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The Anatomy of DSGE Models with Banking Industry for Iran's Economy

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Abstract

The recent financial crisis has raised several questions with respect to the financial institutions and banking industry. Hence, over the last decade the Iranian banking industry has undergone many substantial changes, such as liberalization, government regulation and technological advances. What impacts do these changes have on the policy instruments? We have answered this question in this study. To do this, we used the DSGE models. We also used two kinds of basic DSGE structures: External Finance Premium (EFP) Model and Collateral Constraint (CC) Model. Both models are simulated for Iran. Finally, we have examined the effects of monetary shocks for each model variables. We employed a Bayesian method to estimate the parameters of DSGE models. We have concluded that the prediction power of the EFP models is better than that of CC model. In addition, the results showed that the increase in liquidity raises output, inflation, investment and consumption. Moreover, it was found that the responses of variables to monetary policy in the CC model was greater than of the EFP model.

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1. Introduction

The seminal paper by Kydland and Prescott (1982) started the real business cycle (RBC) theory in particular and Dynamic Stochastic General Equilibrium (DSGE) modeling in general. As the name suggests, RBC models focus on the real economy and hence abstract monetary issues. As the importance of money has been documented by empirical studies, new Keynesian (NK) models have introduced money into the framework as well as monetary authorities. The advantage of these models led to attracting the attention of policy-makers. The last few years have seen an explosion of DSGE models Design for policy analysis and forecasting. These models were developed and new economic sectors were modeled. One of these sectors was banks and financial intermediaries. Of course, the origins of investigation of the influence of the financial markets on business cycles can be found in Bernanke and Gertler (1989) (Brázdik et al., 2012). And later developed, the introduction of financial frictions in a dynamic general equilibrium (DSGE) framework by Bernanke et al. (1999) and Iacoviello (2005). Recently there has been an increasing interest in introducing a banking sector in dynamic models and to analyze economies (Christiano et al., 2007, and Goodfriend and McCallum, 2007). The global recession that followed the burst of the subprime crisis has restored interest in the impact of banks on the real economy.

Previously efforts were made to model the banking industry in Iran. Shahhosseini and Bahrami (2013) owing to the importance of monetary and financial aspects of macroeconomic fluctuations, and the role of financial intermediaries, designed a DSGE model with regard to banking, to analyze the effect of oil, productivity and monetary shocks on Iran's economy. By applying the model, they found that outstanding claims of banking sector reduce the impact of monetary shocks. Parvin et al. (2014), by using DSGE model and the annual data for the period of 1981-2012, examined the response of macroeconomic variables such as output and inflation to banking sector’s balance-sheet shocks. The results showed that the negative effects of balance sheet shocks stemming from the shocks of the reserve of non-performing loans on output and inflation are higher than the shocks resulting from the withdrawal of deposits and bank liquidity shocks, but the effects are diminished in shorter period of time[1]. Ahmadian and Shahchera (2015) augmented that Asset-liability mismatch in balance sheet of banks shows serious challenges in banks.

They suggested a micro funded framework that can evaluate the role of asset and liability management in banking sector in business cycles through a DSGE model.

The importance of the banking industry has caused policy makers in Iran to pay attention to this section. Hence over the last decade the Iranian banking industry has undergone many substantial changes, such as liberalization, government regulation and technological advances. Changes in banking regulations led to changes in banking market structure.

Empirical evidence shows that Iran’s banking industry does not act under a perfect competitive situation. Studies show that there is a high concentration in the banking industry of Iran[2]. Lerner index shows that the banking industry in Iran is different from the perfect competition industry[3]. So banks in Iran have market power. Moreover, the central bank in Iran determines the profit rates. So we need to consider these important features in order to model dynamic stochastic general equilibrium for Iran. So, we are recognizing a degree of monopolistic power for banking industry in DSGE model. Accordingly, in this paper we have introduced a banking sector in a DSGE model for Iran's economy, in order to understand the role of banking system in the transmission of monetary shocks. First we modeled the bank's behaviors and used two kinds of basic DSGE structures: External Finance Premium Model and Collateral Constraint Model. Both models have been simulated for Iran. We compared the simulated and real data for each model. Finally, we examined the effects of monetary shocks in each of the models. Furthermore, we utilized Bayesian methods to estimate the DSGE models parameters. The remainder of the paper is organized as follows: Section 2 introduces the models; Section 3 discusses the results of the two models for Iranian banking industry and Section 4 concludes.

2. Models

In the following, we presented the two basic DSGE models for Iranian economy.

2-1. External Finance Premium Model

The external finance premium concept, whose history begins with the studies of Bernanke and Gertler (1989) and continues with the papers by

Bernanke and Gertler (1989) and Fukunaga (2002) (Brázdik et al., 2012)., It is worth mentioning that two of the most frequently referred financial friction models are Bernanke-Gertler-Gilchrist (BGG) financial accelerator model and liquidity constraint model by Kiyotaki and Moore (1997). They focused on borrower's balance sheet, and showed how borrower's leverage condition generates significant effects in economy. The structure of this model will be explained in the following.

The economy has two production sectors. Firms in the intermediate goods sector produce differentiated goods for sale in monopolistically competitive markets, using labour and capital as inputs. Firms in the perfectly competitive final goods sector combine domestically produced and imported intermediate goods into an aggregate good that can be used for private consumption, private investment. The household sector consists of a continuum of infinitely-lived households that consume the final good, work in firm and bank, and save in bank. The model incorporates nominal rigidities in the nominal bank interest rate (loan and deposit). In this model, bank receives household deposits and provides loans to firms. The main structure of the model can be demonstrated in follows figure.

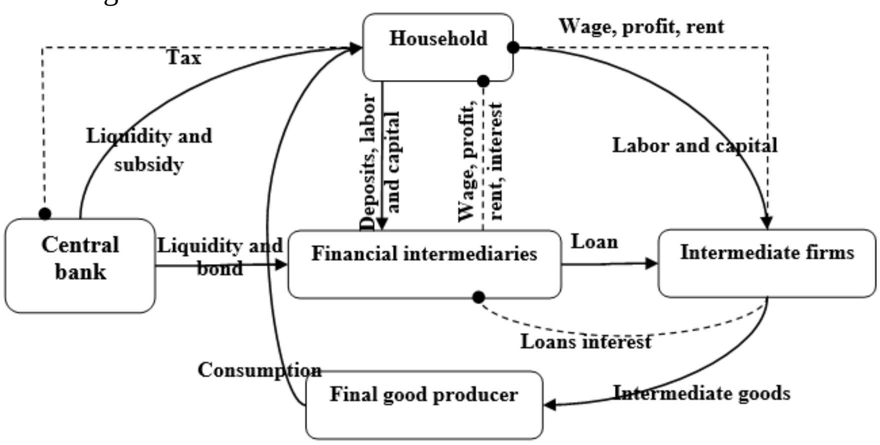


Figure 1. Structure of EFP Model
Source: The Authors

Households: Households are the first group of economic actors. The household chooses consumption, c_t, and the real money holdings at the beginning of period t, M_t/P_t, The decision on the labour supply n_t and s_t

are the shares of total time endowment, normalized to 1, the household spends working in the firm and the bank, respectively. The household dedicates to labour in the intermediate goods-producing firm and the banks, respectively. The expected lifetime utility of a representative household is as follows

$$E_t \sum_{t=0}^{\infty} \beta^t \left\{ \ln c_t + \phi \ln(1 - n_t - s_t) + \psi \ln(\frac{M_t}{P_t}) \right\} \qquad (1)$$

Where, $0 < \beta < 1$ is the subjective discount factor. The households uses labour income $w_t(n_t + s_t)$, dividends $g_t + g_t^f + g_t^{cb}$ from intermediate goods-producing firms, g_t and banks, g_t^f and central bank, g_t^{cb} respectively, and its deposits from the previous period d_{t-1} multiplied by the interest rate on household deposits r_{t-1}^d to finance its consumption and new deposits and real money holdings. They face the following budget constraint

$$c_t + d_t \le w_t(n_t + s_t) + \frac{d_{t-1}(1 + r_{t-1}^d)}{\pi_t} + g_t + g_t^f + g_t^{cb} - \frac{\Delta M_t}{P_t} \qquad (2)$$

The household receives income from profits (firms, bank and central bank), wage (firm and bank), interest, and expenditure on consumption, investment, saving and liquidity asset. Households save through bank deposits. Like Güntner (2011), we supposed that household faces the following the Deposit-in-Advance constraint

$$\alpha c_t \le d_t \qquad (3)$$

Where α is a constant ratio between household consumption and Deposit[4]. Household maximizes the utility function (1) Subject to (2) and (3).

