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Research Article

Optimization and Analysis of Central Bank Losses for Oil Exporting Economy, Application of DSGE Model (Case study of Iranian Economy)

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Abstract
One of the most important macroeconomic challenges has always been creating and implementing an economic policy, and it continues to be a key element of planner's decisions. The importance of the time difference between the design process of a policy and the time of its implementation is important in the decision-making process of the economic planner because if the designed policy changes for various reasons during the implementation stage, the policymaker will be forced to revise the original design. This study emphasizes the teachings of New Keynesian economics school by designing a stochastic dynamic general equilibrium model appropriate to the situation in the country, which looks at household, oil, non-oil, import, final producer, and government sectors, after performing linearization process reviews and evaluating the optimal monetary policy, plus considering the central bank's losses. By adopting the optimal discretionary and Ramsey monetary policy approaches, relying on the importance of the weight of inflation, the results show that the understudy variables (non-oil real GDP, GDP, consumption, and inflation) would experience higher volatility in the case of adopting the discretionary policy. Therefore, the Ramsey monetary policy is a better option to control inflation volatility. Nevertheless, the present study findings on the losses by the central bank indicates less loss in the case of adopting optimal Ramsey policy compared to the discretionary policy.
Keywords: optimal monetary policy, central bank loss amount, dynamic stochastic general equilibrium model (DSGE)

Introduction

As one of the most accepted methods in the study of monetary and fiscal policies, the use of policy rules is one of the most prominent features of policy research in recent decades, especially from the 1990s onwards (Khalili Iraqi, 1388). A policy rule specifies how policy instruments should react to changes in the economy's situation. The ability of basic policy rules to be flexible in monetary and fiscal policies has long been desirable. Macroeconomics has also shown a keen

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interest in examining simple interest rate rules for monetary policy guidance. Furthermore, such rules can contribute to the relevance of using strategies for committing macroeconomic stability in theoretical models with nominal rigidity and imperfect competition (Woodford, 2003).

For many years, the Friedman rule (1959) was the most well-known monetary rule in economic literature. However, this rule relied on uncertainty about the effectiveness of the monetary policy. In summary, Friedman argued that actively manipulating money supply in a system where the length of monetary policy is unpredictable can worsen economic fluctuations, hence proposed the rule of constant monetary growth (Carlson, 1988).

The discussion of rules entered a fundamentally new space by Kydland and Prescott (1977). They demonstrated that the central bank's commitment to a pre-determined rule could have beneficial effects that discretionary policies do not have. Contrary to Friedman's argument in a particular model (quantitative theory of money), Kydland and Prescott's concepts can be used through various macroeconomic models (Welkart, 2007). In general, in the discretionary mode, the policymaker changes the policy depending on the current situation, and as the discretionary planner does not make any binding commitments for themselves, more flexibility can be exercised.

The idea that the commitment policy is a more appropriate version for the central bank is better long-term consequences and better monetary policy response to economic shocks, such as lower inflation. This occurs in the state of commitment, leading to less fluctuation in inflation and production.

Central banks utilize two main techniques to implement their policies: discretionary and applying policy rule processes. In 1936, Simmons first raised the issue of the difference between discretionary and systematic policymaking. The key difference between discretionary policy and a rule-based policy (commitment) is that both policies ultimately make actual production equal to potential production. However, the inflation rate resulting from commitment is expected to be lower than the inflation rate arising from discretionary policy. On the other hand, the monetary economics research has recently concentrated on inflation targeting policy as an indicator of monetary policy direction; an optimal policy refers to the policy that pushes inflation closer to the established optimal level (Aizenman et al., 2011).

Iran's economic experience in recent years has shown that discretionary monetary policies have resulted in a general increase of prices by increasing the growth of liquidity rather than affecting the real sector of the economy and economic growth. On the other hand, the government's fiscal policies have not been very effective, and only the government budget deficit has led to only a change in two important components of the monetary base, namely the public sector debt to the central bank and the net foreign assets of the central bank, therefore increasing liquidity and the general level of prices. As two indicators of economic instability, high average inflation and fluctuations are notable features of the inflation trend in recent years. A feature that has harmed the country's economy by fostering an atmosphere of uncertainty and volatility, which has destroyed the business environment and uncertainty for economic agents in the future (Daraghi and Sharbat Oghli, 2009).

