



# Evaluation of Monetary and Fiscal Policy Based on New Keynesian Dynamic General Equilibrium Model in Iran's Economy

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## ABSTRACT

This paper examines monetary and fiscal policy through the estimation of a New-Keynesian dynamic general equilibrium model for Iran's economy. In this New-Keynesian dynamic general equilibrium model, the consumers encounter the liquidity constraint and the firms face sticky prices, while they are changing them. In the model presented, a role is considered for both government spending and taxation, besides the monetary rule. Then, the model is estimated using Iran's data over the period of 2000-2017, through the method of generalized moments which leads into valuable insight. The results indicate that aggregate demand reacts to changes in interest rates. When inflation occurs, regardless of its source, it is persistent and inertia. The monetary policy has a forward-looking behavior. The output gap with a lag has a negative effect on government spending and the short-term impact of the output gap on government spending is smaller than its impact on taxation (Tax responses to the output gap are stronger and positive).

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## 1 Introduction

A great number of studies have been carried on monetary policy in New Keynesians models in Iran; but they rarely embodied the function of monetary policy along with the financial-policy in terms of New Keynesians models. Of course several articles, in Iran, have examined the interactions between fiscal and monetary policies using other macroeconomic views. This paper provides a small econometric model that includes the monetary and fiscal policies for Iran's quarterly data, from 2002 to 2017. It analyzes the performance of financial stabilizers in the presence of Taylor's forward looking rule based on a New Keynesian dynamic general equilibrium model (NK-DGE). There are three innovations in this article. First, it extends the current DGE models and includes a wider range of financial transfer channels. Second, compared to some studies which calibrate these models or simulate numerical models, here the model is estimated using GMM approach. Third, it shows how monetary policy along with fiscal policy response in an inertia structural model due to the presence of non-optimum consumers and firms. A side benefit to the estimated model is the examination of the coefficient that represents the habits of Iranian households. In the NK-DGE model (see [1]), financial policy usually plays a very limited role. The IS standard curve is forward-looking based on the assumption of "Recardian" that consumers are forward-looking and have access to financial markets. This hypothesis

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contrasts with the constant income hypothesis that confirms a significant portion of non-market consumers. In addition, conventional DGE models cannot offer a well-argued interpretation for the positive response to public expenditure shocks. To calculate these affects, the modeling approach proposed in [2] is used, which assumes some households are obliged to spend more than their current income. The remainder of the article are as follows: in the next section, a summary of the theoretical study of the research and the research background is reviewed. Section 3 deals with the methodology of research and the structure of the estimated model and data. Section 4, the estimates are reported and, finally, the last section presents the Conclusion.

## 2 Literature Review

Dixit and Lambertini [3] examined a model of Baro-Gordon type for  $n$  countries and state that if monetary and fiscal authorities each have different output and inflation purposes in the Nash equilibrium, output or inflation or both will be beyond the target points of the monetary and fiscal authorities. Despite disagreement about relative weights of two goals, and adjusting movements toward goals without fiscal and monetary necessities, agreement about desired output and inflation causes monetary and fiscal symbiosis. Buti et al. [4] by setting up a game between a conservative bank and fiscal officials with limited budget deficit show that the particular form of interdependence between monetary and fiscal policy, that is the replacement of the substitutability strategy and the complementarity strategy of the two policies should not necessarily be interpreted as their incompatibility or cooperation. Their substitutability and complementarity may depend on the shock. In their model, supply shocks have unambiguously triggered policy inconsistencies, but this inconsistency still continues when there are demand shocks. Empirical researches done in this field are mainly based on panel data and VAR analyses. The panel data studies the relationship between monetary and fiscal policy throughout the cycles. Melitz [5] and Muscatelli et al. [6] researches followed these techniques. Melitz [5] examined some cross-country evidence about debt, deficits, and the behavior of monetary and financial authorities. It confirms that monetary and fiscal policy substitutes each other strategically. However, in his work, it is not clear whether the linkage between the monetary and fiscal policies during the cycle is due to systematic policy responses or responses to structural or policy shocks.

Muscatelli et al. [6] examined the interaction of fiscal and monetary policies: empirical evidence and optimal policy using a structural New-Keynesian model using the typical VAR and VAR Bayesian models for the economy of some G7 countries over 1970-2001 period. And show that the fiscal shocks identified in the VAR have a significant effect. They find out that the outcome of a strategic substitutability is not the same in all countries. In addition, they provide strong evidence that after 1980 the relationship between monetary and fiscal policies has changed and become much more complementary. But it is worth noticing that in the model estimated by Muscatelli et al. it is difficult to interpret implicit policy reaction functions in VAR techniques, especially when the structural model is forward-looking. Smets and Wouters [7] using Bayesian technique studied the impact of monetary and fiscal policies on the macroeconomic variables of the countries which are the member of the European continent over the period of 1980-1999. They concluded that monetary policy is less efficient and effective than fiscal policy in the New Keynesian model. On the other hand, Smets and Wouters argued that for monetary policy-making the appropriate rule is to consider the nominal rigidity and imperfect markets in the dynamic stochastic general equilibrium model. Peiris and Saxegaard [8] designed an open economy model for sub-Saharan Africa to explore the impact of monetary policies on macroeconomic variables using New Keynesian approach. Because of the lack of necessary data for these countries, the

