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The Effect of Asymmetric Information in the Money Market on Investment, Employment, and Production in Iran

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Abstract

Nowadays, banks are considered as one of the major components of the financial system of a country and any deficits and malfunction in the banking system will negatively affect the performance of the real sector. Therefore, there is a need for more investigation on the behavior of banks and factors affecting those behaviors in a country. One of the issues that affect the behavior of banks is symmetric information. Thus, the main aim of the present study was to investigate the impact of asymmetric information in the money markets on investment, production, and employment. Hence, based on the New-Keynesian framework, a Dynamic Stochastic General Equilibrium (DSGE) model was adopted in accordance with the structure of the economy of Iran. The designed model entailed nine sectors including households, firms, banks, the Central Bank, oil, the government, exports, imports, and other countries of the world. Moreover, the rigidities of the prices and wages, and the rigidities of the imported and exported goods were taken into account in the model. By using the Bayesian method and data gathered from Iran during 1974-2017, the parameters of equations were estimated and the impact of symmetric information was investigated. The results indicated that increasing the asymmetric information and reducing the honesty in the society through decreasing the resources available to the banks and increasing the cost of banks will lead to an increase in the profit of the facilities. Also, increasing the profit of banks concessional loans decreases investment, production, and employment.

1. Introduction

Within the recent few decades, asymmetric information has been regarded as a serious topic by the scholars because any market analysis without a consideration of the asymmetric information would possibly render an incomplete analysis. Generally, Asymmetric information refers to a context in which economic agents and stakeholders have access to different source and kinds of information. Strategic opportunities based on asymmetric information

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usually lead to inefficiencies in the market, which is a form of market failure (Jehle & Reny, 2011).

Overall, it can be said that asymmetric information leads to two types of opportunistic behaviors including "adverse selection" and "moral hazard". In financial markets[1], the phenomenon of adverse selection occurs before the ratification of a contract while moral hazard occurs after the conclusion of contracts. The adverse selection is about the people who have potentially bad credit risk and are actively seeking loans from the financial markets whereas the moral hazard, as just touched upon, occurs after conclusion of contracts and reduces the possibility of reimbursement of the loan (Meshkin, 2010). Moreover, the optimal performance of the economic system in any given society depends on the existence of two sectors, i.e. the real sector and the financial sector, which are complementary. The main task of an efficient financial sector is to optimize the allocation of the limited financial resources among the competing economic sectors in the economy. Asymmetric information disturbs the activities of financial markets in optimizing the allocation of financial resources to the real sectors of the economy, and this insufficiency in the activities of the market will have negative impacts on the performance of the real sector of the economy, including investment, production, and, consequently, job opportunities, income, the development of domestic and foreign trade, and the efficiency of the government sector (Shafiei, 2011).

Regarding the theoretical and empirical studies which have been done, the main question of the present study was the following:
"How does the asymmetric information in the money market impact the investment, employment, and production?"

This study consists of five sections. In the introduction section, a prelude to the discussion of asymmetric information and its elements are presented. The second section is devoted to a review of the literature. Section three provides an explanation of the methodology applied in this study. Section four provides an analysis of the results of the study, and, finally, the summary of the study and some conclusions are presented in the last section of this research.

2. Literature Review

Asymmetric information refers to a situation where an economic agent has particular information in his trade while the other side of the trade does not have the same kind of information. The asymmetric information in the financial market will lead to two types of opportunistic behaviors including "adverse selection" and "moral hazard" (Shakeri, 2007).

An adverse selection occurs before the ratification of a contracts in the financial markets and loan. People who have a potentially bad credit risk are normally more likely to seek loans from the financial markets than others. Therefore, each of the parties in the contract that produces bad products is

[1] The financial market is classified into two categories: the money market and the capital market.

among the more likely people who will be willing to engage in trade. For example, risky people or fraudsters may are among those who are eager to get a loan because they know it probably will not be repaid (Meshkin, 2010).

Moral hazard occurs after conclusion of the contract. The lender manages the risk of giving a loan to a borrower who is engaging in high-risk activities from the perspective of the lender. This risk may be due to the loans which have not been repaid in such activities. For example, borrowers may use their loans in high-risk cases (may have high returns or maybe failure), actually doing risky activities with others' financial resources. Since moral hazard reduces the probability of repayment loans, it may discourage lenders not to lend loans to some borrowers (Meshkin, 2010).

Most economists believe that the background of the economics of information is related to the twenty-first century and the era of Akerlof (1970), Spence (1973), and Stigler (1961). However, the topic can also be seen in the works of Mirrlees, Vickrey, and even Smith, Marshall, Sismondi, and Mill. For example, Marshall described that because of the workers monitoring problems, they do not always receive wages based on their performance. Moreover, according to him, deficiencies in the economic information make it impossible to provide an accurate and inclusive analysis. Stieglitz believes that researchers who above listed, perceived the results of asymmetric information and understood the importance of it, but none of them sought the logical inference of the discussion (Stieglitz, 2006).

Some other economists have also addressed the topic of asymmetric information. These include Jehle and Reny (2011), Bergeman (2009), Birchler and Manika (2007), Zandt (2006) and Ricardo (2003).

Among the Islamic scholars who have dealt with the issue of asymmetric information, we can refer to Ibn Taymiyyah (Seven century AH), whose studies focused on pricing and market defects, as well as Ibn Khaldun's (eighth century AH), who was interested in exploring the role of government in economic fluctuations (Ghaffari & Abolhasani, 2010).

Sameti et al. (2012) probed into the impact of the financial indexes on the GDP growth in both the developing and developed selected countries. According to the results of their study, increasing the symmetric information in the money market had a positive effect on the economic growth, but enhancing the symmetric information in the capital market had a negative and significant effect on the economic growth in both the developing and developed selected countries. In their research, the ratio of bank credits paid by the public sector to bank credits paid by the private sector was used as a proxy to measure the asymmetric information in the money market (in countries with more asymmetric information, a high percentage of credits is allocated to the public sector and a smaller proportion is allocated to the private sector.

Nasrallahi and Shafie (2016) investigated the impact of honesty in the financial markets on investment and production. The sample in this study is a selection of developed countries (G8) and developing countries during the

period of 1993-2012. The results indicated that increasing honesty caused a decrease in the cost of financial intermediaries and the price and rental rate of capital. Moreover, honesty in the financial markets could lead to a rise in investment, capital, and production in a steady state, thereby enhancing the consumption and welfare of the people. Furthermore, according to results regarding both groups of countries, increasing honesty in the financial market would lead to the expansion of productions and economic growth, and that is in line with the theoretical foundations of research.

Bebczuk (2003) investigated the relationship between private investment financed with bank credit and economic growth by using panel data and simple growth models and by interfering asymmetric information. The results of the study indicated that reducing asymmetric information will increase investment and economic growth. In this research, the asymmetric information index is the ratio of capital invested by banks for the financing investments to the total investment (because in low-level of asymmetric information in the society, directly financing investment projects is done and there is no need for financial intermediaries).

Claus (2010) in his research divided the economy into different sectors, investigated the behavior of each economic sector, and extracted related functions under asymmetric information. Using the DSGE model, he found out that the degree of symmetric information decreased the rental rate of capital, and it also led to an increase in investment and capital and, consequently, production.

Rannenberg (2012) investigated the impact of asymmetric information in the credit market on the US economy. By using the DSGE models, the results showed that the issue of moral hazard between banks and depositors and the costs due to the asymmetric information between employers and banks lead to a steady decline in the GNP and inflation in the US economy.

Heidari and Molabahrami (2015) investigated the household portfolio channel of credit shocks transmission in Iran with the DSGE model. A positive deposit rate shock reduced the proportions of financial and physical assets in the household portfolio and increased marginal cost and inflation. This shock decreased investment and output.

Apergis et al. (2016) examined the effect of asymmetric information on employment by using econometric method and panel data. Results showed that asymmetry of information had a negative effect on employment.

Billett et al. (2017) investigated the impact of asymmetric information in the financial markets on the production. By applying the Difference-In-Difference test, the results indicated that the growth of asymmetric information led to a reduction in sales and production.

Cui and Shibata (2017) probed into the impact of symmetric information on the investment. By assuming the existence of asymmetric information between the capital owner and the manager of the investor, the asymmetric information index was taken to be the discrepancy profit that the manager gained and it had

not been announced to the owner. The results showed that rising the symmetric information would increase the investment.

Marzban et al. (2017) investigated the effective channels of the monetary transmission mechanism in Iran with DSGE model. The findings suggested that increasing the interest rate could cause a reduction in output, consumption, investment, and capital utilization rate.

