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Optimal Monetary and Fiscal Policies for a Non-Inflationary Exit from Stagnation in Iran: A DSGE Approach

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Abstract
The purpose of this paper is to investigate the optimal monetary and fiscal policies with emphasis on a non-inflationary exit from economic stagnation in Iran. In the first stage, Iran's economy has been modeled in the form of a New Keynesian Dynamic Stochastic General Equilibrium model (NK-DSGE). After modeling and extracting the system of equations, the structural parameters of the model have been estimated by using seasonal data from 1989 to 2016 and also the Bayesian approach. The results show that monetary and fiscal expansionary policies increase production though they are associated with inflation. In the second stage, the optimal monetary and fiscal rules have been extracted from a social loss function, and accordingly the conditions of a non-inflationary exit from stagnation have been investigated. The results of the simulation show that the optimal monetary policy cannot by itself lead to the exit of the economy from stagnation without inflation. However, if this policy is applied along with an optimal fiscal policy, a non-inflationary exit from economic stagnation can be achieved.

1. Introduction

Nowadays, the role of the central bank and other monetary institutions and the impact of their policies on the economy are quite obvious. On the other hand, the fiscal sector which includes the government budget and its components has close relationships with monetary policy through the government's budget. Therefore, in order to achieve different macroeconomic goals, a simultaneous optimization should be considered for these policies. Monetary and fiscal policies, as highly important instruments, are very influential on economic growth, inflation, product gaps, government budgets, trade balance, and other macroeconomic indicators. Therefore, the coordination of monetary and fiscal policymakers, considering the potential of the economy and the comparative conditions of inflation, government budget, economic growth, and unemployment rate keep the economy away from crises.

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Iran’s economy is faced with a special situation. On the one hand, the unconventional inflation has created many challenges in recent decades and has caused instability. On the other hand, the economy has experienced a negative growth in production, an increase in unemployment, and a decline in production in some sectors so that most of the country’s policymakers have focused on a “non-inflationary exit from stagnation” more than anything. Monetary and fiscal policies and their combination, which are considered as the most powerful and effective instruments for policymakers, can play an important role in exiting from the current situation. For this purpose, the present study, considering the specific conditions of Iran’s economy, seeks to investigate the effects of optimal monetary and fiscal policies on a non-inflationary exit from stagnation.

After Iran’s economy experienced “stagflation”, many policymakers paid attention to this problem so that the term “non-inflationary exit from stagnation” was added to the economy’s collection of terms. Today, the economists’ attention has been drawn to the efforts of the government and the central bank so that they are more sensitive to the effects of their policies.

According to situation of Iran’s economy, a monetary and fiscal policy package is needed to manage uncertainty in order to control inflation and support monetary discipline and monetary base and provide the conditions for a non-inflationary exit from the recession through special focus to the government budget and oil price fluctuations. Monetary and fiscal policies are mainly examined simultaneously in the recent economic researches. Most economists and researchers seek to achieve a common monetary and fiscal optimality, as discussions of central bank independence and fiscal (monetary) dominance increase. Thus recent studies have focused on polices interaction as well as their feedback.

With reviewing the process of stagflation in Iran and the ways of treatment, as well as role of monetary and fiscal policies and their impact on the economy, the most important question that arises is whether an optimal monetary and fiscal policy can provide a way to non-inflationary exit from the stagnation. Given the importance of this issue, the present study seeks to answer this question. Although the issue of non-inflationary exit from stagnation in Iran has been approved by "Islamic Consultative Assembly", a review of researches in this scope shows that there is no comprehensive study on this issue. Jafari Samimi and Tehranchian (2004), Rajabi et al. (2010), Khalili Iraqi et al. (2009), Komijani et al. (2010) and Izadi and Dehmardeh (2012) are all researchers who have studied monetary and fiscal policies but none of them did not examine the role of these policies in overcoming economic crises, including the stagflation. Also other researchers including Sahabi et al. (2013), Bastaani Fard and Mirzaei (2014), Rahmati and Madani Zadeh (2014) and Safshekan and Momeni (2016) descriptively examined strategies for overcoming inflationary stagnation without considering any policy instruments (fiscal or monetary). The present paper attempts to fill this research gap by applying the DSGE model and links between policies and treatment of stagflation.

In this paper, after reviewing the related literature, in the third section, the model specification will be presented. The fourth section will include the empirical results. Also the conclusion will be presented in the final section of this research.

2. Literature Review

The term “stagflation” has been resulted from the combination of the words “stagnation” and “inflation”. Stagnation is caused by one of two factors: “effective demand failure” or “supply-side deficiencies”. Inflation arises from a number of factors such as increasing money supply, the rise of global and input prices, economic structure, etc. In general, two types of inflation are distinguished by demand stimulation and cost pressures. As it is expressed in economic literature, anti-inflationary policies have deepened stagnation and anti-stagnation policies are usually accompanied by rising inflation. For this reason, policymakers should focus upon one of them in the short- and medium-run. Now, the question that arises is: “can a solution for stagnation or inflation be found without stimulating the other?”

"Non-inflationary growth" and "sustained growth" are terms that came into economic literature after the inflationary recession of 1970s. By definition, non-inflationary growth is the growth in economic activity and production without rising inflation (Myles et al., 2009). Also, growth in economic activity and production without causing other significant economic problems (such as inflation) is called sustained growth. Simultaneously with the enactment of the law of the Non-inflationary exit from stagnation in December 2014, the term "non-inflationary exit from stagnation" was first added into Iranian economic literature. According to this law, the concept of non-inflationary exit from stagnation is to exit the country's economy from recession without causing inflation, or in other words, not at least increasing inflation in the country (Mousavi Nick et al., 2014). So it can be said that the non-inflationary exit from the stagnation is another expression of non-inflationary growth.

There are different views on the treatment of the stagflation among economists. Some believe that, considering the inconsistency of the stagnation and inflation, it is necessary to first focus on the treatment of one of the two problems. But there are economists who believe that the optimal combination of policies can get the economy out of crisis. Proponents of the neoclassical and neo-Keynesian school advocate supply-side policies as remedy such as increasing labor productivity, reducing production costs, and so on. Proponents of the second view are mainly supporters of the demand side. They have introduced appropriate monetary and fiscal policies as treatment of stagflation, including tax cuts and monetary and fiscal discipline.

The Keynesians have expressed that the causes of stagflation include the exit of the labor market from its natural state and the high authority of labor unions in determining the wages. They have also stated that the pressure of costs and supply shocks are the reasons for shifting the Philips curve and then the incidence of stagflation. They have recommended fiscal policies as an instrument for treating stagflation. The Neo-Keynesians have considered the factors of supply-side as the reasons for the incidence of stagflation such that increasing the price of natural resources, including oil and gas, from foreign impulses, as well as government fiscal reform policies (variation in taxes) shifts the supply curve and leads to the incidence of stagflation.

Friedman (1969) suggested the optimal amount of money and monetary regularity. He stated that inflation persistence leads to inflationary expectations and firms consider increasing the wages of workers. This process, which is also considered in the context of the New Keynesians, shifts the Generalized Philips Curve to the left. Friedman, by challenging the Philips curve, claimed that changes in the money supply are the main cause of stagflation. According to Friedman and other monetarists, supply-side policies and monetary control can be the key in exiting from stagflation.

Kydland and Prescott (1977) described the role of rational expectations and time inconsistency in economy. They introduced the government's short-run and discretion interventions, in particular monetary policy, as the causes of stagflation.

One of the most important approaches in finding treatments for stagflation is the identification of the path leading to this crisis. Regarding the structural features of Iran's economy, supply-side factors such as the rise in the price of inputs and demand-side factors such as continuing budget deficits, oil shocks, the government's fiscal indiscipline, and monetary expansion are among the most important reasons of stagflation.

Income and wage taxes will affect labor hours and labor-leisure choices through variation in the time allocation between labor and leisure and thereby will change the national income and production (Pajouyan, 2106). Studies in Iran and similar economies also show that the wage tax reduces the number of work hours of employees by reducing the people's net wage (Zayandeh Roodi, 2001). Thus, it can be said that taxes can shift the supply curve by changing the tendency of the worker about labor or leisure through shifting labor supply curve which changes the level of prices and production in different directions (Branson, 1989). Accordingly, in this research, the optimal monetary and fiscal policies will be evaluated to examine the possibility of a non-inflationary exit from stagnation.

Typically, the optimal policy rule is to ensure maximum social welfare. Therefore, any research seeking to extract optimal policy rules is necessarily based on such a structure. For example, Farazmand et al. (2013) examined the optimal monetary and fiscal policy by considering the implementation of a price reform plan for energy carriers. In this study, the Gini coefficient, money growth rate, inflation, production gap, and government expenditures growth are considered in the loss function while total demand, total supply, and income distribution equation are considered as the constraints. The results of this research show that with the price adjustment of energy carriers, it can be seen that economic growth and income growth are improved without increasing inflation.

Jafari Samimi and Tehranchian (2004) proposed quantitative amounts of optimal monetary and fiscal policies for the third development plan using the optimal control theory. In this research, they calculated the optimal amounts of government expenditures, tax revenues, and the amount of money by minimizing the intertemporal loss function. Comparing the results of this optimization with the amounts considered in the third development plan shows that the optimal liquidity and government expenditures are higher than their proposed values in the third plan. These optimal monetary and fiscal policies improve the economic growth rate, the government deficit to GDP ratio, and current account balance to the proposed values in the third plan.

Khani Gharieh Gapi et al. (2014) have analyzed the reasons for the economic stagflation in Iran's economy by using the threshold error correction model from 1973 to 2011. In this research, the dependent variables include adversity index and the independent variables include liquidity, government deficit, oil revenues, and balance of payments. The results indicate that increasing the growth rate of independent variables from a threshold level will have the same effects on the stagflation in Iran.

Tayebi et al. (2015) examined the reaction of production and foreign trade to exchange policies to exit the economy from stagnation without inflation. The results of this study, which have been presented in the structural vector autoregressive model (SVAR), show that an appropriate exchange policy such as exchange rate uniformity eliminates the fluctuation of production gap and employment in a five-year period and creates a relative stability in economy that can provide a way out of the recession.

