Volume 8, Number 36, Winter 2021

The IS Curve, the Phillips Curve and Monetary Transmission in the Iranian Economy

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Abstract

The purpose of this paper is to examine the mechanism of monetary and fiscal policy transmission based on the framework of the new Keynesian model. The new Keynesian framework is a combination of the features of the dynamic stochastic general equilibrium of the real business cycle model and the Keynesian theory. In the New Keynesian dynamic general equilibrium model, the consumers face liquidity restriction and the firms face sticky prices. In this model, money has no obvious role. Of course, that doesn't mean money doesn't matter. Money is still the center of attention but invisible. The present paper studies the monetary policy rule jointly with fiscal rules through the estimation of a three-equation New Keynesian model (aggregate demand (IS), monetary rule, aggregate supply (Philips curve)). The presented model is estimated by systematic generalized methods of moments using Iran's data from 1989Q1-2017Q4. The obtained results show that the aggregate demand responds to the changes in interest rate and that the coefficient of consumers ‘consumption habits is significant. Also, inflation (regardless of its source) seems to be persistent and inertia. On the other hand, this research indicates that the monetary policy has a forward looking behavior; the output gap with a lag has a negative influence on government expenditure. The short term impact of output gap on government expenditure is less than its effect on taxation. That is tax reaction is positive and stronger compared to output gap reaction. Since monetary and fiscal policy can play a pivotal role in stabilizing the economy, it is recommended to implement a true and precise fiscal policy to pave the way for an active monetary policy using the new Keynesian model.

Keywords: New Keynesian, Money transfer mechanism, Monetary and Fiscal policy, Generalized Methods of Moments

JEL Classification: E52, E62, E12.

1. Introduction

Monetary and fiscal policies play an important role in economic stability, i.e. price

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and production stability. On the other hand, monetary and fiscal policies are highly influenced by the performance of the central bank and the government. So, there is a need to study monetary economy developments and the performance of the central bank in some periods. For example, in the early 1990s, inflation targeting based on the interest rate performance method was popularized by a number of developed countries. Then, the used economic modeling in policy-making followed the new Keynesian approach, i.e. monetary modeling based on micro-bases, imperfect competition and price and wage stickiness in the general equilibrium models of real business cycles were used. This way, the opportunity to analyze the interest rates in applied policies field was provided. The estimation of policy rules (Taylor 1993) and the extraction of the Taylor principle were the two other developments in monetary economics at that time. Finally, in the late 1990s, interest rates gradually became the main instrument of monetary policy (Mishkin, 2010).

In recent years, the new Keynesian model has been introduced as a standard tool for monetary policy analysis among central banks (Woodford, 2011) and it is still one of the most important and efficient areas of macroeconomic research. Therefore, numerous studies have been conducted on New Keynesians. They have presented appropriate behavioral models and interpretation of monetary policy (Gali, 2018, 2020).

It is also essential to use a complete and comprehensive model to analyze the mechanism of monetary policy transfer in Iran. Therefore, extensive researches have been carried out on the economy of Iran using the new Keynesian dynamic stochastic general equilibrium model to study monetary policy. Bayesian approach is commonly used in these studies (Jafari Lilab et al., 2017). In addition, a number of studies have just dealt with one of the equations of the new Keynesian model, such as the curve of Phillips (Kazeruni et al., 2017), or the monetary policy response function as Taylor rule (Yazdani and Momeni, 2017). So, the innovation of the present study lies in investigating the transmission mechanism of monetary policy by estimating the three-equation New Keynesian model (aggregate demand (IS), aggregate, supply (Phillips curve), monetary rule), along with fiscal rules (government spending and taxes) concerning Iran's economy. In this regard, the systematic generalized methods of moments approach was used.

2. Research model

The purpose of this article is to investigate the transmission mechanism of monetary and fiscal policy in the context of the New Keynesian model. For this reason, these five equations (7-11) will be estimated: the demand function (IS), the supply function (Phillips curve), the monetary rule (Taylor) and the fiscal rule (government spending and total tax), respectively.

