} \sim N(0, \sigma_{or}^2) \quad (37)$$

2-1-7. Market clearing conditions

The model's ending involves the addition of equations that represent clearing conditions. The equations have roles in clearing the total economy, consumption, money market, labor market and investment. Thus, according to Equation (38), a clear condition in the final goods market conveys the assumption that outcomes from non-oil productions and oil sale values are equivalent to consumption, investment, government expenditures and all adjustment costs (AC_t).

$$y_t + or_t = c_t + IT_t + g_t + AC \quad (38)$$

$$m_t = \omega m_t^{c,p} + (1 - \omega) m_t^{c,I} \quad (39)$$

$$c_t = \omega c_t^p + (1 - \omega)c_t^I \quad (40)$$

$$h_t = \omega h_t^p + (1 - \omega)h_t^I \quad (41)$$

$$IT_t = i_t + g_t^k \quad (42)$$

2.2. Model under full reserve banking

We now describe the desirable economy model (under full reserve banking). The main framework of the model is designed following studies by Godley & Lavoie (2012), Laina (2018), Prescott & Wessel (2016), Benes and Kumhof (2012, 2014). Their different parts have been adjusted according to the conditions of the Iranian economy and have been then expanded by considering the banking sector as financial intermediaries. the desirable model has a major structure that consists of households, producers of intermediate and final goods, the banking system, the government and central bank, altogether showing differences compared to the previous model. Apart from the cases herein, other cases posit an equality between the calibration and structures of both types of economy. For this reason, in this model, the parts that deviate from the basic model are provided here, and the rest of the parts are the same as the previous model. In this case, there is only one type of household. In the banking sector, monetary and credit obligations are distinct, i.e. deposits in banks should be fully backed by central bank reserves. This eliminates the concept of creating money by banks (endogenous money).

All these features should be considered in the bank balance sheet. The government itself creates money directly and, in practice, the net government debt to banks will be reduced. Also, in practice, bank lending to households is eliminated, and the only credit that banks give is investment and participation in aims that lead to production.

2-2-1. Households

The general assumption states that numerous households constitute the economy and, by referring to the desired model, changes occur to the model as follows. We assume that all households are patient. In defining the population share parameter to $\omega_t = 1$, we model the previous distinct households as one type of household.

The representative household gains utility from the consumption of goods c_t and from the maintenance of real monetary assets x_t , whereas its utility decreases with the supply of labor h_t . The present value of the benefits that the representative household acquires during its lifetime occurs in the form of Equation (1) as in the previous model.

The problem for households is to maximize the present value of the expected utility over the interim budget. In each period, in addition to private consumption (c_t^p) and the maintenance of banknotes and coins ($m_t^{c,p}$), the household spends the surplus income from labor supply ($w_t h_t^p$) on investment (i_t), deposit (d_t^p) and the purchase of bonds b_t^h , while benefiting from their return. Thus, in considering real taxes paid ($\bar{\tau}_t^p$), income from renting capital stock and real profits divided by firms (π_t^m), the real household budget and the process of capital accumulation can be displayed in the form of equations (4) and (43).

$$c_t^p + p_{it} i_t + m_t^{c,p} + d_t^p + b_t^h = w_t h_t^p + r_{k,t} k_{t-1} + (1 + r_{d,t-1}) \frac{d_{t-1}^p}{\pi_t} + (1 + r_{b,t-1}) \frac{b_{t-1}^h}{\pi_t} + \frac{m_{t-1}^{c,p}}{\pi_t} + \pi_t^m - \bar{\tau}_t^p \quad (43)$$

The consumer maximizes the objective function (1) relative to the constraints (4) and (43). It obtains economic relations for the demand of money, deposit, consumption and supply of labor.

2-2-2. Manufacturer of intermediate goods

In this section, there is a chain of monopoly firms that are indexed in a range [0 and 1] which yields $j \in [0,1]$. Each of these firms produces distinct intermediate goods (j) using labor and capital inputs.

$$y_{jt} = a_t h_{jt}^{1-\alpha} k_{jt}^\alpha \quad (44)$$

Where h_{jt} represents the number of working hours, and a_t represents the technology that follows the following equation.

$$a_t = \rho_a a_{t-1} + (1 - \rho_a) \bar{a} + \varepsilon_{a,t}, \quad \varepsilon_{a,t} \approx N(0, \sigma_{\varepsilon_{t,a}}), \rho_a \in (0,1), \alpha \in (0,1) \quad (45)$$

In this case, the main assets of producers are their inventory n_t and bank deposits d_t^m , in this case being maximally supported by reserves. Their balance sheets under the FRB system are shown by the following equation, where l_t^I is the amount of demand by firms for investment loans based on their capital value.

$$l_t^I = d_t^m + n_t \quad (46)$$

$$l_t^I \leq r_t^k k_{jt} \quad (47)$$

The two-stage optimization of the enterprise is the same as the previous model.

2-2-3. Bank

The banking sector is one of the most important parts of the model. Banks play the role of financial intermediaries in this model, but unlike fractional reserve banking in this model, they do not seek to maximize their profits by expanding credit. They attract household deposit resources (d_t) and back 100% of them by central bank reserves. This is because the main feature of the FRB system is that banks should maintain a 100% reserve of deposits with the central bank. This means that the backing of each deposit is the reserves of the central bank (rr_t).

$$d_t = rr_t \quad (48)$$

Accordingly, banks are unable to operate in lending via new deposits. Instead, their loans must be secured through equity and central bank lending (d_t^e). Given that the purpose of the FRB is to make the financing system and the payment system separate. Its purpose is also to separate the monetary policy from the credit policy. This approach rules in practice that credit-lending by banks to households is eliminated, and the only credit that banks give is investment and participation in productive goals. In other words, households replace private money, which is based on debt, with government money which is free from debt. The remaining credit, thus, would come as loans for productive investment. In general, this process of lending by banks does not lead to money creation because banks can only lend existing money (which is actually central bank money) and have no power to create money. In fact, creating money can be done only by the central bank and, thus, the bank institution consolidates its real position as a financial intermediary.

From a balance sheet perspective, the transfer to the balance sheet of the new banking system conceptually means that, immediately after people make deposits in the bank, assuming that the initial reserves rate is zero, the banks increase reserve backing deposits from 0% to 100%. So that $d_t = rr_t$. By doing so, the central bank can independently control exogenous money and credit. With these changes, the general balance sheet of the bank (before the separation of monetary

and credit obligations) under FRB assumes the following equation (Benes and Kumhof, 2014).

$$l_t^I + rr_t = d_t^c + d_t + K_t^B \quad (49)$$

In this equation, l_t^I represents investment loan, rr_t deposit reserves, d_t^c debt of banks to the central bank, d_t deposit, and K_t^B is bank capital. Now, by dividing the bank balance sheet into two parts, money and credit, while considering that $d_t = rr_t$, we can remove these two variables from both sides of equation (49). This means the separation of monetary and credit obligations that belong to the banking system and, thus, the credit performance of the banking system can be represented by equation (50).

$$l_t^I = d_t^c + K_t^B \quad (50)$$

The above balance sheet indicates that now the credit and monetary functions are separated. Money has remained almost unaffected because the reserves fully back it. Credit, which includes exclusively investment loans, is secured by stocks and credit from the central bank and from credit institutions.