Intermediate firms: All intermediate firms are owned by the private households and do not accumulate own funds, apart from the stock of productive capital. A continuum of monopolistically competitive firms produces intermediate domestic goods using labor and capital. They face perfectly competitive physical capital rental and perfectly competitive labor types. Each intermediate-goods firm produces its output using following technology function

$$y_t(j) = A_t k_{t-1}(j)^{\gamma} n_t(j)^{1-\gamma} \qquad (4)$$

Where, A_t is technology level that follows an AR(1) process, and k

is the capital. Households own the physical capital stock, which is generated through a technology that converts investment into physical capital. They rent the physical capital to firms for a rental price that is determined in a competitive market, and also determine the intensity at which firms are to use it. The accumulation of physical capital is introduced by the following equation, with δ is the depreciation rate:

$$k_t(j) = (1-\delta)k_{t-1}(j) + i_t(j) \tag{5}$$

i_t is investment. Intermediate-goods firm maximizes profits $(g_t(i))$; firm profits function is the present value of expected income $(\frac{P_t(i)}{P_t} y_t(i))$ minus total present value of cost that includes present value of production factors cost (wage and interest) plus, price and capital adjustment costs.

$$E_t \sum_{t=0}^{\infty} \beta^t \lambda_t g_t(i) \tag{6}$$

It is weighted by the household's marginal utility $0 < \lambda < 1$ and discount factor β^t, and $g_t(i)$ is real current firm profits in period *t*:

$$g_t(i) = \frac{P_t(i)}{P_t} y_t(i) - \frac{R_{t-1}^l (w_{t-1}(i) n_{t-1}(i) + i_{t-1}(i))}{\pi_t}$$
$$- \frac{\phi_p}{2} \left[\frac{P_t(i)}{\pi P_{t-1}(i)} - 1 \right]^2 y_t(i) - \frac{\phi_k}{2} \left[\frac{k_t(i)}{k_{t-1}(i)} - 1 \right]^2 k_{t-1}(i) \tag{7}$$

$R_{t-1}^l = 1 + r_t^l$ is gross nominal interest rate on loans. Hence, intermediate-goods firm is faced with Adjustment costs for price ϕ_p and capital ϕ_k adjustment. Adjustment cost is estimated by Rotemberg (1982) model. Following Rotemberg (1982), we assumed that price-setting intermediate-goods producers face quadratic adjustment costs when changing either their prices or their stock of physical capital[5]. All firms are owned by the representative households. They do not accumulate own funds, apart from the stock of productive capital. At the end of each period, monopolistic profits g_t are therefore distributed to the household. The risk-neutral manager of firm j chooses {n, P, k} in order to maximize equation 6.

The final good producer: The final good y is produced in a competitive market by combining a continuum of intermediate goods indexed by *j* using a CES technology.

$$y_t = (\int_0^1 y_t(j)^{\frac{\mu-1}{\mu}} dj)^{\frac{\mu}{\mu-1}} \tag{8}$$

Where μ is the elasticity of substitution between intermediate goods of different producers and y_t is the overall demand addressed to the producer of intermediate good j.

If the final producer maximizes his profits, his demand is $y_t(j) = (P_t(j)/P_t)^{-\mu} y_t$ of intermediate good. Substituting $y_t(j) = (P_t(j)/P_t)^{-\mu} y_t$ into equation (8) yields the following relation between the aggregate price level and the prices of intermediate goods

$$P_t = \left[\int_0^1 P_t(i)^{1-\mu} di\right]^{1/(1-\mu)} \tag{9}$$

Prices are sticky and retail sector set prices according to Calvo (1983) contracts, each period a random fraction of firms adjust prices that we supposed the probability that a firm adjusts prices for each period by $1-\theta$.

Financial intermediaries: Following Guntner (2009; 2011) and Gerali et al. (2009) we supposed that financial intermediaries, indexed to the interval j, provide partially differentiated sight deposit and loan contracts, facing a constant finite elasticity of substitution in the markets for deposit and credit, respectively, of ηd and ηl. Thus (as in the standard Dixit-Stiglitz framework for goods markets), agents have to purchase deposit (loan) contracts by each bank in order to save (borrow) one unit of resources. We assumed that deposits and loans to households and to intermediate firms are, in fact, a composite CES basket of partially differentiated products, each supplied by a single bank with elasticity of substitution equal to ηd and ηl, respectively. There are imperfect substitutability between the contracts of different banks which will additionally lead to be explicit monopolistic, similar to the case of price-setters in goods production.

$$l_t(i) = \left(\frac{r_t^l(i)}{r_t^l}\right)^{-\eta_l} \tag{10}$$

$$d_t(i) = \left(\frac{r_t^d(i)}{r_t^d}\right)^{\eta_d} \tag{11}$$

In the present model, financial intermediaries are capable of changing their deposit and loan interest rates at a quadratic adjustment cost. A loan contract supplied by financial intermediary is closed according to the constant returns to scale function

$$l_t(i) = F(g_t + \kappa k_t)^{\sigma} s_t(i)^{1-\sigma} \tag{12}$$

Where s_t is the monitoring effort and g_t, k_t are final good producer profits and installed in the enterprises as productive capital, respectively. Seizing the borrower's capital stock in the event of default, is excluded here. Since k_t is installed in the firm, only a fraction $\kappa < 1$ is considered actually collectible by banks.

The representative household is provided with liquidity services at a cost of $\varpi d_t(i)/m_t(i)$ that is proportionate to the amount of sight deposits and falling in the bank's reserves of central bank money. Financial intermediaries can increase their reserves of *m(i)* by issuing risk-free bonds b which are bought by the monetary authority in open market operations for exchanging high-powered money. The banking sector operates in a regime of monopolistic competition: Banks set interest rates on deposits and on loans in order to maximize profits. According to above structure, bank manager maximizes his profits

$$E_t \sum_{t=0}^{\infty} \beta^t \lambda_t g_t^f(i) \tag{13}$$

Where $g_t^f(i)$ is

$$\begin{aligned} g_t^f(i) &= d_t(i) + b_t(i) + \frac{m_{t-1}(i)}{\pi_t} + \frac{l_{t-1}(i)(1+r_{t-1}^l(i))}{\pi_t} - m_t(i) - l_t(i) \\ &- \frac{d_{t-1}(i)\left(1+r_{t-1}^d(i)\right)}{\pi_t} - \frac{b_{t-1}\left(1+r_{t-1}\right)}{\pi_t} - w_t s_t(i) - \frac{\varpi d_t(i)}{m_t(i)} \\ &- \frac{\phi_{r^d}}{2}\left(\frac{r_t^d(i)}{r_{t-1}^d(i)} - 1\right)^2 d_t(i) - \frac{\phi_{r^l}}{2}\left(\frac{r_t^l(i)}{r_{t-1}^l(i)} - 1\right)^2 l_t(i) \end{aligned} \tag{14}$$

Financial intermediaries maximize (13) Subject to (15) and (16):

$$l_t(i) \geq \left(\frac{r_t^l(i)}{r_t^l}\right)^{-\eta_l} \tag{14}$$

$$d_t(i) \geq \left(\frac{r_t^d(i)}{r_t^d} \right)^{\eta_d} \quad (15)$$

Where ϕ_{r^d} and ϕ_{r^l} are financial intermediaries quadratic adjustment cost of changing deposit and loan interest rates. In order to introduce sticky rates we assumed in our model that banks face quadratic adjustment costs of Rotemberg whenever they change the level of retail rates. So, we assumed that bank interest rates are sticky, i.e. they react slowly to changes in the corresponding market rates[6]. Note that imperfect competition among banks yields a kind of hybrid Phillips curve in retail interest rates, when they are sticky.

