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Optimal Policy Rules for Iran in a DSGE Framework (Islamic Musharakah Approach)

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Abstract

The aim of this paper is determination of an optimal policy rule for Iranian economy from an Islamic perspective. This study draws on an Islamic instrument known as the Musharakah contract to design a dynamic stochastic general equilibrium model. In this model the interest rate is no longer considered as a monetary policy instrument and the focus is on the impact of economic shocks on the Dynamics of Macroeconomic variables. Finally, a policy rule based on Musharakah is introduced from which the optimal policy and empirical coefficients are derived. Using data from Iran, the empirical results indicate that the policy responses of central bank to output gap and inflation are in accordance with expectations and therefore, economically meaningful. So specified instrument policy rule has to be considered as optimal in general. The optimal policy rules indicate that when the authorities pay equal attention to the inflation and output gaps the minimum loss is occurred.

Keywords: *Musharakah, DSGE model, optimal simple rule, Iran*

JEL Classifications: *C61, C63, E42, E52*

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1. Introduction

In conventional economics, interest rates not only play an important role in money allocation between borrowers and lenders but are also unclear and so are conventional tools for monetary policy, such as discount rate and open market operations.

The Taylor (1993) rule is a simple monetary policy rule which mechanically links the level of the policy rate to deviations of inflation from its target and output from its potential level (the output gap). Initially proposed in US as a simple illustration of desirable policy rules rooted in academic literature, it has become a popular gauge for assessments of the monetary policy stance in both advanced and emerging market economies.

From a theoretical view, Islamic economics is different from conventional economics in the sense that interest rate – Riba – is prohibited in Islam, for example, banks are not allowed to offer a fixed rate of return on deposits and to charge interest on loans. An exclusive feature of Islamic economics is its profit and loss sharing paradigm, which is predominantly based on Mudharabah (profit sharing) and Musharakah (joint venture) concepts of Islamic contracts. Under the profit and loss paradigm, the assets and liabilities of Islamic financial system are integrated in the sense that borrowers share profits and losses with the financial institutions, same as depositors. Advocates of Islamic economics, thus, argue that in terms of absorbing external shocks Islamic financial system is theoretically better structured than conventional financial institutions because the way financial institutions' finance the losses can be partially absorbed by the depositors (Khan and Mirakhor, 1989; Iqbal, 1997). Correspondingly, the profit and loss paradigm featured the risk-sharing function, theoretically, allows Islamic banks to make a longer term basis loan with a higher risk-return profiles and therefore, to promote economic growth (Chapra, 1992; Mills and Presley, 1999).

Islamic economics may face the same macroeconomic issues such as economic growth and price stability. Not only are price stability and inflation incompatible with the goals of Islamic economy, but also prolonged recession and unemployment are unacceptable, because they lead to human suffering. Monetary policy, therefore, aims at high rate economic growth with full employment and utilization of productive resources. However, it should not lead to an excessive and overly-rapid use of resources at the expense of present or future generations. Thus the role of monetary policy in Islamic economics is undeniably essential. This is because in conventional economics, interest rate is the key instrument for executing monetary policy. Prohibiting this variable, which performs as a fundamental pillar in Islamic economics, would cause differences in the process of monetary policy between Muslim countries and countries with conventional economic system.

The first experiments of Islamic banking began in 21^{st} century. According to Islamic economists like Ahmad, Rahman, *et al.* (2011) Islamic and conventional banking, are separated in items of interest rate, risk sharing and materialism. While many of Islamic countries have established mixed systems combining aspects of conventional and Islamic banking practices, Iran is one of the pioneering countries in which banking operations comply with the Sharia rules of Islam. Islamic banking is a system based on legally Sharia- compliant financial instruments and transactions, in which conventional transactions based on an ex-ante promise of a risk-free rate of return, are forbidden and partnership contracts in Islamic banking are innovative in the sense that they are neither fully equity nor a debtor-creditor relationship.

The aim of this paper is determination of an optimal policy rule for economy of Iran from an Islamic perspective. The analysis is based on the idea that monetary policy is not concerned in conventional interest rate instrument, but in Islamic instrument. The paper also intends to explore the welfare gains. This study has designed a DSGE model for economy of Iran based on the participation of private sector and the government on funding the investment. The profit sharing is based on Islamic asset Musharakah contracts. For this purpose an Islamic instrument i.e. the Musharakah share of government is introduced. In this model the interest rate is no longer considered as a monetary policy instrument but the impact of economic shocks on the Dynamics of Macroeconomic variables will be considered. Finally, a policy rule based on Musharakah is introduced and optimal policy coefficient will be derived.

The rest of the paper is organized as follows: Section 2 provides an overview of the conventional and Islamic literature .Section 3 describes the model undertaken in this study. The last two Sections are devoted to the empirical finings and the concluding remarks.

2. Literature Review

Grohe & Uribe (2004) in their study of a real business cycle model augmented with sticky prices, computed welfare-maximizing monetary and fiscal policy rules, a demand for money, taxation, and stochastic government consumption. Their main findings are: First, the size of the inflation coefficient in the interest-rate rule plays a minor role for welfare. It matters only insofar as it affects the determinacy of equilibrium. Second, optimal monetary policy features a muted response to output. More importantly, interest rate rules that feature a positive response to output can lead to significant welfare losses. Third, the welfare gains from interest-rate smoothing are negligible. Fourth, optimal fiscal policy is passive. Finally, the optimal monetary and fiscal rule combination attains virtually the same level of welfare as the Ramsey optimal policy.