Loans are characterized by interest rates that are affected by the central bank. In fact, the central bank affects interest rates by controlling the real interest rate on credit (as discount rate), $r_{c,t}$. Also, it affects the amount of investment loans (l_t^I) through regulations on capital adequacy. Nonetheless, as long as these regulations are not strict, banks have considerable power in determining the total amount of credit and, of course, they are fully responsible for allocating that credit. Nothing interferes with the private financing sector's ability to facilitate capital allocation to its most productive uses. Banks are also required to conform into the minimal capital adequacy requirements (CAR) announced by the central bank and would be subject to adjustment costs (k_{KB}) in case they violate CAR. Therefore, a bank's capital is controlled by regulations that comply with the characteristics of the basal regulations frame, which includes fines on violations of minimal capital adequacy (Gertler and Karadi, 2010).

According to a study by Graley et al. (2010), it is assumed that the banking sector's capital formation can be represented as equation (51):

$$K_t^B = (1 - \delta_{KB})K_{t-1}^B + \pi_t^B \quad (51)$$

According to these assumptions, and according to the study by Benes and Kumhof (2014), banks' profits are in the form of the following equations:

$$\pi_{B,t} = R_t^I l_t^I - R_t^d d_t - R_{c,t} d_t^c - \frac{k_{KB}}{2} \left(\frac{k_t^B}{l_t} - \overline{car} \right)^2 K_t^B \quad (52)$$

$$l_t = l_t^I \quad (53)$$

The first and second cases are, namely, "income from interests of investment loans and participation in productive goals" and "the interest cost of bank

deposits”, respectively. The third case is the cost of interest on the central bank’s credit which is paid by banks to the central bank. By maximizing the bank’s interest according to the balance sheet, the behavior of interest rates and loan rates can be determined according to the bank’s conditions.

2-2-4. Central Bank

The balance sheet, owned by the central bank, is determined by the following equation, where b_t^{cb} is the real value of government bonds, d_t^c is debt of banks and fr_t is the central bank’s net foreign assets (which is expressed in the national currency).

$$m_t = fr_t + b_t^{cb} + d_t^c \quad (54)$$

$$fr_t = \frac{fr_{t-1}}{\pi_t} + \omega_{\text{gr}}^{\text{or}} \quad (55)$$

The amount of money the economy needs is determined by the money growth rule. In this model, creating money takes place at the time of budget deficit, in which case, according to Equation (56), the central bank has a great impact on money supply by financing government expenditures, thereby being able to export reserves. In this equation, rr_t is the amount of central bank’s reserves and b_t^{cb} is government debt.

$$rr_t = b_t^{cb} \quad (56)$$

2-2-4-1. Money

Since monetary obligations are now supposedly separated from credit obligations, the money supply can be controlled using various policy tools such as the nominal growth rule of money. Accordingly, in the case of money, Friedman’s money growth rule is applied by the government, whereby a constant rate γ_t^m describes the growth of nominal money quantity. This process is regarded as a first-order self-regression.

$$m_t = \gamma_t^m \frac{m_{t-1}}{\pi_t} \quad (57)$$

$$\gamma_t^m = (\gamma_{t-1}^m)^{\alpha_\gamma} e^{u_t^{\gamma m}} \quad (58)$$

The current monetary system allows the government to act according to equation (57) regarding the narrow monetary aggregates which come into its straight influence. Effectiveness can be obtained when monetary aggregates of broad and narrow types can be linked to each other through a steady deposit multiplier.

2-2-5. Government

A structural deficit rule guides the fiscal policy. In this model, the government attempts to cover its expenditures g_t from several sources, including taxes T_t , the selling of bonds b_t (because under the FRB system, most government expenditures are covered by bonds), Rial revenue from oil sales ($\omega_{\text{gr}}^{\text{or}} or_t$) (of

which the ω_g^{or} % is allocated to the government and the rest to the national development fund). The government attempts to balance the return on capital expenditures (R_t), as another source of government revenue, with seigniorage $m_t - \frac{m_{t-1}}{\pi_t}$. In this case, the government budget constraint in terms of real values is expressed as the following equation.

$$g_t = b_t - \frac{1+r_t^b}{\pi_t} b_{t-1} + m_t - \frac{m_{t-1}}{\pi_t} + \omega_g^{or} or_t + T_t + R_t \quad (59)$$

Government expenditures consist of two components: consumption and investment expenditures. Investment expenditures are financed through oil revenues and consumption expenditures are mainly financed through tax revenues and bond issuance.

$$g_t = g_t^c + g_t^k \quad (60)$$

$$g_t^c = (1 - \rho_{gc}) \bar{g}^c + \rho_{gc} g_{t-1}^c + \rho_{tgc} T_t + \rho_{bgc} b_t + u_t^{gc}, u_t^{gc} \sim N(0, \sigma_{gc}^2) \quad (61)$$

$$g_t^k = (1 - \rho_{gk}) \bar{g}^k + \rho_{gk} g_{t-1}^k + \rho_{ogk} or_t + u_t^{gk}, u_t^{gk} \sim N(0, \sigma_{gk}^2) \quad (62)$$

2-2-6. Market clearing condition

Clearing conditions for the commodity market and bonds are shown in the following equations. The clearing condition for the commodity market reasons that the result of non-oil production and the added value of oil sales are equivalent to consumption, total investment, government expenditures and all adjustment costs (AC_t).

$$y_t + or = c_t + IT_t + g_t + AC \quad (63)$$

$$b_t = b_t^h + b_t^{cb} \quad (64)$$

$$IT_t = I_t + g_t^k \quad (65)$$

3. Calibration of the parameters

By optimizing the target functions of each broker, a set of economic relations is obtained, which is used for the linearization of the equations according to a method by Uhlig (1999) and Taylor. In the next step, to reduce the number of estimated parameters, a number of them were calibrated using data pertaining to Iran's economy (<http://tsd.cbi.ir>) during a specified period, 1991: Q1 – 2023: Q4. The obtained values and the stable ratios of the variables are presented in Table (1).