Central bank: We introduced an authority exercising monetary policy. Every period, the monetary authority conducts open market operations to provide the financial intermediaries with their desired amount of central bank money in exchange for risk-free bank bonds.

$$g_t^{cb} = \frac{b_{t-1}(1+r_{t-1})}{\pi_t} - b_t \quad (16)$$

Where g_t^{cb} is central bank profit that is obtained from lending to banks, r_t, is central bank interest rate. According to Iran monetary policy role, Iran's Central Bank decides on interest rates on deposits and loans. With the implementation of Usury-free Banking Law and the introduction of contracts with fixed return and partnership contracts, the regulations pertaining to determination of profit rate or expected rate of return on banking facilities and the minimum and maximum profit rate or expected rate of return, as is stipulated in the by-law of the Usury free Banking Law, are determined by the Money and Credit Council (MCC). Moreover, the CBI can intervene in determining these rates both for investment projects or partnership and for other facilities extended by banks. Iran's Central Bank will adjust interest rates based on inflation. So we assumed that the interest rate is

$$r_t = (1-\rho)(\beta^{-1} - 1 + \varphi_\pi(\pi_t - \pi_t^*) + \rho r_{t-1} + \varepsilon_t^r \quad (17)$$

Next, we introduced the central bank's balance sheet. We supposed that balance sheet merely contains high-powered money MB is:

$$MB_t = FR_t - DG_t - g_t^{cb} \quad (18)$$

Where FR, is Net foreign assets of the central bank and DG is Net government deposits in the Central Bank and g^{cb} is like equation (16).

Liquidity changes are policy instrument for Iran's central bank. Therefore, Central bank in Iran is able to control the volume of money in the economy by affecting the money supply or monetary aggregate by changing in money base and money multiplier. But the central bank has two goals: Optimal inflation π_t^*(goal inflation) and optimal production, y_t. Central bank determined liquidity growth rate to reach its goals (Optimal inflation and optimal production). Therefore, we denoted the central bank's reaction function (By log-linear) as follows:

$$\hat{\mu}_t = \rho_\mu \hat{\mu}_{t-1} + \lambda^\pi (\pi_t - \pi_t^*) + \lambda^y y_t + \varsigma_t \quad (19)$$

Where $\hat{\mu}_t$, is the liquidity growth rate[7] and $\varsigma_t = \rho_\varsigma \varsigma_{t-1} + \varepsilon_t^{mb}$ is the shock to liquidity growth rate so that $\varepsilon_t^{mb} \approx iid.N(0, \sigma_{mb}^2)$. The source of this shock can be different. In other words, it can be caused by the oil income shocks or monetary base shock. In addition, Inflation target is an unobservable variable that we assumed it to be $\pi_t^* = \rho_{\pi^*} \pi_{t-1}^* + \varepsilon_t^{\pi^*}$, where $\varepsilon_t^{\pi^*} \approx iid.N(0, \sigma_{\pi^*}^2)$ is the shock to the inflation target. The following equations are log-linearized EFP model.

$$0 = \lambda \hat{\lambda}_t - \frac{1}{c}\left[\hat{c}_t\right] + \xi \alpha \hat{\xi} \quad (20)$$

$$0 = \hat{w}_t + \hat{\lambda}_t - \frac{1}{1-n-s}(n\hat{n}_t + s\hat{s}_t) \quad (21)$$

$$0 = (r^d \lambda \frac{M}{P})(\hat{r}^d + \hat{\lambda}_t + \frac{\hat{M}_t}{P_t}) - \psi r^d \hat{r}^d + (\xi \frac{M}{P})(\hat{\xi}_t + \frac{\hat{M}_t}{P_t}) \quad (22)$$

$$0 = c\hat{c}_t + d\hat{d}_t - wn(\hat{w}_t + \hat{n}_t) - ws(\hat{w}_t + \hat{s}_t) - \frac{d}{\pi}\hat{r}_{t-1}^d - \frac{(1+r^d)d}{\pi}(\hat{d}_{t-1} - \hat{\pi}_t) - g\hat{g}_t - g^f \hat{g}_t^f - g^{cb}\hat{g}_t^{cb} \quad (23)$$

$$0 = \hat{d}_t - \hat{c}_t \quad (24)$$

$$0 = \hat{r}_t^l + E_t(\hat{\lambda}_{t+1} - \hat{\pi}_{t+1}) + \hat{w}_t + \hat{n}_t - \hat{\Omega}_t - \hat{y}_t \quad (25)$$

$$0 = (1-\mu)\hat{\lambda}_t + (\mu - 1)\hat{\Omega}_t - \phi_p \hat{\pi}_t + \beta \phi_p E_t \hat{\pi}_{t+1} \quad (26)$$

$$0 = \beta \phi_i \hat{i}_{t+1} - \phi_i (1+\beta)\hat{i}_t + \phi_i \hat{i}_{t-1} - \beta \frac{1+r^l}{\pi}(\frac{\hat{r}^l}{1+r^l} - E_t \hat{\pi}_{t+1}) + \beta\gamma \frac{\Omega}{\lambda}\frac{y}{k} E_t \left[\hat{y}_{t+1} - \hat{\lambda}_{t+1} + \hat{\Omega}_{t+1} - \hat{k}_t\right] \quad (27)$$

$$0 = \hat{k}_t - (1-\delta)\hat{k}_{t-1} - \delta \hat{i}_t \quad (28)$$

$$0=\gamma\hat{k}_{t-1}+(1-\gamma)\hat{n}_t-\hat{y}_t \tag{29}$$

$$0=g\hat{g}_t-y\hat{y}_t+\frac{wn+i}{\pi}\hat{r}^l_{t-1}+\frac{1+r^l}{\pi}\left[wn(\hat{w}_{t-1}+\hat{n}_{t-1})+i\hat{i}_{t-1}+(wn+i)\pi\hat{\pi}_t\right] \tag{30}$$

$$0=\hat{m}_t-\hat{b}_t \tag{31}$$

$$0=\hat{r}_t-\rho\hat{r}_{t-1}-(1-\rho)\varphi_\pi\pi\hat{\pi}_t-\varepsilon^r_t \tag{32}$$

$$0=g^{cb}\hat{g}^{cb}_t-m\hat{m}_t-\frac{b}{\pi}\hat{r}_{t-1}-\frac{b(1+r)}{\pi}(\hat{b}_{t-1}-\hat{\pi}_t)+b\hat{b}_t+\frac{m}{\pi}(\hat{m}_{t-1}-\hat{\pi}_t) \tag{33}$$

$$\begin{aligned}0=&g^f\hat{g}^f_t+l\hat{l}_t-d\hat{d}_t-b\hat{b}_t-\frac{m}{\pi}(\hat{m}_{t-1}-\hat{\pi}_t)-\frac{l(1+r^l)}{\pi}(\hat{l}_{t-1}-\hat{\pi}_t)-\frac{l}{\pi}\hat{r}^l_{t-1}+\frac{d(1+r^d)}{\pi}\\&(\hat{d}_{t-1}-\hat{\pi}_t)+\frac{d}{\pi}\hat{r}^d_{t-1}+\frac{b(1+r)}{\pi}(\hat{b}_{t-1}-\hat{\pi}_t)+\frac{b}{\pi}\hat{r}_{t-1}+m\hat{m}_t+ws(\hat{w}_t+\hat{s}_t)+\frac{\varpi d}{m}(\hat{d}_t-\hat{m}_t)\end{aligned} \tag{34}$$

$$0=l\hat{l}_t-wn(\hat{w}_t+\hat{n}_t)-i\hat{i}_t \tag{35}$$

$$0=\hat{l}_t-\frac{\sigma g}{g+\kappa k}\hat{g}_t-\frac{\sigma\kappa k}{g+\kappa k}\hat{k}_t-(1-\sigma)\hat{s}_t \tag{36}$$