Gerali *et al.* (2010) studied the role of credit-supply factors in business cycle fluctuations and introduced an imperfectly competitive banking sector in a DSGE model with financial frictions. Banks issue collateralized loans to both households and firms, obtain funding via deposits and accumulate capital from retained earnings. Margins charged on loans depend on bank capital-to-assets ratios and on the degree of interest rate stickiness. Bank balance sheet constraints establish a link between the business cycles, which affect bank profits, capital, and the supply and cost of loans. The model is estimated with Bayesian techniques using data from the euro area. The analysis leads to the following results: First, the existence of a banking sector partially attenuates the effects of demand shocks, while it helps propagate supply shocks. Second, shocks originating in the banking sector explain the largest share of the fall of output during 2008 in the euro area, when macroeconomic shocks played a limited role. Third, an unexpected destruction of bank capital has a substantial impact on the real economy and particularly on investment.

Anvari, et al. (2011), by using a dynamic stochastic general equilibrium model simulated the inflation and output gaps by applying an interest rate rule that was consistent with the objectives of Islamic economy in Iran. They concluded that minimum interest rate will be obtained, when the inflation rate reaches 3 percent within 6 years. Anvari, et al. (2011), like other studies of DSGE, have applied interest rate as a monetary rule, while in the present study the main instrument is the government Musharakah share and the profit rate of Musharakah is not a policy instrument, but a subjective and private measurement for agents' future investments. Faizi (2008) using a Bayesian method, makes the first attempt to develop and estimate a New Keynesian small open economy DSGE Model for Iran which is one of the pioneering countries whose banking operations comply with the sharia. He argues that in an Islamic framework, the central banks should develop innovative types of Sharia-compliant financial instruments that are also complying with conventional economics. He introduced the nominal exchange rate as an alternative monetary policy instrument for Iranian economy.

Gan and Yu (2009) determined optimal Taylor rule from Islamic perspective for open and emerging market economies. The method is based on Svensson (2000). The idea that monetary policy is not only concerned with conventional interest rate instrument, but also with Islamic interest rate instrument, constitutes the basis for their analysis. Further, the paper intends to explore the welfare gain. Using data from Malaysia, the empirical results indicate that (1) monetary policy responses of central bank to output gap, inflation and exchange rate are in accordance with expectations and economically meaningful and, (2) Islamic monetary policy rule predicts better where *riba* is prohibited in the economy and (3) the specified instrument policy rule have to be considered as optimal in general. Rasoulinezhad (2012) in his article fundamentally presents the concept of DSGE method in combination with Islamic principles in the financial theme. Moreover, a conceptual model is designed through the Interpretive Structural Model (ISM). The results of this paper show the structure of DSGE method in the financial theme with Islamic concepts which can be very practical for researchers and decision makers. The crucial implication of this research would be using Islamic DSGE for Islamic nations with specific related variables.

Azid and Chaudhry (2014) in their paper discussed the underlying causes of international financial crisis under the models presented by Minsky and Mathur. Furthermore, the conventional financial system is compared with Islamic financial system and the strengths of Islamic financial system to stabilize the economies are discussed.

3. The Theoretical Framework

In this study, a new Keynesian DSGE model for a small open economy is designed for Iran, as an Islamic country. The model consists of representative households, firms and government. In this model it is assumed that:

1. There is a small open economy.
2. Apart from the oil exports, the country has no trade with the rest of the world.
3. The country's total production includes intermediate and final goods.
4. The most important assumption of this model like conventional literature is that households are firm's owners, their savings are spent for a part of capital financing of intermediary producers. The rest of their needs are financed through Musharakah. The intermediary producers are confronted with two kinds of costs: labor costs, and capital costs, i.e. the profit share of government Musharakah.
5. The final producer in a competitive market acts as an aggregator, combining intermediate goods to make final goods.
6. The factors of production are not internationally mobile.
7. Goods are normal.

Households

At the beginning of each period, the representative household spends a part of its income (gained from wage and profit share) for buying final goods and services.The rest of income is spent for financing part of the next period capital of intermediate producers. At the end of each period, money is returned to households as wage and profit share, which is again consumed and saved.

The purpose of representative households is to choose the path of consumption, labor, and capital financing (savings) in order to maximize the present value of life time utility:

$$E_t \sum_{t=0}^{\infty} \beta^t u(c_t, l_t) = E_t \sum_{t=0}^{\infty} \beta^t \left[\frac{c_t^{1-\varphi}}{1-\varphi} + \frac{(1-l_t)^{1-\chi}}{1-\chi} \right] \tag{1}$$

E_t shows the conditional expectation at time t and 1 <β <0 is subjective discount factor of the representative household. It is assumed that the household will face two constraints: First, she should pay money for buying goods and services, i.e. cash in advance (CIA) restriction. In the utility function (1/φ) represents the inter-temporal elasticity of substitution, $(1-l)/\chi l$ is Frisch elasticity of labor supply, and *l* is the amount of steady state labor. We assume that:

$$c_t = m_t \tag{2}$$

The second restriction is the budget constraint. At the beginning of each period the household has two sources of money income .i.e. labor income, $w_t l_t$ and capital income (the net profit gained through Musharakah in the previous period, $pr_t \frac{s_{t-1}}{1+\pi_t}$. The household budget constraint can be written as follows:

$$m_t + s_t = w_t l_t + pr_t \frac{s_{t-1}}{\pi_t} + (1-\delta) \frac{s_{t-1}}{\pi_t} - \tau_t \tag{3}$$

In which, m_t and l_t, are real money balances and hours of labor respectively, δ is depreciation rate, and τ_t is net tax payments to the government. Inflation has also been introduced as $\pi_t = P_t/P_{t-1}$.