$$\hat{y}_t = \lambda_1 \hat{y}_{t-1} + \lambda_2 E_t \hat{y}_{t+1} - \lambda_3 \left(\frac{\overline{C}}{\overline{Y}}\right) \hat{r}_t + \lambda_4 \left(\frac{\overline{G}}{\overline{Y}}\right) \hat{g}_t - \lambda_5 \left(\frac{\overline{G}}{\overline{Y}}\right) \hat{g}_{t-1} - \lambda_6 \left(\frac{\overline{G}}{\overline{Y}}\right) E_t \hat{g}_{t+1} \tag{7}$$

$$\hat{\pi}_t = \gamma_{1b} \hat{\pi}_{t-1} + \gamma_{2f} E_t \hat{\pi}_{t+1} + \gamma_3 \hat{s}_t \tag{8}$$

$$\hat{i}_t = \phi_0 + \phi_1 E_t \hat{\pi}_{t+q} + \sum_{t=0}^{m} \phi_2 \hat{y}_t + \phi_3 \hat{i}_{t-1} \tag{9}$$

$$\hat{g}_t = \sum_{i=1}^{m} \delta_{1i} \hat{g}_{t-i} + \sum_{i=0}^{m} \delta_{2i} \hat{y}_{t-i} + \psi_1 (bd)_{t-k} \tag{10}$$

$$\hat{T}_t = \sum_{i=1}^{m} \varphi_{1i} \hat{T}_{t-i} + \sum_{i=0}^{m} \varphi_{2i} \hat{y}_{t-i} + \psi_2 (bd)_{t-k} \tag{11}$$

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. The index t represents the current period, t + i or t + q represents the future period, t-i or t-k denotes the past period. $\hat{y}$ is the output gap, $\hat{g}$ shows total government expenditures gap, r indicates real interest rate (nominal interest rate minus inflation rate), s is the percentage of the deviation of the share of the labor's income from a steady state, $\hat{i}$ denotes nominal interest rate gap, π_{t+q} represents inflation in future periods, $\hat{T}_t$ is total tax gap, and $(bd)_{t-k}$ is the ratio of budget deficit to GDP.

In this study, the statistical population is Iran and the period under study is 1989Q1- 2017Q4. The data were adjusted seasonally by the X-12 method. One of the features of the New Keynesian models is that the variables appear as deviations from the stability state in the model, so the Hodrick-Prescott Filter was used.

3. Estimation results

3-1. Unit root test results

In this paper, stationary test was performed in two stages: before and after data cycling. The results of this test show that most variables are non-stationary at least in one of the frequencies before cycling. But cycling the variables solves this problem. Unit root test results are presented in 1tables (1) and (2).

Table 1: Unit root test results (HEGY) - before cycling the data

Variable	Statistical (Zero frequency)	Statistical (2 quarters per cycle)	Statistical (4 quarters per cycle)	Test result
Y	(0.14) -2.99	(0.029) -3.13	(0.140) 4.58	Non-stationary
i	(0.137) -2.99	(0.005) -6.51	(0.000) 30.24	Non-stationary (in Zero frequency)
BD	(0.024) -3.73	(0.018) -3.28	(0.300) 3.40	Non-stationary (in 2 quarters per cycle)
Bd ratio (bd)	(0.007) -4.39	(0.184) -2.29	(0.122) 4.96	Non-stationary (in 2 quarters per cycle)
g	(0.668) -1.85	(0.005) -5.54	(0.000) 41.51	Non-stationary (in Zero frequency)
s	(0.544) -2.10	(0.005) -6.01	(0.000) 15.31	Non-stationary (in Zero frequency)
T	(0.754) -1.75	(0.048) -2.92	(0.015) -7.73	Non-stationary (in Zero frequency)

Source: Research Findings (Numbers in parentheses represent P-value)

Table 2: Unit root test results (HEGY) - after cycling the data

Variable	Statistical (Zero frequency)	Statistical (2 quarters per cycle)	Statistical (4 quarters per cycle)	Test result
$\hat{y}$	(0.008) - 4.15	(0.01) -3.56	(0.000) 12.53	stationary
$\hat{i}$	(0.005) -5.02	(0.005) -6.75	(0.000) 31.22	stationary
$\widehat{BD}$	(0.005) -5.19	(0.005) -5.72	(0.000) 16.47	stationary
$\widehat{bd}$	(0.005) -5.46	(0.005) -4.76	(0.000) 16.06	stationary
$\hat{g}$	(0.005) - 6.40	(0.005) -6.13	(0.000) 81.19	stationary
$\hat{s}$	(0.005) - 4.36	(0.005) -5.79	(0.000) 16.28	stationary
$\hat{\tau}$	(0.005) - 4.32	(0.05) -2.92	(0.01) 8.03	stationary

Source: Research Findings (Numbers in parentheses represent P-value)

3-2. Model estimation results

Here, the restriction applied to the IS equation for $\frac{\bar{c}}{\bar{y}}$ and $\frac{\bar{G}}{\bar{y}}$, based on average value of the related variables, are 0.7 and 0.3, respectively.