Table 1: Steady state values of some variables

Variable	$\bar{y}$	$\frac{c}{y}$	$\frac{r}{y}$	$\frac{m}{y}$	$\frac{g}{y}$	$\frac{or}{y}$	$\frac{\omega or}{g}$	$\frac{T}{g}$
Steady state value	1	0.58	0.23	0.12	0.26	0.19	0.45	0.

Source: Research finding

3-1. Bayesian Estimation

In this section, the model has several parameters that are estimated according to Iranian economics and the data thereof. In applying the Metropolis–Hastings algorithm, six parallel length chains (1.7 million) are utilized to make an extraction of the posterior density of parameters. The sampling timespan ranges between 1991-Q1 and 2023-Q4. The data represent the real growth rate of private investment, PPI inflation, non-oil GDP, monetary base and government consumption. The HP filter is used for estimating the private consumption, governmental consumption, private investment and investment gaps, where $\lambda = 677$, according to Barakchian and Einian (2014). We posit $\log X_t / X_{t-4}$ as the growth rate of X_t , and a logarithmic deviation from the steady state is used for expressing all model-based variables.

3-2. Evaluation of model fitness

To validate the model, the selected parameters of the model are estimated using the Bayesian method. The results of estimation are listed in Table (2) and Table (3). It stages the earlier distribution, deviations and the Bayesian estimates that result from the parameters, including the posterior standard deviation, posterior mean, posterior mode and the relevant 90% confidence interval. Furthermore, the prior and posterior distributions are presented graphically in Figure (1). With respect to the difference between the two anterior and posterior distributions of the model parameters, the accuracy of the test is confirmed.

Table 2: The prior and posterior distributions of parameters (the first model)

Parameter	Prior distribution			Posterior distribution		
	type	mean	std deviation	mean	90% HPD interval	
α	Beta	0.412	0.02	0.347	0.319	0.375
ρ_{or}	Beta	0.640	0.05	0.400	0.343	0.455
car	Beta	0.100	0.02	0.108	0.072	0.143
ρ_{ϕ}	Beta	0.550	0.05	0.462	0.394	0.537
ψ_y^{ϕ}	Normal	-1.700	0.05	-1.705	-1.787	-1.623
ψ_q^{ϕ}	Normal	-1.600	0.05	-1.659	-1.740	-1.578
ρ_{rmb}	Beta	0.600	0.05	0.829	0.807	0.852
$\bar{\omega}_{rmb}^y$	Normal	-1.700	0.05	-1.594	-1.678	-1.514
$\bar{\omega}_{rmb}^p$	Normal	-1.548	0.05	-1.501	-1.583	-1.418
ρ_{gc}	Beta	0.340	0.05	0.291	0.220	0.363
ω_{Ξ}^{or}	Beta	0.750	0.02	0.722	0.687	0.758
σ_c	Gamma	1.520	0.01	1.532	1.515	1.548
σ_h	Gamma	2.200	0.01	2.201	2.184	2.217
ltv^l	Beta	0.600	0.01	0.601	0.584	0.617
δ_k	Beta	0.027	0.02	0.151	0.131	0.170
β	Beta	0.969	0.01	0.982	0.974	0.992

S	Gamma	50	0.05	49	49.91	50.07
ltv^m	Beta	0.400	0.05	0.145	0.135	0.158
$\varepsilon_{I,t}$	InvGamma	0.01	∞	6.50	5.561	7.41
$\varepsilon_{a,t}$	InvGamma	0.02	∞	0.02	0.019	0.03
ε_t^{or}	InvGamma	0.01	∞	0.56	0.493	0.64
u_t^{rmb}	InvGamma	0.01	∞	1.18	0.863	0.863
u_t^{gc}	InvGamma	0.01	∞	0.09	0.081	0.081