Monetary policymaker behavior in line with macroeconomic goals can be perfectly achieved by minimizing welfare losses significant to policymakers. However, considering the characteristics of the country's economy, relying on the household, oil, non-oil, import, producer of final goods, and the government, the above study has considered an appropriate monetary policy to reduce losses.

Hassanzadeh Jazdani (2019) designed a random dynamic equilibrium model to study the effect of tax shocks on the consumption of domestic and imported consumer goods, labor income tax, and company tax on GDP variables and inflation. The findings show that tax bases on domestic and imported consumer goods consumption, taxes on labor income, and corporate taxes have smaller but significant effects on GDP and inflation. Among the tax bases examined, import tax has the most significant impact on changes in GDP and inflation. The lowest share in changes in GDP among the tax bases under consideration was taxing on the consumption of domestically produced goods, plus labor income tax had the lowest share in changes within inflation.

Salah manesh and Pour Javan (2017) designed and calibrated a new Keynesian stochastic dynamic general equilibrium model, emphasizing stock market dynamics and examining the mechanisms of stock market channel influence on macroeconomic variables. In this respect, a DSGE model considering households, firms, the banking sector, government, and the central bank was designed, and after linearizing logarithms, the model parameters were calibrated using quarterly data of the years 1997-2017 with the findings of experimental studies (Vukotiśc, 2007). The results indicated that a negative deviation of the adverse shock to stock prices through the channel of economic acceleration and bank capital leads to a decrease in production, consumption, investment, deposits, and inflation. Therefore macroeconomic variables are strongly linked to dynamics within a stock market.

Zahabi et al. (2017) designed the proposed model in their study and calculated the coefficients of the extracted current account by applying the Bayesian approach. Subsequently, three policy rules were introduced to the model, and finally, the use of the compound inflation targeting rule combined with the exchange rate in the face of oil revenues increased the current exchange rate fluctuations further, compared to the use of the other two rules. It should be noted that the optimal policy rule is the rule that minimizes the welfare loss function in the face of any shock factors.

By establishing a capital account change channel through the entrance and outflow of foreign deposits, Zanous et al. (2018) explored the influence of international financial integration on economic fluctuations using a stochastic dynamic general equilibrium model. The merger coefficient is defined in terms of the percentage of total deposits attracted from abroad. This coefficient can be amended under the influence of changes in effective domestic interest rates and global exogenous interest rates. The results show that the oil price shock fluctuates the variables of production, consumption, real exchange rate, and variables of the banking system, including deposits received and loans granted in cases of financial integration. However, there was no significant difference concerning inflation (Eltejaei and Arbab Afzali, 2014; Aastveit, 2014; oil price et al., 2007). Likewise, there was no noticeable difference in the response of variables in the two cases in response to the technology shock.

Using the data from post-World War II data on US corporate income tax changes, Futio et al. (2020) concluded that tax cuts' output effect on capital income depends on government debt. When the debt is large, it is more far-reaching than when debt is low. A stochastic dynamic equilibrium model with fiscal policy has been used to identify the mechanisms that can reflect the government-dependent tax effect. The result is that a reduction in capital gains tax is very dynamic that it is unlikely to lead to financial balance in the future. Once government debt increases, the likelihood of future fiscal adjustment increases, and the expansionary effects of lower capital gains taxes can be significantly reduced.

Using a multi-part stochastic dynamic equilibrium model, Antoswiewicz et al. (2016) investigated the impact of two types of taxes in the EU. One type of tax is related to the tax on inputs used in energy, building, and transportation industries, while the other is connected to the tax on products of these industries. Findings show that these two types of taxes create conflicting incentives and have different effects on resource efficiency. However, introducing a tax on incentives has stimulated investment in efficiency-enhancing technologies. The findings suggest that substituting these tax revenues in reducing labor taxes will strengthen the positive effects of input tax.

Kim and Rescigno (2017) examine the cyclical behavior of monetary and fiscal policies using a new Keynesian stochastic dynamic equilibrium model. In this paper, optimal monetary and fiscal policy in an economy where incomplete infrastructure development affects stabilization policies' dynamics and cyclical behavior is theoretically examined. By solving the Ramsey problem with a linear quadratic welfare loss function, the researcher concluded that optimal monetary and fiscal policy tends to behave periodically in the presence of incomplete infrastructure development. As a result, the economy experiences further fluctuations. Also, by gradually comparing different monetary policy regimes based on the Taylor rule, it was concluded that the inflation targeting rule reduces cyclical monetary and fiscal behavior and ultimately improves welfare (Taylor, 2007).