Roger (1981), in "The proper medicine for stagflation" investigated the solutions for stagflation applied to America's economy. According to this study, there were two economic viewpoints for the treatment of stagflation: first, the viewpoint of supply-side advocates who sought to reduce production costs, along with the Neoclassics who emphasized on policies which would increase the productivity of production and labor. The second viewpoint supported monetary and fiscal policies. They claimed that the reduction of taxes, government expenditure compensation through monetary policies, and the emphasis on monetary and fiscal discipline are the treatment ways. Ultimately, the combination of supply and demand approaches was able to remove the US stagflation.

Barsky and Kilian (2001) argued that there were other origins for the stagflation of 1970s, in addition to the first and second oil shocks. In this research, they presented a model for explaining the stagflation by expansionary and contractionary monetary policies. They said that there was no theoretical hypothesis for explaining that "the oil shock causes the stagflation". They showed that the oil shock reduced GDP but, on the other hand, there was no evidence for CPI variation. The viewpoint of the impact of oil shocks on stagflation could not explain the rise in the price of industrial goods which increased before the rise of oil prices in 1973-1974 and also the fact that the rise in the prices of industrial goods led to an increase in OPEC's oil prices.

Al-shawarby and El Mossallamy (2019) in "Monetary and Financial Policies and Optimal Rules in Egypt" estimated a new dynamic Keynesian stochastic general equilibrium model using the Bayesian technique for the Egyptian economy. The purpose of this study, which uses seasonal data from 2004-2016, is to evaluate monetary and fiscal policies and examine their impact on economic stability in the country. The study also evaluates the implications of monetary and fiscal authorities' commitment to policy instruments such as interest rates, government spending, and taxes using Taylor's rule and other optimal simple rules. The findings of the study showed that monetary and fiscal policy instruments in Egypt affect economic stability by influencing inflation, output and debt. A review of the monetary rule (Taylor, 1993) in the country shows that the Egyptian Central Bank pays particular attention to anti-inflation policies and production targeting. The decisions of the Central Bank of Egypt are significantly affected by interest rates. On the other hand, fiscal authorities play an important role in controlling government debt. They adjust government spending and taxes cyclically and counter-cyclically, respectively.

In this section, the review literature of the current paper was presented which included studies on monetary and fiscal policy as well as those in the field of stagflation. Precise review of Iran's studies shows that, first, the focus of the majority of researches was on the efficiency or effectiveness of monetary or fiscal policies on a specific variable in the economy; second, because the discussion of a "non-inflationary exit from stagnation" in Iran's economy has a short history, there is still no comprehensive research in this regard. By summing up the review of empirical research in these two areas, it can be said that investigating the effect of the optimal monetary and fiscal policies on a non-inflationary exit from stagnation can be considered as necessary in this field.

3. Model Specification

Since such features as nominal sticky, monopolistic competition, and imperfect employment are compatible with the realities of today's economy (as in Iran's economy), the model used in this study will be based on the New Keynesian Paradigm. The main framework of this model is based on the studies of Schmitt and Uribe (2004) and Walsh (2003).

Iran's economy is extremely influenced by oil and other components of government budget (fiscal sector), and the government plays a significant role in the economy. Thus, these variations have been added to the model. Also, because taxes are considered as the most important instrument of applying fiscal policy, they have widely entered the household sector. On the other hand, in conventional New Keynesian models, there is an independent monetary authority for monetary policy. However, in Iran, the central bank is entirely dependent on the government and its policies. Therefore, in this study, the government and the central bank are assumed to comprise one unit. In Iran's economy, as in those of other developing countries, the nominal interest rate has no significant effect in policymaking. For this reason, we used the McCallum rule along with the effects of oil revenue shocks instead of the Taylor rule. Also, for the purpose of examining a "non-inflationary exit from stagnation", a loss function has been used for monetary and fiscal policymakers so that the inflation and production gaps decrease the social welfare. In order to consider the concept of a "non-inflationary" exit, it is assumed that the inflation gap is constant and the production gap is used in order to consider the concept of an "exit from stagnation".

In this paper, Iran's economy is assumed to be a small economy in which the expectations of households and firms are homogeneous. Also the sectors include households, firms, and policymakers that seek to achieve the desired objectives subject to their constraints. Each sector will be illustrated below.

3.1 Households

We suppose that there are a large number of identical households. The representative household solves the following problem:

$$Max\ E_0 \sum_{t=0}^{\infty} \beta^t \left[logc_t + \psi_m \, log\left(\frac{M_t}{P_t}\right) - \psi_n logn_t\right] \tag{1}$$

subject to

$$(1+\tau_{c.t})c_t + m_t + \ i_t + b_t \leq (1-\tau_{w.t})w_t^n n_t + \frac{m_{t-1}}{1+\pi_t} + \frac{D_t}{P_t} + (1-\tau_r)r_{t-1}^k k_{t-1} + (1+r_{t-1}^n)\frac{b_{t-1}}{1+\pi_t} \tag{2}$$

Here, c_t, m_t and n_t denote household consumption, money holding, and supply labor, respectively. Also β denotes discount factor, ψ_m and ψ_n are preferences parameters for keeping money and labor supply, respectively. Also b_t denotes the real participation bonds purchased by the household in period t. $\tau_{c.t}$, $\tau_{w.t}$ and τ_r denote consumption tax rate, wage tax rate, and capital tax rate, respectively. i_t, D_t, w_t^n, π_t, and r_t^n denote investment, dividend, wage, inflation rate, and nominal interest rate, respectively.

Finally, since households supply capital, the second constraint against them is assumed to be

$$k_t = (1-\delta)k_{t-1} + \left[1 - \xi\left(\frac{i_t}{i_{t-1}}\right)\right] i_t \tag{3}$$

Where δ is capital depreciation rate and ξ is capital adjustment function.

3.2 Firms

We will discuss the firms in two groups: final goods firms and intermediate goods firms.

3.2.1 Final Goods Firms:

It is assumed that there are j intermediate goods firms which are producing distinct goods with sticky prices and in monopolistic competition conditions.

These goods are imperfect substitutes for each other and are combined by an aggregator and sold to households as final goods. If we assume a CES function and a constant elasticity substitution θ among j intermediate goods, the Dixit-Stiglitz aggregator can be defined as follows:

$$y_t = \left[\int_0^1 y_{jt}^{\frac{\theta-1}{\theta}} d_j\right]^{\frac{\theta}{\theta-1}} \qquad , \qquad \theta > 1 \tag{4}$$

3.2.2 Intermediate Goods Firms

In this research, we consider a large number of intermediate firms that operate in a monopolistic competition market (Dixit and Stiglitz, 1977). These firms produce intermediate goods, by employing labor and renting capital from households, and pay wages and rent to households as input owners. The producing function of intermediate goods for firm j is a Cobb-Douglas function which is a function of the quantity of labor and capital as follows:

$$y_{jt} = A_t K_{jt}^{\alpha} {n_{jt}}^{1-\alpha} \qquad , \qquad \alpha \in (0.1) \tag{5}$$

Here, A_t denotes a common progress of technology for all intermediate firms.

The problem of optimization for intermediate firms consists of two parts: in the first part, the firm seeks to extract optimal demand functions for each input with the minimum cost. In this step, since the production function is constant return to scale, the cost of each unit is equal to the marginal cost. Therefore, the problem of cost minimizing will be as follows:

$$\begin{aligned} &Min\ TC = w_t\, n_{jt} + r_t^k\, k_{jt} \\ &Subject\ \ to \\ &y_{jt} = A_t K_{jt}^{\alpha} {n_{jt}}^{1-\alpha} \qquad , \qquad \alpha \in (0.1) \end{aligned} \tag{6}$$

By solving this problem, the demand function for inputs is obtained as follows:

$$w_t = (1-\alpha) A_t k_{jt}^{\alpha} n_{jt}^{-\alpha} \tag{7}$$

$$r_t^k = \alpha A_t K_{jt}^{\alpha-1} {n_{jt}}^{1-\alpha} \tag{8}$$

In the second step, the objective of the firm is to choose the price path to maximize the present discounted value of dividend payments. If a constant return to scale is assumed, the real dividend is given by:

$$\frac{D_{jt}}{P_t} \equiv \frac{P_{jt}}{P_t} y_{jt} - tc_t \quad \xrightarrow{tc_t = mc_t y_{jt}} \quad \frac{D_{jt}}{P_t} \equiv \frac{P_{jt}}{P_t} y_{jt} - mc_t y_{jt} \tag{9}$$

Intermediate goods firms have the ability to determine the price since they produce in a monopolistic competition market. However, due to a degree of competition between firms, price adjustment by them requires a cost (Mankiw, 1985). Based on Rotemberg's model (1982), the adjustment cost is as follows:

$$AC_{jt} = \frac{\varphi_P}{2}\left[\frac{P_{j.t}}{P_{jt-1}} - 1\right]^2 y_t \tag{10}$$

In equation (10), AC_{jt} is the price adjustment cost for the intermediate goods firm j and $\varphi_P \geq 0$, denotes the price adjustment factor. Here, the real dividend takes the following form:

$$\frac{D_{j.t}}{P_t} \equiv \frac{P_{jt}}{P_t} y_{jt} - mc_t y_{jt} - \frac{\varphi_P}{2}\left[\frac{P_{j.t}}{P_{j.t-1}} - 1\right]^2 y_t \tag{11}$$

The demand function as a constraint against the firm is as follows:

$$y_{jt} = \left[\frac{P_{j.t}}{P_t}\right]^{-\theta} y_t \tag{12}$$

The problem for intermediate firm j is to choose the quantity of capital, labor, and price so that the present discounted value of the dividend is maximized subject to demand function as follows (Gali, 2007):

$$Max\ E_0 \sum_{t=0}^{\infty} \varpi_t \frac{D_{j.t}}{P_t} \tag{13}$$

In the above relation, ϖ_t is the profit discount factor. Since the firms' profit eventually reaches the households and the firms produce goods according to households' demands, the firm's profit discount factor is equal to the ratio of marginal utility of consumption in two periods multiplied by mental discount factor (β). The reason is that households consider the intertemporal demand, so the discount factor in this case is equal to $\beta \frac{u'(c_{t+1})}{u'(c_t)}$.