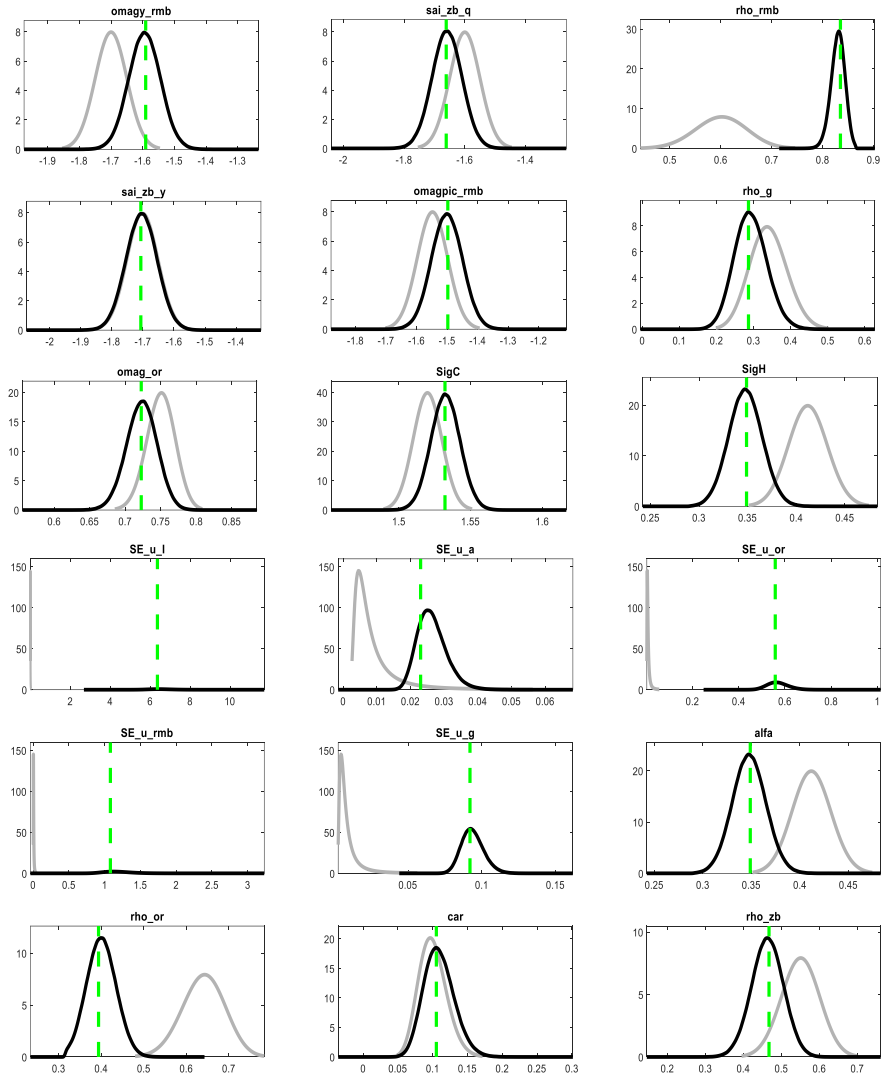
Source: Research finding

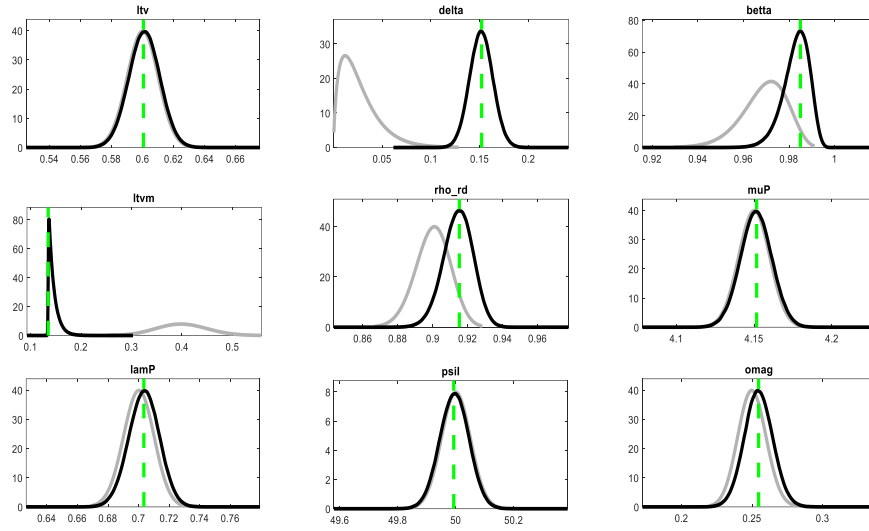
Table 3: The prior and posterior distributions of parameters (the second model)

Parameter	Prior distribution			Posterior distribution		
	type	mean	std deviation	mean	90% HPD interval	
α	Beta	0.412	0.03	0.414	0.364	0.463
ρ_{or}	Beta	0.640	0.05	0.605	0.538	0.683
γ^m	Beta	0.650	0.05	0.532	0.485	0.579
ρ_{gk}	Beta	0.370	0.05	0.249	0.197	0.301
ρ_{or}^{gk}	Beta	0.750	0.05	0.717	0.636	0.801
γ	Beta	0.756	0.01	0.760	0.744	0.776
ρ_{gc}	Beta	0.670	0.05	0.867	0.835	0.900
ρ_t	Beta	0.550	0.01	0.551	0.553	0.566
σ_c	Gamma	1.520	0.01	1.532	1.515	1.548
δ_k	Beta	0.83	0.02	0.146	0.123	0.169
β	Beta	0.969	0.01	0.982	0.974	0.992
S	Gamma	50	0.05	49	49.91	50.07
$\varepsilon_{I,t}$	InvGamma	0.01	∞	0.009	0.002	0.017
u_t^{gk}	InvGamma	0.300	∞	0.387	0.329	0.442
ε_t^{or}	InvGamma	0.01	∞	0.234	0.202	0.265
u_t^{rm}	InvGamma	0.02	∞	0.029	0.034	0.044
u_t^{gc}	InvGamma	0.02	∞	0.042	0.028	0.056

Source: Research finding

The first model





The second model

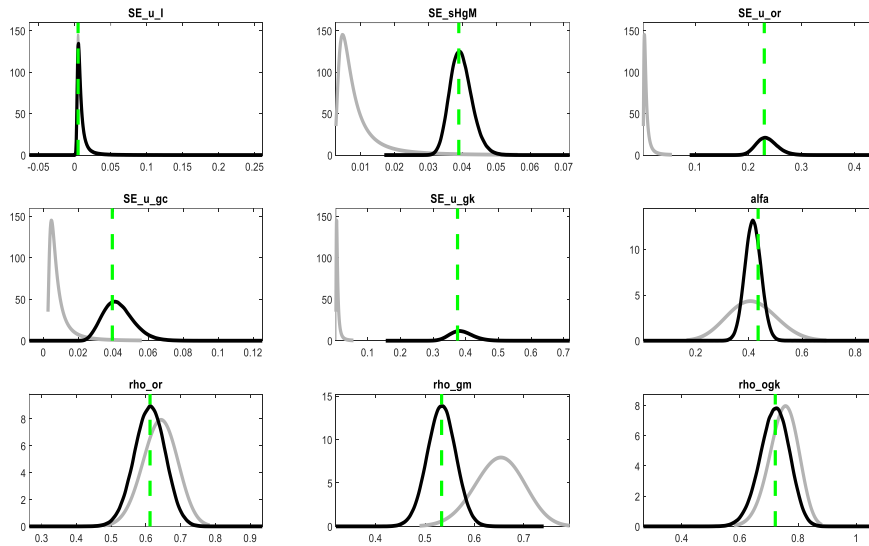


Fig.1. The prior and posterior distributions of parameters

Source: Research finding

To investigate the convergence of parameters as univariate and multivariate, we used the diagnostic test of MCMC (Brooks and Gelman) (which describes the Markov Monte Carlo chain). The results can be seen in Figure (2), (3) and in the

appendix A and B. The data indicate that the estimated parameters of the model are strong enough and that these estimates are reliable.

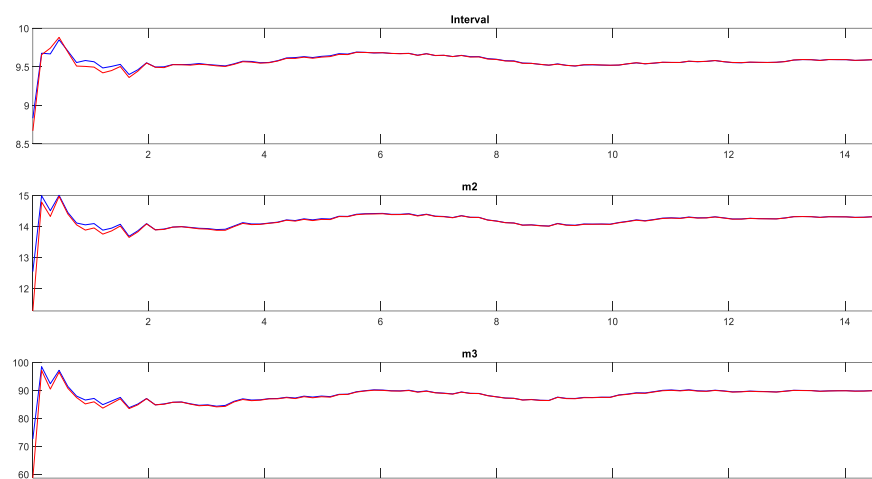


Fig.2. Brroks and Gelman multivariate diagnostic test (the first model)