Miao et al. estimated a DSGE model of stock market bubbles and the business cycle in the United States using the Bayesian method (Miao et al., 2013; Miao et al., 2015). Their findings reveal that emotional shock explains a sizable portion of stock market volatility and changes in investment, consumption, and product and that the driving factor behind simultaneous movements in stock prices and real economic values is significant (Zare Shahneh et al., 2020; Filis et al., 2011; Castelnuovo and Nisticò, 2010).

Theoretical foundations

The central bank's policy rule is a policymaking process that consistently uses information and determines how monetary policy controllable tools respond to changes in targeted variables. The ability of policymakers or central banks to perform their objectives depends on possessing the right tools to reduce production, inflation volatility and inflation as a whole. However, the question is how these tools are used to achieve the ultimate goals through intermediate goals. There are two perspectives for answering this question: discretionary monetary policy and regular monetary policy.

Kydland and Prescott suggest that the monetary authority's expedient measures lead to short-run economic imbalances by introducing time inconsistencies. As a result, following a regulation can lessen the central banks' negative impact on discretionary policies.

On the other hand, Taylor argues that the true meaning of the rule must go beyond the concept of the rule, according to Kydland and Prescott, because a rule must be able to account for short-term imbalances in the economy based on the mechanism of automatic stabilization fix. Although Taylor does not deny the necessity of the rule, he emphasizes that expediency must also be considered in the context of the rule.

Monetary policy guidelines have improved in recent years when evaluating and describing the central bank's policy performance. However, there is still no conclusive consensus on the actual meaning of the phrase "monetary rule," but according to John Taylor, who offered one of the most well-known monetary rules, which later became the foundation of many global studies of banking policies in the subject. Central monetary policy is a program that clearly defines the conditions under which a monetary policymaker must change the intermediate goals of monetary policy.

The leading economics textbooks place more emphasis on monetary policy rules as a method of teaching monetary policy. In this regard, Kydland and Prescott (1977) began a discussion Barro and Gordon (1983) continued. They raised the inflation bias issue resulting from a discretionary monetary policy that incentivized inflation to achieve several alternative desirable goals. In this context, adherence to the monetary policy rule can create the necessary restrictions to correct the inflation bias. Parallel to the changes in "real business cycle" theory in the 1980s, another school of thought in the evolution of monetary policy thinking evolved, resulting in the requirement for the central bank to respond optimally to inflation variations.

As a result, "central bank independence" has remained in the spotlight since the early 1990s. The necessity to attain pre-determined inflation targets at low levels and discuss the rule versus diagnosis was further debated and deepened when the flaws in the monetary targeting method were found. Following the expansion of the literature on central bank independence, "inflation targeting" became the next step in the evolution of policy concepts. The optimal response of an independent central bank should be in the face of the current inflation rate deviation from the target inflation rate. However, studies have shown that, even with total independence, adopting inflation targeting using the monetary rule for the central bank is not the only criterion for ensuring price stability. What is evident is that both monetary and fiscal policy influence that price stability.

The optimal monetary rule is derived from the first-order condition for minimizing the inter-period loss function by limiting how the economy moves over time. Taylor introduced his famous rule in 1992, which was a simple instrumental rule. Svensson (1997) re-expanded the discussion of the optimal monetary rule and used an inter-period optimization process to find the optimal monetary rule. Following Svensson, the optimal monetary rule was re-examined, and more research was conducted. In most research within the field, the central bank is assumed to have an intermediate loss function, typically a quadratic function of the product gap and the difference between inflation and the targeted rate.

In general, optimal monetary policy is the derivation of an optimal rule of conduct, according to which the central bank regulates and applies its monetary instrument. The term "optimal" means that the optimal rule is achieved through optimization over time. In the optimal monetary policy method, the objective function, often referred to as the loss function, is a function that the central bank is willing to minimize. The reasoning for the term "loss function" is that there are variables in the function, which causes social costs and costs producers and consumers, such as inflation. According to research, the loss function is expressed in diverse ways, and in general, according to research, this function has at least one variable and a maximum of three variables. Examples of variables include inflation, unemployment rate, production gap, and money supply growth rate (Chung and Ariff, 2016).