$$0=\frac{\beta}{\pi}(\hat{r}_t-\hat{r}^d_t)-\frac{\beta}{\pi}(r-r^d)E_t(\hat{\pi}_{t+1}-\hat{\lambda}_{t+1}+\hat{\lambda}_t)+\frac{\varpi}{m}\hat{m}_t+\frac{\lambda^d}{\lambda}(\hat{\lambda}^d_t-\hat{\lambda}_t) \tag{37}$$

$$0=\frac{\beta}{\pi}(\hat{r}^l_t-\hat{r}_t)-\frac{\beta}{\pi}(r^l-r)E_t(\hat{\pi}_{t+1}-\hat{\lambda}_{t+1}+\hat{\lambda}_t)-\frac{ws}{(1-\sigma)l}(\hat{w}_t+\hat{s}_t-\hat{l}_t)+\frac{\lambda^l}{\lambda}(\hat{\lambda}^l_t-\hat{\lambda}_t) \tag{38}$$

$$0=\frac{\beta}{\pi}\hat{r}_t-\frac{\beta r}{\pi}E_t(\hat{\pi}_{t+1}-\hat{\lambda}_{t+1}+\hat{\lambda}_t)-\frac{\varpi d}{m^2}(\hat{d}_t-2\hat{m}_t) \tag{39}$$

$$0=\beta\hat{r}-E_t(\hat{\pi}_{t+1}-\hat{\lambda}_{t+1}+\hat{\lambda}_t) \tag{40}$$

$$\begin{aligned}0=&\beta\frac{\phi_{r^d}}{r^d}E_t\hat{r}^d_{t+1}-\left[(1+\beta)\frac{\phi_{r^d}}{r^d}+(1+\eta_d)\frac{\beta}{\pi}\right]\hat{r}^d_t+\frac{\phi_{r^d}}{r^d}\hat{r}^d_{t-1}+\eta_d\frac{\varpi}{m}\hat{m}_t\\&+\frac{\beta}{\pi}\left[(1+\eta_d)r^d+\eta_d\right]E_t(\hat{\pi}_{t+1}-\hat{\lambda}_{t+1}+\hat{\lambda}_t)-\eta_d\frac{\lambda^d}{\lambda}(\hat{\lambda}^d_t-\hat{\lambda}_t)\end{aligned} \tag{41}$$

$$\begin{aligned}0=&\beta\frac{\phi_{r^l}}{r^l}E_t\hat{r}^l_{t+1}-\left[(1+\beta)\frac{\phi_{r^l}}{r^l}-(1-\eta_l)\frac{\beta}{\pi}\right]\hat{r}^l_t+\frac{\phi_{r^l}}{r^l}\hat{r}^l_{t-1}\\&-\frac{\beta}{\pi}\left[(1-\eta_l)r^l-\eta_l\right]E_t(\hat{\pi}_{t+1}-\hat{\lambda}_{t+1}+\hat{\lambda}_t)+\eta_l\frac{\lambda^l}{\lambda}(\hat{\lambda}^l_t-\hat{\lambda}_t)\end{aligned} \tag{42}$$

$$\hat{\mu}_t=\rho_\mu\hat{\mu}_{t-1}+\lambda^\pi(\pi_t-\pi^*_t)+\lambda^y y_t+\varsigma_t \tag{43}$$

$$\hat{\mu}_t=\hat{M}_t-\hat{M}_{t-1}+\hat{\pi}_t \tag{44}$$

$$\pi_t^* = \rho_{\pi^*}\pi_{t-1}^* + \varepsilon_t^{\pi^*} \tag{45}$$

$$\varsigma_t = \rho_{\varsigma}\varsigma_{t-1} + \varepsilon_t^{mb} \tag{46}$$

2-2. Collateral Constraint Model

An alternative approach to the external finance premium accelerator mechanism is to incorporate a limit on the amount of funds available. The availability and amount of the debtor's assets facilitates the provision of loans by means of the debtor's assets (collateral) used to secure the loans. Considering Andre´s and Arce (2009; 2012) and Iacovilo (2005) models, we have designed a model for Iran economy. The economy has two production sectors. Firms in the intermediate-goods sector produce differentiated goods for sale in monopolistically competitive markets, using labour, real estate and capital as inputs. Firms in the perfectly competitive final goods sector combine domestically produced and imported intermediate goods into an aggregate good that can be used for private consumption, private investment and housing service. The household sector consists of a continuum of infinitely-lived households that consume the final good, demand housing service, work in firm and save in bank. In this model, bank receives household deposits and provides loans to firms. There is a fixed value of mortgage assets that Households used for housing services and Entrepreneur is using to get loans. The main structure of the model can be demonstrated as the following figure.

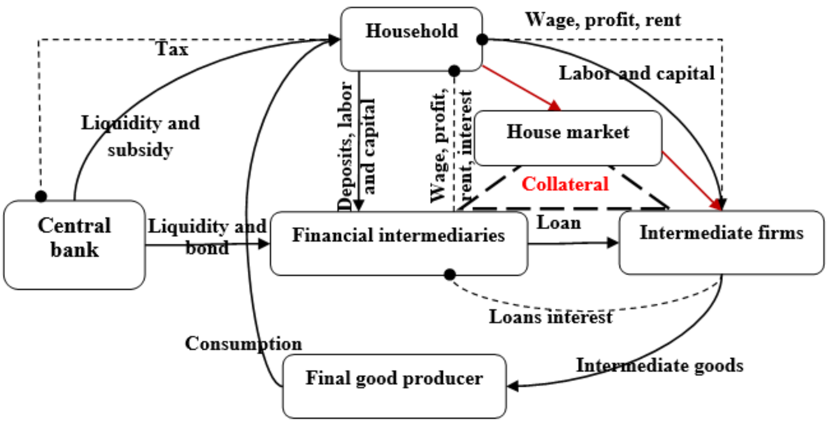


Figure 2. Structure of Collateral Constraint Model
Source: The authors

Households: The economy consists of continuum of households with measure 1, and a continuum of entrepreneurs of mass 1 producing homogenous consumption goods. Households and entrepreneurs obtain utility from consumption of a composite good. Also, the flow of services produced by their housing stocks delivers utility directly to households, while entrepreneurs employ housing services as a production factor. Households and entrepreneurs participate in the credit market either lending or borrowing funds. Households are the first part of this model. If the C_t, h_t , M_t/P_t and l_t represent, respectively, consumption, housing services, real money holding and hours worked for a household who has a subjective discount factor $0 < \beta < 1$ and seeks to maximize his utility function. Households can increase their utility, if increased consumption, housing services, real money holding or decrease hours worked. The lifetime expected utility of household is:

$$\sum_{t=0}^{\infty}\beta^{t}\left(\log c_{t}-l_{t}+\vartheta\log h_{t}+\psi\log\frac{M_{t}}{P_{t}}\right) \tag{47}$$

Subjected to budget constraints

$$c_{t}+i_{t}+\frac{\phi i_{t}^{2}}{2K_{t-1}}+q_{t}(h_{t}-h_{t-1})+d_{t}=w_{t}l_{t}+P_{t}^{k}K_{t-1}+\int_{0}^{1}\Theta_{jt}dj+\sum_{i=1}^{n}\Omega_{t}^{i}+\frac{R_{t-1}^{d}d_{t-1}}{\pi_{t}}+\frac{\Delta M_{t}}{P_{t}} \tag{48}$$

Where in this equation, variables are introduced as the following: Investment, i_t, house price, q_t, labor wage, w_t, capital price, P_t^k, capital, K_t, deposit, d_t, deposit interest rate, R_t^d, inflation, π_t. In addition Θ_{jt} are dividends from ownership of the j_{th} retail firm and Ω_t^i are dividends from ownership of the, i_{th} bank. The household receives income from profits (firms and bank), wage, rent, and interest, and spends on consumption, investment, accumulate housing (which is, on aggregate, provided in fixed supply), saving and real money holding. Households save through bank deposits. The capital stock available for production in period t, K_t, is determined at the end of period t-1 according to the following accumulation equation:

$$K_{t}=i_{t}+(1-\delta)K_{t-1} \tag{49}$$

Capital depreciates at a rate δ . Households own the physical capital stock, which is generated through a technology that converts investment into physical capital. They rent the physical capital to firms for a rental price that is determined in a competitive market, and also determine the intensity at which firms are to use it. Household maximizes your utility function (47) subjected to (48) and (49).