Money growth follows an AR (1) exogenous process:

$$mu_t = \rho_m mu_{t-1} + (1-\rho_m)\overline{mu} + \varepsilon_t^m \tag{4}$$

where $|\rho_m| < 1$ and ε_t^m is a white noise with zero means and σ_m^2. $\overline{mu}$ stands for the steady state level of money growth.

The net profit gained by household pr_t share of household is:

$$pr_t = \frac{(1-\gamma_t)f_t}{s_{t-1}} = \frac{f_t}{k_{t-1}} \tag{5}$$

f_t is the total profit of intermediate firm which is used by households and government Musharakah for capital financing. γ_t and $(1-\gamma_t)$ are defined as the profit shares of government and households Musharakah:

$$1-\gamma_t = \frac{s_{t-1}}{k_{t-1}} \tag{6}$$

Household's choice variables are consumption, labor, money and share of Musharakah in financing capital.

The Lagrangian function can be formulated as follows:

$$\mathcal{L} = \max \sum_{t=0}^{\infty} E_t \beta^t \left[u(c_t, l_t) + \lambda_t (m_t - c_t) + \mu_t \left(w_t l_t + pr_t \frac{s_{t-1}}{1+\pi_t} + (1-\delta)\frac{s_{t-1}}{1+\pi_t} - m_t - s_t - \tau_t \right) \right] \tag{7}$$

The optimality conditions of this problem can be written as follows:

$$\frac{-u_2(c_t, l_t)}{u_1(c_t, l_t)} = w_t \tag{8}$$

$$\frac{u_1(c_t, l_t)}{E_t u_1(c_{t+1}, l_{t+1})} = \beta \frac{1-\delta+pr_{t+1}}{1+\pi_{t+1}} \tag{9}$$

The above properties reveal the optimality conditions, i.e. the inter-temporal choice between labor supply and consumption and the Euler equation.

Firms

Final goods producer

Final product market is a competitive market in which the continuous amounts of intermediate products $f \angle 0,1$ are aggregated through a CES function:

$$Y_t = \left(\int_{\circ}^{1} y_t(f)^{1-\theta} df \right)^{\frac{\theta}{\theta-1}} \tag{10}$$

Here, $\theta > 1$ shows the elasticity of substitution of demand for intermediate goods. The final firm buys the input at price $p_t(f)$ and presells the final goods at price p_t. The demand for intermediate product (f) is derived by the profit maximization of the final good producers as follows:

$$\max \pi = P_t Y_t - \int_{\circ}^{1} p_t(f) y_t(f) df \tag{11}$$

By replacing Y_t from (10) we will have:

$$\max \pi = P_t \left(\int_{\circ}^{1} y_t(f)^{1-\frac{1}{\theta}} df \right)^{\frac{\theta}{\theta-1}} - \int_{\circ}^{1} p_t(f) y_t(f) df$$

The solution to F.O.C problem yields the demand for final goods:

$$y_t(f) = \left(\frac{p_t(f)}{P_t} \right)^{-\eta} Y_t \tag{12}$$

Where

$$P_t = \left(\int_{\circ}^{1} p_t(f)^{-\frac{1}{\theta}} df \right)^{-\theta} \qquad (13)$$

Intermediate good producer firms

It is supposed that economy consists of a continuous number of intermediate goods producers act in monopolistic competitive market indexed by $f \angle [\circ,1]$. These producers adjust their price according to Calvo process and rent labor in a competitive market. The producers operate through a Cobb-Douglas production function:

$$y(f)_t = A_t k(f)_t^{1-\eta} l(f)_t^{\eta} \qquad (14)$$

A_t is a static productivity shock, $k_t(f)$ and $l_t(f)$ are capital and labor inputs. Technology shock follows from an AR (1) process:

$$logA_t = \rho_A logA_{t-1} + \varepsilon_t^A \qquad (15)$$

Where ε_t^A is white noise process with zero mean and variance σ_A^2 and $<|\rho_A| < 1$

In this model, the firm's capital is funded by government and households. In each period, the required capital is financed by participation of household's savings s_t and government Musharakah in capital funding (x_t). The total capital can be written as:

$$k_t = x_t + s_t \qquad (16)$$

In each period, the equation for the movement of capital can be written as follows:

$$k_{t+1} = (1 - \delta)k_t + i_t \qquad (17)$$

Final goods firms set the prices based on Calvo process with probability of $1-\xi$. At the end of the contract the firm can set its contracts freely again. The price sets in period t is shown with $p_t(f)$. In a period that the contract is valid, the firms should supply the demanded product at $p_t(f)$ and rent labor at $l_t(f)$. The maximization relation of the firm can be formulized as follows:

$$\max_{p_t(f)} E_t \sum_{j=0}^{\infty} \xi^j \lambda_t [p_t(f) y_t(f) - w_t l_t - \gamma_t f_t] \tag{18}$$

Where, λ_t is the marginal utility of consumption. The phrase in the parenthesis is the distributed profit between households and government. Where, f is defined as:

$$f_t = p_t(f) y_t(f) - w_t l_t \tag{19}$$

The total cost can be defined as:

$$CC_t = w_t l_t + \gamma_t f_t \tag{20}$$

Minimizing the cost subject to production function, yields the cost function:

$$CC_t = A_t^{-1} \left(\frac{w_t}{\eta}\right)^{\eta} \left(\frac{pr_t}{1-\eta}\right)^{1-\eta} y_t(f) \tag{21}$$