Central banks demand a policy system to achieve their goals. At the heart of this system is the political regime, which is a decision-making framework. The monetary policy rule is set as a rule for monetary policy to be followed in the medium term in this regime. Monetary policy is organized around a precise and quantitative goal known to the public. Thus, targeting inflation as the latest monetary strategy by focusing on the domestic economy and an independent monetary policy and increasing the central bank's credit reduces the effects of inflation shocks.

Material and Methods

Using Medina and Soto (2005) and Allegret and Benkhodja (2011) models, this study emphasizes a Keynesian stochastic dynamic general equilibrium model for Iran as an oil-exporting economy to adopt an optimal monetary policy, considering shocks. For this purpose, the model is constructed according to the characteristics of Iran's economy as a small open oil-exporting economy.

The economic sectors included in this study are the household, oil sector, non-oil sector, import, final producer, and government, where households are considered to provide labor and capital to the oil producer and non-oil producers. The oil sector uses technology, capital, and labor to produce crude oil, exported entirely at world prices. According to the non-oil sector, it is assumed that there is an infinite number of non-oil commodity firms that produce specific commodities in a monopolistic competitive market, so the non-oil commodity firm possesses price placement powers in the Galvo model (1983) and Yun model (1996).

In the import sector, imported consumer goods are imported at world prices. These distinctive goods are sold by importers who use the Kalu and Yan pricing models within a competitive domestic monopolized market. Furthermore, the final product producer operates in a completely competitive environment, and for producing the final product, a combination of domestically produced goods and imported goods is used. The government also owns the oil sector, exports crude oil, imports refined oil at world prices, sells them to non-oil producers at subsidized prices, and finally assumes that the central bank has a short nominal interest rate. Finally, adjustments to the duration in response to inflation fluctuations using the Taylor -type monetary policy rule are made.

It is worth noting that stochastic dynamic equilibrium models, which were first developed as part of the real business cycle school, frequently attribute economic fluctuations to technological shocks and have little interest in assessing the impacts of monetary policy on the economy. Therefore, the advancement of the New Keynesian school and the gradual evolution of models within this school, plus the definition of nominal rigidity, attracted much attention from monetary circles to these models. As a result, building a stochastic dynamic equilibrium without taking nominal rigidity into account makes it impossible to examine the real effects of monetary policy. We can only examine the actual effects of monetary policy by introducing nominal rigidity and building this model in the New Keynesian paradigm.

Household

The representative household gains utility (c_t) and leisure $(1-h_t)$, and the household preferences follow the expected utility function:

$$E_0 = \sum_{t=0}^{\infty} \beta^t U(c_t, h_t) \tag{1}$$

In the above relation, β is the mental discount rate and is a function of household utility as follows:

$$u = \frac{c_t^{1-\gamma}}{1-\gamma} - \frac{h_t^{1+\sigma}}{1+\sigma} \tag{2}$$

γ The alternative inverse elasticity between consumption periods and σ is the inverse elasticity of the labor supply wage, $h_t$is the household labor supply for which the Cobb-Douglas function is defined as follows:

$$h_t = h_{o,t}^{\alpha_{ho}} h_{no,t}^{\alpha_{hno}} \qquad \alpha_{ho} + \alpha_{hno} = 1 \tag{3}$$

$h_{o.t}$ and $h_{no.t}$ show household working hours at time t within the oil and non-oil sectors. The parameters α_{ho} and α_{hno} are the elasticity of labor replacement in the oil and non-oil sectors. It should be noted that the utility function u is strictly infinite.

Oil sector

To model oil production, we assume that the oil sector in full competition uses capital technology $A_{0,t}$, labor $h_{o,t}$, capital $k_{o,t}$, oil factor $O_t$to produce crude oil and then exports based on international price $P^f_{o,t}$. The problem of maximization in the oil sector follows the following relation:

$$max_{k_{o,t}h_{o,t}\,o_t}\left[e_t P^f_{o,t} Y_{o,t} - Q_{o,t}\,k_{o,t} - w_{o,t}\,h_{o,t} - P_{o,t}\,O_t\right] \tag{4}$$

Production function in the oil sector, a Cobb-Douglas production function, and coefficients also show the share of each factor in oil production:

$$Y_{o,t} \leq A_{0,t}\,k^{\alpha_0}_{o,t}\,h^{\beta_0}_{o,t} O^{\theta_0}_t \qquad \alpha_0 + \beta_0 + \theta_0 = 1 \tag{5}$$

$\alpha_0, \beta_0, \theta_0$, represent the share of oil resources, labor, and capital for oil production.