In sum, from the existing studies, one may conclude that each study deals with the issue of asymmetric information from a different perspective and has adopted various criteria to measure it. Furthermore, there is a great diversification in terms of the methods used for investigating the impact of asymmetric information on the target variables. The research method in the present study is based on the New-Keynesian DSGE models.

3. Model

In this research, a DSGE model was applied. The main framework of the equations used in this method was adapted from the studies conducted by Escude (2013), Gerali et al. (2010), Claus (2010), Adlofson (2007), Monacelli (2005), Dib (2003), Ireland (2003), Valibeigi et al. (2017), Manzor and Taghipour (2015), Shah Hoseini and Bahrami (2012), and Bahrami and Qureishi (2011).

In the present study, a set of the equations describing the economy were allocated to nine sectors, i.e. households, firms, banks, the Central Bank, oil, government, exports and imports, and other countries in the world. It is imperative to note that the set of equations used is one of the most complete New-Keynesian equations on the economy of Iran, and it's one of the contributions of the present study.

3.1 Households

3.1.1 Utility Function (Preferences)

It is assumed that households are infinitely lived and also there is direct link between their utility and consumption of goods and services and the real balance of money. On the other hand, there is indirect link between their utility and the supply of labor force. Accordingly, the expected present value of the utility of the i[th] household, during its lifetime is as follows:

$$U_t^i\left(C,N,\frac{M}{P}\right)=E_t\sum_{t=0}^{\infty}\beta^t\left[\frac{(C_t^i)^{1-\sigma_c}}{1-\sigma_c}-\frac{(N_t^i)^{1+\sigma_n}}{1+\sigma_n}+\frac{1}{1-b_m}\left(\frac{M_t^i}{P_t^c}\right)^{1-b_m}\right] \quad (1)$$

where E_t is the expected value operator, β is discount rate ($0\leq\beta\leq1$), C_t denotes the real consumption of household in period t, M_t is the nominal money balance, P_t^c is the consumer price index, $\frac{M_t}{P_t}$ is the real balance of money, and N_t denotes the total supply of labor force by the household, and i represents the i[th] household. σ_c expresses the relative risk aversion coefficient, that its reverse the intertemporal elasticity of substitution. The parameter of σ_n is the inverse of the elasticity of labor supply with respect to the real wages, b_m is the inverse of the

elasticity of the money real balance ($m_t^i = \frac{M_t^i}{P_t^c}$) of the i[th] household with respect to the interest rate.

The goal of household is to choose the optimal value of consumption (c_t), supply of labour (N_t) and real balance of money ($\frac{M_t}{P_t}$) regarding to the budget constraint to maximize their utility.

In this research, the budget constraint of the i[th] household, following the study of Grill et al, (2010) is define as Equation (2):

$$c_t^i + I_t^i + \frac{M_t^i}{P_t^c} + \frac{D_t^i}{P_t^c} \leq \left(1 + R_{t-1}^d\right)\frac{D_{t-1}^i}{P_t^c} + \frac{M_{t-1}^i}{P_t^c} - \frac{T_t^i}{P_t^c} + y_t^i \quad (2)$$

The left side of Equation (2) shows the expenditure of household and the right side of this equation is income of the i[th] household. In Equation (2): I_t^i is real investment, D_t^i is bank deposits, M_t^i is the nominal money balance, T_t^i denotes the tax paid by the i[th] household, and P_t^c is the consumer price index. y_t^i denotes income of the i[th] household and is obtained from the following equation. It should be noted that, in this equation the nominal variables are converted to the real variables by usingP_t^c.

$$y_t^i = \frac{W_t^i}{P_t^c}N_t^i + R_t^l z_t^i k_{t-1}^i - \psi(z_t^i)k_t^i \quad (3)$$

According to the Equation (3), the total income of household earned from sum of the wage of labour ($\frac{W_t^i}{P_t^c}N_t^i$) and the capital rent minus the cost of capital that is utilized. where $W_t^i$is the nominal wage, N_t^i denotes the supply of labour force, R_t^l is the interest rate of the capital rental or the interest rate on the bank loans. By using capital in the production process with utilization rate z_t^i, a part of the capital will evaporate and hence would not gain rental rate and therefore impose a cost on household which is shown by $\psi\left(z_t^i\right)$ in budget constraints.

And the capital accumulation is done via the following equation:

$$K_t^i = (1-\delta)K_{t-1}^i + \left[1 - S(\frac{I_t^i}{I_{t-1}^i})\right]I_t^i\varepsilon_t^I \quad (4)$$

where δ is the depreciation of capital and $S(\frac{I_t^i}{I_{t-1}^i})$ is the cost function of investment adjustment and ε_t^I is the production of capital goods shocks[1].

Assuming that the preferences of households are similar, from the optimizing household's behavior up one may achieve to the nonlinear equations. Then, in order to simplify the solving of the research model, the nonlinear equations have been linearized by approximation methods. Also, in other parts of the research, only linearized equations are presented[2]. So we have:

- The Euler's equation of the total consumption of households

$$\hat{c}_t = \hat{c}_{t-1} + E_t\hat{c}_{t+1} - \frac{1}{\sigma_c}\hat{r}_t^d + \frac{1}{\sigma_c}E\hat{\pi}_{t+1}^c \quad (5)$$

[1] For more details refer to Justiniano et al. (2009).
[2] For more details refer to Gelain and Kulikov (2009) and Manzor and TaghiPur (2015).

- Money demand equation

$$\hat{m}_t^c = \frac{\sigma_c}{b_m}\hat{c}_t - \frac{1}{b_m \bar{r}^d}\hat{r}_t^{\,d} \quad (6)$$

- Capital accumulation equation

$$\hat{k}_t = (1-\delta)\hat{k}_{t-1} + \delta(\hat{\imath}_t + \varepsilon_t^I) \quad (7)$$

- Equation of the capital price dynamics

$$\hat{q}_t = \frac{1-\delta}{1-\delta+\bar{r}^d}\hat{q}_{t+1} + \frac{\bar{r}^d}{1-\delta+\bar{r}^d}\hat{r}_{t+1}^d - (\hat{r}_t^d - \hat{\pi}_{t+1}^c) \quad (8)$$

- Investment equation

$$\hat{\imath}_t = \frac{1}{1+\beta}\hat{\imath}_{t-1} + \frac{\beta}{1+\beta}E_t\hat{\imath}_{t+1} + \frac{1}{\varphi(1+\beta)}\hat{q}_t + \varepsilon_t^I \quad (9)$$

where $\varphi = s^{"}(0)$ is the elasticity of the investment adjustment cost function.

3.1.2 Labor Supply and Wage Rigidities

As households supply their labor force in the monopoly market, they are able to adjust their wages. In the same line of the studies of Smets and Wouters (2002), Kollman (1997) and Erceg et al. (2000), supposed that ξ_w is the probability of household that is not able to adjust the nominal wages as optimal, then $(1-\xi_w)$ reveals the probability of the i[th] household who is able to determine their nominal wage as optimal.

Thus, the wage equation which is obtained from the First-order condition of maximizing the equation of labor supply is as Equation (10):

$$\begin{aligned}\hat{w}_t = {} & \frac{\beta}{1+\beta}E\hat{w}_{t+1} + \frac{1}{1+\beta}\hat{w}_{t-1} + \frac{\beta}{1+\beta}E\hat{\pi}_{t+1}^c - \frac{1+\beta.\tau_w}{1+\beta}\hat{\pi}_t^c + \frac{\tau_w}{1+\beta}\hat{\pi}_{t-1}^c \\ & - \frac{1}{1+\beta}.\frac{(1-\beta\xi_w)(1-\xi_w)}{\xi_w}[\hat{w}_t - \sigma_n\hat{n}_t - \sigma_c\hat{c}_t]\end{aligned} \quad (10)$$

3.1.3 Inflation Rate

The equation of inflation rate based on the consumer price index of the domestic manufactured and imported goods, that log-linear form is as follows:

$$\hat{\pi}_t^c = \alpha_c(\hat{\gamma}^{dc})^{1-\eta_c}\hat{\pi}_t^d + (1-\alpha_c)(\hat{\gamma}^{mc})^{1-\eta_c}\hat{\pi}_t^{mc} \quad (11)$$

where α_c and $(1-\alpha_c)$ respectively are the share of the domestically produced goods and imported goods in the consumption basket of households, and $\hat{\pi}_t^d$ and $\hat{\pi}_t^{mc}$, respectively are the inflation rate of the domestic goods and the inflation of imported goods. $\hat{\gamma}^{dc}$ is the ratio of domestic goods price index to total goods price index, and $\hat{\gamma}^{mc}$ is the ratio of imported goods price index to total goods price index. The log-linear form of these equations are as Equations (12) and (13):

$$\hat{\gamma}_t^{dc} = \hat{\pi}_t^d - \hat{\pi}_t^c + \hat{\gamma}_{t-1}^{dc} \quad (12)$$

$$\hat{\gamma}_t^{mc} = \hat{\pi}_t^{mc} - \hat{\pi}_t^c + \hat{\gamma}_{t-1}^{mc} \quad (13)$$

3.2 The Producers

3.2.1 Intermediate Goods

An economy consists of a chain of the producers of intermediate goods in the monopolistic competition market and each of the firms produce distinct

goods. These firms by employing labour force, capital and other inputs will produce the intermediate goods (j).