seasonal data of Mozambique from 1996 to 2005 were used to estimate the parameters by the Bayesian method. The results showed that part of the fluctuations of the actual exchange rate and inflation were due to fluctuations in the interest rate variable. Resende and Rebei [9] studied the interaction between monetary and fiscal policy in these four countries: America, South Korea, Mexico and Canada. They modeled the monetary and fiscal policies in a way that part of the government debt should be provide through discounted value of the current and future deficit to satisfy the intertemporal budget constraint, and the rest of that should be provided by taking out loan from the central bank. Moshiri et al. [10] based on the New Keynesian model using Bayesian method investigate the interaction between fiscal and monetary policies in order to determine the degree of fiscal policies' dominance in Iran's economy with seasonal data over the period of 1959-1999. The results demonstrated that the level of fiscal policy dominance was 77%, which indicates the central bank's low independence. Zarra Nezhad and Anvari [11] determined the optimal monetary and fiscal policies in Iran's economy using the dynamic stochastic equilibrium model and the New Keynesian approach. The results indicated that with the rise of inflation, the output gap and liquidity level, increasing the interest rates is a proper policy to reduce instability.

On the other hand, given the results of the model's uncertainty, the performance of the policy and policy makers' reactions have improved during the observed period. Komijani and Tavakolianstudied [12] based on an adjusted New Keynesian model for Iran's economy over the period of 1989-2011 and using calibration method they found out that, monetary policy makers did not pursue the targets in most of these years. Khiabani and Amiri [13] using calibration method and simulation for Iran's economy during the period of 1974-2011, showed that the price and crude oil output shocks have a positive and significant effect on investment, national production, marginal cost of production and inflation. Also, these shocks have a positive and significant impact on government spending, tax revenues, and monetary base components. Eslamloueyan and Yazdanpanah [14] with a structural vector of autoregressive model, Using seasonal data over the period of 2006-2015, concluded that there is a risk-taking channel in Iran's banking system and the central bank can consider this risk-taking channel into its loss function and design the optimal monetary policy based on that can help to gain financial stability and strengthen the banking system and reduce the negative impacts of this channel on macroeconomic variables. Izadkhasti in [15] investigated the impacts of monetary policy in the framework of dynamic general equilibrium model on inflation and welfare based on money that the theoretical results obtained from solving the money pattern in the utility function in Iran's economy. Calibration results and sensitivity analysis in steady state shows that the decline in the growth rate of money decreases the nominal interest rate and inflation and increases real money balances. But it has no impact on the production level and consumption in the steady state. Hence, as the rate of monetary growth declines and real money balances increase, the welfare increases in the steady state situation.

### 3 Theoretical Foundations

The New Keynesian economy has actually evolved out of the Keynesian economy. This school has existed since early 1980s, and it came into existence due to the failure of the clear market models of the New Classics to explain and clarify the changes in output, employment and inflation. The New Keynesian approach to monetary policy analysis has emerged as one of the most active and influential sectors in macroeconomic research in recent years. The New Keynesian forms the basis for the new generation of developed models in central banks. Among the key features that reflect their approach to monetary policy analysis, the followings are emphasized:

- This approach uses many of the tools associated with the Real Business Cycle theory. It includes the use of DSGE models based on rational expectations, market clearing, optimized behavior of firms and households, and so on.
- Firms are modeled in a monopolistic competitive market, that is, each firm encounters a specific demand function for the product it produces and determines its price (rather than accepting the given prices) to maximize their profits.
- Nominal prices and wages stickiness are the key factor for the model and the main cause that makes monetary policy non-neutral. They often state that firms or labors' time limitation in adjusting nominal prices and wages is the major reason for stickiness. The reason for such constraints is that decisions that are made about wages and prices are forward looking. Because economic agents are well-aware that current prices or wages that are set will be effective within future.
- More emphasis is placed on the endogenous component of monetary policy (monetary policy rules) and the obtained results of the specification in that component, rather than on the impacts of exogenous changes in a monetary policy instrument.
- The New Keynesian structure can be used to assess the optimal conditions of other policy rules, and to determine such optimal rules, using a welfare benchmark, based on maximizing consumer's utility in the economy, and in a way that is immune to Lucas's critique.

In addition to the previous elements which are essential to the New Keynesian model, it should be emphasized that one of the important features of the New Keynesian framework which makes it flexible and consistent with many changes made to the original model, the introduction of features such as the ones that include features of open economy, friction, unemployment, incomplete learning and information, and so on [16].

The three equations that make up the simplest form of the new Keynesian model are:

First, the New Keynesian Phillips curve (NKPC), in which the output gap, expected inflation, and cost shock influence inflation. The second key equation of the model is the output gap (or IS curve) that has a positive relation with the expected output gap of the next period; it has a negative relation with the real interest rate. The last equation describes how monetary policy functions. The simplest way to express this description is to use the Taylor rule, in which the short-term nominal interest rate is a function of the deviation (logarithm) of output from its steady state (or trend level) and current inflation.