3.3 Policymaker

In Iran and most oil-rich countries' economy, the central bank or the monetary authority entirely follows the government's policies. Therefore, it can be said that the central bank is dependent in these countries. Hence, in this model, the government and monetary authority are assumed to comprise one unit sector which is responsible for the implementation of monetary and fiscal policies (Motevaseli et al., 2010)

As benevolent institutions, the central bank and the government act to maximize utility and social welfare. On the other hand, maximizing the social welfare is equivalent to minimizing an intertemporal loss function (Wood Ford 1999). This value function is a function of the variables which increase the social costs and impose costs to firms and consumers. The most important variables that enter the loss function are inflation gap, production gap, government expenditure gap, unemployment rate, wages etc. (Tavakolian, 2017). Inflation increases the cost of keeping money, leads to the allocation of inefficient resources, reduces the purchasing power of money and consumer utility, and creates distortions in financial markets. Similarly, the production gap, in addition to the inefficient allocation of resources and the nonoptimal utilization of economic capacities, brings the level of production and the national income lower than the desired level. Therefore, business cycles and economic recessions will occur. Sometimes the persistence of recession can lead to unemployment and other social consequences (Walsh, 2010).

According to the main purpose of this study, the loss function and constraints for the policymaker should be considered in a way that allows focusing on a “non-inflationary exit from stagnation”. For this reason, in the present model, we consider the production gap in the loss function in order to verify the business cycle. It is also necessary to consider the “non-inflationary” concept. The above-mentioned challenges will be discussed in the section on optimal monetary and fiscal rules. As long as the policymaker minimizes the loss function simultaneous with considering an upper bond for the inflation gap, the gap between real production and full employment production will become minimum. As a result, this sector follows the process of a non-inflationary exit from stagnation.

In summary, it can be said that the government seeks to minimize the loss function subject to its constraints by using its policy instruments (monetary and fiscal instruments), the result of which is a non-inflationary exit of economy from stagnation. The loss function of the monetary and fiscal policymaker is defined as follows:

$$E_t \sum_{t=0}^{\infty} \beta^t L_t \tag{14}$$

where β is the discount factor ($0 < \beta < 1$) and L_t is the loss function.

Crude oil and its revenues play a very significant role in Iran’s economy, especially in the government budget and consequently in fiscal policies. Thus, considering this component is very important in economic analysis. In this model, oil export revenues are considered in the form of an exogenous AR (1) process. Thus, the oil revenues will be as follows:

$$or_t = \rho_{or} or_{t-1} + (1 - \rho_{or})\overline{or} + \varepsilon_{or} \tag{15}$$

where or_t, $\overline{or}$ and ε_{or} denote the real oil revenues in period t, the oil revenues in steady state, and the oil revenue shocks, respectively. Oil revenue shocks are caused by export variation, exchange rate variation, and oil price variation. In Iran’s economy, oil production revenues are distributed between the government and the National Development Fund. Here, it is assumed that ϕ ratio and ($1-\phi$) ratio of total oil revenues are allocated to the government budget and the National Development Fund, respectively.

The government revenues include oil revenues, the proceeds from the sale of participation bonds in each period, and the seigniorage (borrowing from the central bank). These revenues are allocated to expenditures and other government transfers. The following relation shows government budget:

$$g_t + \frac{(1+r_{t-1})b_{t-1}}{\pi_t} = ta_t + b_t + \phi or_t + \left(\frac{M_t}{P_t} - \frac{M_{t-1}}{P_t}\right) \tag{16}$$

Here, g_t and $(\frac{M_t}{P_t} - \frac{M_{t-1}}{P_t})$ denote real government expenditures and seigniorage, respectively. ta_t shows the total tax revenues which are equal to consumption tax, wage tax, and capital return tax and are given by

$$ta_t = \tau_{ct} c_t + \tau_{wt} \frac{w_t^n}{P_t} + \tau_r r_{t-1}^k k_{t-1} \tag{17}$$

The government expenditures are assumed as an AR (1) process:

$$g_t = \rho_g g_{t-1} + (1-\rho_g)\bar{g} + \varepsilon_g \quad (18)$$

where $\bar{g}$ denotes government expenditures in a steady state.

3.3.1 Specification of Monetary Rules:

Typically, monetary rules can be expressed in two forms. First, the rules are expressed according to monetary aggregates. Second, monetary rules are modeled on interest rates. In most economic studies, the Taylor rule is used as the monetary rule. According to this rule, the monetary authority reacts to variations in nominal interest rate relative to inflationary and productive deviations from their target values.

In this research, considering the structure of Iran's economy, monetary aggregates are considered as monetary policy instruments. There are generally two famous principles in this field: the Feldstein-Stock rule and the McCallum rule. The monetary instrument of the central bank for the Feldstein-Stock is M2 and for McCallum is monetary growth rate. According to the McCallum principle, we consider the monetary growth rate ($\dot{m}_t$) as the monetary instrument because fundamentally controlling and changing the monetary base is more possible than M2. The McCallum rule is defined as:

$$\dot{m}_t = \rho_{\dot{m}}\dot{m}_{t-1} + \rho_\pi(\Pi_t - {\Pi_t}^*) + \rho_y(Y_t - {Y_t}^*) + \rho_{or}\varepsilon_{or} \quad (19)$$

where $\dot{m}_t = \frac{m_t}{m_{t-1}}\pi_t$. According to this equation, the policymakers' decisions and oil revenue shocks can affect the money growth rate.

The parameters ρ_y and ρ_{or} are the production gap's weight and the oil revenue shock's weight in the monetary reaction function, respectively. The value of these parameters shows the importance of these variables and the existence of equilibrium.

An optimal monetary policy is extracted from an optimal behavioral rule, based on which, the central bank adjusts and applies its monetary instrument. This policy maximizes the social welfare or minimizes the social loss. The "optimal rule" results from an intertemporal optimization by the central bank (Tavakolian-1396). In this case, two categories of function are considered including the objective function and the constraints. According to our purpose, the objective function includes the intertemporal social loss function as follows:

$$Min_{\pi.y} \sum_{i=0}^{\infty} \beta^t[(y_{t+i} - y_t^*)^2 + (\pi_{t+i} - \pi_t^*)^2] \quad (20)$$

In the above relation, π_t^* and y_t^* show the target inflation rate and production, respectively. In this form of loss function, the policymaker will be able to concentrate on the targets of inflation and real variables (Bernanke et al., 1999). The policymaker, in order to solve this problem, should be able to trade-off between the inflation rate and the production gap targets over time. For this reason, this problem is a constrained optimization. The first constraint is the Philips curve[1] which is as follows:

$$\pi_t = \beta\xi_p E\pi_{t+1} + \beta\gamma_p E\Delta y_{t+1} + \varsigma_p mc_t \quad (21)$$

[1] See the appendix (A1) for details.

As was mentioned before, in order to examine the conditions of a non-inflationary exit from stagnation, the new constraint should be added to this optimization problem. Therefore, in order to limit inflationary pressures, firstly, it is necessary to consider an upper bound for inflation gap and, secondly, to provide conditions for the analysis of the "non-inflationary exit" process. Therefore, in this model, it is assumed that the policymaker faces the inflation gap's constraint in order to maximize the welfare of the society. He/she should make such a decision in any period of time so that the inflation gap does not exceed its target value (h). This constraint will be as follows:

$$(\pi_t - \pi_t^*)^2 \leq h \tag{22}$$

By considering the policymaker's objective function, the Phillips curve, and the inflation gap constraint, the Lagrange function is as follows:

$$\begin{aligned} La = min_{\pi.y} \sum_{i=0}^{\infty} \beta^i \{ &(y_{t+i} - y_t^*)^2 + (\pi_{t+i} - \pi_t^*)^2 \\ &- \lambda_{t+i}[\pi_t - \beta\xi_p E\pi_{t+i+1} - \beta\gamma_p E\Delta y_{t+i+1} - \varsigma_p mc_t] \\ &- \Lambda_{t+i}[(\pi_{t+i} - \pi_t^*)^2 - h]\} \end{aligned}$$

where λ_t and Λ_t denote the coefficient corresponding to the Phillips curve and the inflation gap constraint, respectively. The first-order conditions are as follows:

$$2(\pi_{t+i} - \pi_t^*) - \lambda_t - 2\Lambda_t(\pi_{t+i} - \pi_t^*) = 0 \tag{23}$$

$$2(y_{t+i} - y_t^*) - \lambda_t\beta\gamma_p = 0 \tag{24}$$

By using (23) and (24) and also Fisher's rule, we have:

$$(r_t^n - r_t^{*n}) = \frac{1}{\beta\gamma_p(1-\Lambda_t)}(y_t - y_t^*) \tag{25}$$

where r_t^{*n} denotes the nominal interest rate corresponding to the inflation rate target. By considering money demand function, the following result can be obtained:

$$\hat{r}_t^n = (\hat{c}_t - \widehat{m}_t) + \frac{\bar{\tau}_c}{(1+\bar{\tau}_c)}\hat{\tau}_{c.t} \tag{26}$$

By replacing and simplifying the above relations, the optimal monetary rule is obtained in terms of the money amount:

$$\widehat{m}_t = \hat{c}_t - \frac{1}{\beta\gamma_p(1-\Lambda_t)}(y_t - y_t^*) - r_t^{*n} + \frac{\bar{\tau}_c}{(1+\bar{\tau}_c)}\hat{\tau}_{c.t} \tag{27}$$

The optimal monetary rule can be rewritten as:

$$\widehat{\widehat{m}}_t = \widehat{m}_{t-1} - \hat{\pi}_t + \hat{c}_t - \frac{1}{\beta\gamma_p(1-\Lambda_t)}(y_t - y_t^*) - r_t^{*n} + \frac{\bar{\tau}_c}{(1+\bar{\tau}_c)}\hat{\tau}_{c.t} \tag{28}$$

where $\widehat{\widehat{m}}_t = \widehat{m}_t - \widehat{m}_{t-1} + \hat{\pi}_t$.

Relation (28) is the optimal monetary rule which leads to the minimal loss. As the monetary reaction function shows, the relationship between the money growth rate and inflation is negative as well as the relationship between the money growth rate and production gap. In other words, the money growth rate should be reduced relative to steady state growth rate, in response to an increase of inflation and production gaps, because with an inflationary impulse, return to the initial equilibrium requires the reduction of demand intensity by using a contractionary policy. This contractionary policy arises from a decline in the monetary growth rate (the negative reaction of the monetary base to inflation and production fluctuates).