The marginal cost is a differentiation of product level variable of each firm. Differentiating from (19) subject to $p_t(f)$ and regarding cost function of (21) reaches to standard optimization condition of firm:

$$p_t(f) = \frac{(1+\tau) E_t \sum_{j=0}^{\infty} \xi^j m_{t,t+j} mc_{t+j}(f) y_{t+j}(f)}{E_t \sum_{j=0}^{\infty} \xi^j m_{t,t+j} y_{t+j}(f)} \tag{22}$$

Where $mc_t(f)$ shows the marginal cost of firm *f* in time *t*:

$$mc_t(f) = A_t^{-1}\left(\frac{w_t}{\eta}\right)^{\eta}\left(\frac{pr_t}{1-\eta}\right)^{1-\eta}$$

Oil Sector

Oil production has not been modeled as a separate productive sector, because oil revenue is exogenous and a function of the exogenous changes in oil prices. The oil revenue shock follows a AR (1) process as follows:

$$or_t = \rho_{or} or_{t-1} + (1-\rho_{or})\bar{or} + \varepsilon_t^{or} \quad (23)$$

Where $<|\rho_{or}| < 1$ and ε_t^{or} is a white noise process with zero mean and σ_{or}^2 variance. Moreover, $\bar{or}$ is the steady state value of the oil revenues and or_t is the real flow of oil revenues. It is assumed that the oil revenue is a part of government income.

Government and monetary authority

It is assumed that government is in charge of both monetary and fiscal policies. The real government budget constraint is defined as:

$$g_t + x_t = or_t + \tau_t + \gamma_t f_t + (1-\delta)x_{t-1}$$

Where, g_t is the real government expenditure, τ_t is the lump sum tax revenue, or_t is the real oil revenue, and x_t is the participation share of government in capital funding. It is assumed that the government real expenditures follow an AR (1) process:

$$g_t = \rho_g g_{t-1} + (1-\rho_g)\bar{g} + \varepsilon_t^g$$

Where, $<|\rho_g| < 1$, ε_t^g is a white noise process with zero mean and σ_g^2 variance, and $\bar{g}$ is the steady level of government expenditures.

As a monetary authority, government implements the monetary policy to close the inflation and output gaps. In this article, the monetary policy instrument is government's share of Musharakah (γ_t) instead of interest rate. The Policy rule that monetary authority applies to close the gaps is formulated as:

$$\left(\frac{\gamma_t}{\gamma}\right) = \left(\frac{\pi_t}{\pi}\right)^{g_\pi} \left(\frac{y_t}{y}\right)^{g_y} \left(\frac{\gamma_{t-1}}{\gamma}\right)^{g_\gamma} e_t \qquad (24)$$

Market-clearing conditions

Total labor and capital required for manufacturing enterprises. L_t and K_t can be written as:

$$L_t = \int_0^1 l_t(f)\, df$$
$$K_t = \int_0^1 k_t(f)\, df \qquad (25)$$

and the aggregate production function for the economy is:

$$Y_t = \Delta_t^{-1} A_t K_t^{1-\eta} L_t^{\eta} \qquad (26)$$

Factor market equilibrium implies that $L_t = l_t$_t and $K_t = S_t + X_t$, in other words, supply and demand for the factors of production are equal. In the money market demand and supply of money should be equal: $m_t = c_t$.

The equilibrium condition can be written as:

$$y_t + or_t = c_t + i_t + g_t \qquad (27)$$

in which, oil and non-oil production are allocated to household consumption expenditure, government expenditure, and investment.

IS and Philips curves

By solving the model, IS and Phillips curves can be derived as:[1]

$$\tilde{y}_t = \tilde{y}_{t+1} + \frac{(c_{ss}/y_{ss})}{\varphi}\tilde{\pi}_{t+1} + \zeta_t \tag{28}$$

The difference between the above mentioned IS and the conventional one is that, IS is no longer dependent on interest rate.

$$\tilde{\pi}_t = \text{o}\tilde{y}_t + \vartheta\tilde{\gamma}_t + \beta E_t\tilde{\pi}_{t+1} + \epsilon_t \tag{29}$$

Phillips curve indicates that, inflation is a function of output, the share of government Musharakah, and the expected inflation. The share of government Musharakah, $\tilde{\gamma}$ is added to Phillips curve. By removing the government Musharakah from the model, the standard Phillips will be obtained. It is noticeable that $\tilde{\gamma}$ has affected the economy through supply side. Now we add the third equation to the model, i.e. a policy rule. Then by using an optimal simple rule (OSR) the optimal coefficients in policy rule can be obtained.

Following Rotenberg and Woodford, a large number of literatures provide a welfare base criterion that uses second order approximation of social welfare function. According to Gali (1961) the social loss functioning in a new Keynesian model can be derived as follows:

$$W = \frac{1}{2}E_0\sum_{t=0}^{\infty}\beta^t\left(\left(\varphi + \frac{\varphi + 1 - \eta}{\eta}\right)\tilde{y}_t^2 + \frac{\epsilon}{\lambda}\tilde{\pi}_t^2\right) \tag{30}$$

Where, $\epsilon = 1 + \theta/\theta$ and $\lambda = (1-\xi)(1-\xi\beta)/\xi$.