The concept of forward-looking in setting prices and consumption decisions signifies that inflation and the output gap are affected by both the current variables and expected future values; that is, inflation and the output gap are forward looking variables. Consequently, the predicted policy functions will have an impact on the outcomes, so the central bank may benefit from its power of influencing expectations [17]. In the following, three main equations of the new Keynesian will be expressed:

### a) Aggregate Supply: the New Keynesian Philips Curve:

The price of the firms is determined based on the optimum profit within one period time. Equation (1) shows the firms' profits:

$$E_t \sum_{i=0}^{\infty} \omega^i \Delta_{i,t+i} \left[ \left( \frac{P_{jt}}{P_{t+i}} \right)^{1-\theta} - \varphi_{t+i} \left( \frac{P_{jt}}{P_{t+i}} \right)^{-\theta} \right] c_{t+i} \quad (1)$$

According to the first order condition for optimal choice, (1) is derived with respect to  $p_{jt}$ , (assuming  $p_{jt} = p_t^*$ ) and it is set equal to zero.

$$E_t \sum_{i=0}^{\infty} \omega^i \Delta_{i,t+i} \left[ (1-\theta) \left( \frac{p_t^*}{p_{t+i}} \right)^{1-\theta} - \theta \varphi_{t+i} \right] \left( \frac{1}{p_t^*} \right) \left( \frac{p_t^*}{p_{t+i}} \right)^{-\theta} c_{t+i} = 0 \quad (2)$$

Here  $\theta$  is the price elasticity of demand for  $j$  product;  $\omega$  is a criterion for the degree of nominal price stickiness.  $p_t^*$  is the level of optimum price chosen by all the firms that adjust prices in at time  $t$ ,  $p_{t+i}$  refers to the price in next period.  $\varphi_{t+i}$  is the marginal cost (mc) in next period, and  $c_{t+i}$  is household consumption in future period;  $\Delta_{i,t+i}$  is called random rate of discount [18].

$$\Delta_{i,t+i} = \beta^i \left( \frac{c_{t+i}}{c_t} \right)^{-\sigma} \quad (3)$$

Replacing (3) in (2) and rearranging that the following equation is given:

$$\left( \frac{p_t^*}{p_t} \right) = \left( \frac{\theta}{1-\theta} \right) \frac{E_t \sum_{i=0}^{\infty} \omega^i \beta^i c_{t+i}^{1-\sigma} \varphi_{t+i} \left( \frac{p_{t+i}}{p_t} \right)^{\theta}}{E_t \sum_{i=0}^{\infty} \omega^i \beta^i c_{t+i}^{1-\sigma} \left( \frac{p_{t+i}}{p_t} \right)^{\theta-1}} \quad (4)$$

In Calvo model of sticky prices,  $(1-\omega)$  percent of the firms (which are selected randomly) can adjust the price of their own products in each period, and determine the new optimum price ( $p_t^*$ ) concerning the expected future marginal price.  $\omega$  percent of the firms cannot adjust the price of their products and set prices in next period based on the last average price of all the firms. So the public level of the prices in at time  $t$  is

$$p_t^{1-\theta} = (1-\omega)(p_t^*)^{1-\theta} + \omega p_{t-1}^{1-\theta} \quad (5)$$

$\theta$  denotes the price elasticity of demand for  $j$  product.  $\omega$  is a criterion for the amount of nominal price stickiness and  $\omega \in [0, 1]$ .

Equations (4) and (5) lead to an equation which shows aggregate inflation around a steady state.

$$\pi_t = \beta E_t \pi_{t+1} + \tilde{\kappa} \hat{\varphi} \quad (6)$$

Equation (6) is the same New Keynesian Philips Curve.

$$\tilde{\kappa} = \frac{(1-\omega)(1-\beta\omega)}{\omega} \quad (7)$$

$\tilde{\kappa}$  is an incremental function of the percentage of the firms that can adjust prices in each period and denotes that current inflation ( $\pi_t$ ) depends on the gap of real marginal cost ( $\hat{\varphi}$ ).  $E_t \pi_{t+1}$  is the expected future inflation or forward looking inflation?

## b) Aggregate Demand: the Dynamic IS Curve:

In the optimum model, the goal of the household is to maximize their utility function. Equation (8) gives the expected utility function by households:

$$E_t \sum_{i=0}^{\infty} \beta^i \left[ \frac{c_{t+i}^{1-\sigma}}{1-\sigma} + \frac{\gamma}{1-b} \left( \frac{M_{t+i}}{P_{t+i}} \right)^{1-b} - \chi \frac{N_{t+i}^{1+\eta}}{1+\eta} \right] \tag{8}$$

In (8),  $\beta$  is subjective rate of discount,  $c_t$  shows household consumption,  $\sigma$  indicates the household relative risk aversion,  $b$  is reversed the interest elasticity of the demand

for real money balances,  $M$  is nominal money balances,  $P$  is the price index,  $\chi$  is the fixed parameter,  $N$  shows household labor supply,  $\eta$  is reversed elasticity of labor supply.