Entrepreneurs: Entrepreneurs are the second group of economic actors in this DSGE model. The entrepreneur operates in a perfectly competitive environment and produces an intermediate good, Y_t. A continuum of monopolistically competitive entrepreneurs produces intermediate domestic goods using labor, capital, and real estate. They face perfectly competitive physical capital rental and primary commodities markets and perfectly competitive labor types and total constant real estate. Entrepreneur production function is

$$Y_t = A_t (K_t^e)^{\mu} (l_t)^{1-\mu-\nu} (h_{t-1}^e)^{\nu} \quad (50)$$

Where A_t is an exogenous productivity, K_t^e is entrepreneurs capital demand, l_t is labour and h_t^e is real estate. Following Andre´s and Arce (2012), we assumed that the entrepreneur located at point *k* and it seeks to maximize the following utility function

$$E_0 \sum_{t=0}^{\infty} \gamma^t (\ln c_t^e - \alpha d_t^{k,i}) \quad (51)$$

Where c_t^e, $d_t^{k.i}$ and α denote consumption, the distance between entrepreneur *k* and bank, *i*, and the utility loss per distance unit, respectively. Following Iacoviello (2005) and Andre´s and Arce (2012), we assumed that the entrepreneurs are less patient than the households, too[8]. So that entrepreneurs discount future utility more than the households. The entrepreneur faces the following funds constraint

$$\frac{Y_t}{X_t} + b_t = c_t^e + q_t \Delta h_t^e + \frac{R_{t-1}^e b_{t-1}}{\pi_t} + w_t l_t + P_t^k K_t^e \quad (52)$$

where X_t denotes the markup of final over intermediate goods charged by retailers and b_t is Loan amounts received by entrepreneurs that is the real value of a nominal one-period bank loan taken at t and R_t^e is the gross nominal interest rate on such loan, payable at the beginning of t+1. But there is a limit to get loans. Following Kiyotaki and Moore (1997), many authors (Iacoviello, 2005, and Iacoviello and Neri, 2008, and Andre´s and Arce 2012) have assumed that agents are constrained in the amount of funds they can borrow by the value of collateral they can pledge as a guarantee to the lenders. So borrowing constraint is the following:

$$b_t \leq \Phi E_t \left(\frac{q_{t+1} h_t^e \pi_{t+1}}{R_t^e}\right) \tag{53}$$

where Φ is the loan-to-value ratio. This states that the loan to repay cannot exceed the expected future value of collateral multiplied by the loan-to-value ratio. From a microeconometric point of view, (1-Φ) can be interpreted as the proportional cost of collateral repossession for banks which are given default. As in Kiyotaki and Moore (1997) mentioned, the constraint is assumed to bind eternally. Entrepreneur seeks to maximize (51) subjected to (52) and (53).

The final good producer: The output of each intermediate firm (that is active in monopolistically competitive industry with elasticity of substitution in consumers preferences and equals to ε) is purchased by a perfectly competitive final goods sector at a real price X_t^{-1}. Each intermediate firm (Entrepreneur) thus faces a downward-sloping demand curve for its product j, $Y_t(z) = (p_t(z)/p_t)^{-\varepsilon} Y_t^f$ where the Aggregate final output, Y_t^f, and the aggregate price per unit of the final good, p_t ,are defined by

$$Y_t^f = \left(\int_0^1 Y_t(z)^{1-\varepsilon} dz\right)^{\frac{\varepsilon-1}{\varepsilon}} \tag{54}$$

and

$$p_t = \left(\int_0^1 p_t(z)^{1-\varepsilon} dz\right)^{\frac{1}{1-\varepsilon}} \tag{55}$$

Prices are sticky and retail sector set prices according to Calvo (1983) contracts, in each period a random fraction of firms adjust prices that we supposed the probability of this $1-\theta$. If we denote optimal price by $P_t^*(z)$ so we have

$$\sum_{k=0}^{\infty} \theta^k E_t \left\{ \Lambda_{t,k} \left(\frac{p_t^*(z)}{p_{t+k}} - \frac{X}{X_{t+k}}\right) Y_{t+k}^*(z) \right\} = 0 \tag{56}$$

where $\Lambda_{t,k} = \beta^k (c_t^e / c_{t+k}^e)$ and price hadn't adjusted will be equal

$$p_t = \left(\theta p_{t-1}^{1-\varepsilon} + (1-\theta)(p_t^*)^{1-\varepsilon}\right)^{\frac{1}{1-\varepsilon}} \tag{57}$$

Combining the two equations (29) and (30) will result in a new Keynesian Phillips curve.

Financial intermediaries: As previously mentioned, studies showed that there was a high concentration in the banking industry of Iran. The Lerner index shows that the banking industry in Iran, is not a perfect competition. So, banks in Iran have market power and hence Iranian banking industry is not a perfect competitive context. Moreover, Iran's central bank sets the interest rates for each period for the banking sector. However, commercial banks are able to compete with others by differentiating their products. We hold that banks can compete to lend. Banks cause product differentiation in lending service. So, following Andre´s and Arce (2012), supposed that bank, *i* chooses the interest rate on loans to an intermediate firm, R_t^e, and the volume of deposits d_{it} , in order to maximize their objective functions.

$$E_t \sum_{t=0}^{\infty} \beta^t \frac{c_t}{c_{t+s}} \frac{\Omega_{t+s}^i}{p_{t+s}} \tag{58}$$

Where Ω_{t+s}^i denotes for the bank's profit dividends, subject to the set of flow of bank's funds constraints

$$\Omega_t^i + B_t^i + R_{t-1} D_{t-1}^i = R_{t-1}^{e,i} B_{t-1}^i + D_t^i \tag{59}$$

and the balance-sheet identity

$$B_t^i = D_t^i \tag{60}$$

Each bank takes all prices, the interest rate R_t (which is set by Iran's central bank), the interest charged on loans made by its competitors and the intermediate firm demand for loans. Like Andre´s and Arce (2012) we assumed that banks are competing in industry like the spatial monopolistic competition model of Salop (1979). Andre´s and Arce (2009; 2012) showed that the solution to this optimization problem in a symmetric equilibrium in which all banks set the same lending rate, R_t^e, implied the following expression for the interest rate margin

$$R_t^e = R_t + \left(\frac{R_t - \Phi E_t \left(\frac{\pi_{t+1} q_{t+1}}{q_t} \right)}{\vartheta \Phi E_t \left(\frac{\pi_{t+1} q_{t+1}}{q_t} \right) - R_t} \right) R_t \tag{61}$$

Where $\vartheta = 1 + (n/\alpha)(\gamma/1-\gamma)$ and, n, denoted bank numbers in industry so, *n*, can indicate the degree of competition in the industry.

Central Bank: In 1983 the interest-free banking law was passed in Iran, and it became illegal for banks to engage in any activity that involved interest. In this method central bank tries to control the banks interest rate (or expected profit rate)[9]. The main instrument of central bank for this purpose is determining a maximum for banks interest rate (or expected profit rate). Accordingly, Iran's Central Bank decides on interest rates on deposits. According to Monetary and banking law, Iran's Central Bank will adjust interest rates (or expected profit rate) based on inflation. So we assumed that the interest rate is

$$R_t = (R_{t-1})^{r_R} (\pi_{t-1}^{1+r_\pi} \overline{rr})^{1-r_R} \quad (62)$$

In other words, we assumed that in each period the central bank adjusted interest rates as r_π percent of inflation and r_R close enough to 1, to further show the fixed interest rate (or expected profit rate).