Due to interfering government in the economy, development budgets play a crucial role in the productivity of the private sector. Therefore, it is needed to consider the formation of the government capital in the production function of the producer firm of intermediary goods. The production function of firms producing intermediate goods in the form of a Cobb-Douglas is as Equation (14):

$$y_{jt} = A_t\,(z_t k_{jt-1})^{\alpha}\left(N_{jt}\right)^{1-\alpha}(I_t^m)^{v}(K_{t-1}^G)^{\kappa} - \phi_j \qquad (14)$$

where ϕ_j is the fixed cost in production, $\tilde{k}_{t-1} = z_t k_{jt-1}$ is the effective capital stock and α is the share of capital in production. K_{t-1}^G denotes the capital formation in public sector and assumes that it is common for all firms in this sector, I_t^m is the imports of capital goods, and v is the share of imported capital goods in production, and κ is the share of government expenditures in production. A_t represents the productivity which is common for all firms and follows of the AR(1) process as Equation (15):

$$log(A_t) = \rho_a\, log(A_{t-1}) + u_t^a \qquad , \qquad u_t^a \sim (0, \sigma_A^2) \qquad (15)$$

In this paper, it is also assumed that each of producers of the domestic intermediate goods provides part of the capital input of their required through a bank loan with an exchange rate of R_t^l. Thus, if one considers the j[th] firm, therefore, the financing constraint of the j[th] firm can be written as Equation (16):

$$Lo_{jt} = fik_{jt} \qquad (16)$$

The other issue facing the producers of the intermediate goods is the prices adjustment. In the present study, the Calvo (1983) method is used to the prices adjustment. This means that, in each period only $(1-\xi_P)$ percent of firms are able to adjust their prices optimally. Besides in each period of $t \geq 0$, the goal of the domestic producers is to maximize the present value of the expected profit flow in the future period regarding to the demand function of the output from final good producer. So we have:

$$\max_{P_{jt}} \; E_t \sum_{t=0}^{\infty} (\beta\xi_P)^{\kappa} \frac{\lambda_{t+k}}{\lambda_t} \left\{ \prod_{s=1}^{k} (\pi_{t+s-1}^d)^{\tau_P} \frac{P_{jt}}{P_{t+k}^d} - mc_{t+k}^d \right\} y_{jt+k}$$

$$s.t. \quad y_{jt+k} = \left[\prod_{s=1}^{k} (\pi_{t+s-1}^d)^{\tau_P} \frac{P_{jt}}{P_{t+k}^d} \right]^{\frac{1+\lambda_{t+k}^p}{\lambda_{t+k}^p}} y_{t+k} \qquad \forall k \geq 0$$

As a result, the log-linear form of New Phillips-Keynesian curve is as Equation (17):

$$\hat{\pi}_t^d = \frac{\beta}{1+\beta.\tau_p} E\hat{\pi}_{t+1}^d + \frac{\tau_p}{1+\beta.\tau_p}\hat{\pi}_{t-1}^d + \frac{1}{1+\beta.\tau_p}\frac{(1-\beta\xi_p)(1-\xi_p)}{\xi_p}\widehat{mc}_t + \hat{\lambda}_t^p \qquad (17)$$

where mc_t represents the deviation of the marginal cost of the domestic production in stability position. Therefore, the log-linear form can be written as:

$$\widehat{mc}_t = -\hat{a}_t + (1-\alpha)\hat{w}_t + \alpha\hat{R}_t^k + v\hat{\gamma}_t^{dc} - \kappa\hat{k}_{t-1}^G \qquad (18)$$

From maximizing profit of the intermediate and marginal goods, the log-linear function of the labor force demand and the return rate of real capital are obtained as Equations (19) and (20):

$$\hat{n}_t = -\hat{w}_t + (1+\psi)\hat{R}_t^k + \hat{k}_{t-1} \quad (19)$$

$$\hat{R}_t^k = \hat{\imath}_t^m + \hat{k}_{t-1} - \hat{\gamma}_t^{mc} \quad (20)$$

where R_t^k is the return rate of the real capital, and $\hat{\gamma}_t^{mc}$ is the price index of imported goods to the consumer price index ratio.

3.2.2 Oil and Non-Oil Production Function

The total production (y_t) is a combination of oil and non-oil production, in the form of CES function by using a Dixit –Stieglitz aggregator[1] can be written as Equation (21):

$$\hat{y}_t = (\alpha^o)^{\frac{1}{\mu^o}} \left(\frac{\overline{yo}}{\bar{y}}\right)^{\frac{\mu^o-1}{\mu^o}} \widehat{yo}_t + (1-\alpha^o)^{\frac{1}{\mu^o}} \left(\frac{\overline{ynO}}{\bar{y}}\right)^{\frac{\mu^o-1}{\mu^o}} \widehat{ynO}_t \quad (21)$$

where yo and ynO are the oil and non-oil production, respectively. μ^o is the substitution elasticity between the oil and non-oil production, and α^o denotes share of the oil sector value added in total production (value added of oil and non-oil). The oil production function is as follows:

$$\widehat{yo}_t = \hat{o}_t + \widehat{rer}_t + \hat{\gamma}_t^{dc} \quad (22)$$

While the non-oil production function is as follows:

$$\frac{\widehat{ynO}_t}{1+\phi} = \hat{a}_t + \alpha\hat{k}_{t-1} + \alpha\psi\hat{R}_t^k + (1-\alpha)\hat{n}_t + \nu^{mi}\hat{\imath}_t^m + \kappa\hat{k}_{t-1}^G + (1-\bar{\omega})\hat{\vartheta}_t \quad (23)$$

where ϕ is the fixed cost in production, ϑ denotes the credits of a National Development Fund to the production sector, ψ is inverse of elasticity of cost function with respect to productivity cost, and $(1-\bar{\omega})$ is the percentage of the oil revenues deposited to the development fund.

3.3 Foreign Trade

In order to investigate the foreign sectorin of the model, the model developed by Adolfson et al. (2007) and Valibeigi et al. (2017) was applied. In this section, the price of the imported and exported goods is calculated in terms of the domestic currency. The effect of exchange rate pass-through appears incompletely on the prices of imports and exports, and the importing and exporting firms are operating under the conditions of monopolistic competition.

3.3.1 Importer Firms

There are a large number of firms in the import sector that purchase homogeneous goods from foreign markets. For instance, firm j purchased the homogeneous imported goods from foreign markets at the price of P_{jt}^f and converted into the final imported goods by using the Dixit -Stieglitz aggregator, then, sold them on the domestic market to the households (P_t^f is the foreign

[1] Extraction of consumption function should be done in ways similar to the previous processes.

consumer price index). In this study, total imported goods are classified into two categories: The imported consumer goods and the imported capital goods. In what follows, the behaviors of firms in both groups are expressed separately:

Using the Dixit-Stieglitz aggregator in the form of the CES function to the final imported goods (χ_t^m), the importers of various imported goods χ_{jt}^m ($\chi = C, I$, where C and I are the imported consumer goods, and the intermediate and imported capital goods, respectively) is written as Equation (24):

$$\chi_t^m = \left(\int_0^1 Y_{jt}^{\frac{1}{1+\lambda_t^{m_c}}} dj \right)^{1+\lambda_t^{m_c}} \tag{24}$$

In other words, the marginal imported consumer goods is a continuous combination of $j \epsilon [0,1]$ of various imported consumer goods, in which each of them supplies the domestic section, through the help of various firms, at a price of $P_{jt}^{m_c}$.

Similar to what was explicated in the previous section germane to the domestic firms, the firms combines the goods in such a way that the cost of the imported goods is minimized regarding the specified amount of imports (χ_t^m).