Non-oil sector

In this section, we assume that non-oil producers operate under conditions of monopoly competition. Based on this hypothesis, it is assumed that each company *i* produces non-oil goods based on the following production function:

$$Y_{o,t}(i) \leq A_{no,t}\,k^{\alpha_{n0}}_{no,t}(i) h^{\beta_{n0}}_{no,t}(i) Y^{I^{\theta_{no}}}_{o,t}(i) \qquad \alpha_0 + \beta_0 + \theta_0 = 1 \tag{6}$$

According to the time-dependent random rule, Calvo, every manufacturer in any period, has a fixed probability of price change (Calvo, 1983). Assuming that the producers of non-oil goods are unable to change their prices, the price indexation will be applied as follows: (π is the long-term average gross inflation rate)

$$P_{no,t} = \pi P_{no,t-1} \tag{7}$$

Import section

The manufacturer of the end product uses imported composite goods Y_{It} purchased in a competitive domestic monopolized market for their production needs. To produce Y_{It} the firm uses distinctive products "products produced by a chain of domestic importers and homogeneous intermediate goods produced abroad that are imported at the global price of P^f_t". Distinctive products are sold at $P_{It}(i)$ prices that follow the Kahlo adhesion pattern. The problem of importer maximization is as follows:

$$max_{P_{I,t}(i)}\; E_0 \sum_{s=0}^{\infty}(\beta \emptyset_I)^s \lambda_{t+s}(\pi^s \tilde{P}_{I,t}(i) - e_{t+s}(\mu + (1-\mu)\xi_t)P^f_{t+s})Y_{I,t+s}(i) \tag{8}$$

The nominal price index of total imports evolves with an emphasis on the following return form:

$$(P_{I,t})^{1-\vartheta} = \phi_I(\pi P_{I,t-1})^{1-\vartheta} + (1-\phi_I)\left(\tilde{P}_{nT,t}\right)^{1-\vartheta} \tag{9}$$

Dividing Equation (8) by *Pt* results in the following real import price index:

$$(P_{I,t})^{1-\vartheta} = \phi_I\left(\pi \frac{P_{I,t-1}}{\pi_t}\right)^{1-\vartheta} + (1-\phi_I)(\tilde{P}_{I,t})^{1-\vartheta} \tag{10}$$

Final goods producer

It is assumed that the producer of the final goods operates in a fully competitive environment and uses CES technology to produce the final $\mathcal{Z}_t$ product, which includes domestic $Y_{no,t}$ non-oil production, and $Y_{I,t}$, imports. τ>0 is the alternative tension between non-oil products and imported goods and $\mathcal{X}_{NO}$and $\mathcal{X}_I$is the share of imported and non-oil goods in the final goods.

$$\mathcal{Z}_t = \left[\mathcal{X}_{no}^{1/\tau}\ Y_{no}^{\tau-1/\tau} + \mathcal{X}_I^{1/\tau}\ Y_I^{\tau-1/\tau}\right]^{\tau/\tau-1} \quad \mathcal{X}_{NO} + \mathcal{X}_I = 1\ ,\ \tau > 0 \tag{11}$$

By solving the problem, the following demand function is obtained:

$$Y_{I,t} = \chi_I \left(\frac{P_{I,t}}{P_t}\right)^{-\tau} z_t, Y_{no,t} = \chi_{no} \left(\frac{P_{no,t}}{P_t}\right)^{-\tau} z_t \tag{12}$$