According to (8), the household utility depends on the amount of consumption, the real money balances, and the number of hours dedicated to working. Equation (9) gives the budget constraint of household in real terms:

$$C_t + \frac{M_t}{P_t} + \frac{B_t}{P_t} = \left( \frac{w_t}{P_t} \right) N_t + \frac{M_{t-1}}{P_t} + (1+i_{t-1}) \frac{B_{t-1}}{P_t} + \Pi \tag{9}$$

Where,  $\frac{B_t}{P_t}$  is the real amount of bonds,  $\frac{W_t}{P_t}$  is the real wage,  $\frac{M_t}{P_t}$  is the real money balances, and  $\Pi_t$  is real

profits received from firms. Household decisions about choosing optimal consumption choice, labor supply, money, and securities are possible through maximizing the current value of the expected utility function concerning the budget constraint (9).

This maximization (8) subject to (9) leads to Euler equation (or the optimal smoothing consumption path). Euler equation for optimal intertemporal allocation of consumption is:

$$c_t^{-\sigma} = \beta (1+i_t) E_t \left( \frac{P_t}{P_{t+1}} \right) c_{t+1}^{-\sigma} \tag{10}$$

Log-linearizing (10) and rewriting it gives:

$$\ln C_t = -\frac{1}{\sigma} \beta + E_t \ln C_{t+1} - \frac{1}{\sigma} \ln(1+i_t) + \frac{1}{\sigma} (E_t \ln p_{t+1} - \ln p_t) \tag{11}$$

Now, linearizing (11) around a steady state, the following log-line Euler equation is given:

$$\hat{C}_t = E_t \hat{C}_{t+1} - \frac{1}{\sigma} (\hat{i}_t - E_t \hat{\pi}_{t+1}) \tag{12}$$

Here, in this simple model, by omitting investment, government expenditure and foreign sector, it is assumed that  $Y=C$ . So

$$\hat{Y}_t = E_t \hat{Y}_{t+1} - \frac{1}{\sigma} (\hat{i}_t - E_t \hat{\pi}_{t+1}) + u_t \tag{13}$$

Equation (13) represents a simple equation of New Keynesian forward looking IS. In (13),  $\hat{Y}_t$  shows the output gap,  $\hat{\pi}_t$  is the inflation rate (the deviation of inflation rate from target inflation),  $\hat{i}_t$  is nominal interest rate,  $u_t$  denotes demand shocks. In dynamic IS curve, current output (defined as output gap i.e. the deviation of current output from potential output), depends on expected future output and real interest rate  $(\hat{i}_t - E_t \hat{\pi}_{t+1})$ .

### C) Monetary Policy Reaction Function: the Taylor Rule:

Monetary policy reaction function is used to complete the New Keynesian model. To decrease the fluctuations in output and inflation, monetary officials adjust the nominal interest rate. This policy reaction results in an equation named Taylor rules. As is mentioned in theoretical studies, Taylor rule is forward looking. Here, the interest rate is adjusted in reaction to the deviation of future inflation from target inflation and the deviation of output from potential output. In other word, the target variables depend both on current policy and expected future policy stance. However, there are some empirical studies on Taylor rules that show Taylor rules which have both forward looking and backward looking variables are the best fit to data, particularly, when a lagged interest rate is included in Taylor rules to assess the policy reaction of central bank (or interest rate smoothing) [19]. Equation (14) shows the monetary policy reaction function general form:

$$\hat{i}_t = c_o + c_\pi E_{t-j}(\hat{\pi}_{t+k}) + c_y E_{t-j}(\hat{y}_{t+m}) + c_r \hat{i}_{t-1} + w_t \quad (14)$$

Here,  $i_t$  denote nominal interest rate (short-term) as the variable of the monetary policy,  $\pi_t$  is the deviation of inflation from its target value (which can be explicit or implicit),  $c_o$  is the equilibrium rate or the natural interest rate,  $y_t$  shows the output gap, and  $w_t$  is the error sentence.  $j$  refers to the lag in the information about central bank operation.

## 3 Methodology of Research

This study, using a small structural model, estimates the rules of monetary and fiscal policy. Following the Muscatelli et al. [6, 20], this study uses a forward-looking NK-DGE model, which includes a dynamic IS model for the output and a New Keynesians Phillips Curve to determine inflation. In this section, first, the structural model and then the rules of fiscal and monetary policy that are required to be estimated are listed:

### 3.1 Structural Model of New Keynesian

The intertemporal utility function for each consumer, such as  $i$ , is as follows:

$$E_t \sum_{s=0}^{\infty} \beta^s \left( \frac{1}{1-\rho} (C_{t+s}^i - H_{t+s}^i)^{1-\rho} - \frac{\varepsilon'}{1-\rho} (1 - N_{t-s}^i)^{1-\rho} \right) \quad (15)$$

The consumption of a basket of goods is  $C_t$ ,  $H_t$  is the consumption habits index,  $\rho$  is the coefficient of relative risk aversion,  $N_t$  is the level of employment.