Source: Research finding

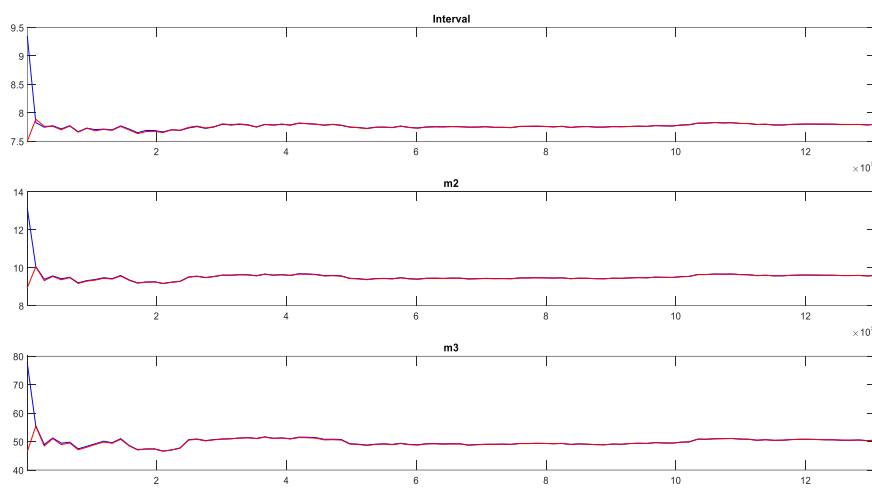


Fig.3. Brroks and Gelman multivariate diagnostic test (the second model)

Source: Research finding

4. Empirical results and IRFs analysis

Another suitable tool for examining a model's fitness is to investigate the behavior of the impulse response function in response to shocks. In this section, by entering shocks into the model, the final effects of these shocks are examined on important economic variables under two types of fractional reserve banking

and full reserve banking. The shocks that come under examination are, namely, the shock of government consumption expenditure and the shock of government investment expenditure

4.1. Impulse Response to Government Consumption Expenditure

One of the standard tools for evaluating the dynamics and validity of a DSGE model is the analysis of impulse response functions (IRFs) to structural shocks. IRFs illustrate the magnitude and persistence of deviations of each variable from its steady-state path following an exogenous shock. In this study, all impulse response functions are reported as percentage deviations from the steady state. The horizontal axis represents time periods (quarters) after the occurrence of the shock, while the vertical axis shows the percentage deviation of each variable from its steady-state path.

In this subsection, the effects of a positive government consumption expenditure shock equal to one standard deviation (10 percent) are examined. It is assumed that a positive shock to government consumption expenditure enters the economy under fractional reserve banking and full reserve banking. The resulting responses of key macroeconomic variables are presented using impulse response functions in Figure 5. An increase in government consumption expenditure by one standard deviation initially raises government consumption expenditure and subsequently leads to an increase in total expenditure.

As an expansionary fiscal policy, increase government consumption expenditure increases aggregate demand in the first stage. Through the goods market equilibrium condition, this rise directly boosts total demand and increases economic activity. Given the presence of price stickiness based on the Calvo pricing mechanism, firms are unable to fully adjust prices in the short run; therefore, the increase in aggregate demand is mainly accommodated through an expansion in real output. As production rises, firms' demand for labor increases, leading to increase employment through the production function. Given the substantial size of the government sector in Iran, an increase in government expenditure significantly stimulates aggregate demand, and the magnitude of this effect is considerably larger under full reserve banking than under fractional reserve banking.

The increase in production and employment raises households' real income, thereby activating the transmission of the fiscal shock to private consumption. However, the consumption response differs under the two types of banking. under fractional reserve banking, increase government expenditure and economic activity increase the demand for real money. In this framework, banks respond to the increase money demand through credit expansion and deposit creation, which leads to an increase in the money supply. Since real money enter households' utility function in the model, an increase in real money demand—when not fully accommodated by money supply—adjusts through a rise in the real interest rate.

Through the Euler equation for consumption, the increase real interest rate reduces current consumption by generating an intertemporal substitution effect, causing private consumption reduces in the short run. Over time, as output and labor income increase persistently, the income effect dominates, and private consumption rises again.

In contrast, under full reserve banking, the elimination of endogenous money creation and consumer lending by banks prevents the fiscal shock from being accompanied by an increase in the interest rate. Direct control of the money supply by the central bank avoids pressures in the money market, resulting in an immediately positive path for private consumption. Moreover, the reduction in private debt and the elimination of interest payments associated with bank-created money increase households' disposable income and further strengthen the positive consumption response.

Furthermore, according to the structure of the model, banks under the full reserve banking system are not able to create money, and only central bank money circulates in the economy. In this setting, financing government expenditures through the central bank does not lead to credit expansion or endogenous money creation due to the requirement of full reserve backing of deposits. Consequently, the reduction in quasi-money lowers inflationary pressures and, by increasing households' real purchasing power, reinforces private consumption, providing an additional channel through which consumption increases.

It should be noted that although the government faces budget deficits under the two types of banking and part of these deficits is financed through the central bank, but the transmission mechanism to money supply differs fundamentally. Under fractional reserve banking, government financing through the central bank is amplified by the money multiplier and bank credit expansion, resulting in a substantial increase in the money supply. This is because in fractional reserve banking, banks do not actually play the role of financial intermediation; rather, they create money through deposit expansion, leading to endogenous money creation. The increase in endogenous money causes larger deviations of money supply from its steady-state path and, in turn, raises inflation and firms' marginal costs. Under full reserve banking, however, the requirement of 100 percent reserve backing and the elimination of the credit creation channel prevent such amplification effects. Moreover, since the money multiplier equals one and money supply equals the monetary base, government borrowing affects the monetary base but does not generate a proportional expansion in overall money supply.

Differences between the two types of banking become more pronounced in monetary and price variables. Under fractional reserve banking, the monetary policy rule leads to an increase in money supply, followed by a rise in the real interest rate. The increase real interest rate increases firms' marginal costs and, through the New Keynesian Phillips curve based on the Calvo

mechanism, results in increase inflation. Due to price stickiness, price adjustment occurs gradually, making the inflationary effects of the shock larger and more persistent.

In contrast, under full reserve banking, the elimination of bank credit creation and the elimination of money supply expansion through the multiplier channel imply that government expenditure does not generate a significant increase in money supply. The limited monetary expansion and the gradual decline in the interest rate reduce firms' marginal costs, causing inflation to rise only temporarily and return to its steady-state paths after a short lag.

Overall, although macroeconomic variables under the two types of banking converge back to their steady-state paths after approximately 30 periods, the results indicate that full reserve banking—by eliminating endogenous money creation and weakening monetary amplification mechanisms—allows output and consumption to increase without requiring a substantial expansion in money supply. As a result, the magnitude and persistence of macroeconomic fluctuations are significantly reduced.