Solving the first-order condition, the demand function of each importer j can be shown as Equation (25):

$$\chi_{jt}^m = \left(\frac{P_{jt}^{m_c}}{P_t^{m_c}} \right)^{\frac{1+\lambda_t^{m_c}}{\lambda_t^{m_c}}} \chi_t^m \tag{25}$$

where $P_t^{m_c}$ denotes the total price index of the imported goods, $P_{jt}^{m_c}$ is the price of the imported goods unit j in units of the domestic money and it is equal to $EX_t P_{jt}^f$, where P_{jt}^f is the price of imported goods in terms of dollar and EX_t is a nominal exchange rate. By replacing Equation (25) in Equation (24), the import price index could be measured as Equation (26):

$$P_t^{m_c} = \left(\int_0^1 P_{jt}^{\frac{1}{-\lambda_t^{m_c}}} dj \right)^{-\lambda_t^{m_c}} \tag{26}$$

where $\lambda_t^{m_c}$ denotes the markup shock of the consumer price of imported goods and is defined in the Logarithmic form as follows (Adolfson et al., 2007):

$$log\lambda_t^{m_c} = (1 - \rho_{\pi^m}) log\lambda^{m_c} + \rho_m log\lambda_{t-1}^{m_c} + u_t^{m_c} \quad , \quad u_t^{m_c} \sim N(0, \sigma_{m_c}^2) \tag{27}$$

And it could be written in the form of log-linear:

$$\hat{\lambda}_t^{m_c} = \rho_{\pi^m} \hat{\lambda}_{t-1}^{m_c} + u_t^{m_c} \quad , \quad u_t^{m_c} \sim N(0, \sigma_{m_c}^2) \tag{28}$$

In order to model the price adjustment of the imported goods following the studies done by Adolfson et al. (2007) and Monacelli (2005), the Calvo method (1983) was applied. In our modeling, in each period, only $(1 - \xi_{m_c})$ percentage of the importing firms may have the opportunity to set their prices optimally, and the remaining firms (ξ_{m_c} percent) set the price of their imported goods based on the Inflation index, as shown in the Equation (29):

$$P_{jt+1}^{m_c} = \left(\pi_t^{m_c}\right)^{\tau_{m_c}} P_{jt}^{m_c} \tag{29}$$

where $\pi_t^{m_c} = \frac{P_t^{m_c}}{P_{t-1}^{m_c}}$ denotes the inflation rate based on the import price index. $\tau_{m_c}(0 < \tau_{m_c} < 1)$ is the coefficient of the import price index.

Firms which have the opportunity to adjust their prices as to determine the optimal price attempt to maximize the present value of the future expected profit flow.

It is assumed that each firm of j will determine the price of $P_{jt}^{m_c}$ in a way that maximizes the present value of the expected future profit so we have:

$$\underbrace{Max}_{P_{jt}^{m_c}} \quad E_t \sum_{k=0}^{\infty} (\beta\xi_x)^k \frac{\lambda_{t+k}}{\lambda_t} \left[\prod_{s=1}^{k} \left(\pi_{t+s-1}^{m_c}\right)^{\tau_{m_c}} \frac{P_{jt}^{m_c}}{P_{t+k}^{m_c}} - mc_{t+k}^{m_c}\right] c_{j,t+k}^{m_c}$$

$$s.t. \quad c_{j,t+k}^{x} = \left[\prod_{s=1}^{k} \left(\pi_{t+s-1}^{m_c}\right)^{\tau_{m_c}} \frac{P_{jt}^{m_c}}{P_{t+k}^{m_c}}\right]^{-\left(\frac{1+\lambda_{t+k}^{m_c}}{\lambda_{t+k}^{m_c}}\right)} c_{t+k}^{m_c} \tag{30}$$

where the marginal cost of the importer firm of consumer goods is equal to:

$$mc_{t+k}^{m_c} = \frac{ER_{t+k}(1+\tau_t^{trf})P_{t+k}^{f}}{P_{t+k}^{m_c}} \tag{31}$$

This means that the marginal cost, in terms of the real prices, is equal to the ratio of the nominal marginal cost (the foreign import price multiplied by the exchange rate to the price index of imported goods in terms of the domestic price. The import profits are discounted by the rate of $(\beta\xi_{m_c})^k \frac{\lambda_{t+k}}{\lambda_t}$ and, certainly, the import profits are equal to zero at a steady state. It is assumed that the shock of the customs tariff rate (τ_t^{trf}) is exogenous to and is followed by the *AR(1)* process.

$$\tau_t^{trf} = \rho_{trf}\tau_{t-1}^{trf} + u_t^{trf} \qquad , \qquad u_t^{trf} \sim N(0, \sigma_{trf}^2) \tag{32}$$

Having dealt with the algebraic operations, the first-order condition of Equation (24) would be as Equation (34):

$$\underbrace{Max}_{P_{jt}^{m_c}} \quad E_t \sum_{k=0}^{\infty} \left(\beta\xi_{m_c}\right)^k \frac{\lambda_{t+k}}{\lambda_{t+k}^{m_c}} \left[\prod_{s=1}^{k} \left(\frac{\pi_{t+s-1}^{m_c}}{\pi_{t+s}^{m_c}}\right)^{\tau_{m_c}} \frac{P_{jt}^{m_c}}{P_{t+k}^{m_c}}\right]^{-\left(\frac{1}{\lambda_{t+k}^{m_c}}\right)} \frac{\bar{P}_t}{P_t^{m_c}} c_{t+k}^{m_c} =$$

$$E_t \sum_{k=0}^{\infty} (\beta\xi_{m_c})^k \lambda_{t+k} \frac{1+\lambda_{t+k}}{\lambda_{t+k}^{m_c}} \left[\prod_{s=1}^{k} \left(\frac{\pi_{t+s-1}^{m_c}}{\pi_{t+s}^{m_c}}\right)^{\tau_{m_c}}\right]^{-\left(\frac{1+\lambda_{t+k}}{\lambda_{t+k}^{m_c}}\right)} mc_{t+k}^{m_c} c_{t+k}^{m_c} \tag{33}$$

With respect to the fact that in each period of time, only $(1-\xi_P)$ percentage of importing firms will have the opportunity to determine their prices optimally and the remaining firms ($\xi_P$percent) will index the prices based on the price of the previous period, the rule of changes in the import price index, using Equation (33) , can be written as follows:

$$\left(P_t^{m_c}\right)^{-\frac{1}{\lambda_t^{m_c}}} = \xi_{m_c}\left[\left(\pi_{t-1}^{m_c}\right)^{\tau_{m_c}} P_{t-1}^{m_c}\right]^{-\frac{1}{\lambda_t^{m_c}}} + (1-\xi_{m_c})\left[\bar{P}_t^{m_c}\right]^{-\frac{1}{\lambda_t^{m_c}}} \tag{34}$$

Solving the first-order conditions, finally, the dynamics of the imported inflation rate is obtained as a log-linear equation as Equation (35):

$$\hat{\pi}_t^{m_c} = \frac{\beta}{1+\beta.\tau_{m_c}} E_t \hat{\pi}_{t+1}^{m_c} + \frac{\tau_{m_c}}{1+\beta.\tau_{m_c}} \hat{\pi}_{t-1}^{m_c} + \frac{1}{1+\beta.\tau_{m_c}} \frac{(1-\xi_{m_c})(1-\beta\xi_{m_c})}{\xi_{m_c}} (\widehat{mc}^{m_c} + \hat{\lambda}_t^{m_c}) \quad (35)$$

where $\widehat{mc_t}^{m_c} = (\widehat{ER}_t + \hat{p}_t^f + \hat{\tau}_t^{trf}) - \hat{p}_t{}^{m_c}$[1] represents the deviation amount of the foreign price of imported goods from the price index of the imported goods in term of the domestic prices, and $\lambda_t^{m_c}$ is the markup shock of the imported consumer goods price and could be defined as follows (Adolfson et al., 2007):

$$log\lambda_t^{m_c} = (1-\rho_{\pi^m}) log\lambda^{m_c} + \rho_m log\lambda_{t-1}^{m_c} + u_t^{m_c} \quad , \quad u_t^{m_c} \sim N(0, \sigma_{m_c}^2) \quad (36)$$

3.3.2 The Real Exchange Rate

On the condition that the effect of the exchange rate on import prices in term of the domestic currency is not fully pass-through, the unit price law is not ruling and that will have some impacts on the relationship between the exchange rate and the terms of the trade.