Unsurprisingly, OSR estimation leads to high values of g_y an g_π in Musharakah rule because there is no compensation in the objective

1. For proofs please see the appendix.

function for high variance of the policy instrument (here Musharakah rule). A more realistic model requires a compensating term for high variance of policy instrument (Juillard, 2010), as:

$$W = \lambda_1 \tilde{y}_t^2 + \lambda_2 \tilde{\pi}_t^2 + \lambda_3 \widetilde{\Delta\gamma}_t^2$$

The optimal inflation rate is its steady state value, i.e. zero, and the optimal output growth is computed by using HP filter for the economy of Iran during the period 1979-2012.

4. Results

Calibration

In this model, the interest rate no longer acts as a monetary policy instrument. But an Islamic instrument i.e. the Musharakah share is introduced into the model. Estimating the parameters of the model is one of the important stages of empirical measurement in general equilibrium models. The required ratios for the calibration are derived from the Central Bank annual data during the period 1979-2012. It is noticeable that the household discount factor is derived from steady state values.

As the first step, the parameters of the model are either calibrated on the basis of previous studies, or computed based on the observed steady-state levels of real variables. The calibrated parameters are shown in table 1.

Steady State Parameters

In this section, the parameters influencing the deterministic steady state of the model are identified. Table 2 shows the steady state ratios of variable of the economy of Iran during the period 1979-2012. Table 2 shows the steady state ratios of variable of the economy for 1979-2012 period.

Table 1: The Calibrated Parameters

Symbol	**Parameter explanation**	**Calibrated value**	**Resource**
φ	substitution elasticity of consumption	1.5	Bahatarchi and Tuneinson (2005)
η	share of labor supply in production	0.656	Research findings
β	subjective discount rate	0.976	Research findings
$\frac{1+\theta}{\theta}$	demand elasticity of intermediate products	4.33	based on 30% mark up
$\frac{1-l_{ss}}{\chi l_{ss}}$	elasticity of labor supply subject to wage (Frisch)	0.46	Taei (2006)
δ	depreciation rate	0.07	Research findings
ρ_i	government participation weight in the of monetary policy	0.3	Research findings
g_y	production weight in the monetary policy	1.37	Research findings
g_π	inflation weight in the monetary policy	0.3	Research findings

Source: Research findings

Table 2: The Steady State Ratios Gained from the Time Series of Iran's Economy

Ratio of steady states	Explanation of ratios	Calculated amount
$\frac{c_{ss}}{y_{ss}}$	Steady ratio of consumption of private sector to non-oil production	0.58
$\frac{or_{ss}}{y_{ss}}$	Steady ratio of oil incomes to non-oil production	0.104
$\frac{g_{ss}}{y_{ss}}$	Steady ratio of government expenditures to non-oil production	0.195
$\frac{\tau_{ss}}{y_{ss}}$	Steady state ratio of government tax incomes to non-oil production	0.048
γ_{ss}	Steady state level of government participation rate to investment	0.28

Source: Research findings

Second Order Moments of Variables

In order to complete the quantitative analysis, Table 3 shows the standard deviations of key variables of the model. The results show that the standard deviation of consumption is the highest for both real and simulated data. The volatility of investment is more than non-oil sector. The simulated standard deviations of real and simulated variables are close together. Using data from Iran, the empirical results indicate that the policy responses of central bank to output gap and inflation are in accordance with expectations and economically meaningful and, the specified instrument policy rule has to be considered as optimal in general. We may conclude that the simulated model represents the economy of Iran.

Table 3: Comparison between Second Moments of Simulated and Real Data Variables

Variable	Standard Deviation (S.D.)		Correlation with non-oil production		Relative S.D.	
	Model	Real data	Model	Real data	Model	Real data
Non-oil production	0.059	0.05	1	1	1	1
Consumption	0.062	0.07	0.70	0.83	1.05	1.4
Investment	0.159	0.13	0.69	0.73	2.69	2.6

Source: Research findings

Discussion

In this section, four economic shocks are divided into supply and demand shocks. The effects of demand and supply shocks on the output and inflation gaps and on the share of government Musharakah are shown in the following figures. To analyze these shock effects in this model, each shock is considered to have either direct or indirect effects through policy rule. The direct effect of a positive demand shock increases the output gap in period t and through policy rule increases $\tilde{\gamma}_t$ and consequently inflation gap through Phillips curve due to inflationary expectations leads to adjust the output gap. So in this model, $\tilde{\gamma}_t$ acts as a countercyclical instrument.

A positive supply shock increases directly the inflation and indirectly the share of government Musharakah through policy rule. This indirect effect with one period lag through IS curve (inflation expectation) and policy rule decreases output. Supply shock affects output, first, immediately after initial supply shock, and then through increasing $\tilde{\gamma}_t$ in policy rule. Then, the output change affects $\tilde{\gamma}_t$. Therefore, $\tilde{\gamma}_t$ decreases until the economy converges to the steady state.