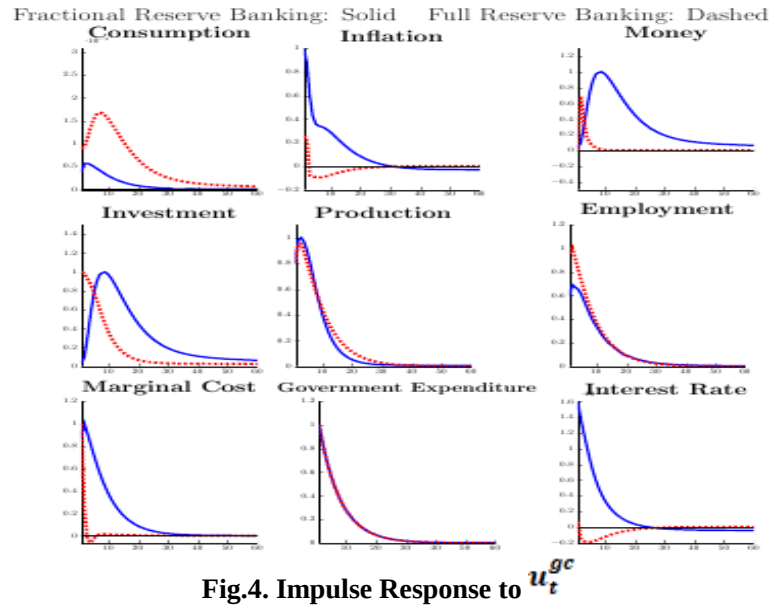


Fig.4. Impulse Response to u_t^{gc}

Source: Research finding

4.2. Impulse Response to Government Investment Expenditure

Impulse response functions to a positive shock in government investment expenditure equal to one standard deviation are reported in Figure 6 for the Iranian economy under fractional reserve banking and full reserve banking. An increase in government investment expenditure, as a component of expansionary

fiscal policy, initially raises aggregate demand through the goods market equilibrium condition. This rise in demand leads to an increase in real output. As economic activity expands, the demand for labor also increases, resulting in increase employment through the production function.

Unlike a government consumption expenditure shock, which is mainly transmitted through current demand and consumption channels, a government investment expenditure shock generates more persistent effects on real economic activity. In addition to its short-run demand-side impact, this shock operates through stronger incentives for private investment and gradual capital accumulation. Increase output and firm profitability raise the marginal value of capital, which—through optimal investment conditions (the Tobin's Q equation)—stimulates private investment. Consequently, the capital stock of patient (saver) households increases gradually, generating a more persistent expansion in the economy's productive capacity.

The response of private consumption differs under the two types of banking. under fractional reserve banking, increase economic activity and increased investment raise the demand for real money. Banks respond to this increase demand through credit expansion and deposit creation, leading to an increase in the money supply. Since real money enter households' utility function, the resulting pressure in the money market is adjusted through a rise in the real interest rate. Through the consumption Euler equation, the increase real interest rate generates an intertemporal substitution effect that constrains private consumption in the short run. Over time, however, as real income rises due to increase output and capital accumulation, the income effect dominates, and private consumption gradually increases.

In contrast, under full reserve banking, the elimination of endogenous money creation and the restriction of banks' role to pure financial intermediation prevent government investment expenditure shocks from generating significant pressure in the money market. Direct control of the money supply by the central bank avoids an increase in the real interest rate. As a result, private consumption responds more positively, driven by increased real income and improved economic conditions rather than by credit constraints. Moreover, the decreasing consumer debt and the reduction in interest payments strengthen households' disposable income and generate a smoother consumption path.

Differences between the two types of banking become more pronounced in monetary and price variables. Under fractional reserve banking, the financing of government investment expenditures—largely funded by oil revenues—is amplified through the money multiplier and bank credit expansion, leading to an increase in the money supply. This monetary expansion raises the real interest rate and firms' marginal costs, which, through the New Keynesian Phillips curve, results in increase inflation. Due to price stickiness, these inflationary effects tend to be more persistent.

Under full reserve banking, however, the requirement of full reserve backing of deposits and the elimination of the credit channel prevent the amplification of monetary effects associated with government financing. Although the government still runs budget deficits and partially finances them through the central bank, the money multiplier equals one; therefore, an increase in the monetary base does not translate into a proportional expansion in money supply. As a result, increase real economic activity is mainly absorbed through real demand and private capital accumulation, while inflationary pressures remain more limited and less persistent.

Overall, the impulse response function indicate that government investment expenditure shocks have more persistent effects on output and employment than government consumption expenditure shocks. This is because, in addition to stimulating short-run demand, they also strengthen the supply side of the economy through increase private investment and capital accumulation. Moreover, full reserve banking—by weakening monetary and credit amplification mechanisms—allows these real effects to materialize with lower monetary and inflationary fluctuations, thereby accelerating the convergence of macroeconomic variables back to their steady-state paths.

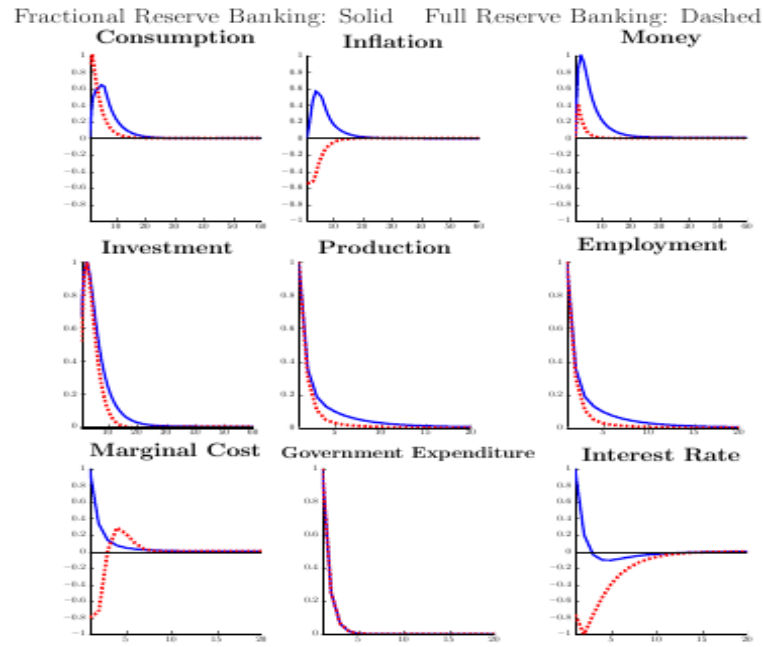


Fig.5. Impulse Response to u_t^{gk}

Source: Research finding

4.3. Welfare Loss Evaluation under Fractional and Full Reserve Banking

To evaluate the welfare implications of monetary policy under fractional reserve banking and full reserve banking, the Ramsey optimal policy framework is employed. In this approach, the monetary policymaker commits to an optimal rule by choosing a policy in the initial period that minimizes welfare losses and continues to follow this policy over all subsequent periods. In order to derive the optimal policy, a social loss function based on a second-order approximation of the representative household's welfare loss, following the approach of King (2016), is defined as Equation (66). This loss function captures deviations of the economy from its long-run efficient allocation.