Finally, the final commodity is divided between total consumption and total investment:

$$z_t = c_t + i_{o,t} + i_{no,t} \tag{13}$$

Government

According to a study, in an oil export economy, domestically refined oil is sold to non-oil companies at a price of $P_{o,t}$ which can be classed as the domestic price of fuel, subsidized by the government. By considering the study of Boaks et al. (2008) and Ben Bukha (2011), the domestic price of oil $P_{o,t}$ as a convex combination of its world price $P_{o,t}^f$with a weight υ and the domestic price of the previous period, where the weight *(1-υ)* is determined as follows:

$$P_{o,t} = (1-\upsilon)P_{o,t-1} + \upsilon e_t\ \xi_t P_{o,t}^f \tag{14}$$

When $\upsilon = 1$, there is no subsidy, and the world price of oil determines the price. Furthermore, in the case of $\upsilon = 0$, the domestic oil price is wholly subsidized, and domestic companies buy oil at the price of *P(o, t)*. As a result, the government budget is as follows:

$$\varpi \sum_{j=0,T,nT} W_{j,t}\ h_{j,t} + s_t P_{o,t}^f Y_{o,t} = \left(s_t \Xi_t P_{o,t}^f - P_{o,t}\right) Y_{o,t}^I + \omega_{o,t} h_{o,t} + q_{o,t} k_{o,t} \tag{15}$$

The left shows the government revenue equation, which includes general taxes, ϖ, and oil sales revenue $s_t P_{o,t}^f Y_{o,t}$ and the right shows government spending, which includes expenditures. Salary, return on capital $\omega_{o,t} h_{o,t} + q_{o,t} k_{o,t}$ in the oil sector and the amount of oil subsidies $\left(s_t \Xi_t P_{o,t}^f - P_{o,t}\right) Y_{o,t}^I$

Market Clearing Condition

In a symmetrical equilibrium, all importers and producers of non-oil products make the same decision as follows:

$$Y_{not}(i) = Y_{not}\ ,\ Y_{ot}^I(i) = Y_{ot}^I\ ,\ \tilde{p}_{not}(i) = \tilde{p}_{not}\ ,\ Y_{It}(i) = Y_{It},\ \tilde{p}_{It}(i) = \tilde{p}_{It} \tag{16}$$

$$Y_t = P_{no,t} Y_{no,t}^{va} + s_t\ P_{o,t}^f\ Y_{o,t} \tag{17}$$

Y_t and $Y_{no,t}^{va}$ are GDP and value-added output in the non-oil sector. The variable $Y_{no,t}^{va}$is as follows:

$$Y_{no,t}^{va} = Y_{no,t} - s_t \, P_{o,t}^{f} \, \frac{Y_{ot}^{T}}{P_{no,t}} \tag{18}$$

Combining the household budget constraints, the unit period functions of the non-oil producing companies and the importers of foreign goods, and the first-order terms of the three segments and the use of the market settlement condition, the following current account equation is obtained:

$$\frac{b_t^f}{R_t^f k_t} = \frac{b_{t-1}^f}{\pi_t^f} + p_{o,t}^f y_{o,t}/\Xi_t - p_{o,t}^f Y_{ot}^I - (\mu + (1-\mu)\Xi_t) Y_{It}/\Xi_t \tag{19}$$

Monetary policy

For examining the appropriate monetary policy in the Iranian economy, the model should be solved by considering the monetary policy rule. In New Keynesian models, the number of equations available to the policymaker is less than the unknowns in the model. Now, to complete the model, an equation is considered the model's monetary policy behavior. This is usually the well-known Taylor rule, but when optimal monetary policy is considered, the targeting rule is based on specifying a loss function for policymaking and the policy objective instead of using the instrumental rule. The transition to minimize this loss function is such that no inconsistencies occur between times. This approach is made in discretionary policymaking with a slight difference in optimization. In both of these approaches (optimal and discretionary policymaking), it is impossible to estimate the parameters as the goal in both approaches when it comes to optimization. With these interpretations, this study introduces the loss function for the central bank, and two methods, optimal and discretionary, examine the model.

Solution method

Optimizing equations in the form of linear logarithms

Typically, general equilibrium patterns form a nonlinear set of differential equations, which is not adequate for practical analysis. It is impossible to find a stable uniform answer in most cases. However, once converted, it can provide the basis for a suitable device for experimental analysis. Therefore, it is significant in preparing a more straightforward pattern to construct a linear approximation of the original nonlinear pattern. In this case, the system of random differential nonlinear equations becomes a random differential linear system.