Figure 1: Demand side shock effects

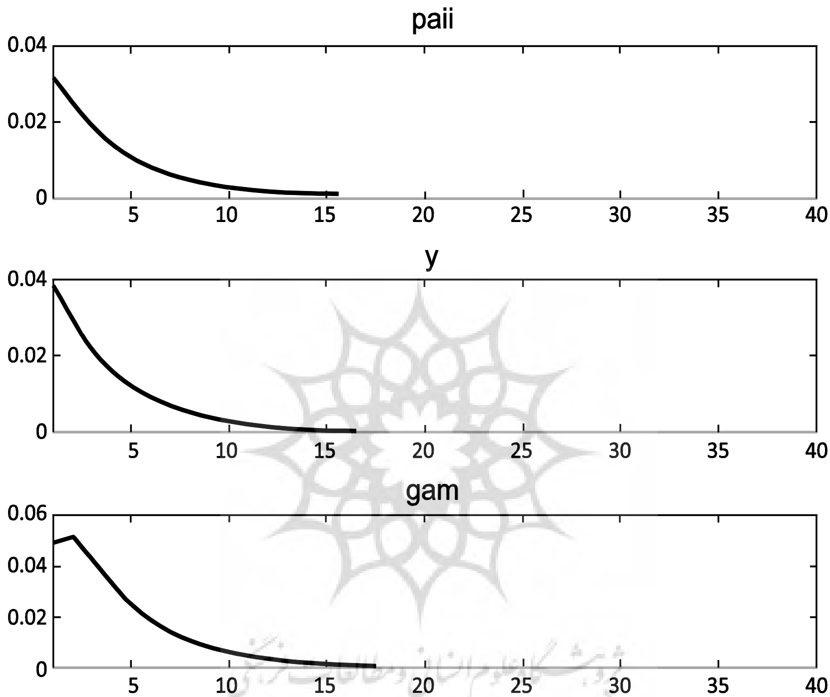
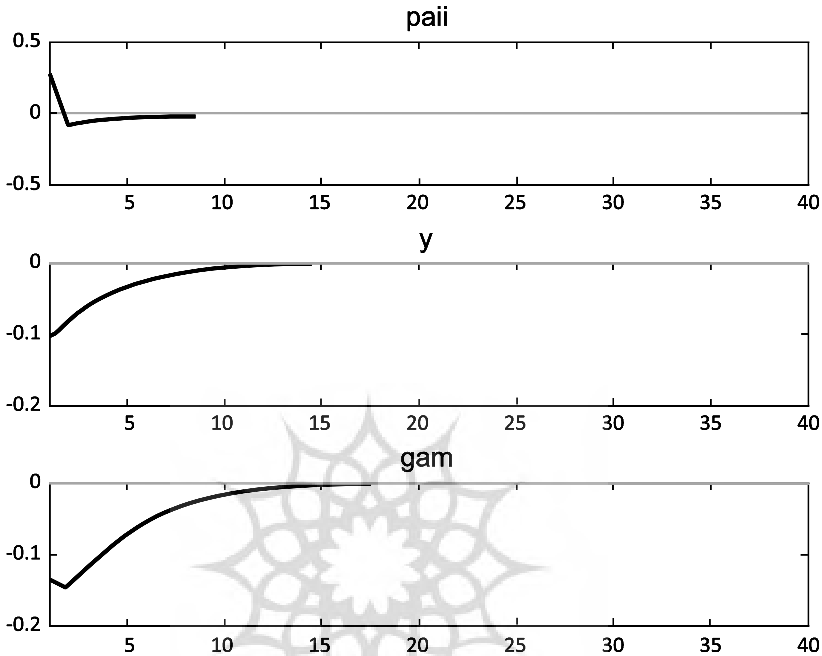


Figure 2: Supply side shock effects



According to Figure 2 a supply shock increases inflation rate (paii) and decreases output (y) and then $\tilde{\gamma}_t$ (gam) until the gaps are closed.

The optimal policy coefficients

In this section we characterize the optimal policy problem in a small open economy with sticky prices. For this purpose the policy rules and quadratic welfare loss functions can be derived from the model above as:

$$\tilde{\gamma}_t = \rho_i \tilde{\gamma}_{t-1} + (1-\rho_i)\left[g_y(\tilde{y}_t - \bar{y}) + g_\pi(\tilde{\pi}_t)\right]$$

$$W = \lambda_1 \tilde{y}_t^2 + \lambda_2 \tilde{\pi}_t^2 + \lambda_3 \widetilde{\Delta\gamma}_t^2$$

Table 3: The Optimal Coefficients of Musharakh Rule

	Optimal Rules						
	ρ_i^*	g_y^*	g_π^*	W	V_γ	V_y	V_π
Ramsey Rule	-	-	-	0.458	0.4160	0.0177	0.0843
$g_y = 0.3$ $g_p = 1$ $\rho_i = 0.3$	0.648	0.366	1.067	0.0514	0.016	0.0246	0.0878
$g_y = 0$ $g_p = 1$ $\rho_i = 0.3$	0.722	0.315	1.311	0.0512	0.0181	0.0245	0.0879
$g_y = 1$ $g_p = 0.3$ $\rho_i = 0.3$	0.644	1.062	0.364	0.0514	0.0156	0.0247	0.0878
$g_y = 1$ $g_p = 0$ $\rho_i = 0.3$	0.713	1.275	0.272	0.05136	0.0159	0.0246	0.088
$g_y = 1$ $g_p = 1$ $\rho_i = 0.3$	0.653	0.963	0.962	0.0508	0.0276	0.0239	0.0873
Empirical Non-optimal Rules							
Smoothing rules	0.3	1.37	0.3	0.19791	0.0458	0.0234	0.0858
No-smoothing rules	-	1.37	0.3	0.199562	0.0485	0.0236	0.0852
Simple rules	-	-	0.3	0.220575	0.0005	0.0324	0.0940

Source: Research findings

In this paper, the loss function equation indicates social cost or loss associated with twin “evils” of deviations of inflation from equilibrium (desired) rate and deviations of output from potential (full employment) levels. One of the methods for analyzing the optimal policy drawn from the model is finding the coefficients that maximize (or minimize) the social welfare (central bank’s loss function). For this purpose, different weights for output, inflation and share of government Musharakah in objective function are estimated for the optimal and non-optimal rules by Dynare software. Table 3 compares the results for the optimal and non-optimal rules. The scenarios with the least welfare loss and the least gaps are the preferred policies.