Lagrange coefficient Λ_t plays a special role in the above relationships. In mathematics, the Lagrange coefficient shows the value of variation in the objective function, as a result of the variation in the relevant constraints. In simpler terms, the variation in one unit of constraint will change the objective function in Lagrange coefficient proportion (Dean Corbae et al., 2003). The Lagrange coefficients are interpreted as shadow prices, marginal utility, and adjustment coefficients in economic optimization and mathematical planning. In this section, the constraint of the inflation gap indicates that the inflation gap does not exceed a certain value, such as "h". In Lagrange's function, this constraint is adjusted with coefficient Λ_t in each period. In other words, the coefficient Λ_t is the adjustment percentage which is considered for the inflation gap in each period. A non-inflationary exit process from stagnation is followed in this model by the adjustment coefficient Λ_t in each period. Also, the coefficient Λ_t shows the importance of the inflation gap and its effect on the policymaker's loss function. The variation of inflation gap will have a larger effect on the loss function with the increase of this coefficient so that the inflation gap will lead to more losses for the monetary and fiscal policymaker.

The optimal monetary policy (relation (28)) shows that by increasing the sensitivity of the policymaker's loss function to the inflation gap (increasing the Lagrange coefficientΛ_t), the production gap coefficient $(\frac{1}{\beta\gamma_p(1-\Lambda_t)})$ also increases. The negative reaction of monetary policy to the variation in production gap will be greater by increasing Λ_t.

3.3.2 Specification of Fiscal Rules

Fiscal policy is largely based on the ideas of British economist John Maynard Keynes (1883-1946), who argued that governments could stabilize the business cycle and regulate economic output by adjusting spending and tax policies. Fiscal policies can influence aggregate demand (AD) and the level of economic activity.

Stimulating economic growth in a period of a recession, keeping inflation low, stabilization economic growth, avoiding a boom and bust economic cycle are the purposes of fiscal policy.

The facts of Iran's economy confirm the "fiscal dominance". In many periods, monetary dependence has caused double-digit inflation rates none of which has been in the desired range for the policymaker. Therefore, an exit from stagflation cannot be expected without conducting and designing a suitable fiscal policy that is consistent with optimal monetary policy. When both monetary and fiscal authorities act optimally, the fiscal authority will use tax instruments in order to decrease the production gap and the central bank will control inflation through monetary policies (Dixit and Lambertini, 2003).

There is no specific rule for fiscal policy which is generally acceptable by fiscal authorities, contrary to monetary policy. Today, the importance of tax instruments has been confirmed in applying fiscal policies so that in developed countries, authorities try to increase the share of tax resources as sustainable revenues and the appropriate instrument of financing the government budget. In this study, following the conventional approach, taxes are used as fiscal policy instruments. In order to specify the tax rule, it is assumed that the total tax revenues are adjusted in response to oil revenues, government expenditures and debts arising from the sale of participation bonds:

$$ta_t = b_t + \phi or_t + \left(\frac{M_t}{P_t} - \frac{M_{t-1}}{P_t}\right) - \frac{(1+r_{t-1})b_{t-1}}{\pi_t} - g_t \tag{29}$$

where ta_t denotes the total tax revenue which includes: the consumption tax, the nominal wage tax, and the tax on capital return. It can be rewritten as:

$$ta_t = \tau_{c,t}.c_t + \tau_{wt}.\frac{w_t^n}{P_t} + \tau_r.r_{t-1}^k.k_{t-1} \tag{30}$$

In order to extract the optimal rule of fiscal policy, it is necessary to adjust the loss function so that it includes one of the government's fiscal variables. Typically, in the literature of optimal monetary and fiscal policies, the government, in addition to controlling inflation and production gaps, seeks to control its expenditure around a predetermined level (Gali and Monacelli, 2008). With this approach, the loss function is adjusted as follows:

$$L = \sum_{i=0}^{\infty} \beta^i [(y_{t+i} - y_t^*)^2 + (\pi_{t+i} - \pi_t^*)^2 + (g_{t+i} - g_t^*)^2] \tag{31}$$

Here, g_t^* denotes the specific level of government expenditure. According to the loss function (31), in addition to the production and inflation gaps from their target values, deviation of government expenditures from predetermined levels will also impose a social loss on the economy. Therefore, the constraint of the government budget should be considered.

As discussed in section 3.3.1, in order to study the concept of a non-inflationary exit from stagnation, relation (31) should be minimized subject to the Phillips curve, the government budget constraint, and the inflation gap limiter constraint. Thus, the Lagrange function of this problem is as follows:

$$\begin{aligned} La = min_{\pi,y,g} \sum_{i=0}^{\infty} \beta^i \{ & (y_{t+i} - y_t^*)^2 + (\pi_{t+i} - \pi_t^*)^2 + (g_{t+i} - g_t^*)^2 \\ & - \lambda_{t+i}[\pi_{t+i} - \beta\xi_p E\pi_{t+i+1} - \beta\gamma_p E\Delta y_{t+i+1} - \varsigma_p mc_{t+i}] \\ & - \mu_{t+i}[\eta_1 g_{t+i} + \eta_2 b_{t+i-1} - \eta_3 t_{t+i} - \eta_4(m_{t+i} - m_{t+i-1}) \\ & - \eta_5 or_{t+i} - b_{t+i}] - \Lambda_{t+i}[(\pi_{t+i} - \pi_t^*)^2 - h]\} \end{aligned}$$

where λ_t, μ_t and Λ_t denote the Lagrange coefficient related to the Philips curve, the government budget, and the constraint of the inflation gap, respectively. The first-order conditions for this problem are as follows:

$$\begin{aligned} & 2(\pi_{t+i} - \pi_t^*) - \lambda_{t+i} - 2\Lambda_{t+i}(\pi_{t+i} - \pi_t^*) = 0 \\ & 2(y_{t+i} - y_t^*) - \lambda_{t+i}\beta\gamma_p = 0 \\ & 2(g_{t+i} - g_t^*) - \mu_{t+i}\eta_1 = 0 \end{aligned} \tag{32}$$

As in the previous section, relation (28), the optimal monetary rule is as follows:

$$\widehat{m}_t = \widehat{m}_{t-1} - \hat{\pi}_t + \hat{c}_t - \frac{1}{\beta\gamma_p(1-\Lambda_t)}(y_t - y_t^*) - r_t^{*n} + \frac{\bar{\tau}_c}{(1+\bar{\tau}_c)}\hat{\tau}_{c.t}$$

Given the optimal condition (32) and the constraint of government budget we have:

$$\frac{1}{\eta_1}(b_t - \eta_2 b_{t-1} + \eta_3 t_t + \eta_4(m_t - m_{t-1}) + \eta_5 or_t) = \frac{1}{2}\mu_t\eta_1 + g_t^* \quad (33)$$

By simplifying relation (33), relation (34) can be written as

$$ta_t = \frac{1}{\eta_3}\left(\frac{1}{2}\mu_t\eta_1^2 + \eta_1 g_t^* - b_t + \eta_2 b_{t-1} - \eta_4(m_t - m_{t-1}) - \eta_5 or_t\right) \quad (34)$$

Relation (34) shows the optimal fiscal rule. Its corresponding loss function has a minimum value. This relation also shows that by increasing government spending, tax revenues should increase as long as oil revenues and seigniorage are fixed. The role of taxes in a non-inflationary exit from stagnation is discussed in the next section.

3.4 Market Clearing

One of the principles of general equilibrium models is to set equilibrium in all sectors. In the final goods market, the equilibrium condition is as follows:

$$y_t + or_t = c_t + i_t + g_t \quad (35)$$

According to the above equation, for clearing the goods market, the aggregate supply (sum of oil and non-oil products) should be equal to the aggregate demand (sum of consumption, government expenditures, and private sector investment)

3.5 The Linearized Equations System

The system of equations consists of the first-order conditions, government budget, taxes, and the McCallum rule, each of which has been converted to a linear pattern by using the Uhlig's approach, log-linearization, and Taylor's first-order expansion around the steady state. The system of linearized equations around the steady state is as follows:

A) The Linearized Form of Household Optimization:

$$\widehat{c_t} = \hat{c}_{t+1} + (\hat{\tau}_{c.t+1} - \hat{\tau}_{c.t}) - (\hat{r}_t^n - \hat{\pi}_{t+1})$$

$$\widehat{m}_t = \hat{c}_t + \frac{\bar{\tau}_c}{(1+\bar{\tau}_c)}\hat{\tau}_{c.t} - \hat{r}_t^n$$

$$\hat{\imath}_t = \frac{1}{(1+\beta)}[\vartheta\hat{q}_t + \hat{\imath}_{t-1} + \beta\hat{\imath}_{t+1}]$$

$$\hat{q}_t = -(r_t^n - \hat{\pi}_{t+1}) + \frac{(1-\delta)}{\bar{r}_\tau^k + 1 - \delta}E\hat{q}_{t+1} + \frac{\bar{r}_\tau^k}{\bar{r}_\tau^k + 1 - \delta}\hat{r}_{\tau.t}^k$$

$$\hat{k}_t = (1-\delta)\hat{k}_{t-1} + \delta\hat{\imath}_t$$

B) The Linearized Form of Firm Optimization:

$$\hat{\pi}_t = \beta\xi_p E\hat{\pi}_{t+1} + \beta\gamma_p E\Delta\hat{y}_{t+1} + \varsigma_p\widehat{mc}_t$$

$$\widehat{mc}_t = \alpha\hat{y}_t - \upsilon\hat{\pi}_t$$

C) The Linearized Form of Government's Relations:

$$\hat{\hat{m}}_t = \widehat{m}_t - \widehat{m}_{t-1} + \hat{\pi}_t$$

$$\hat{\hat{m}}_t = \phi_1 \hat{\hat{m}}_{t-1} - \phi_2 \hat{\pi}_t - \phi_3 \hat{y}_t$$

$$\hat{b}_t = \eta_1 \hat{g}_t + \eta_2 \hat{b}_{t-1} - \eta_3 \widehat{ta}_t - \eta_4 (\widehat{m}_t - \widehat{m}_{t-1}) - \eta_5 \widehat{or}_t$$

$$\widehat{ta}_t = \omega_1 (\hat{\tau}_{c,t} + \hat{c}_t) + \omega_2 (\hat{\tau}_{w,t} + \widehat{w}_t^n) + \omega_3 (\hat{\tau}_{r.t}^k + \hat{k}_{t-1})$$

$$\hat{r}_t = \hat{r}_t^n - E\hat{\pi}_{t+1}$$

D) Exogenous Shocks:

$$\widehat{or}_t = \rho_{or} \widehat{or}_{t-1} + \varepsilon_t^{or}$$

$$\hat{g}_t = \rho_g \hat{g}_{t-1} + \varepsilon_t^g$$

$$\hat{\tau}_{c.t} = \rho_c \hat{\tau}_{c.t-1} + \varepsilon_t^c$$

$$\hat{\tau}_{l.t} = \rho_l \hat{\tau}_{l.t-1} + \varepsilon_t^l$$

$$\hat{\tau}_{r.t} = \rho_r \hat{\tau}_{r.t-1} + \varepsilon_t^r$$

$$\widehat{w}_t = \rho_w \widehat{w}_{t-1} + \varepsilon_t^w$$

$$\hat{l}_t = \rho_l \hat{l}_{t-1} + \varepsilon_t^l$$

E) The Market Clearing Condition:

$$\hat{y}_t = \frac{\bar{c}}{\bar{y}} \hat{c}_t + \frac{\bar{\imath}}{\bar{y}} \hat{\imath}_t + \frac{\bar{g}}{\bar{y}} \hat{g}_t - \frac{\overline{or}}{\bar{y}} \widehat{or}_t$$