The real exchange rate can be written as Equation (37):

$$RER_t = ER_t \frac{P_t^f}{P_t^c} \quad (37)$$

where ER_t and RER_t are the nominal exchange rate and the real exchange rate, respectively. Equation can be expressed in terms of the inflation rate as follows.

$$\widehat{rer}_t = \Delta\widehat{ER}_t + \hat{\pi}_t^f - \hat{\pi}_t^c + \widehat{rer}_{t-1} \quad (38)$$

where $\Delta\widehat{ER}_t$ represents the changes in the growth rate of the nominal exchange rate.

3.3.3 Exporter Firms

Each of the domestic firms sells its goods in both domestic and foreign markets. Assuming that the demand for the exported goods is similar to the demand for the domestic products, the demand function for Iran's exports in the foreign markets can be written as Equation (39):

$$X_t = (\frac{P_t^x}{P_t^f})^{-\eta_f} c_t^f \quad (39)$$

where η_f is the substitution elasticity between the domestically produced goods and the imported goods in foreign markets; P_t^f is the foreign consumer price index ; P_t^x is the exported goods price index in the foreign markets (in dollars) and c_t^f denotes the total consumption of the world. Since Iran's economy is small open economy in Equation (39), we can replace the gross domestic product of the world y_t^f with c_t^f:

$$X_t = \left(\frac{P_t^x}{P_t^f}\right)^{-\eta_f} Y_t^f \quad (40)$$

Equation (40) would change to the following after being transformed into a log-linear form:

[1] This equation can also be written as $\widehat{mc_t}^{m_c} = \widehat{rer}_t + \hat{\tau}_t^{trf} - \hat{y}_t{}^{m_c}$

$$\hat{x}_t = \hat{y}_t^f - \eta_f ln\left(\frac{P_t^x}{P_t^f}\right) = \hat{y}_t^f - \eta_f \hat{\gamma}_t^x \quad (41)$$

$$\hat{\gamma}_t^x = \hat{\pi}_t^x - \hat{\pi}_t^f + \hat{\gamma}_{t-1}^x \quad (42)$$

In Equations (41) and (42), $\hat{\gamma}_t^x$ is the ratio of the export goods price index to the foreign consumer price index.

Moreover, it is assumed that the export prices are rigidities to the foreign currency. To this end, the effective channel of the exchange rate fluctuations acts incompletely on the export market. Also, the rigidities of Calvo-type are considered in export prices. For that reason, in each period, only $(1-\xi_x)$ percentage of exporting firms have the opportunity to determine the optimal price and the remaining firms (ξ_x percent) determine the prices of export goods similar to a domestic producer based on the inflation index. This can be formulated as follows (Adolfson et al., 2007).

After performing the optimization calculations (similar to the importing firms), the exported goods inflation along with the rigidities as a log-linear could be measured as[1]:

$$\hat{\pi}_t^x = \frac{\beta}{1+\beta.\tau_x} E_t\hat{\pi}_{t+1}^x + \frac{\tau_x}{1+\beta.\tau_x}\hat{\pi}_{t-1}^x + \frac{1}{1+\beta.\tau_{m_c}}\frac{(1-\xi_x)(1-\beta\xi_x)}{\xi_x}(\widehat{mc}_t^x + \hat{\lambda}_t^x) \quad (43)$$

In Equation (43), the changes of the real marginal cost $\widehat{mc}^x$ are equal to:

$$MC_t^x = \frac{P_t^d}{ER_t} \xrightarrow{\times\frac{1}{P_t^x}} mc_t^x = \frac{P_t^d}{ER_t P_t^x} \quad \rightarrow \quad \widehat{mc}_t^x = \hat{\pi}_t^d - \hat{\pi}_t^x - \widehat{ER}_t \quad (44)$$

where λ_t^x is the markup shock of the export price and the log-linear function can be written as Equation (45):

$$\hat{\lambda}_t^x = \rho_{\pi^x}\hat{\lambda}_{t-1}^x + u_t^x \quad , \quad u_t^x \sim N(0, \sigma_x^2) \quad (45)$$

3.4 Government and Monetary Authorities

Due to the lack of independency of the Central Bank in Iran, it is impossible to categorize and model the government and the Central Bank in two sectors and one has to consider both sectors as one category. It is assumed that the government following the budget balanced rule. The Central Bank is supposed to adopt policies that help the government achieve its goals. With respect to the fact that the goal of the Central Banks is to maintain the stability of the prices and enhance the economic growth, the Central Bank, along with the government, seeks to adopt the monetary policies that aid it to achieve its two goals.

3.4.1 Government Revenues

The government revenues to finance government expenditure consist of oil revenues, taxes, and other revenues (such as asset sales and etc.).

A. Oil revenues

Taking into account the specific characteristics of Iran's economy, which is oil-oriented, and the export revenues gained from the crude oil production, it

[1] For more detail, refer to Adolfson et al. (2007).

seems necessary to consider the oil sector in the model proposed earlier to consider the shocks in this sector. Considering the quota determined by OPEC, and the exogenous fluctuations in the production of crude oil regarding to the existing oil reserves, the oil production process (O_t), in the form of AR(1) with the coefficient $\rho \in (-1, 1)$ is defined as Equation (46):

$$log(O_t) = (1 - \rho_O)\, log(O) + \rho_O\, log(O_{t-1}) + e_{Ot} \quad (46)$$

where O is the steady state level of the oil sector production and e_{Ot} denotes the shocks entered this sector which could impact the equilibrium in the amount of oil revenues randomly and exogenously.

B. Tax Revenues

In this study, the value added tax (T_t^{vat}) is distinguished from other taxes (T_t^d). Value added tax is a function of the public and private final consumption whereas the remaining taxes are a function of the total national income. Therefore,

$$\hat{T}_t^d = \tau^d . \hat{y}_t \quad (47)$$

$$\hat{T}_t^{vat} = \tau^{vat} . (\hat{c}_t + \hat{c}_t^g) \quad (48)$$

$$\hat{T}_t = \frac{\bar{T}^d}{\bar{T}} \hat{T}_t^d + \frac{\bar{T}^{vat}}{\bar{T}} \hat{T}_t^{vat} \quad (49)$$

where τ^d is the income elasticity of direct tax, and τ^{vat} is the elasticity of value added tax with respect to consumption.

3.4.2 Capital Expenditures and Current Expenditures of the Government

Government expenditures are defined in terms of current expenditures (c_t^g) and capital expenditures (I_t^g) and can be measured based on Equation (50):

$$G_t = c_t^g + I_t^g \quad (50)$$

It is assumed that the current expenditure of government (log-linear) follows an AR(1) and is affected by the current expenditures of the previous period and also the tax and oil revenues.

$$\hat{c}_t^g = \rho_{cg} \hat{c}_{t-1}^g + \bar{t}^g . \hat{t}_t + (1 - \nu_o) e_{ot} \quad (51)$$

where $\bar{t}^g$ is the share of the government tax revenues in the current expenditure. Other log-linear equations of government behavior are as Equations 52-54:

$$\hat{g}_t = \frac{\bar{c}^g}{\bar{g}} \hat{c}_t^g + \frac{\bar{I}^g}{\bar{g}} \hat{I}_t^g \quad (52)$$

$$\hat{k}_t^g = (1 - \delta_G) \hat{k}_{t-1}^g + \delta_G \hat{\imath}_t^g \quad (53)$$

$$\hat{\imath}_t^g = \rho_{Ig} \hat{\imath}_{t-1}^g + \nu_o e_{ot} \quad (54)$$

3.4.3 The Central Bank Balance Sheet

The Central Bank balance sheet is defined as Equation (55):

$$MB_t = DC_t^g + DC_t^b + ER_t . FR_t \quad (55)$$

where MB_t is the monetary base, DC_t^g is the net debt of the government to the Central Bank, DC_t^b is the debt of the banks to the Central Bank, FR_t is the net foreign assets of the Central Bank, and ER_t is the nominal exchange rate.