The results show that when the authorities respond equally to the inflation and output gaps, minimum loss occurs.

Table 3 shows that in the case of implementing non – optimal rules, the maximum loss is occurred when policy instrument responds strictly to the inflation gap. The welfare losses in optimal rules are less than non - optimal rules. Furthermore, optimal rules need less government response to close the gaps. Finally, the volatility of output and inflation in optimal rules are less than non – optimal rules.

Table 4: Real Gaps, Empirical Gaps, and Optimized Gaps in the Model

Optimal policy%	Empirical rules %	Real Data%	
0	0.3	18.7	Inflation gap
1.6	6.4	9.1	Output Gap

Source: Research findings

The above table which is based on the real data of the economy of Iran during the period 1981-2012, shows that the output gap is 9.1 % of potential output, while this ratio is 6.4 % and 1.6% in empirical and optimal rules respectively. The inflation gap is 18.7%, 3% and 0% for real data, empirical and optimal rules respectively. These results indicate that the simulated optimal and empirical models have the ability to converge economy to their targeted values.

5. Concluding Remarks

The purpose of this study is providing a dynamic stochastic general equilibrium model by introducing an Islamic instrument i.e. the Musharakah contracts in Iran. In this model the interest rate no longer acts as a monetary policy instrument. Then, the impact of economic shocks on the Dynamics of Macroeconomic variables is considered. Finally, a policy rule based on Musharakah is introduced and optimal policy and empirical coefficients are derived. Using data from Iran, the empirical results indicate that policy responses of central bank to output gap and inflation are in accordance with expectations and are economically meaningful and, the specified instrument policy rule have to be considered as optimal in general. Moreover, the results reveal that: First in non – optimal empirical rules, the maximum loss is occurred when, policy instrument responses strictly to inflation gap. Second, the welfare losses in optimal rules are less than non- optimal rules. Third, in optimal rules, less government response is required to close the gaps, and, finally, in optimal rules, the volatility of both output and inflation are less than the non –optimal rules. The optimal policy rules indicate that when the authorities respond equally to the inflation and output gaps, the minimum loss is occurred. The results confirm that the new policy rule introduced in this paper can be a good substitute for Tailor Rule in conventional models.

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Appendices

Appendix 1: Log-Linearized equation system

$$\chi\left(\frac{l_{ss}}{1-l_{ss}}\right)\tilde{l}_t + \varphi\tilde{c}_t = \widetilde{w}_t \tag{17}$$

$$\tilde{c}_t = E_t\tilde{c}_{t+1} - \frac{1}{\varphi}E_t(\widetilde{pr}_{t+1} - \tilde{\pi}_{t+1}) \tag{18}$$

$$\widetilde{mc}_t = -\tilde{a}_t + \eta\widetilde{w}_t + (1-\eta)(\widetilde{pr}_t + \tilde{\gamma}_t) \tag{19}$$

$$\tilde{\pi}_t = \frac{(1-\xi)(1-\xi\beta)}{\xi}\widetilde{mc}_t + \beta E_t\tilde{\pi}_{t+1} \tag{20}$$

$$E_t\tilde{k}_{t+1} = \tilde{k}_t + \delta\tilde{\imath}_t \tag{21}$$

$$\tilde{k}_t\left(\frac{k_{ss}}{y_{ss}}\right) = \tilde{s}_t\left(\frac{s_{ss}}{y_{ss}}\right) + \tilde{x}_t\left(\frac{x_{ss}}{y_{ss}}\right) \tag{22}$$

$$\widetilde{pr}_t = \tilde{f}_t - \tilde{k}_{t-1} + \tilde{\pi}_t \tag{23}$$

$$\tilde{x}_t = E_t\tilde{\gamma}_{t+1} + \tilde{k}_t \tag{24}$$

$$\tilde{y}_t = \tilde{a}_t + (1-\eta)\tilde{k}_t + \eta\tilde{l}_t \tag{25}$$

$$\tilde{g}_t\left(\frac{g_{ss}}{y_{ss}}\right)+\tilde{x}_t\left(\frac{x_{ss}}{y_{ss}}\right)=\widetilde{or}_t\left(\frac{or_{ss}}{y_{ss}}\right)+\tilde{\tau}_t\left(\frac{\tau_{ss}}{y_{ss}}\right)+\left(\tilde{\gamma}_t+\tilde{f}_t\right)\gamma_{ss}\left(\frac{f_{ss}}{y_{ss}}\right)+(1-\delta)\tilde{x}_{t-1}\left(\frac{x_{ss}}{y_{ss}}\right) \quad (26)$$

$$\tilde{k}_t-\tilde{l}_t=\widetilde{w}_t-\widetilde{pr}_t-\tilde{\gamma}_t \quad (27)$$

$$\widetilde{mu}_t=\widetilde{m}_t-\widetilde{m}_{t-1}+\tilde{\pi}_t \quad (28)$$

$$\tilde{\gamma}_t=\rho_i\tilde{\gamma}_{t-1}+(1-\rho_i)\left[g_y(\tilde{y}_t-\bar{y})+g_\pi(\tilde{\pi}_t)\right] \quad (29)$$

$$\tilde{c}_t=\widetilde{m}_t \quad (30)$$

$$\tilde{y}_t+\widetilde{or}_t\left(\frac{or_{ss}}{y_{ss}}\right)=\tilde{c}_t\left(\frac{c_{ss}}{y_{ss}}\right)+\tilde{\iota}_t\left(\frac{i_{ss}}{y_{ss}}\right)+\tilde{g}_t\left(\frac{g_{ss}}{y_{ss}}\right) \quad (31)$$