Five equations (7-11) were estimated in different situations (in terms of backward and forward independent variables) and the best estimation was selected in terms of fit. In estimating the system of equations, all instrumental variables including output gap, government spending, taxes, real interest rates, wages and inflation were considered constant with four lags.

Analysis of the obtained statistics (Table 3) shows that: according to J- Hansen statistics, the used instrumental variables are valid and exactly identify the 20 coefficients of this study, and 13 "extra" instrumental variables are also suitable to be used.

All estimated coefficients have a probability value of zero, the value of t-statistic is in the acceptable distribution region, and the standard deviation value is close to zero. Therefore, all coefficients have statistical validity.

Table 3: Model estimates by GMM system method

IS curve		NKPC		i		g		T	
Parameter	Estimation	Parameter	Estimation	Parameter	Estimation	Parameter	Estimation	Parameter	Estimation
$\hat{y}_{t-1}$	0.44 (0.002) (0.000)	$\hat{\pi}_{t-1}$	0.264 (0.002) (0.000)	ϕ_0	-0.00105 (0.0001) (0.000)	$\hat{g}_{t-1}$	0.53 (0.004) (0.000)	$\hat{T}_{t-1}$	0.25 (0.003) (0.000)
$\hat{y}_{t+1}$	0.51 (0.003) (0.000)	$\hat{\pi}_{t+1}$	0.478 (0.003) (0.000)	$\hat{\pi}_{t+1}$	0.424 (0.009) (0.000)	$\hat{y}_{t-1}$	0.17 (0.009) (0.000)	$\hat{y}_{t-1}$	0.47 (0.01) (0.000)
r_t	-0.22 (0.002) (0.000)	s_t	0.034 (0.0007) (0.000)	$\hat{y}_t$	0.48 (0.003) (0.000)	$(bd)_{t-4}$	-0.004 ٠/٠٠٠١) ((0.000)	$(bd)_{t-4}$	0.027 (0.00004) (0.000)
$\hat{g}_{t}$	1.29 (0.008) (0.000)	-	-	$\hat{y}_{t-1}$	0.295 (0.003) (0.000)	-	-	-	-
$\hat{g}_{t-1}$	-0.221 (0.006) (0.000)	-	-	$\hat{i}_{t-1}$	0.66 (0.002) (0.000)	-	-	-	-
$\hat{g}_{t+1}$	0.238 (0.009) (0.000)	-	-	-	-	-	-	-	-
λ	0.863	-	-	-	-	-	-	-	-
$\bar{R}^2$	0.50		0.46		0.32		0.29		0.33
Reg. S. E	0.032		0.019		0.048		0.082		0.17
Sum $\hat{u}^2$	0.12		0.03		0.24		0.03		0.19

J- statistic: 0.174388 (Zero assumption instrumental variables are valid)

Determinant residual covariance: 9.36 * e $^{-14}$

Source: Research Findings (The numbers in parentheses are standard errors and P-Value, respectively)

3-3. Checking the strength and accuracy of the results

In what follows, the strength and accuracy of the results are investigated by comparing both the values of coefficients and the Confidence Interval of coefficients in system estimation and single equation, and using in-sample forecast.

- Equations (7) to (11) were also estimated by the GMM method of single equation.

The results of estimating the equations related to the interest rate rule and the government expenditure rule (Table 4) show that the values of the coefficients obtained by estimating the GMM method of single equation are close to the values of the coefficients obtained by estimating this method in the system state, which confirms the accuracy of the preliminary results in Table 3.