$$L_t^{CB} = \frac{1}{2} \sum_{t=0}^{\infty} \beta^t [\lambda_{\pi} \hat{\pi}_t^2 + \lambda_y \hat{y}_t^2] \quad (66)$$

It is assumed that the central bank aims to stabilize inflation and the output gap by minimizing a loss function that includes the squared deviations of these variables from their target levels. In this formulation, λ_{π} and λ_y denote the relative weights assigned to inflation and the output gap in the welfare loss function, respectively. The welfare loss calculations indicate that, under the two types of banking, the minimum welfare loss is achieved when the weight on the output gap in the loss function is set equal to 0.5. The minimum welfare loss is estimated at 0.011820 under fractional reserve banking and is substantially lower—equal to 0.000010—under full reserve banking. These results showed that, under the two types of banking, prioritizing inflation stabilization over output fluctuations is more welfare-efficient.

Overall, the findings imply that, in designing optimal monetary policy, the Central Bank of Iran should place greater emphasis on controlling inflation rather than stabilizing output fluctuations. Moreover, the welfare results indicate that full reserve banking, by reducing monetary and inflation fluctuations, can generate lower welfare losses compared to fractional reserve banking and lead to improved macroeconomic stability.

Table 4: Sensitivity Analysis of the Loss Function

Welfare Loss	$\lambda_{\pi} = 0.5$	$\lambda_{\pi} = 1$	$\lambda_{\pi} = 1$
	$\lambda_y = 1$	$\lambda_y = 1$	$\lambda_y = 0.5$
Fractional Reserve Banking	0.020501	0.023170	0.011820
Full Reserve Banking	0.000014	0.000011	0.000010

Source: Research finding

Conclusion and Recommendations

Different years of the Iranian economy have indicated that the growth of money supply through various channels has been more than the growth of GDP. This indicates a lack of coordination between the real sector and monetary sector of the Iranian economy as a result of banks performance. To alleviate this problem, full reserve banking was proposed in this research. Since creating money in this

way stabilizes the whole system and creates a very strong link between money and the real economy (Fisher, 1935), two Dynamic Stochastic General Equilibrium (DSGE) models were first designed to evaluate the macroeconomic and welfare effects of government spending shocks under two banking systems (fractional and full reserve). Upon modeling the optimization problem by the DSGE method, the linearization model and then the model parameters were estimated using quarterly data of Iran's economy from 1991 to 2023. This also involved using the Bayesian method and Hastings metropolis algorithm. Model simulations, based on the estimated parameters, resulted in the following.

The results show that the shock of government consumption expenditures through fractional reserve banking results in higher inflation, money supply, interest rates, production and employment. These results are consistent with previous findings by Khiabani and Delfan (2018), Adeli (2019) and Afshon (2020), whereas under full reserve banking this shock results in higher inflation for a very short period of time, along with an increase in production, employment and money supply, but reduced levels of interest rates. Also, the intensity of fluctuations by these variables, in spite of full reserve banking, is relatively smaller than fractional reserve banking, because of the coordination between the real sector and the monetary sector of the Iranian economy. That, in turn, occurred because of the abolishment of bank lending and the abolishment of money creation through the channel of money multiplier, which cannot be seen in previous research.

The shock of government investment expenditures had effects on macroeconomic variables that are similar to the shock of government consumption expenditures, except that in the shock of investment expenditures, under fractional reserve banking, returning to a stable condition of variables can take a long time, and the effects of the shock will disappear slowly. Meanwhile, under full reserve banking, macroeconomic variables return to a stable condition within a shorter timeframe. These results of the decrease in fluctuations under full reserve banking are consistent with previous findings by Lina (2018), Borhani et al. (2019) and Benz and Kamhuf (2014).

Furthermore, by comparing the impulse response function of the selected variables in the two models, it is observed that full reserve banking caused a change in the share of shocks that make fluctuations in key variables. Even the condition of some of them has been replaced by shocks of government expenditures.

To assess the welfare effects of monetary policy, the central bank's welfare loss function under the Ramsey optimal policy framework was computed for fractional reserve banking and full reserve banking. The results indicate that changes in the relative weights assigned to the output gap and inflation in the loss function have a significant impact on the magnitude of welfare losses.

Specifically, under the two types of banking, the minimum welfare loss is achieved when the weight on the output gap is set equal to 0.5. The estimated minimum welfare loss amounts to 0.011820 under fractional reserve banking, while it is substantially lower—equal to 0.000010—under full reserve banking. These results showed that prioritizing inflation stabilization over output gap fluctuations is more welfare-efficient in both banking frameworks. In other words, assigning an increased weight to the output gap in the loss function increases welfare losses by amplifying macroeconomic fluctuations and inducing greater deviations from the efficient allocation. Accordingly, the optimal policy results imply that, in designing Ramsey optimal monetary policy, the Central Bank of Iran should assign increased relative importance to inflation stabilization than to output gap stabilization.

In addition, the impulse response function shows that transitioning from fractional reserve banking to full reserve banking is associated with a reduction in both the magnitude and persistence of economic fluctuations generated by shocks, thereby improving economic welfare. Overall, the policy implication of this study is twofold. First, the Central Bank of Iran should place its primary focus on controlling inflation. Second, moving toward full reserve banking and enhancing the soundness of the banking sector—by decreasing monetary and credit fluctuations—can contribute to lower welfare losses, reduced business cycle fluctuations, and greater macroeconomic stability.