On the other, liquidity changes are policy instrument for Iran’s central bank. Therefore, Central bank is able to control the volume of money in the economy by affecting the money supply or monetary aggregate by changing in money base and money multiplier. But central bank will have two goals: Optimal inflation π_t^* (goal inflation) and optimal production y_t.Central bank determined liquidity growth rate such that able to reach its goals (Optimal inflation and optimal production). Therefore, we denoted the central bank's reaction function (By log-linear) as follows:

$$\hat{\mu}_t = \rho_\mu \hat{\mu}_{t-1} + \lambda^\pi (\pi_t - \pi_t^*) + \lambda^y y_t + \varsigma_t \quad (63)$$

Where $\hat{\mu}_t$, is liquidity growth rate and $\varsigma_t = \rho_\varsigma \varsigma_{t-1} + \varepsilon_t^{mb}$, is shock to liquidity growth rate so that $\varepsilon_t^{mb} \approx iid.N(0, \sigma_{mb}^2)$. The source of this shock can be different. In other words, can be caused by the oil income shocks or monetary base shock. In addition, inflation target is unobservable variable that we assume it to be $\pi_t^* = \rho_{\pi^*} \pi_{t-1}^* + \varepsilon_t^{\pi^*}$, where $\varepsilon_t^{\pi^*} \approx iid.N(0, \sigma_{\pi^*}^2)$ is shock to the inflation target.

Finally, we introduced the market-clearing conditions

$$H = h_t' + h_t \quad (64)$$

$$Y_t = c_t + c_t' + i_t + \left(\frac{\emptyset i_t^2}{2K_{t-1}}\right) \quad (65)$$

$$K_{t-1} = K_t^e \quad (66)$$

$$l_t = l_t' \quad (67)$$

After having identified the model's assumptions, the first-order equilibrium conditions have to be derived. Together with the structural equations, they build a system of stochastic difference equations. This system in two models is non-linear, so in the next step, approximation methods lead to a linear system whose solution approximates the solution of interest. So we used Uhlig (1999) method to linear approximation equation system. The model equations are log-linearized around the steady state values of each variable and stacked into a system of linear expectational difference equations. In addition, we set for the models a deterministic steady state. The following equations are log-linearized CC model.

$$\hat{Y}_t = \frac{c}{Y}\hat{c}_t + \frac{c'}{Y}\hat{c}'_t + \frac{i}{Y}\hat{i}_t + (\frac{\phi\delta^2}{2}\frac{K}{Y})(\hat{i}_t - \hat{K}_{t-1}) \tag{68}$$

$$(\hat{K}_{t-1} + \hat{\Gamma}_t)(1+\phi\delta) = \hat{K}_{t-1} + \phi\delta\hat{i}_t \tag{69}$$

$$\Gamma(\hat{\Gamma}_t - \hat{c}'_t) = \frac{\beta\phi\delta^2}{2}(2\hat{i}_{t+1} - 2\hat{K}_t - \hat{c}'_{t+1}) + \beta(1-\delta)\Gamma(\hat{\Gamma}_{t+1} - \hat{c}'_{t+1}) + P^k(\hat{P}^k_{t+1} - \hat{c}'_t - \hat{c}'_{t+1}) \tag{70}$$

$$\hat{q}_t - \hat{c}'_t = \beta(\hat{q}_{t+1} - \hat{c}'_{t+1}) - j\frac{c'}{qh'}\hat{h}'_t \tag{71}$$

$$\hat{q}_t - \hat{c}_t = \gamma\frac{\nu Y}{qh}\left[\hat{Y}_{t+1} + \hat{X}_{t+1} - \hat{h}_t\right] + \hat{q}_{t+1} - (1+\frac{\nu Y}{qh})\hat{c}_{t+1} + \Phi\left[\frac{1}{R^e} - \gamma\right](\hat{\xi}_t + \hat{q}_{t+1} - \hat{R}^e_t + \hat{\pi}_{t+1}) \tag{72}$$

$$-\hat{c}_t = \gamma R^e(\hat{R}^e_t - \hat{c}_{t+1} - \hat{\pi}_{t+1}) + (1-\gamma R^e)\hat{\xi}_t \tag{73}$$

$$\hat{b}_t = \hat{q}_{t+1} + \hat{h}_t + \hat{\pi}_{t+1} - \hat{R}^e_t \tag{74}$$

$$\hat{Y}_t = \hat{A}_t + \nu\hat{h}_{t-1} + \mu\hat{K}_{t-1} + (1-\nu-\mu)\hat{l}_t \tag{75}$$

$$\eta\hat{l}_t = \hat{Y}_t - \hat{X}_t - \hat{c}'_t \tag{76}$$

$$\hat{\pi}_t = \beta E_t\hat{\pi}_{t+1} - \frac{(1-\theta)(1-\beta\theta)}{\theta}\hat{X}_t \tag{77}$$

$$\hat{K}_t = \delta\hat{i}_t + (1-\delta)\hat{K}_{t-1} \tag{78}$$

$$\frac{c}{Y}\hat{c}_t + \frac{qh}{Y}(\hat{h}_t - \hat{h}_{t-1}) + \frac{R^e b}{Y}(\hat{R}^e_{t-1} + \hat{b}_{t-1} - \hat{\pi}_t) = \frac{b}{Y}\hat{b}_t + \frac{\nu}{X}(\hat{Y}_t - \hat{X}_t) \tag{79}$$

$$\hat{R}_t = (1-r_R)((1+r_\pi)\hat{\pi}_{t-1} + r_R\hat{R}_{t-1} + \hat{e}_{R,t} \tag{80}$$

$$\hat{P}^k_t = \hat{Y}_t - \hat{X}_t - \hat{K}_{t-1} \tag{81}$$

$$\hat{h}'_t = -\frac{h}{h'}\hat{h}_t \tag{82}$$

$$\hat{R}_t^e = \frac{\beta\bar{R}^e - 1}{\beta\bar{R}^e}\left\{\frac{\hat{R}_t + \hat{q}_t - \Phi\beta E_t(\hat{\pi}_{t+1} + \hat{q}_{t+1})}{1-\Phi\beta} - \frac{\vartheta\Phi\beta E_t(\hat{\pi}_{t+1} + \hat{q}_{t+1}) - (\hat{R}_t + \hat{q}_t)}{\vartheta\Phi\beta - 1}\right\} + \hat{R}_t \quad (83)$$

$$\hat{R}_t = (\frac{\beta+1}{\beta})(\hat{m}_t - c_t') \quad (84)$$

$$\hat{\mu}_t = \hat{m}_t - \hat{m}_{t-1} + \hat{\pi}_t \quad (85)$$

$$\hat{\mu}_t = \rho_\mu \hat{\mu}_{t-1} + \lambda^\pi(\pi_t - \pi_t^*) + \lambda^y y_t + \varsigma_t \quad (86)$$

$$\hat{rr}_t = \hat{R}_t - E_t\hat{\pi}_{t+1} \quad (87)$$

$$\pi_t^* = \rho_{\pi^*}\pi_{t-1}^* + \varepsilon_t^{\pi^*} \quad (88)$$

$$\varsigma_t = \rho_\varsigma \varsigma_{t-1} + \varepsilon_t^{mb} \quad (89)$$

3. Results

The model is estimated on quarterly, seasonally adjusted data for the Iranian economy covering the period of 1989 as Q1 to 2009 as Q4. The estimation is based on GDP and price index CPI. In this section, we discussed the results. First, we have explained the estimation method parameters and calibration and then we calculated the steady-State. In the second part, we compared models. Finally, we reviewed the results of monetary shocks in the models. In so doing, we have used Eviews, Dynare and Matlab software.

3-1. Calibration, Estimation and Steady-State Analysis

To compute impulse responses the parameters into the model have to be calibrated. And to calibrate we had to estimate the parameter. To estimate the parameters, we used Bayesian approach and choose prior distributions for the parameters which are added to the likelihood function. Bayesian inference combines the prior belief (knowledge) with the empirical data to form a posterior distribution, which is the basis for statistical inference. In the first step, we estimated the model parameters using Bayesian methods. Furthermore, we used Markov chain Monte Carlo (MCMC) algorithms to provide an approximation to the exact posterior distribution for a parameter. We needed to find a kernel that has the target density as its invariant distribution. So we used Metropolis-Hasting algorithm that provides a general principle to find such kernels. The likelihood function is evaluated using the Kalman filter and we used a Metropolis-Hastings (MH) algorithm to draw the posterior distribution of the structural parameters starting from the posterior mode of the parameters computed in a first step. The estimation of the DSGE was based on the MCMC algorithm to draw the joint posterior distribution described in Del Negro & Schorfheide (2004). Table 1 reports the posterior mean and standard devotions for the structural parameters. Draws from the posterior distribution of the parameters are obtained using the random walk version of the Metropolis algorithm. We ran ten parallel chains, each with a length of 20,000. Convergence was assessed by means of the multivariate convergence statistics taken from Brooks and Gelman (1998) and also computing recursive means of the model's parameters. Appendix 1 and 2 report the prior and posterior marginal densities of the parameters of the model, excluding the standard deviation of the innovations of the shocks.