$1 - N_{t+s}$  signifies leisure,  $\varepsilon'$  is a labor supply shock. It is assumed that consumption habits depend on aggregate consumption in previous period:

$$H_{t+s}^i = \lambda C_{t+s-1} \tag{16}$$

Consumers maximize their utility function in (15) based on their intertemporal budget constraint. The consumer i budget constraint is expressed as:

$$(\frac{1}{r_t})a_{t+1}^i = a_t^i - C_t^i + w_t^i N_t^i + D_t - T_t \tag{17}$$

Consumers' financial wealth ( $a_t^i$ ) is maintained as government securities in a period that has a return rate ( $r_t$ ). Disposable income of consumer includes income from work ( $w_t^i N_t^i$ ) plus dividends from the interests of firms (with imperfect competition) ( $D_t$ ), minus tax ( $T_t$ ).

In this study, it is assumed that consumers' preferences and initial wealth are the same; in this case, the problem of the consumer can be solved in the form of a dynamic optimization problem and aggregate the whole consumers. Then, using the condition of equilibrium in the commodity market (and neglecting investment and the net export), one can write:

$$Y_t = C_t + G_t \tag{18}$$

By logarithm-linearizing the consumption Euler equation around the steady state and (18), the New Keynesian IS curve can be derived.

Neglecting the shocks produced by the labor supply, (19) is given:

$$y_t = \frac{\lambda}{(1+\lambda)} y_{t-1} + \frac{1}{(1+\lambda)} E_t y_{t+1} - \frac{(1-\lambda)}{(1+\lambda)\rho} \left(\frac{\bar{C}}{\bar{Y}}\right) r_t + \left(\frac{\bar{G}}{\bar{Y}}\right) g_t - \frac{\lambda}{(1+\lambda)} \left(\frac{\bar{G}}{\bar{Y}}\right) g_{t-1} - \frac{1}{1+\lambda} \left(\frac{\bar{G}}{\bar{Y}}\right) E_t g_{t+1} \tag{19}$$

The 'hat' sign (^) above the variables indicates that this variable is considered in terms of the percentage of deviations from the steady state and the 'bar' sign (-) represents the value of the steady state of that variable. Firms set prices based on a competitive monopoly model with price stickiness. A simple Cobb Douglas function represents production technology of the firm in which labor and capital are used to produce various consumption goods (z). The capital is assumed to be fixed (K=1).

$$Y_t(z) = A (N_t(z))^{1-\alpha} \tag{20}$$

The whole consumption is presented as a CES function including various consumption products (z) that can substitute each other imperfectly.

$$C_t^i = \left[ \int_0^1 (C_t^i(z))^{\frac{\theta}{\theta-1}} dz \right]^{\frac{\theta-1}{\theta}} \tag{21}$$

And the consumption of each kind of consumption goods is given as follows:



$$C_t^i(z) = \left[ \frac{P_t(z)}{P} \right]^{-\theta} C_t^i \quad (22)$$

In (22),  $P(z)$  is the price of commodity  $z$  and  $P$  is the index of consumption price given by the aggregator (23):

$$P = \left[ \int_0^1 (P_t(z))^{1-\theta} dz \right]^{\frac{1}{1-\theta}} \quad (23)$$

In this model, Stickiness of prices is expressed in terms of Calvo pricing mechanism. That is, a proportion of firms  $(1-\zeta)$  adjust their prices in each period, some of these firms  $(\gamma)$  set prices based on the inflation within past period, and the other firms  $(1-\gamma)$  will set their prices in an optimum way in order to maximize the expected discounted real profits (considering the technology and the consumer discount factor  $(\beta)$ ). The optimization of the firm (concerning Calvo's pricing method) leads to an expression, known as Philips Hybrid Curve. The log-linearized form of this expression is given in (24):

$$\begin{aligned} \pi_t = & \frac{\gamma}{\zeta + \gamma(1-\zeta)(1-\beta)} \pi_{t-1} + \frac{\beta\zeta}{\zeta + \gamma(1-\zeta)(1-\beta)} E_t \pi_{t+1} \\ & + \frac{(1-\gamma)(1-\zeta)(1-\gamma\zeta)}{[\zeta + \gamma(1-\zeta)(1-\beta)][1 + (\alpha/(1-\alpha))\theta]} s_t \end{aligned} \quad (24)$$

Here,  $s_t$  is the percentage of the deviation of the share of the labor's income from a steady state. It is given by  $\hat{s}_t = \hat{w}_t + \hat{n}_t - \hat{y}_t$ . Equations (19) and (24) form the structural model of this research, which are estimated along with the policy rules.

### 3.2 Rules of Monetary and Fiscal Policy

The previous studies state that Taylor's rules, with both forward-looking and backward-looking variables, fit the data best. Especially, when the interest rate is included in Taylor's rules to eliminate the inertia of the central bank policy response (or calculate the degree of interest rate smoothing) [21, 22, 19].