$$a_t=\rho_A a_{t-1}+(1-\rho_A)\bar{a}+\varepsilon_t^a \quad (32)$$

$$g_t=\rho_g g_{t-1}+\left(1-\rho_g\right)\bar{g}+\varepsilon_t^g \quad (33)$$

$$mu_t=\rho_m mu_{t-1}+(1-\rho_m)\overline{mu}+\varepsilon_t^m \quad (34)$$

$$or_t=\rho_{or}or_{t-1}+(1-\rho_{or})o\bar{r}+\varepsilon_t^{or} \quad (35)$$

Appendix 2: IS and Phillips curves derivation

IS is derived from substituting equity (45) in Euler (32):

$$\tilde{y}_t - (i_{ss}/y_{ss})\tilde{\imath}_t - (g_{ss}/y_{ss})\tilde{g}_t + (or_{ss}/y_{ss})\widetilde{or}_t = \tilde{y}_{t+1} - (i_{ss}/y_{ss})\tilde{\imath}_{t+1} - (g_{ss}/y_{ss})\tilde{g}_{t+1} + (or_{ss}/y_{ss})\widetilde{or}_{t+1} + \frac{(c_{ss}/y_{ss})}{\varphi}(\tilde{\pi}_{t+1} - \widetilde{pr}_{t+1})$$

Rearranging the properties of above parameters gives:

$$\tilde{y}_t = \tilde{y}_{t+1} + (i_{ss}/y_{ss})\widetilde{\Delta\imath}_t - (g_{ss}/y_{ss})\widetilde{\Delta g}_t + (or_{ss}/y_{ss})\Delta\widetilde{or}_t + \frac{(c_{ss}/y_{ss})}{\varphi}(\tilde{\pi}_{t+1} - \widetilde{pr}_{t+1})$$

The second terms carries the demand side variables which are independent of Policy (*tip.*) Summarized as ζ_t:

$$\tilde{y}_t = \tilde{y}_{t+1} + \frac{(c_{ss}/y_{ss})}{\varphi}\tilde{\pi}_{t+1} + \zeta_t$$

where ζ_t is a white noise demanding side shocks with zero mean and variance of σ_t^2 . The most important feature of this IS is its independence of interest rate as a policy instrument.

Philips curve is derived from substituting (33) in (34). Substituting in (33) from (31) for $\widetilde{w}_t$ implies that:

$$\widetilde{mc}_t = -\tilde{a}_t + \eta(\nu\tilde{l}_t + \varphi\tilde{c}_t) + (1-\eta)(\widetilde{pr}_t + \tilde{\gamma}_t)\widetilde{mc}_t = -\tilde{a}_t + \eta(\nu\tilde{l}_t + \varphi\tilde{c}_t) + (1-\eta)(\widetilde{pr}_t + \tilde{\gamma}_t)$$

where $\nu = \chi\left(\frac{l_{ss}}{1-l_{ss}}\right)$. Knowing that profit rate is *t.i.p.* substituting from (39) and (44), imply;

$$\widetilde{mc}_t = -\tilde{a}_t + \eta\left(\frac{\nu}{\eta}(\tilde{y}_t - \tilde{a}_t + (1-\eta)\tilde{k}_t) + \varphi\tilde{m}_t\right) + (1-\eta)(\widetilde{pr}_t + \tilde{\gamma}_t)$$

$$\widetilde{mc}_t = \nu\tilde{y}_t + (1-\eta)\tilde{\gamma}_t + (t.i.p)$$

Substituting the above equation in Philips curve, obtains:

$\tilde{\pi}_t = \frac{(1-\xi)(1-\xi\beta)}{\xi}(\nu\tilde{y}_t + (1-\eta)\tilde{\gamma}_t + (t.i.p)) + \beta E_t\tilde{\pi}_{t+1}$

$substituting\ 0 = \lambda\,\nu$, and $\vartheta = \lambda(1-\eta)$ in which
$\lambda = (1-\xi)(1-\xi\beta)/\xi$ gains Phillips curve:

$$\tilde{\pi}_t = \text{o}\tilde{y}_t + \vartheta\tilde{\gamma}_t + \beta E_t\tilde{\pi}_{t+1} + \epsilon_t$$

Appendix 3: Empirical coefficients

Dependent Variable: LGAM_CY
Method: Least Squares
Date: 04/27/15 Time: 17:08
Sample (adjusted): 1982- 2001
Included observations: 30 after adjustments
Convergence achieved after 12 iterations
No d.f. adjustment for standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.085836	0.046885	1.830788	0.0791
LGAM_CY(-1)	0.300540	0.155479	1.932995	0.0646
YHAT(1)	0.964931	0.495519	1.947312	0.0628
LINF_CY(1)	0.199932	0.070619	2.831134	0.0090
AR(3)	0.010809	0.182675	0.059171	0.9533

R-squared	0.364930	Mean dependent var	0.008038
Adjusted R-squared	0.263319	S.D. dependent var	0.168644
S.E. of regression	0.144747	Akaike info criterion	-0.876645
Sum squared resid.	0.523793	Schwarz criterion	-0.643112
Log likelihood	18.14967	Hannan-Quinn criter.	-0.801936
F-statistic	3.591437	Durbin-Watson stat	2.045038
Prob.(F-statistic)	0.019075		

Inverted AR Roots	.22	-.11-.19i	-.11+.19i