A log-linear form of the monetary base equations (Central Bank balance sheet) are as Equations (56) and (57):

$$\widehat{mb}_t = \frac{\overline{dc^g}}{\overline{MB}}\widehat{dc}_t^{\,g} + \frac{\overline{dc^b}}{\overline{MB}}\widehat{dc}_t^{\,b} + \frac{\overline{FR}}{\overline{MB}}(\widehat{rer}_t + \widehat{fr}_t) \quad (56)$$

$$\widehat{fr}_t = \widehat{fr}_{t-1} - \pi_t^f + \left\{\omega\frac{\bar{o}}{\overline{FR}}\hat{o}_t + \frac{\overline{P^x X}}{\overline{FR}}(\hat{\gamma}_t^x + \hat{x}_t) - \left[\frac{\overline{\gamma^{mc}(\bar{c}^m + \bar{I}^m)}}{\overline{FR}\,\overline{rer}}\right](\hat{\gamma}_t^{mc} + \hat{c}_t^m + \hat{I}_t^m - \widehat{rer}_t)\right\} \quad (57)$$

where $\frac{\bar{o}}{\overline{fr}}$ is the ratio of oil export to net foreign assets of the Central Bank, $\frac{\overline{P^x X}}{\overline{FR}}$ is the ratio of non-oil exports to the net foreign assets of the Central Bank, $\frac{\overline{\gamma^{mc}(\bar{c}^m + \bar{I}^m)}}{\overline{FR}\,\overline{rer}}$ is the ratio of total imports to the net foreign assets of the Central Banks, and ω is the percentage of the foreign exchange that is earned from the sale of oil to the Central Bank.

3.4.4 Monetary Policy Makers

In Iran, the government has a dominant role in the economy of the country, specifically in the monetary policy (Komejane & Tavakolyan, 2011). Moreover, one of the limitations of applying the DSGE model is the specification of the reaction function of the Central Banks as the monetary policy makers of the country.

In this regard, the discussions revolving around these functions have been emphasized in the literature for about three decades. The major specification which is applied in the analysis of this issue is the specification of Taylor's rule.

In Iran, Taylor's rule is not enforced because of the limitations on use of the nominal interest rate as a policy tool. Accordingly, the Central Bank of Iran will mainly achieve this objective by controlling the growth rate of money. Therefore, the pressent study by considering the realities of the Iranian economy, was an attempt to follow Escude (2013), Valibeigi et al. (2017), and Komejane and Tavakolyan (2011) to introduce a function similar to Taylor's rule to control the growth rate of the monetary base. In this way, the behavioral function of the Central Bank, as the monetary policymaker, is meant to achieve three goals: Reducing the current production diversion from the potential production, reducing the deviation of inflation from the target inflation, and decreasing the deviation of the real exchange rate from its long-run trend. The target inflation is a latent variable and monetary authorities are the only ones who aware of it.

The log-linear form of the reaction functions of the monetary policymakers are shown as Equations 58-60:

$$\hat{\Theta}_t = \rho_\Theta\hat{\Theta}_{t-1} + \theta_\pi(\hat{\pi}^c{}_t - \hat{\pi}_t^*) + \theta_y\hat{y}_t + \theta_{rer}\widehat{rer}_t + \varepsilon_t^\Theta \quad (58)$$

$$\hat{\pi}_t^* = \rho_{\pi^*}\hat{\pi}_{t-1}^* + u_t^{\pi^*} \quad , \quad u_t^{\pi^*} \sim N(0, \sigma_{\pi^*}^2) \quad (59)$$

$$\varepsilon_t^\Theta = \rho_\Theta\varepsilon_{t-1}^\Theta + u_t^\Theta \quad , \quad u_t^\Theta \sim N(0, \sigma_\Theta^2) \quad (60)$$

where $\widehat{\Theta}_t$ is the nominal growth rate of the monetary base, θ_π, θ_y and θ_{rer}, are the importance coefficient of the gaps of inflation, production, and exchange rate considered by policymakers respectively. $\hat{\pi}_t^*$ denotes the deviation of the

implicit target inflation from the equilibrium value which is assumed to follow a AR(1) process. ε_t^{Θ} represents the monetary policy shocks.

3.4.5 National Development Fund

The resources of the National Development Fund are mainly financed via the foreign exchange earnings from the sale of the oil and gas. Thus, $(1-\omega)$ percent of the oil revenue in each period is kept as the deposit in the National Development Fund is spent over the course of time. It is believed that the reserve accumulation of the National Development Fund follows this process:

$$DF_t = DF_{t-1} + (1-\omega)O_t + LB_t - \vartheta_t \quad (61)$$

where DF_t is the balance of the National Development Fund in the period t, O_t is the foreign exchange revenue of oil exports, LB is the reimbursement of the principal and interest rate of the concessional loans and also the deposit profits of the National Development Fund at the Central Bank, and ϑ_t is the number of concessional loans of the National Development Fund allocated to the economic sectors that affects the economy via the production function. All variables in the model are in terms of dollar. Therefore, the form of the log-linearized function can be written as Equation (62):

$$\widehat{df}_t = \widehat{df}_{t-1} - \pi_t^f + \frac{(1-\omega)\bar{o}}{\overline{df}}\hat{O}_t + \frac{\overline{lb}}{\overline{df}}\widehat{LB}_t - \frac{\bar{\vartheta}}{\overline{df}}\hat{\vartheta}_t \quad (62)$$

3.4.6 Foreign Exchange Policies

It is supposed that the foreign exchange regime of a country is the managed floating exchange rate. Therefore, the Central Bank strives to maintain the managed floating exchange rate to achieve the following two objectives. First, the Central Bank attempts to maintain competitiveness in the economy. In achieving this objective, the difference between the domestic and foreign inflation is of overriding significance. Second, the Central Bank tends to keep the exchange reserves at a reasonable level.

Taking into consideration both the above points and the studies carried out by Peiris and Saxegaard (2007), Escude (2013), and Manzoor and Taghipour (2015), the foreign exchange policies rule can be written as the following:

$$\Delta\widehat{ER}_t = k_0\Delta\widehat{ER}_{t-1} + k_1(\hat{\pi}_t^c - \hat{\pi}_t^*) + k_2\left(\widehat{fr}_t - \widehat{mb}_t\right) + u_t^{\Delta ER}, \quad u_t^{\Delta ER} \sim N(0, \sigma_{\Delta ER}^2) \quad (63)$$

where $\frac{FR_t}{MB_t}$ is the ratio of the net foreign reserves of the Central Bank To the monetary base.

3.5 Banks

The assumption ruling on the banking sector is that the instrument for the savings of the households is only bank deposits, and the only way to finance firms is using bank loans. In addition, it is presumed that the monopolistic

competition[1] is operating and the profit gained from the banking activities are used to increase the bank's capital.

The amount of provided concessional loans by banks is determined as the percentage of deposits received by the bank; thus, the banking activities could lead to profits. Moreover, banks are faced with the probability of a loan default by firms, which is the result of asymmetric information.

Asymmetric information in banking sector leads to moral hazard and adverse selection. In this research, in order to investigate the impacts of the asymmetric information on the macroeconomic variables, such as investment, employment and production, *Pd* were used (Nasrollahi & Shafiei, 2016; Sameti et al., 2012). The *Pd* is the loan default. As one of the consequences of the asymmetric information is the moral hazard, this could result in an increase in the bank withdrawals.

On one hand, in order to prevent the occurrence of this phenomenon, banks have to spend cash on identifying their good customers. On the other hand, firms have to pay for some costs, such as collateral, promissory notes, guarantees, and so on, as to increase their credits and win the trust of banks to receive the concessional loans from them. This whole process could raise the costs for the banks and reduce the profits of the banks. Some part of the increase in the costs is borne by the firms and some other is borne by the banks, and these amounts depend on the elasticity of the supply and the demand of the facilities.

Another concern pertinent to the pattern is the banks' balance sheet and it ir- represented in the following Equation (64):

$$Lo_t = (1-\gamma^d)D_t + K_t^b + DC_t^b \quad (64)$$

where Lo_t is a bank loan, D_t is the bank deposit, DC_t^b is the debt of the bank to the Central Bank, K_t^b is the bank's capital, and γ^d is the deposit required reserves to the Central Bank, which does not have any profit for the bank. Every bank is able to lend loans to the producer firms of intermediate goods at the maximum equivalent of sum of the bank capital(K_t^b) and the net deposits of lending$(1-\gamma^d)D_t$. Banks are required to observe the optimal ratio of capital to assets that are specified by the monetary authority, and any deviation from this could inflict costs on the banks. The bank's capital is accumulated in each period based on the following rule:

$$K_t^b = (1-\delta^b)K_{t-1}^b + \pi_{t-1}^b \quad (65)$$

where δ^b denotes the depreciation rate of the bank capital and π_{t-1}^b is the profits gained from the banking activities in the previous period. Therefore, the problem of optimizing banks are the optimal choice of loans and bank deposits in order to maximize the real value of expected profits, with respect to the constraints on the bank's balance sheet. Accordingly[2]:

$$maxE_0 \sum_{t=0}^{\infty}\left[(1-pd)\left(R_t^l \frac{Lo_t}{P_t}\right) - R_t^d \frac{D_t}{P_t} - \frac{\phi_{kb}}{2}\left(\frac{K_t^b/P_t}{Lo_t/P_t}\right)^2 \frac{K_t^b}{P_t}\right] \quad (66)$$