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Appendix

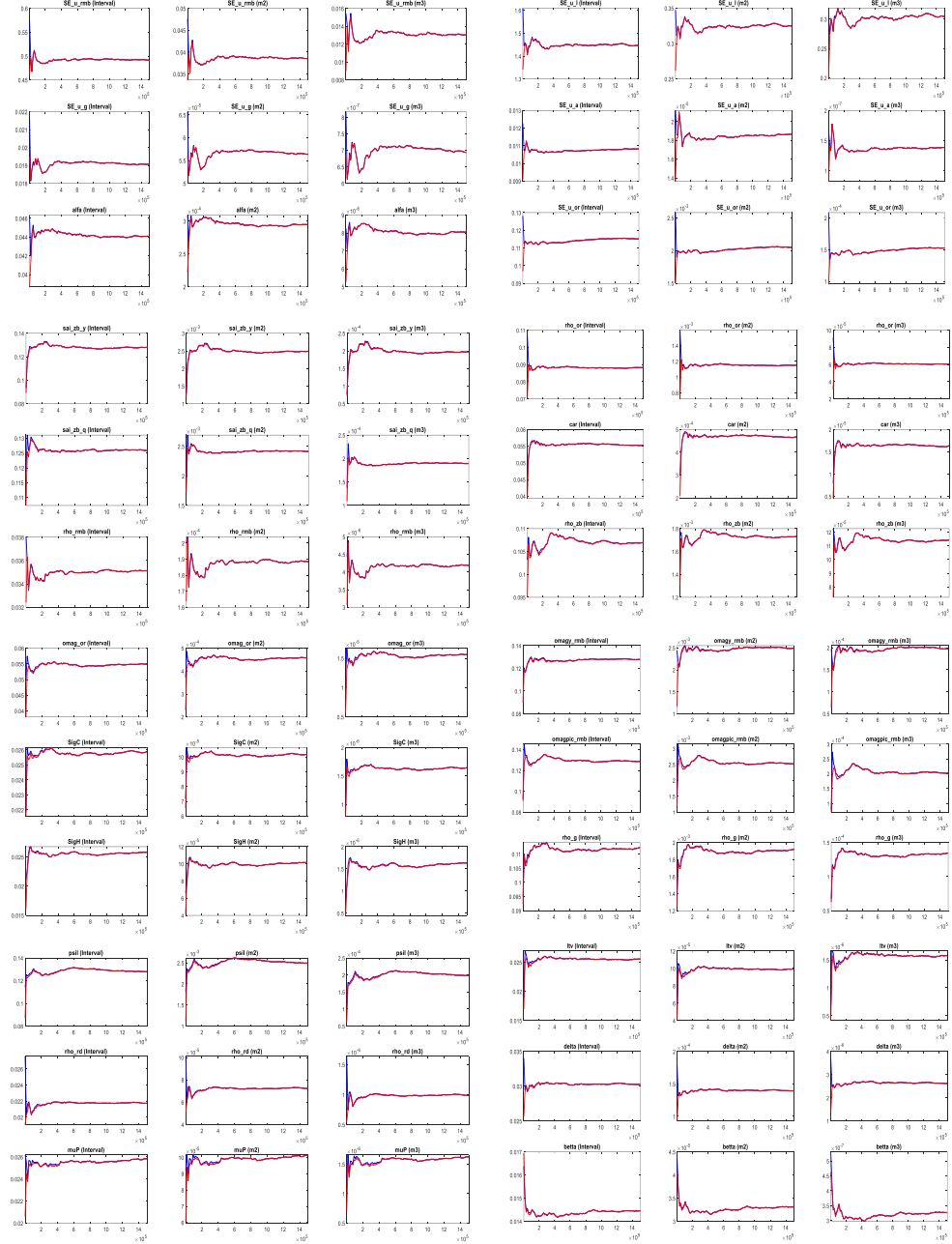
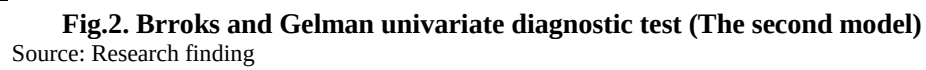


Fig.1. Brooks and Gelman univariate diagnostic test (The first model)

Source: Research finding



ارزیابی آثار کلان اقتصادی و رفاهی شوک‌های مخارج دولت در دو نظام بانکی: رویکرد DSGE

چکیده

هدف این پژوهش بررسی آثار کلان اقتصادی و رفاهی شوک‌های مخارج مصرفی و سرمایه گذاری دولت در چارچوب دو نظام بانکداری ذخیره جزئی و ذخیره کامل در اقتصاد ایران است. بدین منظور، دو مدل تعادل عمومی پویای تصادفی کینزی جدید طراحی شده و رفتار اقتصاد تحت این دو نظام بانکی به صورت مقایسه‌ای تحلیل شده است. پارامترهای مدل با استفاده از داده‌های فصلی اقتصاد ایران طی دوره ۱۳۷۰-۱۴۰۳ و به روش برآورد بیزی تعیین شده‌اند. نتایج حاصل از تحلیل توابع واکنش آنی نشان می‌دهد که آثار شوک‌های مالی دولت به طور معناداری به نوع نظام بانکی وابسته است. در بانکداری ذخیره جزئی، شوک‌های مخارج مصرفی و سرمایه گذاری دولت از طریق کانال اعتباری و خلق پول درون‌زا موجب افزایش تولید و حجم پول می‌شوند، اما افزایش نرخ بهره حقیقی، مصرف خصوصی را در کوتاه‌مدت محدود کرده و فشارهای تورمی ماندگارتری ایجاد می‌کند. در مقابل، در بانکداری ذخیره کامل، حذف خلق پول بانکی و کنترل مستقیم عرضه پول سبب می‌شود افزایش مخارج دولت با نوسانات پولی و تورمی کمتری همراه باشد؛ به گونه‌ای که مصرف و تولید افزایش یافته و بازگشت متغیرها به وضعیت پایدار سریع‌تر رخ می‌دهد. همچنین نتایج نشان می‌دهد که شوک مخارج سرمایه گذاری دولت نسبت به شوک مخارج مصرفی، اثرات پایدارتر و کم‌نوسان‌تری بر فعالیت‌های حقیقی اقتصاد دارد. به منظور ارزیابی پیامدهای رفاهی، یک تابع زیان رفاهی مبتنی بر نوسانات تورم و شکاف تولید تعریف و مقادیر آن تحت سیاست پولی بهینه در هر دو نظام بانکی محاسبه شده است. نتایج نشان می‌دهد که کمترین زیان رفاهی در نظام بانکداری ذخیره کامل تحقق می‌یابد و در هر دو مدل، حالتی که وزن شکاف تولید نسبت به تورم کمتر در نظر گرفته می‌شود، از منظر رفاهی مطلوب‌تر است. این یافته‌ها حاکی از آن است که تمرکز بیشتر بانک مرکزی بر کنترل تورم، به ویژه در مقایسه با بانکداری ذخیره جزئی، می‌تواند از طریق کاهش نوسانات کلان به بهبود ثبات اقتصاد کلان و رفاه اقتصادی منجر شود.

کلمات کلیدی: بانکداری ذخیره جزئی، بانکداری ذخیره کامل، تعادل عمومی پویای تصادفی، شوک‌های مالی، کسری بودجه.