4. Experimental Results and Discussion

In this section, firstly we will analyze the fiscal and monetary expansion, regardless of entering the optimal monetary and fiscal rules in the equations system. Then, we will investigate the possibility of a non-inflationary exit from stagnation by replacing the optimal monetary rule into the model and using the simulation results and the impulse reaction functions for economic variables. Finally, we will analyze the possibility of a non-inflationary exit from stagnation by simultaneously replacing both optimal monetary and fiscal rules into the system of equations.

4-1 Estimating Model Parameters

To estimate the parameters, the posterior density of the parameters was extracted by using Metropolis-Hastings algorithm in the form of two parallel chains with one million and one hundred thousand repetitions of sampling. In order to estimate the present model, seasonal data from 1989 to 2016 were used for seven observable variables including taxes, government expenditures, monetary base, consumption, investment, capital stock, and inflation rate. Here, the estimation method used is the Bayesian Analysis in which the prior density function and initial values are initially attributed to the parameters in order to verify the existence of equilibrium (Del Negro and Schorfheide, 2008). The Blanchard-Kahn's algorithm is used to investigate the existence of equilibrium based on the initial values. In this algorithm, if the number of forward-looking variables is equal to the number of unit roots greater than 1, then the model has a unique equilibrium (Blanchard and Kahn, 1980).

In the present model, the number of forward-looking variables is equal to 6 and the number of unit roots which is greater than 1 is equal to 6. Hence, the condition of Blanchard-Kahn is satisfied. In the second step, in order to estimate the model, it is necessary to define the prior distribution functions for all parameters, and then estimate the posterior distribution functions by using the model data. The estimated results are presented in Table (1):

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

parameters	prior mean	prior instribution	reference	posterior mean	HPD interval	standard divation
β	0.90	beta	Kavand (1388)-Romero Villarreal (2007)	0.9819	(0.9794,0.9852)	0.0100
$1/\vartheta$	5.50	gamma	Research Assumption	5.7354	(5.1696,6.3129)	2.0000
δ	0.03	beta	Manzour et al. (1394)	0.0107	(0.0100,0.0114)	0.0200
ξ_p	0.70	beta	Research Computioans	0.9645	(0.9138,1.0000)	0.2000
γ_p	0.40	beta	Feyzi (2008)	0.4376	(0.3962,0.4653)	0.1000
ς_p	0.80	beta	Khalili Iraqi et al. (1388)	0.8659	(0.7752,0.9322)	0.1500
α	0.70	beta	Research Computioans	0.7096	(0.6383,0.7759)	0.1000
η_5	0.60	beta	Tavakolian (2012)	0.5901	(0.5709,0.6088)	0.0500
ω_1	0.30	beta	Ehsani et al. (1395)	0.2515	(0.1875,0.3377)	0.1500
ω_2	0.50	beta	Ehsani et al. (1395)	0.4678	(0.4350,0.5062)	0.1000
ω_3	0.40	beta	Research Computioans	0.3989	(0.3659,0.4264)	0.0500
ϕ_1	0.70	beta	Tavakolian (2012)	0.8124	(0.7927,0.8320)	0.1000
ϕ_2	1.00	gamma	Shah Hosseini and bahrami (2014)	0.8801	(0.6891,1.0371)	0.5000
ϕ_3	0.10	norm	Research Assumption	0.1017	(0.0837,0.1190)	0.0200
ν	0.50	beta	Research Computioans	0.3835	(0.2937,0.4931)	0.1000

Brooks and Gelman test (1998).

The above parameters are the outcome of the Bayesian estimation. The Bayesian method combines the prior values and maximum likelihood function and result posterior values. For this purpose, the Markov chain with the Monte Carlo principle is used by the Metropolis-Hastings algorithm. Also the Brooks and Gelman method is used (1998) to test the accuracy of the posterior density and extracted chains. Accordingly, two random parallel chains are selected and the simulation is done within each chain. According to the Brooks and Golman (1998) Diagnosis Test, the model converges if, firstly, the variance between the chains reaches zero, and secondly, the variance within each chain be fixed.

These conditions have been satisfied for the present model as shown in Figure (1). As can be seen in Figure (1), the parameters converge at all three levels and so the simulation results are reliable, according to Brooks and Goleman test.

Figure (1) shows that convergence is achieved for all three levels and all parameters. Therefore, the general results of the model are trusted. Also, the acceptance rate of the Metropolis-Hastings algorithm for the parameters ranges from 25% to 40% (29.76% for the first chain and 30.48% for the second chain). Accordingly, the results and the model can be tenable.

In this study, taxes are used as fiscal instruments and the money growth rate is utilized as the monetary instrument. Also, in the previous sections, taxes were expressed as the most important channel of a non-inflationary exit from stagnation. Hence, in the empirical analysis, the shock of tax cuts and raising money growth rates are generally used.

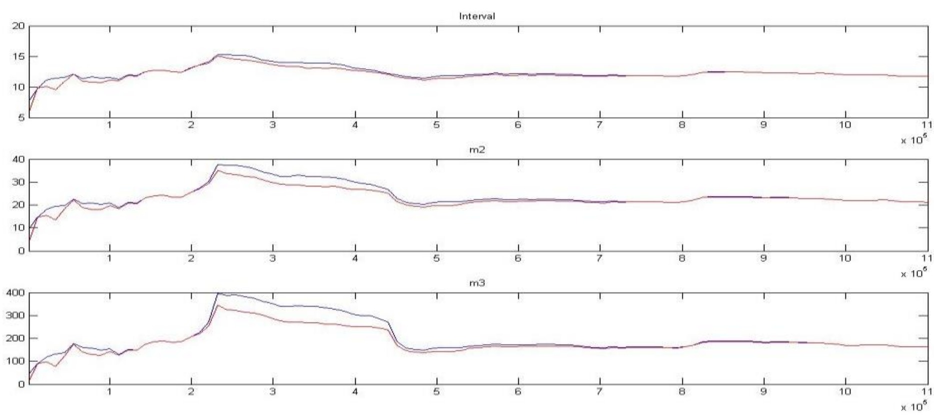

Figure 1. The MCMC outcomes

4.2 Simulation of Shocks and Impulse Reaction Functions

In the first stage, the initial model will be estimated without considering the optimal monetary and fiscal rules. To follow the primary purpose of the current paper, the monetary and fiscal expansionary shocks will be examined for analyzing their effect on economic variables such as inflation and production. With regard to the estimated parameters, the result of monetary and fiscal shocks can be analyzed. Accordingly, Figure (2) shows the response of the model variables to monetary shocks.

As was stated above, in this study, the monetary policy instrument is the monetary growth rate. Initially, a positive monetary shock was imposed by increasing $\widehat{m}_t$. The response of the economic variables is distinct in Figure (2). Accordingly, the positive shock of monetary policy would increase the consumption (c) because of price stickiness. By increasing the monetary base, the level of prices does not increase equally and thus the real level of money (m) and the purchasing power of the household will increase. As a result, the consumption will increase. On the other hand, as can be seen in Figure (2), while the Q-Tobin increases, the return of each unit of investment increases and therefore the amount of investment (i) will increase. An increase in investment will be followed by a rise in capital.

It can be seen that in Iran's economy, an expansionary monetary shock increases the aggregate demand through increasing consumption and investment. As a result, the inflation (pi) arises from the demand pressures. In summary, it can be said that in Iran's economy, a monetary positive shock can increase consumption and investment by demand stimulation. This process is not supported by the supply-side. Therefore, inflation will occur.

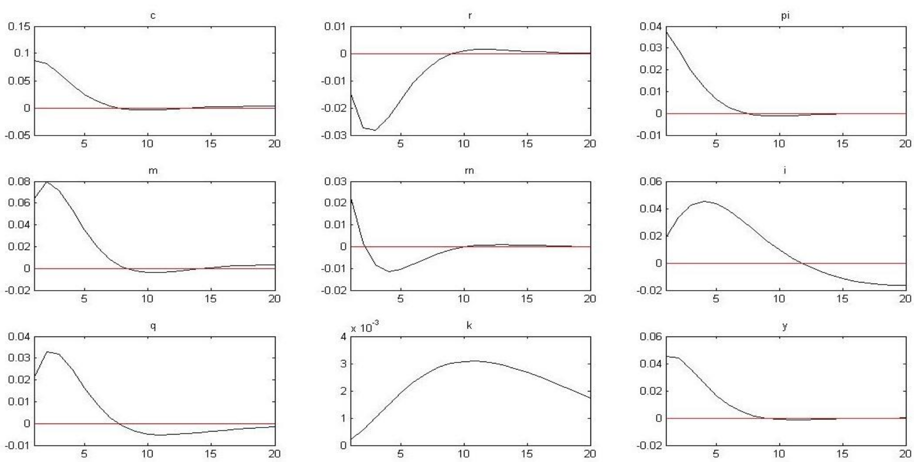

Figure 2. The response of the model variables to monetary policy shock

Figure (3) shows the reaction of the model variables to the fiscal policy shock. According to this figure, the aggregate demand is increased by an expansionary fiscal policy through the expansion of government expenditures. On the other hand, the financing of government expenditures (debt creation) decreases investment and consumption by reducing the household's resources. The reduction of Q-Tobin is another reason for the decline of investment. Also, the incentive for investors will reduce by decreasing the real interest rate. Therefore, investment tends to fall downward. In short, the expansionary fiscal policy increases production and inflation.