[1] For more detail, refer to Shah Hoseini and Bahrami (2012).
[2] For more detail, refer to Gerali et al. (2010).

where pd indicates the asymmetric information index and its value falls within the interval [0, 1]. ϕ_{kb} is the deviation cost of the optimum capital adequacy ratio, R_t^d denotes the profit rate of the bank deposits, and R_t^l is the interest rate received by banks from the loan lent. The First-order condition of the bank's optimization to the LO_t and D_t is as Equation (67):

$$R_t^l = \left[\frac{R_t^d}{1-\gamma^d} - \phi_{kb}\left(\frac{k_t^b}{lo_t}\right)^3\right]\frac{1}{1-pd} \tag{67}$$

As a consequence, the interest rate of the loans which are received by the banks is a function of the required reserves of the bank deposits, the deviation from the optimal ratio of the capital adequacy (determined by the Central Bank), and the degree of asymmetric information in the financial market. The log-linear equations of the bank section can be written as Equations 68-72:

$$\hat{R}_t^l = \left[\frac{\frac{\bar{R}_t^d}{1-\gamma^d}}{\frac{\bar{R}_t^d}{1-\gamma^d}-\phi_{kb}\left(\frac{\bar{k}_t^b}{\bar{lo}_t}\right)^3}\hat{R}_t^d - \frac{\phi_{kb}3\left(\frac{\bar{k}_t^b}{\bar{lo}_t}\right)^3}{\frac{\bar{R}_t^d}{1-\gamma^d}-\phi_{kb}\left(\frac{\bar{k}_t^b}{\bar{lo}_t}\right)^3}(\hat{k}_t^b - \hat{lo}_t)\right] + \widehat{pd} \tag{68}$$

$$\hat{d}_t = \frac{1}{\gamma^d}\left(\frac{\bar{lo}}{\bar{d}}\hat{lo}_t - \frac{\bar{k}^b}{\bar{d}}\hat{k}_t^b\right) \tag{69}$$

$$\widehat{pd}_t = \rho_{pd}\,\widehat{pd}_{t-1} + u_t^{pd} \quad , \; u_t^{pd} \sim (0, \sigma_{pd}^2) \tag{70}$$

$$\hat{k}_t^b = (1-\delta_b)\frac{\bar{k}_{t-1}^b}{\bar{k}_t^b}\hat{k}_{t-1}^b + \frac{\bar{R}_t^l \bar{lo}_t^b}{\bar{k}_t^b}(\hat{R}_t^l + \hat{lo}_t) \tag{71}$$

$$\hat{r}_t^d = \hat{R}_t^{l1} \tag{72}$$

3.6 Inflation and Foreign Production

The production and inflation behavior of the rest of the world is considered exogenous. This means that the foreign inflation (π^f) and the foreign production (y^f) are considered exogenous in our model. Following Adolfson et al. (2007), and Justiano and Preston (2008), the rest of the world is modeled as a Vector Autoregressive (VAR) Model. In this case, the log-linear function can be written as Equations (73) and (74):

$$\hat{\pi}^f{}_t = \rho_{\pi^f}\,\hat{\pi}^f{}_{t-1} + u_t^{\pi^f} \quad , \quad u_t^{\pi^f} \sim (0, \sigma_{\pi^f}^2) \tag{73}$$

$$\hat{y}^f{}_t = \rho_{y^f}\,\hat{y}^f{}_{t-1} + u_t^{y^f} \quad , \quad u_t^{y^f} \sim (0, \sigma_{y^f}^2) \tag{74}$$

3.7 Equilibrium Condition

The final goods market is in equilibrium when the total supply (y_t) is equal to the total demand (demand for the household consumer goods, the investment demand of producer firms, government expenditures, and exports minus imports). So we have:

$$y_t = c_t + c_t^g + I_t^T + \psi(z_t)K_{t-1} + \left(\frac{P_t^x x_t + O_t}{P_t^c}\right)EX_t - \left(\frac{P_t^{m_c} c_t^m + P_t^{m_c} I_t^m}{P_t^c}\right)IM_t \tag{75}$$

[1] The initial function is non-linear and written as $r_t^d = \alpha e^{\hat{R}_t^l t}$.

where $I_t^T = I_t + I_t^g$ is equal to the sum of the private and government investment.

4. Results

4.1 Data

For the empirical evaluation of the designed model in the present study, 58 equations and 58 variables were considered; also, the Bayesian estimation method and parameterization were used. In this study, various variables, such as investment, government expenditures, non-oil GDP, the export inflation, inflation and interest rates, were used to provide a comprehensive description of Iran's economy. By taking into account the stutus of Iran's economy, the specified models could well describe Iran's economy. The data were gathered from the Central Bank of the Islamic Republic of Iran and they captured the period from 1974 to 2017. Furthermore, by applying the Hedrick-Prescott filter, the data were detrended and the analyses were performed on their cycle component.

Some parameters did not require any estimation and were calibrated through Iran's economic data. For instance, the depreciation rate of the private capital was derived from the ratio of the steady state of two variables of investment and capital. Some other parameters were extracted from the previous studies (Table 1).

In order to estimate other parameters using Bayesian method, first, and based on the domain and characteristics of parameters and the emprical studies, prior distribution and their means were determined. Then, based on the information obtained, the parameters were estimated using Bayesian method. In addition, to calculate the post-distribution of the parameters, the Metropolis-Hestings Algorithm (Monte Carlo Markov Chain (MCMC)) was applied. The parameters estimated by the Bayesian method are shown in Table 2.

Table 1. The parameter value of calibration result

Parameter	Symbol	Value	Source
Share of oil revenues in the government budget	$\bar{\omega}$	0.3942	research calculations
Ratio of current expenditures to total government expenditures	$\frac{\bar{c}^g}{\bar{g}}$	0.7313	research calculations
Capital depreciation rate	δ	0.082	research calculations
Ratio of non-oil GDP to GDP	$\frac{\overline{yno}}{\bar{y}}$	0.7934	research calculations
Ratio of private investment to total investment	$\frac{\bar{i}}{\bar{i}^T}$	0.728	research calculations
Ratio of government investment to total investment	$\frac{\bar{i}^g}{\bar{i}^T}$	0.272	research calculations
Coefficient of inflation in the reaction function of monetary authority	θ_π	-1.6410	Manzoor and Taghipour (2015)
Coefficient of production in the reaction function of monetary authority	θ_y	-1.6266	Manzoor and Taghipour (2015)
Coefficient of exchange rate in the reaction function of monetary authority	θ_{rer}	0.6842	Manzoor and Taghipour (2015)
Autoregressive process coefficient of the target inflation impulse reaction function of monetary authority	ρ_{π^*}	0.8005	Manzoor and Taghipour (2015)
Ratio of total investment (government and non-government) to production	$\frac{\bar{i}}{\bar{y}}$	0.321	research calculations
Ratio of oil exports to production	$\frac{\overline{rer} \times \bar{o}}{\bar{y}}$	0.200	research calculations
Share of government tax revenues in current government expenditures	$\bar{t}^g$	0.70	research calculations
Ratio of consumption to production	$\frac{\bar{c}}{\bar{y}}$	0.510	research calculations
Ratio of government consumption expenditures to production	$\frac{\bar{c}^g}{\bar{y}}$	0.123	research calculations

***Source**: Research findings*

Table 2. Estimated parameters by applying Bayesian method (1974-2017)

Parameter	Symbol	Prior Distribution		Posterior Distribution
		Distribution type	Prior mean	Post mean
Discount rate	β	Beta	0.80	0.762
Percentage of households who are not able to determine their optimal wages	ξ_w	Beta	0.511	0.5339
Percentage of producer firms which are indexed based on price of previous periods	ξ_P	Beta	0.60	0.7533
Percentage of inflation is reflected in the firm prices	τ_p	Beta	0.5203	0.4788
Substitution elasticity between the domestic and imported production of foreign markets	η_f	Gamma	3.519	3.5169
Percentage of exporter firms which are indexed based on prices of previous periods	ξ_x	Beta	0.320	0.2515
Coefficient of the export price index	τ_x	Beta	0.682	0.6323
Elasticity of value added tax with respect to consumption	τ^{vat}	Beta	0.6445	0.4766
Coefficient of the asymmetric information index	ρ_{pd}	Beta	0.40	0.7181
Importance coefficient of policy makers' for the inflation gap of the reaction function of foreign exchange policy	k_1	Normal	1.908	2.0064
Substitution elasticity between the domestic and imported goods of the country	η_c	Gamma	1.0516	1.0783

***Source**: Research findings*

The results of MCMC test indicated that there was no problem in the estimation of the parameters and the provided parameters were reliable (Fig. 1). Also, the Identification Analysis test of the model was performed. The results showed that the rank condition had not been violated, there was no collinearity between the parameters, and all the parameters were identifiable.