Data

One problem in applying stochastic dynamic general equilibrium models is their parameterization using economic statistics. There are two quantification methods and estimation for parameterization, the estimation itself can be done by generalized torque, maximum likelihood, or Bayesian methods. Calibration is essential in evaluating stochastic dynamic equilibrium models in real and New Keynesian schools, often based on quantifying pattern parameters based on related studies. In many countries, due to many studies on applying stochastic dynamic general equilibrium models, researchers often find the values of the parameters in their model without any concern for the accuracy of the data and information. Other researchers place reputable sites. Considering that many studies have been conducted in Iran in recent years using these models, we also use the parameter quantification method in this study with confidence in some studies. For quantifying other parameters, as mentioned above, the findings from previous studies have been used. Table 1 shows the calibrated parameters.

Table 1. Calibrated parameters and ratios of the model

Source	Value	Parameter	Description
Jalali-Naini and Naderian (2011)	0.985	β	Mental discount factor
Tavakolian and Jalali-Naini (2016)	1.57	γ	Reverse substitution elasticity between consumption periods
Tavakolian (2012)	2.17	σ	Reverse labor supply wage elasticity
Mehregan et al., 2017	0.042	δ	Capital depreciation rate
Result & discussion	0.81	$\frac{kno}{k}$	Stable ratio of capital in the non-oil sector to the total capital stock
Result & discussion	0.42	$\frac{c}{y}$	Stable ratio of consumption to GDP
Result & discussion	0.28	$\frac{I}{y}$	Stable ratio of investment to GDP
Result & discussion	0.19	$\frac{g}{y}$	Stable ratio of government spending to GDP
Result & discussion	0.26	$\frac{sp_o^f y_o}{y}$	Stable ratio of exports to GDP
Result & discussion	0.22	$\frac{sp_o^f y_o^i - sy_i}{y}$	Stable ratio of imports to GDP
Result & discussion	0.5	$\frac{sp_o^f y_o}{g}$	Stable ratio of oil export revenues to government expenditures

In the above study, the data of the seasonal time series 1370 to 1397, taken from the Central Bank, have been used to calculate the stable values of some variables in equilibrium.

Loss function of the Central Bank

In this section, the specification of the central bank's loss function is presented. It is assumed that the central bank to adopt an optimal monetary policy seeks to achieve goals such as inflation, output gap, monetary base growth, and real exchange rate. Accordingly, the central bank loss function consists of the squares of deviations of target variables from their target level and are introduced as follows:

$$L_t = E_t \sum_{t=0}^{\infty} \beta^t (\lambda_\pi \hat{\pi}_t^2 + \lambda_y \hat{y}_t^2) \quad (20)$$

Where λ_y and λ_π are the weight of GDP deviations and inflation, respectively, in other words, the above loss function includes inflation deviation from the target value and the output gap. Any deviation from the target values (positive or negative) is undesirable and is considered a loss. The interpretation that any deviation from the target values of the loss is a good criterion for determining social loss because considering a target rate, values of more or less than this rate cause the loss function to be positive. Therefore, the loss function is the product of the second power of the deviation from the variables from the total target value as per their weight.

In the following, two different monetary policy regimes are considered. In a monetary policy regime, the central bank acts optimally in each period. The other, which is a type of commitment to goals, seek a competitive balance that maximizes the desirability of the entire life cycle of economic agents. Moreover, this method offers total commitment to achieve maximum well-being in all periods.

Pattern analysis

In this section, the results of the template are analyzed. In the first step, the variance of the model's key variables is evaluated and analyzed under different scenarios (through both optimal Ramsey and discretionary policies). In this way, under different scenarios, the variance of the key variables of total production, consumption, GDP without oil, inflation is examined. In the second step, the loss of the central bank under the specified conditions is examined as follows. It should be noted that the importance coefficient of the production gap in the central bank loss function has been assumed according to $\lambda_y = 0.5$ (Table 2 and Table 3).

Table 2. Comparison of variance of key variables (Discretionary model)

Variable	1=λ_π	1.5=λ_π
Gross domestic product without oil	0.0063	0.0063
GDP	0.000096	0.000096
Consumption	0.000034	0.000034
Inflation	0.0001	0.0001

According to the table above, the variance of variable consumption is 0.000034, which is lower than other variables studied. Nevertheless, increased weight of parameter λ_π according to the table above, the variance of the understudy variables does not change.