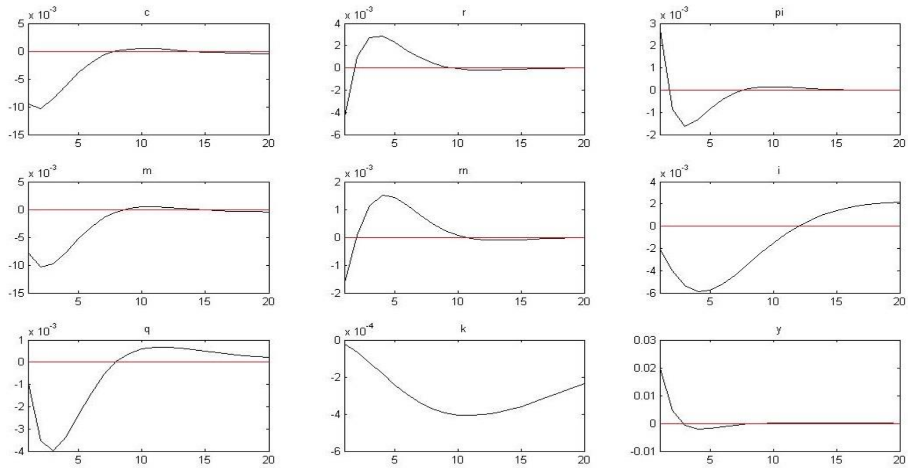

Figure 3. The response of the model variables to the fiscal policy shock

4.3 Optimal Monetary and Fiscal Policies and a Non-Inflationary Exit from Stagnation

In this section, in the first stage, we will extract the monetary reaction function by minimizing the policymaker's loss function subject to his constraints. After that, the reaction function will be replaced with the McCallum rule in the system of equations. Then, the possibility of an exit from stagflation will be analyzed. In the second stage, the optimal monetary and fiscal rules will be extracted in a similar manner. The possibility of an exit from stagflation will be analyzed by applying fiscal and monetary shocks.

4.3.1 Optimal Monetary Policy and a Non-Inflationary Exit from Stagnation

As illustrated in Figures (2) and (3), the expansionary monetary and fiscal policies that lead to a positive production gap and exit from recession are accompanied by inflation. Here, there are two questions: First, if the policymaker seeks to extract the optimal monetary and fiscal policy, then what will their functional form be? Second, if the policymaker's objective is to exit from stagflation in such a way that it does not increase inflation, then what should he/she do?

As discussed in the model specification, the optimal policy leads to a minimum social loss. In this section, the monetary policy will be analyzed in order to examine the possibility of a non-inflationary exit from stagnation. The optimal monetary rule which leads to the minimum loss (maximum welfare) can be extracted as follows:

$$\hat{m}_t = \hat{m}_{t-1} - \hat{\pi}_t + \hat{c}_t - \frac{1}{\beta\gamma_p(1-\Lambda_t)}(y_t - y_t^*) - r_t^{*n} + \frac{\bar{\tau}_c}{(1+\bar{\tau}_c)}\hat{\tau}_{c.t}$$

In order to verify the above reaction function, the optimal relation (28) will be replaced with the McCallum rule in the system of initial equations. Again, the simulation results will be examined according to the estimated parameters in Table (1). In this case, in order to increase production and exit from the stagnation, the expansionary monetary policy needs to be applied in optimal status by increasing $\widehat{m}_t$. The effects of this policy on the economic variables and the process of exit from stagflation will be examined as shown in Figure (4).

As shown in Figure (4), by applying an expansionary monetary shock in optimal status, the purchasing power of the household will increase because of price stickiness. Hence, consumption will increase. On the other hand, with an increase in the households' real income, their investment capability also increases, and due to the increase in the value of Q-Tobin, investment will be profitable. As can be seen in Figure (4), this process has increased investment (i) and capital accumulation (k). By increasing investment and private consumption, production (y) increases.

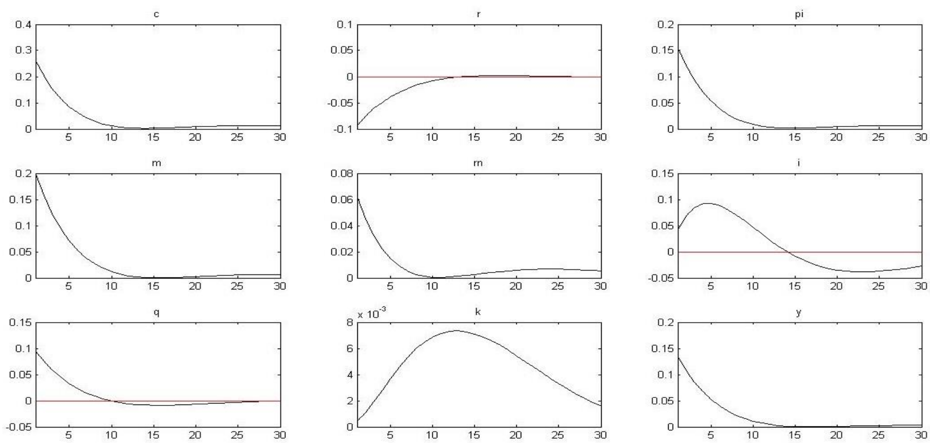

Figure 4. The reaction of the model variables to the expansion of monetary policy in the optimal mode

The comparison between expansionary monetary policy in nonoptimal and optimal status shows that, as expected, expansionary monetary policy in both cases increases the demand and output by demand stimulation. However, due to demand pressure, this increasing production is accompanied by inflation. Also, the comparison between Figures (2) and (4) shows that the expansionary monetary policy in optimal status will have more real effects so that the effects of this policy on production, inflation, and other variables in optimal status are more than those of the nonoptimal status. Therefore, it can be said that the expansionary monetary policy in the optimal status will still be accompanied by inflation, although it can increase production more than the nonoptimal status by increasing the real effects of money. Therefore, the optimal monetary policy can only be considered as a remedy for the period of recession, and this by itself cannot be a treatment for stagflation. Therefore, another policy with the optimal monetary policy (28) must be designed and implemented in such a way that the exit of economy from stagnation is guaranteed and the inflation rate does not rise.

4.3.2 Simultaneous Optimal Monetary and Fiscal Policies and a Non-Inflationary Exit from Stagnation

As mentioned in section 3.3, observations of Iran's economy confirm that monetary policy always follows the fiscal policy. In many periods, monetary dependence has caused double-digit inflation rates none of which was in the desired range for the policymaker. Therefore, an exit from stagflation cannot be expected without conducting and designing a suitable fiscal policy that is consistent with optimal monetary policy. In this regard, the "non-inflationary exit from the stagnation" will be simulated and analyzed by using the modified loss function that includes the government expenditures as well as optimal monetary and fiscal rules.

In this stage, the optimal monetary and fiscal rules (relations 28 and 34) are replaced with the McCallum and the initial fiscal rules in the system of linear equations and then the effects of optimal monetary and fiscal policies on macroeconomic variables will be analyzed by re-simulation:

$$\widehat{\hat{m}}_t = \hat{m}_{t-1} - \hat{\pi}_t + \hat{c}_t - \frac{1}{\beta\gamma_p(1-\Lambda_t)}(y_t - y_t^*) - r_t^{*n} + \frac{\bar{\tau}_c}{(1+\bar{\tau}_c)}\hat{\tau}_{c.t}$$

$$ta_t = \frac{1}{\eta_3}\left(\frac{1}{2}\mu_t\eta_1^2 + \eta_1 g_t^* - b_t + \eta_2 b_{t-1} - \eta_4(m_t - m_{t-1}) - \eta_5 or_t\right)$$

Given the new structure of the equations system, the effect of an expansionary monetary shock (a rise in the manetary growth rate) and an expansionary fiscal shock (tax cuts) are shown in Figures (5) and (6), respectively:

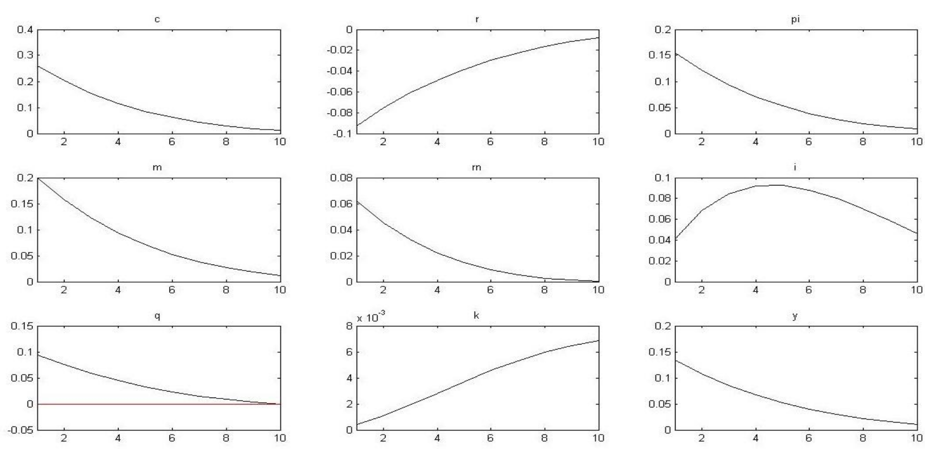

Figure 5. The response of the model variables to the expansionary monetary policy in optimal status

Assuming that the economy is in recession at time t, an expansionary policy for increasing demand and production needs to be applied in order to exit from recession. Figures (5) and (6) show the effect of monetary and fiscal expansion policies on macroeconomic variables based on the extracted optimal rules. Figure (5) shows that although an optimal monetary policy increases production more than the nonoptimal status, inflation increases and thus an exit from recession is accompanied by a higher inflation. The reason is that increasing the money growth will increase the household's consumption as well as the investment expenditures which in turn increase the intensity of the demand pressure. With an increase in the aggregate demand, although aggregate supply is also rising in response to it, due to the fact that this curve is not highly elastic, an increase in the general level of prices and inflation is observed. Thus, it can be said that although optimal monetary policy can be a way to exit from the business cycle, it will not be without inflation.