Finally, a sensitivity analysis test was performed on the parameters. By applying this test and utilizing the Smirnov statistics, the most important parameters of the model were identified, and the condition of the existence of the unique solution of the model was investigated. The result of this test indicated that there was a unique solution to the proposed model.

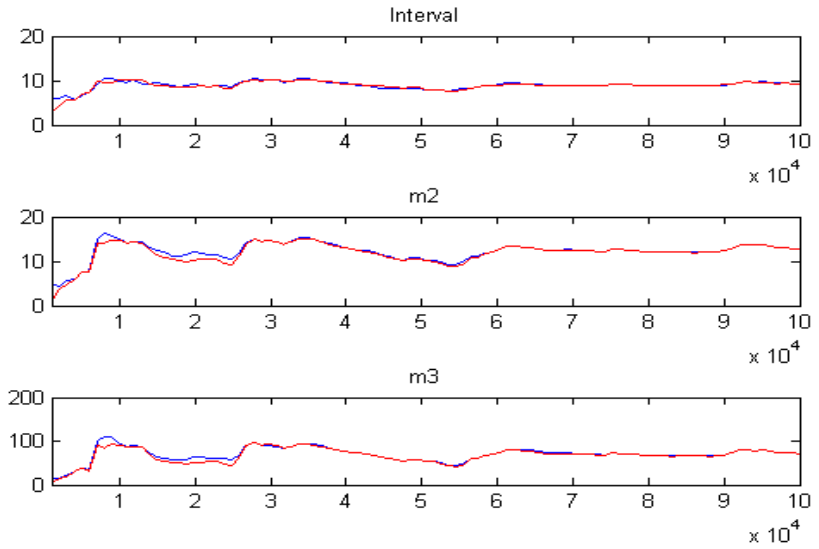

Figure 1. Brooks & Goldman MCMC of for all Parameters

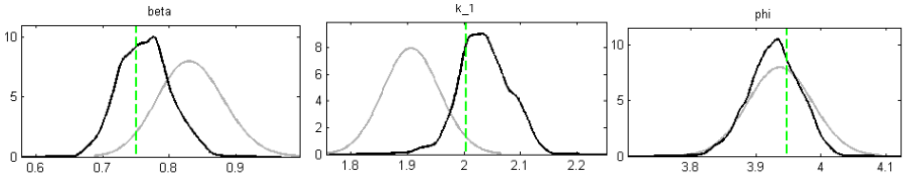

Figure 2. Prior Distribution & Post Distribution

4.2 Impulse Response Functions

In the present study, the impacts resulted from the impulse of increasing asymmetric information on selected variables, specifically on the production, employment, and investment, were analyzed. The results coming from the dynamics of variables reveal that the asymmetric information impulse had an effect on the economy by transferring the bank's interest rate (Equation 67). The increase in the asymmetric information resulted from the reduction of resources available to the bank and the rising costs of banks had led to an increase in the concessional loans profit. The increase in the profit of concessional loans belonging to banks, with regard to Equations 7, 9, 8, 67, and 68, reduced the q, investment, and the capital goods stock. Furthermore, according to the Equation (14), this decline in the capital stock reduced the production of intermediate goods (y_{jt}). As shown in Equations (21) and (23) and as the empirical results of the study confirm, the decline in the production of the intermediate goods and the capital stock could lead to a reduction in the non-oil products and employment, and, ultimately, based on Equation (21), the total production could decrease. As one may notice, according to Equation (5), increasing the interest rate reduces the household consumption.

The results of a 10% impulse in increasing the asymmetric information are shown in Figure 3. As it can be observed, increasing the asymmetric information by 10% in the first year led to the reduction of investment by 17%, the total production by 2%, the non-oil production by 2.2%, and the employment by 2%. Moreover, most of the variables converged in less than a ten-year period.

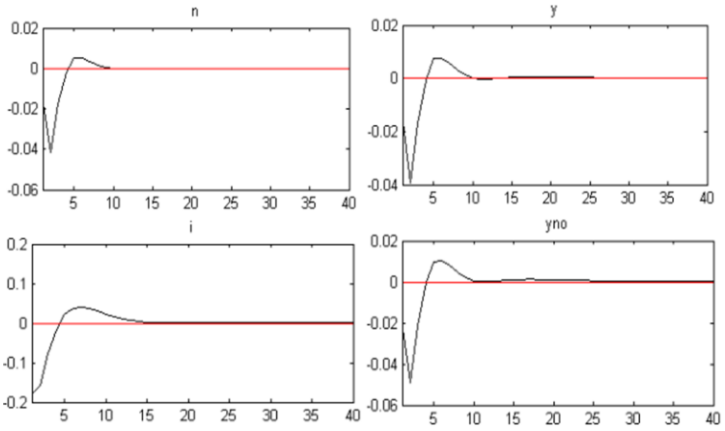

Figure 3. The impact of increasing the impulse of asymmetric information on investment, production, and employment

As stated early in this article, another objective of this research was to introduce an accurate model, model it close to the economy of Iran, and offer precise estimations of its variables. For instance, in this research, the discount rate (β) was estimated to be 0.762 and the discount rate, or the time preference rate, in the economy of Iran was estimated to be 31% based on the results from our modeling and using $\frac{1-\beta}{\beta}$formula. This estimation appears to be more consistent with the economy of Iran compared to the estimates made in the previous studies.[1]

5. Concluding Remarks

The optimal performance of the economic system in any given country depends on the existence of the real sector and the efficiency, complementarity, and robustness of the financial sector. The main responsibility of an efficient financial sector is to optimize the allocation of the limited resources of an economy among the competing economic sectors. Failure in the activity of the financial or real sector will affect the performance of other sectors. Among all

[1] For example, the discount rate estimated in Manzor and Taghipour's (2015) study was 0.9745 and 0.9701 in Tavakolian and Naeni's (2017) study. Using the $\frac{1-\beta}{\beta}$ formula, the estimate for the discount rate, or the time preference rate, corresponding to the discount rate, cited in the two studies referred to above, for the economy of Iran, would be 2.5 and 3 %, respectively, in a year.

the economic factors, symmetric information (honesty) is one of the most vital factors in delivering good performance in the financial markets.

The asymmetric information is one of the major elements that affect the behavior of banks. Asymmetric information in banks leads to, as fleshed out before, moral hazard and adverse selection. Therefore, in order to prevent the occurrence of these two phenomena, on one hand, banks need to spend costs to identify their good customers. On the other hand, firms have to pay some costs, including collateral, promissory notes, guarantees, and so on, in order to increase their credits and win the trust of the banks as to receive some concessional loans from them. This whole process leads to a rise in the costs involved in financing the banks. Part of the brunt prompted by this increase in the costs will be taken by the firms and part of it will be taken by the banks. How much each is going to suffer depends on the elasticity of the supply and demand for the loans. The present study investigated this issue by utilizing several equations describing Iran's economy and determined its impact on other economic variables. These equations, describing Iran's economy, were divided into nine sectors, including households, firms, banks, the Central Bank, oil, government, exports and imports, and other countries in the world. It appears that the set of equations represented in this study were among the most complete New-Keynesian DSGE model used for describing the economy of Iran.

In order to empirically evaluate the model designed and developed in this study, Bayesian estimation and the calibration of the parameters were used. The findings of the research indicated that when, due to the reduced resources available and heightened costs to the banks, the asymmetric information is intensified and honesty is diminished in a society, the exchange rate of banking concessional loans will increase, and, consequently, the country will suffer a decline in the investment and a significant downturn in the production of intermediate goods. Finally, the decline in the production of intermediate goods and the reduction in the capital stock will reduce the production of marginal goods and employment.

In the end, in order to reduce the asymmetric information in the financial market, and, specifically, in the credit market, the following points are suggested:

- Ranking the customers of the banks;
- Adopting appropriate laws and regulations in the financial markets of the country;
- Forming a strong legal system banking;
- Identifying and presenting the bank with the appropriate contracts and financing tools;
- Monitoring the banks before and after the concessional loans have been presented as to prevent the moral hazard and the adverse selection;

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