Table 4: Examining the strength of the results of the monetary policy rule and the fiscal policy rule

monetary policy rule	system estimation	single Equation estimate	government spending rule	system estimation	single Equation estimate
$\hat{i}_{t-1}$	0.66 (0.0000)	0.65 (0.0000)	$\hat{g}_{t-1}$	0.53 (0.0000)	0.57 (0.0000)
$\hat{y}_t$	0.48 (0.0000)	0.434 (0.0001)	$\hat{y}_{t-1}$	0.17 (0.0000)	0.228 (0.0000)
$\hat{y}_{t-1}$	0.295 (0.0000)	0.228 (0.0000)	$(bd)_{t-4}$	-0.004 (0.0000)	-0.004 (0.0000)
$\hat{\pi}_{t+1}$	0.424 (0.0000)	0.405 (0.0000)	-	-	-
$\overline{R}^2$	0.32	0.34	-	0.29	0.25
Q-statistic	-	0.98 (0.534)	-	-	7.8 (0.199)
J-statistic	0.174388	18.99 (0.92)	-	0.174388	28.4 (0.52)
Reg.S.E	0.048	0.04	-	0.082	0.084
Sum $\hat{u}^2$	0.14	0.14	-	0.03	0.06

Notes: The numbers in parentheses are the p- value.
The Q statistic represents the significance level of the Box- Ljung statistic for residual autocorrelation up to four lags.

Source: Research Findings

- Comparing the confidence interval of the coefficients obtained by the system method and the single equation method (Tables 5 and 6) signifies that there is a 95% common confidence interval between these two methods, which confirms the accuracy and strength of the initial results presented in Table (3).

Table 5: Coefficient Confidence Intervals in the government expenditure rule (at 95% level)

Variable	Coefficient (system estimation)	Low	High	Coefficient (single equation)	Low	High
$\hat{g}_{t-1}$	0.53	0.523	0.541	0.57	0.53	0.61
$\hat{y}_{t-1}$	0.17	0.155	0.187	0.228	0.13	0.32
$(bd)_{t-4}$	- 0.004	- 0.005	- 0.003	- 0.004	- 0.005	- 0.003

(Source: Research Findings)

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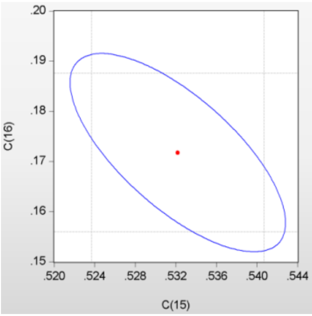

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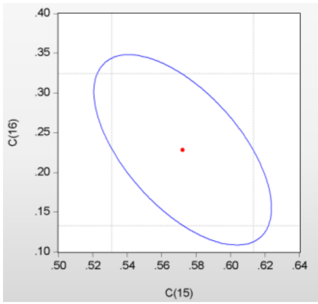
Confidence Ellipse in the systematic estimation of the government expenditure rule

C(15) = (Coefficient $\hat{g}_{t-1}$)

C(16) = (Coefficient $\hat{y}_{t-1}$)



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Confidence Ellipse in estimating the single equation of government expenditure rule

C(15) = (Coefficient $\hat{g}_{t-1}$)

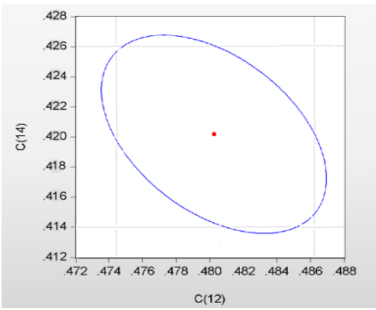
C(16) = (Coefficient $\hat{y}_{t-1}$)

Figure 2: Confidence Ellipse of $\hat{g}_{t-1}$ and $\hat{y}_{t-1}$ Coefficients in government spending rule Source: Research Findings)

Table 6: Coefficient confidence interval in the monetary policy rule (at 95% level)

Variable	Coefficient (systematic estimation)	Low	High	Coefficient (single equation)	Low	High
$\hat{i}_{t-1}$	0.66	0.60	0.72	0.65	0.56	0.74
$\hat{y}_{t}$	0.48	0.474	0.486	0.434	0.22	0.63
$\hat{y}_{t-1}$	0.295	0.19	0.32	0.288	0.17	0.40
$\hat{\pi}_{t+1}$	0.424	0.414	0.426	0.405	0.19	0.61

(Source: Research Findings)

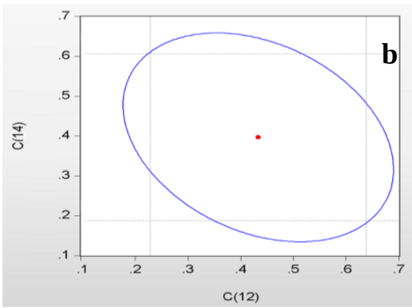


a

Confidence Ellipse in the systematic estimation of the monetary policy rule

C(14) = (Coefficient $\hat{\pi}_{t+1}$)