Figure (6) shows an expansionary fiscal policy arising from the reduction of tax rates. In the present study, these rates include the consumption tax rate (tau), the labor income tax rate (taul), and the capital tax rate (tauk). The total tax (t) decreases with the fall of each rate. As the figure shows, the total consumption increases with the reduction taxes because of the negative relation between taxes and consumption.

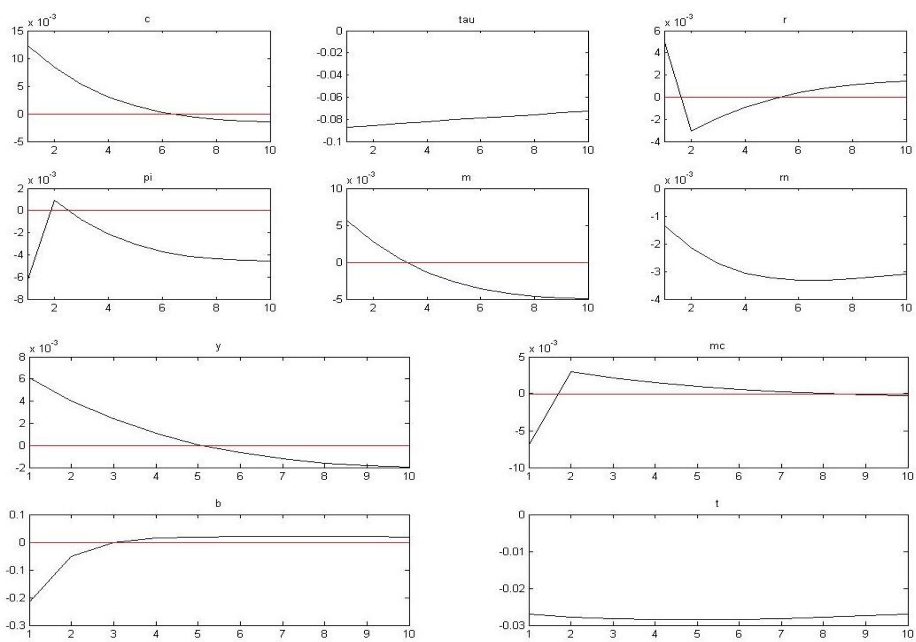

Figure 6. The response of the model variables to the expansionary fiscal policy in optimal status

On the other hand, by reducing the taxes, the household's real income is increased, and therefore the demand for the real money (m) rises. A rise in money demand and consumption will increase the aggregate demand and thus the aggregate supply will increase in response to it. Therefore, by the simultaneous consideration of the monetary and fiscal policymaker's reactions in accordance with relations (28) and (34), the policy of tax cuts could lead to the gradual exit of the economy from recession. In this case, although the economy faces the supply and demand growth, this increase is not accompanied by the growth of inflation and at the beginning of the process, inflation is decreasing as can be seen in the figure. Therefore, it can be said that if an expansionary monetary policy (34) is accompanied by an optimal monetary behavior (Equation (28)), it can simultaneously increase the total production (y) and move towards an exit from stagnation without the inflationary pressure. Thus, it can be a way for a non-inflationary exit from stagnation.

Now, why optimal fiscal policies can provide the necessary conditions for a non-inflationary exit from stagnation? This question can be answered in several ways. As discussed, along with tax cuts (such as consumption taxes and wage taxes), households change their preferences in order to choose the optimal level of consumption, leisure, and labor supply. Therefore, they will increase their labor supply. In the labor market analysis, the equilibrium wage will be reduced and the labor will rise simultaneously, because of the shift in labor preferences and thus the shift in the labor supply curves to the right. Therefore, on the one hand, the production cost of goods has decreased and on the other, with an increase in the labor force as one of the inputs, the amount of production will also increase. The influence path of optimal policies on a non-inflationary exit from stagnation is in the cost structure of firms. In the firm's F.O.Cs, the marginal cost of the firm is directly related to the wage tax and inversely with the labor supply (n). Therefore, if taxes decrease, the households increase their labor supply (because of rising wages) and so the firms increase labor demand and therefore have more inputs to produce. This reduces the firm's marginal cost and causes the rising of production and aggregate supply. On the other hand, the firms use the average cost per production in their profit function when they find the optimal price. Given the assumption of constant returns to scale, the marginal cost is equal to the average cost per unit of production. As a result, by reducing the taxes, the cost per unit of production decreases. Hence, the price that maximizes the firm's profit will decrease. Therefore, the general level of prices in the economy decreases and production without inflationary pressure rises.

5. Concluding Remarks

In this paper, the structure of Iran's economy was modeled by considering price stickiness using a new Keynesian dynamic stochastic general equilibrium model. In this model, the economy's sectors include the households, firms, and the policymaker and the behavior of each of them has been considered based on microeconomic foundations. The system of equations was formed from the extracted and linearized optimal conditions. Then, the structural parameters were estimated by using seasonal data from 1989 to 2016 and Bayesian estimation. Finally, the monetary and fiscal structural shocks were simulated. The results showed that monetary and fiscal expansion policies increase both production and inflation.

In the second stage, a quadratic loss function was used in terms of inflation, production, and government expenditures in order to extract the optimal monetary and fiscal policies. Since in this research, in particular, a non-inflationary exit from stagnation has been investigated, the production gap and inflation limiter constraint were used. The production gap helped us to analyze the business cycle and the inflation limiter constraint represented the non-inflationary argument in the analyses. Accordingly, Lagrange's function was used to solve this problem. The constraints included the aggregate supply, the government budget, and the inflation limiter constraint. Then, the optimal monetary and fiscal rules were replaced in the initial equations system. The effects of monetary and fiscal shocks were investigated in optimal status on macroeconomic variables as well as the conditions of exit from recession by estimating the new equations system.

The results of the simulation showed that an expansionary monetary policy for increasing output will be accompanied by a rising inflation because this policy stimulates demand and increases the prices of goods and services and it is not supported by the supply-side. On the other hand, an expansionary fiscal policy in the form of tax cuts leads to a growth in output and exit from stagnation. However, it does not have inflationary pressures. Since tax cuts not only increase the purchasing power of the household, but also bring a reduction in the marginal costs of the firm that it prevents prices from rising. Thus, it can be argued that an optimal fiscal policy in the present structure, if it is accompanied by the optimal behavior of the monetary sector, can lead to a non-inflationary exit from stagnation since this policy affects the demand-side and the labor supply and, consequently, the aggregate supply. Therefore, in this framework, it is suggested that the government use the tax cuts policy for a non-inflationary exit from stagnation provided that the monetary and financial response functions are considered optimal.

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Appendices

Appendix A: The linearization of New Keynesian Phillips curve

Equation (21) is the linearized form of the new Keynesian Phillips curve. We will clarify this equation in below.

In this section we extract the equation (21) form the first-order conditions of firm optimization as follows:

$$Max\ A = E_t\ \sum_{i=0}^{\infty} \varpi_{t+i} \left[\left(\frac{P_{jt+i}}{P_{t+i}} - mc_{t+i} \right) y_{jt+i} - \frac{\varphi_P}{2} \left[\frac{P_{jt+i}}{P_{jt+i-1}} - 1 \right]^2 y_{t+i} \right]$$

$s.t$

$$y_{jt+i} = \left[\frac{P_{jt}}{P_t} \right]^{-\theta} y_{t+i}$$

The first-order conditions of the firm are as follows:

$$\frac{\partial\ \mathrm{A}}{\partial P_{jt}} = 0 \ \Longrightarrow\ \frac{1}{P_t} y_{jt} - \theta \frac{1}{P_t} \left[\frac{P_{jt}}{P_t} \right]^{-\theta-1} y_t \left(\frac{P_{jt}}{P_t} - mc_t \right) - \frac{1}{P_{jt-1}} \varphi_P \left(\frac{P_{jt}}{P_{jt-1}} - 1 \right) y_t$$
$$+ \varpi_{t+1} \frac{P_{jt+1}}{(P_{jt})^2} \varphi_P \left(\frac{P_{jt+1}}{P_{jt}} - 1 \right) y_{t+1} = 0$$

Firms can change their prices at any time, with the cost of adjusting prices. Given the assumption of homogeneity, firms face the same problem. So they set similar prices and produce similar quantities. Using the assumption of symmetry and simplification (Rotemberg, 1982) we have:

$$\xRightarrow{symmetry} \begin{cases} P_t = P_{jt} \\ y_t = y_{jt} \end{cases}$$

$$\xRightarrow{\times \frac{P_t}{y_t}} \ 1 - \theta(1 - mc_t) - \varphi_P \pi_t (\pi_t - 1) + \varpi_{t+1} \varphi_P \pi_{t+1} (\pi_{t+1} - 1) \frac{y_{t+1}}{y_t} = 0$$

In above relation, $\pi_t = \frac{P_t}{p_{t-1}}$ denotes inflation rate. Given that the firm's profit discounting factor is $\varpi_{t+1} = \beta\ \frac{u'(c_{t+1})}{u'(c_t)}$, we have:

$$\frac{u'(c_{t+1})}{u'(c_t)} = \frac{\frac{1}{c_{t+1}}}{\frac{1}{c_t}} = \frac{c_t}{c_{t+1}}$$

$$\Longrightarrow 1 - \varphi_P \pi_t (\pi_t - 1) + \varphi_P \beta \frac{c_t}{c_{t+1}} \left[\pi_{t+1} (\pi_{t+1} - 1) \frac{y_{t+1}}{y_t} \right] = \theta(1 - mc_t)$$

We use the Uhlig's approach in order to linearization above relation and extract the new Keynesian Phillips curve.