Bayesian estimation of DSGE models has 3 characteristics (Sungbae and Schorfheide, 2007). First, compared to GMM estimation, Bayesian estimation is system-based (this is also true for maximum likelihood estimation). Second, the estimation is based on likelihood function generated by the DSGE model, rather than the discrepancy between model-implied impulse responses and VAR impulse responses. Third, prior distributions can be used to incorporate additional information into the parameter estimation. Hence, one of the best methods for parameter estimation is Bayesian methods. Moreover, many of these parameters were not being estimated for Iran’s economy. Table 1 shows the results of the estimated parameters. Our priors are listed in Tables 1. Overall, they are either consistent with the previous literature or relatively uninformative.

Table 1. Results of the Estimated Parameters

Collateral restriction model				**EFP model**			
parameter	Meen (s.t) prior	Prior data source	estimated	parameter	Meen (s.t) prior	Prior data source	estimated
Φ	0.85 (0.01)	Andre´s and Arce (2012)	0.8521	α	0.8 (0.01)	Güntner (2011)	0.8026
θ	0.5 (0.02)	Tavakolyan (2012)	0.5020	σ	0.6 (0. 1)	Güntner (2011)	0.6023
ν	0.06 (0.01)	Andre´s and Arce	0.0813	γ	0.412 (0.01)	Shahmoradi et al. (2010)	0.4119

Collateral restriction model				EFP model			
parameter	Meen (s.t) prior	Prior data source	estimated	parameter	Meen (s.t) prior	Prior data source	estimated
		(2012)					
μ	0.412 (0.01)	Shahmoradi et al. (2010)	0.6501	ϕ_i	2 (0.15)	Iacoviello (2005)	2.0317
ℓ	2 (0.07)	Iacoviello (2005)	2.0198	f	6 (0.13)	Güntner (2001)	6.006
j	0.11 (0.01)	Andre´s and Arce (2012)	0.1122	κ	0.2 (0.03)	Güntner (2011)	0.1915
rr	0.9 (0.01)	-	0.9016	μ	4.3 (0. 1)	Motavaseli et al. (2011)	4.2979
r_π	0.03 (0.05)	-	0.0299	β	0.97 (0.01)	Kavand (2008)	0.9703
β	0.97 (0.01)	Shahmoradi et al. (2010)	0.9735	ϕ	2.17 (0.05)	Shahmoradi and Ebrahimi (2011)	2.1708
γ	0.92 (0.01)	-	0.9197	ρ_m	0.7 (0.05)	-	0.6994
η	2.17 (0.05)	Shahmoradi et al. (2011)	2.1859	ρ_π	0.9 (0. 1)	tavakolian and Komeyjani (2013)	0.927
ρ_m	0.7 (0.02)	-	0.6993	λ_π	-1.06 (0.01)	tavakolian and Komeyjani (2013)	-1.0578
ρ_π	0.9 (0.01)	Shahmoradi et al. (2010)	0.9	λ_y	-2.31 (0.17)	tavakolian and Komeyjani (2013)	-2.2807
λ_π	-1.06 (0.01)	tavakolian and Komeyjani (2013)	-1.0604	σ_{mb}	0.02	tavakolian and Komeyjani (2013)	0.0171
λ_y	-2.31 (0.17)	tavakolian and	-2.3235	σ_π	0.02	tavakolian and	0.0136

Collateral restriction model				**EFP model**			
parameter	Meen (s.t) prior	Prior data source	estimated	parameter	Meen (s.t) prior	Prior data source	estimated
		Komeyjani (2013)				Komeyjani (2013)	
σ_{mb}	0.02	tavakolian and Komeyjani (2013)	0.0143	-	-	-	-

In addition, we needed to calculate the steady state values of the variables. We solved the system of equilibrium equations to get the steady state values. Of course, for EFP model steady state values, we needed to solve systems of nonlinear equations. To do this, we employed MATLAB software and Taylor approximation method. The results of these calculations are shown in Table (2).

Table 2. Results of the Calculated Steady State

EFP Model	Output (y)	consumption(c)	Loans (l)	Deposit (d)	Capital (k)
	0.5568	0.4545	0.3493	0.3648	2.3981
	Bank profit (g^f)	Firms profit (g)	Wage (w)	Investment (i)	Firm Labor (n)
	0.0004	0.1929	1.2415	0.1007	0.2002
	Loansinterest rate (r_l)	Banks Labor (s)	Loans interest rate (r_d)	bondsinterest rate (r_l)	
	0.0417	0.0015	0.0249	0.0306	
Collateral Constraint Model	Output (y)	Household consumption(c')	Entrepreneur Consumption (c)	Loans (l) or deposit (d)	Labor (n)
	2.5428	1.7073	0.0554	2.9563	0.4050
	Household House (h')	Entrepreneur House (h)	Wage (w)	Investment (i)	House price (q)
	0.6681	0.3318	1.2969	0.7483	1.6733
	Loansinterest rate (r_l)	Loans interest rate (r_d)	Capital price (P_k)		
	1.0350	1.0272	0.0713		

3-2. Impulse Response Analysis

In order to analyze the model performance, impulse response functions or second moments were computed. In this section we studied the dynamics of the linearized model using impulse responses. Figure 3-8, shows impulse response functions given expansionary monetary shock, that is, one- unit increase in liquidity growth by the central bank. The red line plots impulse responses of the CC model, described in Section 2-2 and black line plots impulse responses of the EFP model, described in Section 2-1. As in usual New Keynesian model we can observe a rise in the output and inflation, as well as investment and consumption. According to Figure 4, with the increase in liquidity, inflation in both models has increased. In normal economic circumstances, if the money supply grows faster than real output it will cause inflation. When the economy recovers and velocity of circulation rises, increased money supply is likely to cause inflation. Therefore increases in the money supply forecast higher inflation. However, note that the increase in inflation in the CC model is more than EFP model. In other words, inflationary pressures from money into the EFP model are less than the CC model. After the liquidity growth rise, since prices are sticky, inflation does not rise on impact and thus real rates rise too.

Furthermore, according to Figure 3, the money has real effects. In most growing economies the money supply is expanded regularly to keep up with the expansion of gross domestic product (GDP). In this dynamic context, expansionary monetary policy can mean an increase in the rate of growth of the money supply, rather than a mere increase in money. In the CC model, initial change in output is higher than the EFP model. Monetary shock causes that output rise sharply for ten periods. After that, the real effect of money disappears. While, in the EFP model, the real effects of money need more time to appear. This figure shows that CC model in the banking industry tends to induce a milder and less real response of output. Therefore, the preceding simulations suggest that monopolistic competition in the loan market (EFP model) represents a potential bottleneck for monetary policy. In this respect, the model matches the empirical evidence in literature (van Leuvensteijn et al., 2008; de Bondt, 2005).

As, can be seen in Figures 5 and 6, almost similar results are obtained for both consumption and investment. Tobin's q theory provides a mechanism through which monetary policy affects the economy through its effects on the valuation of equities. An alternative channel for monetary transmission through equity prices occurs through wealth effects on consumption. This channel has been strongly advocated by Modigliani model[10]. Furthermore, monetary policy can affect firms' balance sheets in several ways. Expansionary monetary policy, which causes an increase in equity prices along lines described earlier, higher the net worth of firms and so leads to higher investment spending and aggregate demand, because of the decrease in adverse selection and moral hazard problems (Mishkin, 1995). In this way the real effects of money into the EFP model remain longer periods. In CC model the investment increases initially, but falls and stays negative over a period while in EFP model the investment increases for a quiet. Higher money provides saving household more incentives to save, thus the more becomes the supply of credit. From a quantitative point of view, however, the CC model differs substantially from the EFP model.