C(12) (Coefficient $\hat{y}_{t}$)



b

Confidence Ellipse in estimating the single equation of monetary policy rule

C(14) = (Coefficient $\hat{\pi}_{t+1}$)

C(12) = (Coefficient $\hat{y}_{t}$)

Figure 3: Confidence Ellipse of $\hat{\pi}_{t+1}$ and $\hat{y}_{t}$ coefficients in monetary policy rule (Source: Research Findings)

- All the information presented in Table (7) and Figure (4) indicates that in-sample forecast is a good one. Therefore, the presented model in this research is approved and it does not need to be modified or revised.

Table 7: Forecasting Performance

Statistic	Monetary policy rule		Government expenditure rule	
	Static	Dynamic	Static	Dynamic
Mean absolute error	0.04	0.04	0.06	0.07
Root mean square error(RMSE)	0.04	0.05	0.08	0.09
RMSE(%)	31.1	34.6	12.8	35.9
Theil inequality measure	0.31	0.17	0.16	0.21
Bias Proportion	0.000	0.000	0.000	0.000
Variance Proportion	0.16	0.18	0.16	0.26
Covariance Proportion	0.83	0.81	0.84	0.73

(Source: Research Findings)

Fig. 4: Forecasting of Government Expenditure Rule - Static (Source: Research Findings)

5. Conclusion

The results of estimating the IS equation in the economy of Iran show that the expected output gap carries a greater weight in determining the current output gap than the output gap with a lag.

The significance of the real interest rate coefficient also indicates that in the new Keynesian framework model in the Iranian economy, the real interest rate has a negative effect on aggregate demand.

In other words, the real interest rate coefficient in the IS curve reflects the effect of monetary policy on economic activities; so that one-percent reduction in interest rates will lead to an increase of about 0.39 percent in economic activity in the long run. Also, the calculated value of consumption habits coefficient in IS equation indicates the persistence of consumption habits in Iranian consumption behavior.

This study shows that the increase in government spending in the last period lowers the production and economic activity in the current period.

On the other hand, estimation of the Phillips Hybrid curve has produced results that show the expected inflation and wage gap exert a positive effect on the current period inflation. Since the expected inflation coefficient is bigger than the coefficient of inflation with a lag, it can be concluded that firms pay more attention to future prices in setting their prices, and that expected inflation plays an important role in the formation of prices. In addition, the value of the expected inflation coefficient indicates the inertia and persistence of inflation in Iran's economy.

The results of estimation of the monetary policy rule show that the interest rate coefficient with a lag is significant and positive. It indicates the degree of interest rates inertia and stability. That is, most policy decisions aim at maintaining current interest rates.

The value of inflation in the monetary policy rule (0.42) corresponds to the weight that the central bank should place on deviation of inflation from targeting inflation. It reflects that as inflation increases, interest rates should increase to eliminate this problem. The interest rate response to long-term inflation, which is, in fact, the Central Bank's forward-looking response to inflation, was 1.23.

In the policy rule, the central bank assigns a positive weight to the activities of the real economy, which indicates the Central Bank's commitment to the production stability. That is, the Central Bank must increase the interest rate by 1.41 percent in order to stabilize production in the long run.

To ensure that a monetary policy rule leads to a permanent and unique equilibrium, the output gap coefficient must be bigger than one. Since the short-term inflation rate is less than one, the Central Bank must be more sensitive to the changes in output gap to achieve its goal i.e. stable equilibrium.

Estimation of financial rules revealed that the degree of government spending rule smoothing is greater than that of the tax rule. The positive effect of the output gap on government spending signifies that the government's fiscal policy is in line with the trade cycle, and the tax response to the output gap is positive and stronger than government spending.

Also, based on the calculation of the financial feedback coefficient (budget deficit) in the government expenditure rule, the rise of debts is expected to decrease the government expenditures after a year.

However, the impact of this variable is very small and indicates that the government does not pay attention to the last year's debts or budget deficits in adjusting its expenditures. The insignificant amount of financial feedback in the tax rule shows that the government budget deficit is not mainly financed through the tax system, but through other means (e.g. the banking system).

Concerning the fact that monetary and fiscal policy play a crucial role in economic stability, it is recommended to implement a correct and accurate fiscal policy to pave the way for an active monetary policy using the new Keynesian model.

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