The estimated monetary rule in this research is shown in (25). In this equation,  $(i)$  is the nominal interest rate.

$$\hat{i} = \phi_0 + \phi_1 E_t \hat{\pi}_{t+q} + \sum_{t=0}^m \phi_2 \hat{y}_t + \phi_3 \hat{i}_{t-1} \quad (25)$$

Here,  $\phi_3$  is the level of the interest rate smoothing.

Fiscal policy rules are expressed in the following equations (26) and (27), which are backward-looking and reflect the fiscal policy response to macroeconomic variables more realistically and this is partly due to the frequency of financial policy, it is also due to the fact that it will be an integral part of the financial policy response due to automatic stabilization. The present study estimates two different equations for government expenditure (26) and tax (27) which are backward-looking. In both equations, the variables react to output, the ratio of lagged budget deficit, and to GDP (deficit/GDP) as a stabilization mechanism and an effective factor on current fiscal policy.

$$\hat{g}_t = \sum_{i=1}^m \delta_{1i} \hat{g}_{t-i} + \sum_{i=0}^m \delta_{2i} \hat{y}_{t-i} + \psi_1 (bd)_{t-k} \tag{26}$$

$$\hat{\tau}_t = \sum_{i=1}^m \phi_{1i} \hat{\tau}_{t-i} + \sum_{i=0}^m \phi_{2i} \hat{y}_{t-i} + \psi_2 (bd)_{t-k} \tag{27}$$

bd<sub>t</sub> is (deficit/GDP). Several estimates have been made that the determination of k = 4 provides a good estimate for the deficit variable, while for self-regression and production variables, less lag (usually one or two) are needed. In the theoretical models of fiscal and monetary imaging, they assume that both functions of policy makers define the same goals (usually inflation and output gap) [6, 20]. This study also determined the separate equations for taxes and expenditures to describe the separate effect of expenditures on the production gap, following Muscatli et al. [6, 20]. In some investigations, the financial reaction function estimates the financial position with the production gap and the ratio of debt to GDP, but in the present study, the ratio of deficit to GDP ratio has been used as a correction mechanism instead of debt to gross domestic product ratio that is because the deficit variable was much more significant for GDP.

### 3.3 Estimated Method

There are several methods for estimating and evaluating the NK-DGE model. These techniques include calibration, generalized momentary method (GMM), full-information likelihood, Bayesian estimation, and minimum distance estimation based on the distance between the impulse response functions received from the VAR and the DGE model [23]. This article has chosen the method of generalized momentary moments. The GMM technique makes it possible to estimate the parameters accurately. On the other hand, the New Keynesian model contains equations in which the parameters might be nonlinear. As Hansen suggests, a model with rational expectations offers some orthogonal restrictions that can be used within GMM method [24]. Therefore, the system of the estimated equations in this research follows the (28) form:

$$y_t = f(\theta, z_t) + u_t \tag{28}$$

y<sub>t</sub> is the vector of dependent variables, θ states an unknown parameter, (a × 1) vector, and z<sub>t</sub> is vector of explanatory variables, (k × 1) vector. The GMM approach is based on the fact that  $\tilde{\theta}$  (the true value of θ) has this feature that  $E[h(\tilde{\theta}, w_t)] = 0$ , so that  $w \equiv (y'_t, z'_t, x'_t)$ , and x<sub>t</sub> is a (r × 1) vector of the instrumental variables that are correlated with z<sub>t</sub>. The GMM then selects its estimate θ, which can make sample moment as close as possible to the population moment of zero.

A point about the instrumental variables is worth mentioning. In New Keynesian literature and interest rate rules, instrumental variables include some lagged values of regressors. For example, Gali et al. [2] use a wide range of lagged values of the regressors as the instrumental variables for the values of the expected inflation, output and wages in the Philips equation in Europe and the United States. This type of instrument is acceptable as long as the error term in the equations is not correlated with the previous values of the regressors (and if there is a correlation between these two, the identification will be weak). While this assumption is completely true for Philips equation and the IS equation, with regard to the monetary policy rule, this assumption implies

that monetary policy decisions are rational, that is, the central bank decisions are based on all available information at the time of making decisions; therefore, the forecast errors are not correlated with the available information [21,25,26]. In this research, dependent variables and exogenous variables with four lags, as well as are used as instrumental variables. Their validity is tested by J-test Hansen, distributed as  $\chi^2(r-a)$ , under null hypothesis that the orthogonality conditions are acceptable and valid ones. The problem that is found in the IS equations and the New Keynesian Phillips curve (NKPC) equations is that the parameters in these equations are nonlinear and the rank conditions are not applicable for identification unless several parameters are fixed in these two equations. This research also has some restrictions for some of the parameters. For example, in the NKPC equation, following the research carried out in Iran,  $\theta = 33/4$  (Which represents a 30% price mark-up on the Iranian economy)  $\alpha-1=0.6$  is considered to be fixed [27, 28, 13]. Also, the restriction applied to the IS equation for  $\frac{\bar{c}}{\bar{y}}$  and  $\frac{\bar{g}}{\bar{y}}$  are 0.7 and 0.3 respectively, which are equal to average value of the variables. Equations of policy rules are not complicated. In this study, both the monetary policy rule and the fiscal policy rule are estimated several times using different independent variables. Regarding the monetary policy rule the best estimation is when the inflation variable is considered to have a single lead and the output is current. For the fiscal rules, it is found that the two lags on the output and the AR term can appropriately describe the fiscal variables (government expenditures and tax). Also, for the independent variable of the ratio of budget deficit to GDP, four lags are considered (k=4).