Table 3. Comparison of variance of key variables (Ramsey model)

Variable	1=λ_π	1.5=λ_π
Gross domestic product without oil	0.00051	0.00048
GDP	0.00002	0.00003
Consumption	0.00059	0.00056
Inflation	0.000001	0.000001

The statistical values of Table 3 show that the variance of variable inflation is at the minimum (0.000001) compared to other parameters, with increased parameter weight λ_π from 1 to 1.5; therefore, the policy-makers will be able to control inflation volatilities by adopting the above policies. In the case of the increased weight parameter λ_π, the variance of non-oil GDP and consumption decreased from 0.00051 and 0.00059 to 0.00048 and 0.00056, respectively, and the variance of GDP experienced a minor increase.

Comparing the statistical results of Tables 2 and 3, by increasing the weight of parameter λ_π from 1 to 1.5, to magnify the importance of inflation policy, variances under consideration for the discretionary policy did not significantly change, showing the policy insensitivity to the increase. However, according to Table (3), regarding the optimal Ramsey policy, increasing the weight of parameter λ_π from 1 to 1.5, GDP faced a slight increase in fluctuations. consumption and non-oil experienced decreased volatilities, and the inflation variable experienced minimum volatilities in the face of the above changes.

It should be noted that the Ramsey policy has fewer fluctuations in the variables under study, especially inflation, compared to the discretionary policy and is, therefore, a more appropriate basis for economic policymaking.

Regarding the losses by the central bank, Table 4 shows the absence of changes in the loss in optimal discretionary policy given the increased λ_π parameter from 1 to 1.5. In the case of adopting the Ramsey optimal policy, the losses by the central bank would have a 0.00003272 unit increase by considering the increased λ_π parameter weight. In general, the losses by the central bank would be less in the case of implementing the policy above compared to implementing the discretionary policy.

Table 4. Comparison of Central Bank Losses

Variable	$1=\lambda_\pi$	$1.5=\lambda_\pi$
Ramsey	0.00014809	0.00018081
Discretionary	0.01025094	0.01025094

Conclusion

Using the models of Medina and Soto (2005) and Algert and Ben Khoja (2011), this study aimed to examine the optimal monetary policy by confirming the shocks to the Iranian economy as an oil-exporting country; as a result, a dynamic New Keynesian general equilibrium model for Iran as an oil-exporting economy in the form of the New Keynesian school is constructed. For this purpose, the model is made according to the characteristics of Iran's economy "as a small open oil-exporting economy."

Considering the specificity of nominal rigidity, among other factors, and after performing the optimization process in the form of a linear logarithm to select the optimal monetary policy, the study examines the optimal policies based on the two approaches; Ramsey optimal and discretionary policy. It should be noted that policymakers can manage the economic environment by defining a specific approach to monetary policy and adhering to it. However, there is no guarantee that a commitment to that approach will be desirable in the future.

The results of the discretionary and Ramsey optimal approaches demonstrate significant variations in the analyzed variables, including inflation, when a discretionary policy is used instead of the optimal Ramsey policy. However, it should be noted that the Ramsey policy has fewer fluctuations in the variables under study, especially inflation, compared to the discretionary policy and is, therefore, a more appropriate basis for economic policymaking.

The statistical analysis of results in Tables 2 and 3 shows that with increased λ_π weight parameter from 1 to 1.5 and $\lambda_y = 0.5$, regarding the adoption of monetary policy, the volatilities in the understudy variables (non-oil GDP, GDP, consumption, and inflation), with emphasis on the discretionary policy, have not had a significant change. However, the consumption variable is at the minimum compared to other variables, and therefore, the policy above is not appropriate for adopting an inflation control policy.

Particularly in the case of adopting the Ramsey optimal policy, the inflation variable would experience the least volatilities compared to other variables (0.000001), and consumption and non-oil GDP variables would experience a few percent decreases in volatilities.

Given that the importance of inflation parameter is increased, the losses by the central bank would experience limited increase by adopting the cryptography key management policy in the case of increased λ_π weight parameter. Nevertheless, the losses by the central bank would be less in the case of adopting Ramsey optimal policy compared to the discretionary policy.

Ultimately, adopting the discretionary policy in the present study disables the policy-maker to reach the optimal result in controlling inflation. While in the case of adopting Ramsey policy, focused on decreasing the volatilities in inflation and other economic variables, a more optimal approach would be available for improving the economic processes.

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