$$1 - \varphi_P \bar{\pi}(1 + \hat{\pi}_t)(\bar{\pi}(1 + \hat{\pi}_t) - 1) + \varphi_P \beta \frac{\bar{c}(1+\hat{c}_t)}{\bar{c}(1+\hat{c}_{t+1})}$$
$$\left[\bar{\pi}(1 + \hat{\pi}_{t+1})(\bar{\pi}(1 + \hat{\pi}_{t+1}) - 1) \frac{(1+\hat{y}_{t+1})}{(1+\hat{y}_t)} \right] = \theta(1 - \overline{mc}(1 + \widehat{mc}_t))$$

$$\Longrightarrow 1-(\varphi_P\bar{\pi}+\varphi_P\bar{\pi}\hat{\pi}_t)(\bar{\pi}+\bar{\pi}\hat{\pi}_t-1) + \varphi_P\beta\frac{(1+\hat{c}_t)}{(1+\hat{c}_{t+1})}\left[\bar{\pi}(1+\hat{\pi}_{t+1})(\bar{\pi}(1+\hat{\pi}_{t+1}) - 1)\frac{(1+\hat{y}_{t+1})}{(1+\hat{y}_t)}\right] = \theta(1-\overline{mc}-\overline{mc}\widehat{mc}_t)$$

The above equation can be rewritten as follows:

$$1-\varphi_P\bar{\pi}^2-\varphi_P\bar{\pi}^2\hat{\pi}_t+\varphi_P\bar{\pi}-\varphi_P\bar{\pi}^2\hat{\pi}_t-\varphi_P\bar{\pi}^2{\hat{\pi}_t}^2+\varphi_P\bar{\pi}\hat{\pi}_t +\varphi_P\beta(1+\hat{c}_t-\hat{c}_{t+1}) \left(\bar{\pi}^2+\bar{\pi}^2\hat{\pi}_{t+1}-\bar{\pi}+\bar{\pi}^2\hat{\pi}_{t+1}+\bar{\pi}^2{\hat{\pi}_{t+1}}^2-\bar{\pi}\hat{\pi}_{t+1}\right)(1+\hat{y}_{t+1}-\hat{y}_t) =\theta(1-\overline{mc}-\overline{mc}\widehat{mc}_t)$$

According to the Uhlig's rules we have:

$$\xrightarrow{{\hat{\pi}_{t+1}}^2\cong 0} 1-(\varphi_P\bar{\pi}^2-\varphi_P\bar{\pi})-2\varphi_P\bar{\pi}^2\hat{\pi}_t+\varphi_P\bar{\pi}\hat{\pi}_t + \varphi_P\beta(1+\hat{c}_t-\hat{c}_{t+1})(\bar{\pi}^2-\bar{\pi}+2\bar{\pi}^2\hat{\pi}_{t+1}-\bar{\pi}\hat{\pi}_{t+1})(1+\hat{y}_{t+1} -\hat{y}_t)=\theta(1-\overline{mc}-\overline{mc}\widehat{mc}_t)$$

And

$$\hat{\pi}_t\hat{c}_t=\hat{\pi}_t\hat{y}_t=\hat{c}_t\hat{y}_t=0$$

$$\xrightarrow{\text{Uhlig rules}} 1-(\varphi_P\bar{\pi}^2-\varphi_P\bar{\pi})+\varphi_P\bar{\pi}\hat{\pi}_t(-2\bar{\pi}+1) + \varphi_P\beta(1+\hat{c}_t-\hat{c}_{t+1})[(\bar{\pi}^2-\bar{\pi})+(2\bar{\pi}^2-\bar{\pi})\hat{\pi}_{t+1}](1+\hat{y}_{t+1} -\hat{y}_t)=\theta(1-\overline{mc}-\overline{mc}\widehat{mc}_t)$$

$$\Longrightarrow 1-(\varphi_P\bar{\pi}^2-\varphi_P\bar{\pi})+\varphi_P\bar{\pi}(-2\bar{\pi}+1)\hat{\pi}_t + \varphi_P\beta(1+\hat{c}_t-\hat{c}_{t+1})[(\bar{\pi}^2-\bar{\pi})+(\bar{\pi}^2-\bar{\pi})\Delta\hat{y}_{t+1} + (2\bar{\pi}^2-\bar{\pi})\hat{\pi}_{t+1}]= \theta(1-\overline{mc}-\overline{mc}\widehat{mc}_t)$$

$$\Longrightarrow 1-(\varphi_P\bar{\pi}^2-\varphi_P\bar{\pi})+\varphi_P\bar{\pi}(-2\bar{\pi}+1)\hat{\pi}_t + \varphi_P\beta[(\bar{\pi}^2-\bar{\pi})+(\bar{\pi}^2-\bar{\pi})\Delta\hat{y}_{t+1}+(2\bar{\pi}^2-\bar{\pi})\hat{\pi}_{t+1} -(\bar{\pi}^2-\bar{\pi})\Delta\hat{c}_{t+1}]= \theta(1-\overline{mc}-\overline{mc}\widehat{mc}_t)$$

We have already reached to relation (**):

$$1-\varphi_P\pi_t(\pi_t-1)+\varphi_P\beta\frac{c_t}{c_{t+1}}\left[\pi_{t+1}(\pi_{t+1}-1)\frac{y_{t+1}}{y_t}\right]=\theta(1-mc_t)$$

$$\xrightarrow{st-st} 1-\varphi_P\bar{\pi}^2+\varphi_P\bar{\pi}+\varphi_P\beta(\bar{\pi}^2-\bar{\pi})=\theta-\theta\overline{mc}$$

$$\Longrightarrow \varphi_P\bar{\pi}(1-2\bar{\pi})\hat{\pi}_t + \varphi_P\beta[(\bar{\pi}^2-\bar{\pi})\Delta\hat{y}_{t+1}+(2\bar{\pi}^2-\bar{\pi})\hat{\pi}_{t+1}-(\bar{\pi}^2-\bar{\pi})\Delta\hat{c}_{t+1}] =-\theta\overline{mc}\widehat{mc}_t$$

$$\Longrightarrow \varphi_P\bar{\pi}(2\bar{\pi}-1)\hat{\pi}_t =\varphi_P\beta(\bar{\pi}^2-\bar{\pi})[\Delta\hat{y}_{t+1}-\Delta\hat{c}_{t+1}]+\varphi_P\beta(2\bar{\pi}^2-\bar{\pi})\hat{\pi}_{t+1} +\theta\overline{mc}\widehat{mc}_t$$

$$\Longrightarrow \hat{\pi}_t=\frac{\varphi_P\beta(\bar{\pi}^2-\bar{\pi})}{\varphi_P\bar{\pi}(2\bar{\pi}-1)}[\Delta\hat{y}_{t+1}-\Delta\hat{c}_{t+1}]+\frac{\varphi_P\beta(2\bar{\pi}^2-\bar{\pi})}{\varphi_P\bar{\pi}(2\bar{\pi}-1)}\hat{\pi}_{t+1} +\frac{\theta\overline{mc}}{\varphi_P\bar{\pi}(2\bar{\pi}-1)}\widehat{mc}_t$$

For the simplification, we define the following coefficients*:*

$$\frac{(\bar{\pi}^2-\bar{\pi})}{\bar{\pi}(2\bar{\pi}-1)}=\alpha_1 \quad , \quad \frac{(2\bar{\pi}^2-\bar{\pi})}{\bar{\pi}(2\bar{\pi}-1)}=\xi_p \quad , \quad \frac{\theta\overline{mc}}{\varphi_P\bar{\pi}(2\bar{\pi}-1)}=\varsigma_p$$

Since consumption is a factor of production, the above expression can be simplified as follows:

$$\Delta\hat{c}_{t+1}=\alpha\Delta\hat{y}_{t+1}$$

$$\Longrightarrow \qquad \hat{\pi}_t=\beta\alpha_1(1-\alpha)\Delta\hat{y}_{t+1}+\alpha_2\hat{\pi}_{t+1}+\alpha_3\widehat{mc}_t$$

$$\xRightarrow{\alpha_1(1-\alpha)=\gamma_p} \qquad \hat{\pi}_t=\beta\xi_p E\hat{\pi}_{t+1}+\beta\gamma_p E\Delta\hat{y}_{t+1}+\varsigma_p\widehat{mc}_t \tag{21}$$

Equation (21) denotes the linearized form of new Keynesian Phillips curve (NKPC).

Appendix B: The Proof of Relation (25)

From the below optimization, we extract the first- order conditions (23) and (24) and by simplification of them and use the Fischer rule we have relation (25).

$$La = min_{\pi.y} \sum_{i=0}^{\infty} \beta^i \begin{Bmatrix} (y_{t+i} - y_t^*)^2 + (\pi_{t+i} - \pi_t^*)^2 - \lambda_{t+i}\big[\pi_t - \beta\xi_p E\pi_{t+i+1} \\ -\beta\gamma_p E\Delta y_{t+i+1} - \varsigma_p mc_t\big] - \Lambda_{t+i}[(\pi_{t+i} - \pi_t^*)^2 - h] \end{Bmatrix}$$

where λ_t and Λ_t denote the Lagrange coefficient corresponding to the Phillips curve and the inflation gap constraint, respectively. The first-order conditions are as follows:

$$2(\pi_t - \pi_t^*) - \lambda_t - 2\Lambda_t(\pi_t - \pi_t^*) = 0$$

$$2(y_t - y_t^*) - \lambda_t\beta\gamma_p = 0$$

$$2(\pi_t - \pi_t^*) - \frac{2}{\beta\gamma_p}(y_t - y_t^*) - 2\Lambda_t(\pi_t - \pi_t^*) = 0$$

$$(\pi_t - \pi_t^*) - \frac{1}{\beta\gamma_p}(y_t - y_t^*) - \Lambda_t(\pi_t - \pi_t^*) = 0$$

$$(1 - \Lambda_t)(\pi_t - \pi_t^*) - \frac{1}{\beta\gamma_p}(y_t - y_t^*) = 0$$

$$(\pi_t - \pi_t^*) = \frac{1}{\beta\gamma_p(1 - \Lambda_t)}(y_t - y_t^*)$$

According to Fisher's rule:

$$r_t^n = \pi_t + r_t \qquad (*)$$

And according to Fisher's rule, nominal interest rate proportional to the target inflation rate (π_t^*) is as follows:

$$r_t^{*n} = \pi_t^* + r_t \qquad (**)$$

$$\xRightarrow{(*)-(**)} (r_t^{*n} - r_t^n) = (\pi_t^* - \pi_t)$$

Where r_t denotes the real interest rate. By simplification, we have:

$$(r_t^n - r_t^{*n}) = \frac{1}{\beta\gamma_p(1-\Lambda_t)}(y_t - y_t^*) \qquad (25)$$