### 3.4 Data

This paper estimates the new Keynesian model, along with the monetary and fiscal policy rules, including equations (19) and (24) - (27), based on seasonal data of Iran, over the period of 2000Q1-2017Q4. The series of the data is comprised of the following variables: inflation (changes in the consumer price index as inflation), output gap (the sum of government consumption and investment expenditure, and household consumption expenditure) and real interest rate, i.e. nominal interest rate (interbank transactions weighted interest rate) minus the inflation rate, the government budget deficit and total tax revenue. The statistical data are based on the statistics in the Central Bank statistics and the Management and Planning Organization. The estimates are done using the Eviews software, version 9. First the logarithmic data are adjusted seasonally (X-12 method). Since stationary data are required in the GMM, the data integration properties are evaluated before carrying out the estimation. The stationary test is done using the HEGY method, which is mainly used for seasonal data. The test of the unit root shows that the null hypothesis ( $H_0$ ) cannot be rejected for some variables. Since in the New Keynesian model, the gap of variables are commonly used, the data is changed so that the variables are expressed in terms of deviation from their steady state. To do so, the Hodrick-Prescott Filter is used. After filtering, the stationary test is repeated and the null hypothesis implying the existence of a unit-root and non-stationary variables is rejected, in other words, all the variables become stationary.

## 4 Empirical Results

The model described in Section 3, jointly with the points mentioned in Section 3.4 (Data), is applied to Iran's economy over the period of 2000Q1-2017Q4. Table 1 reports the estimated New Keynesian model using the GMM method during the given period. As was mentioned in the previous section, even after applying the restriction suggested by the theory that  $\lambda, \beta, \forall, \xi$  should be less than 1; the estimation of the parameters was

inaccurate. Therefore, the constant value for the discount factor ( $\beta$ ) is considered to be 0/96, which corresponds to the researchers conducted in Iran [13, 12]. This increased the accuracy of other estimated parameters. The estimation of the IS curve indicates that the current output gap depends on the expected output gap and also has a negative relationship with the expected real interest rate. The real interest rate coefficient in the IS curve shows the impact of monetary policy on economic activities; in the long run, when the interest rate reduces by one percentage point, output increases by about 0.52 (relative to potential value). Phillips curve coefficients show that the current inflation positively depends on the expected inflation and wage gap. The effect of an increase in wage on inflation is significant, but relatively weak, (the long-run impact of an increase in wage on inflation is about 0.0022).

**Table 1:** Model Estimates

IS		NKPC		i		g		t	
Parameter	Estimate	Parameter	Estimate	Parameter	Estimate	Parameter	Estimate	Parameter	Estimate
$\lambda_1$	0.396	$\Upsilon 1$	0.275	$\phi_0$	- 0.001054	$\delta_{11}$	0.581	$\varphi_{11}$	0.231
$\lambda_2$	0.56	$\Upsilon 2$	0.451	$\phi_1$	0.266	$\delta_{12}$	-	$\varphi_{12}$	-
$\lambda_3$	-0.23	$\Upsilon 3$	0.00122	$\phi_{20}$	0.246	$\delta_{20}$	0.796	$\varphi_{20}$	1.266
$\lambda_4$	0.546	$\beta$	0.96	$\phi_{21}$	0.313	$\delta_{21}$	-0.791	$\psi_2$	-0.333
$\lambda_5$	-0.236			$\phi_3$	0.659	$\delta_{22}$	-		
$\lambda_6$	-0.295					$\psi_1$	-0.059		
$\lambda$	0.707								
$\overline{R^2}$	082		0.56		0.68		0.61		0.41
Reg.S.E	0.0024		0.0019		0.0039		0.007		0.0017
Sum $\hat{u}^2$	0.0055		0.0038		0.0015		0.0065		0.003

J : 0.277 (Zero assumption instrumental variables are valid)

**Note:** All parameters have value-p zero.

Turning to monetary policy rule, the lag of interest rate coefficient (0.65) indicates the degree of interest rate inertia is significant and that the interest rate is fairly smooth. The inflation effect, which is statistically significant, shows that Iran's monetary policy has not been so active during the studied period which is probably thanks to restrictions on capital mobility that is specific to undeveloped capital markets. The value of inflation coefficient expresses that when the inflation grows by 1%, in the long run, nominal interest rates increase by 0.77. Moreover, since inflation has a lead, this value reflects the central bank's reaction to inflation has been forward looking. The response of interest rate to the output gap is also meaningful (and in the long run it is equal to 0.71). The functions related to fiscal rules are very similar. The degree of inertia or smoothness of the government expenditures rule (0.58) is more than that of the tax rule (0.23). Both of these coefficients are statistically significant. Interestingly, the government expenditures response to the current output gap is not stable; so that, when the output gap is placed, with a lag, in government expenditures rule the estimated coefficient implies the negative impact of the output gap on government expenditures, which reflects the counter-cyclical policy of the government. The short-term impact of the output gap on government

expenditures (0.79) is smaller than its effect on tax (1.27) (i.e. the tax response to the output gap is stronger and positive). The estimated value of the fiscal feedback parameter (budget deficit) in government spending rule is negative and statistically significant, that is, as the debt increases, government spending will react and decline after one year. While the same parameter in the tax rule, although statistically acceptable, is negative and it indicates that during the observed period, the tax policy has not been in line with stabilizing of government debt.

#### 4.1 The Robustness of the Results

In this section, the robustness of the results is checked concerning the type of estimation (i.e. system or single equation). Here, only the estimations of monetary policy rule and the government spending rule are provided. It will be examined if the results vary when the policy rule is estimated as a single equation (not a system).

**Table 2:** Evaluating the Strength of the Results of The rule of monetary policy and the rule of fiscal policy

monetary policy rule	system estimation	single Equation estimate	government spending rule	system estimation	single Equation estimate
Constant	***-0.001054	***0.00			
interest rate gap (-1)	***0.65	**0.75	government spending gap (-1)	***0.581	***0.538
output gap	***0.246	***0.35	output gap(-1)	***- 0.791	*-0.275
output gap (-1)	***0.313	**0.34	budget deficit(-4)	***-0.059	***-0.062
inflation	***0.37	***0.34			
Inflation (-1)	***0.11	*0.12			
Q-statistic	-	0.94		-	0.85
J-test	0.277			0.277	

**Notes:** (i) \*\*\*, \*\* and \* indicate statistical significance at 1%, 5% and 10% levels, respectively.  
(ii) The Q-statistic denotes the Box-Ljung test statistic for residual autocorrelation.

According to the data presented in Table 2, the coefficients derived from the estimation of the single equation are close to the coefficients derived from the system estimation, which confirms the accuracy of the primary results in Table 1.

#### 5 Conclusions

The researches that have been carried out so far concerning the monetary policy analysis in Iran are faced with fundamental questions about the behavior of monetary and fiscal policy, which are tools for macroeconomic stability. This article proves the credibility of this expectation that the New Keynesian framework can provide a scientific logic for the current monetary and fiscal policy framework in Iran. As it is common among central banks to form their operations around the interest rates as the main channel of transmitting monetary policy position to the variables of the macro-economy, the same method can be operated in Iran regarding the Islamic Banking. The New Keynesian model has at least three merits. First, in this model, the impact of interest rates on aggregate demand in terms of its effects on the output gap is tangible. Second, in

the short run, there is a trade-off between the output gap and inflation, that explains why monetary and fiscal policies are used as stabilizing tools and that their appropriate responses to fluctuations and inflation lead to social welfare. By correct understanding of the economic operation in space and time, one can prioritize the weights given to output fluctuations and inflation. Third, this model is flexible and fit modeling and simulating applied policies. The New Keynesian model which is merely theoretical is a forward-looking model, but the best one is a combination of forward-looking and backward-looking model that is consistent with realities. The New Keynesian model can be designed for an open economy and specific features of a country. Nevertheless, the present paper provides a very brief presentation of the function of the economy which the wise policymaker should be aware of its limitations. As was stated, this research discusses how to adjust a New Keynesian model encompassing inflation and output jointly with monetary and fiscal rules to analyze the monetary and fiscal policy .

Then, this modified model is estimated regarding Iran's seasonal data using GMM system estimation from 2001 Q1 – 2016 Q4. The estimated results clarify some facts about the mechanism of money transaction in Iran. The most prominent of these is the channel of the money-transaction mechanism is based on aggregate demand components. Monetary policy (expansionary) leads to a reduction in real interest rate, and it increases the aggregate demand and the output. Therefore, the real interest rate affects Iranian consumers' decisions. The real long-term interest rate is considered as the major effective factor on consumptions. The fact that the real interest rate affects consumption offers an important mechanism revealing how monetary policy impacts Iran's economy, so that if nominal interest rates get close to zero, the commitment to future monetary policy (expansionary) can increase the expected price level that will consequently increase the expected inflation and decrease the real interest rate which leads to the increase of consumption and output. Using the five-equation-model of the New Keynesian, the following results are found. First, the aggregate demand reacts to the changes in the real interest rates. And the presence of organizational obstacles in the credit market, such as managed interest rates, can result in the persistence of the monetary policy impact. It is essential to recognize this effect in setting monetary policy when the inflationary pressures are caused by excess demand. Second, when the inflation is caused, it is very persistent and inertia. Third, the monetary policy is forward-looking. Finally, the output gap with a lag has a negative effect on government spending and the impact of the short-term output gap on government expenditures is smaller than its impact on taxation (tax response to the output gap is stronger and positive). Therefore, these findings indicate that the interaction between monetary and fiscal policy can play a pivotal role in stabilizing the economy. Implementing a true and precise fiscal policy pave the way for an active monetary policy. On the other hand, the use of Islamic profit rate as the main instrument of monetary policy is suggested.

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