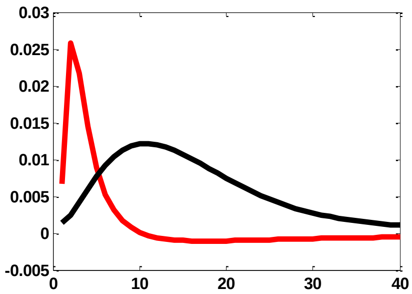


Figure 3. Output Response

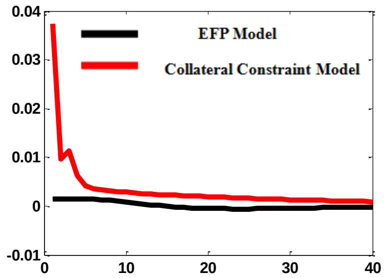


Figure 4. Inflation Response

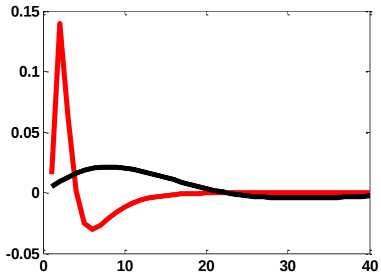


Figure 5. Investment Response

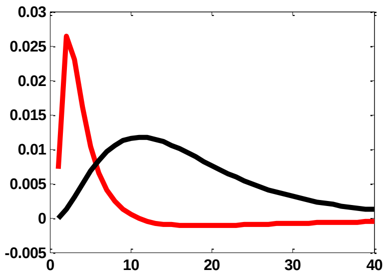


Figure 6. Consumption Response

As it is generally understood Clarida, Gali, and Gertler (2000) the expectation of the future money growth rates has the effect upon the current interest rates. An increase in the money supply can have two effects: (i) it can reduce the real interest rate (this is called the "liquidity effect", more money, i.e. more liquidity, tends to lower the price of money which is equivalent to lowering the interest rate) (ii) it forecasts higher future inflation (called the expected inflation or Fisher effect). Therefore to generate a falling nominal interest rate in response to a positive money supply shock we require the liquidity effect to outweigh the Fisher effect[11]. According to Figures 7 and 8, monetary shock will cause a rise in interest rates. Therefore in response to a positive money supply shock to the Fisher effect is outweighing liquidity effect in Iran economy. As, we can be seen in Figures 7 and 8, The CC model, interest rate (deposit and loan) will have a higher growth. While the interest rate adjustment costs in EFP model causes that interest rate adjusted slowly. In particular, the loan-interest rate markup determines a bigger increase of the relevant rates for the CC model. As a consequence, savers' consumption and investment increase initially by more (in CC with respect to EFP). This effect is due to the presence of sticky bank rates, which dampen the response of retail loan rates, thus reducing the contraction in loans, consumption and investment (see the difference between the CC and the EFP lines in Figure 7 and 8).

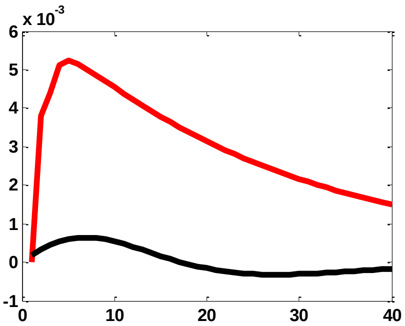


Figure 7. Deposit Interest Rate Response

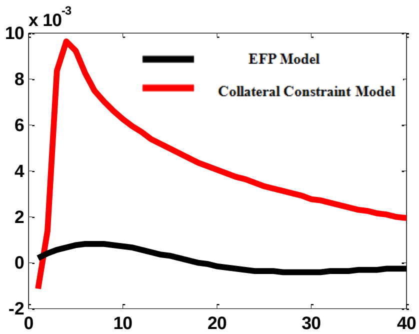


Figure 8. Lending Interest Rate Response

The comparison between the red line and black line shows how the financial accelerator mechanism in EFP model has decreased variation of output, consumption, investment and interest rates.

3-3. Comprising Models Power

As previously mentioned, we used two DSGE model for the Iran's economy. But which one is stronger and better? In other words, the results of which models are closer to the realities of the Iran economy. To answer this question, first, we compared the variability of the simulated data and real data. Table 3 shows the results of comparisons. Taking the model to the data, involves the isolation of cycles from the original data. To this end, among the several empirical techniques, this paper employed the Hodrick–Prescott's (HP) filter developed by Hodrick and Prescott (1997), which is widely used among researchers. Since the current paper used the quarterly data, we chose λ= 1600, relative weight on smoothness, following Hodrick and Prescott's suggestion. According to the Table 3, it can be seen that the EFP model results are closer to reality than CC model.

Table 3. Results of Comparing Variability of the Simulated and Real Data

variables	**EFP Model** σ_x / σ_y		**Collateral Constraint Model** σ_x / σ_y	
	Real	**Simulated**	**Real**	**Simulated**
Consumption (c)	1.016	1.014	0.693	1.105
Investment (i)	1.105	1.675	1.4928	3.532
Price index	0.721	0.321	0.729	1.241
House	-	-	4.142	5.956

In addition, we compared the prediction power of the models. To compare the two models, we forecast data for the period 2009Q4-2011Q3 for Iran's economy. Figure 8 shows the values simulated by two models and the real data of Iran economy. According to Figure 9 and the simulations results, we can calculate the mean squared prediction error[12] for the two models. Based on the results of the EFP model, MSPE is equal 0.001515 and according to the results of the CC model is equal to 0.00377, therefore, we have concluded that EFP model is better than CC model because EFP model can better predict Iran's economy realities than CC model.

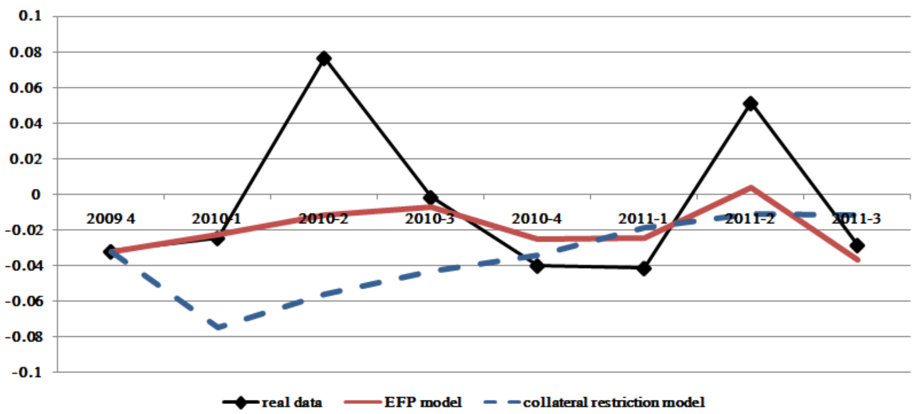


Figure 9. Results of Comparing Tow Models Prediction and Real Data

But, it should be noted that this standard model (EFP and CC models) is limited. For this reason, it can be erroneous to explain real changes in the economy. This study wanted to compare the two models in Iran's economy. Of course, the model needs to be developed to improve the simulation results; for instance, modeling open economy, fiscal policy and the government, stock market, foreign exchange regimes, heterogeneous households, public and private banks and etc. can cause the errors to be lessened.

4. Conclusion

In this study, we used the DSGE models to answer these Questions:

- ❖ What is the effect of monetary policy on the Iran's economy?
- ❖ What structure is suitable for modeling the Iran's economy?

We used two kinds of basic DSGE structures: External Finance Premium Model (EFP) and Collateral Constraint Model (CC). Both models will be simulated for Iran. We compared the simulated and real data for each of the models. Furthermore, we used Bayesian methods to estimate the parameters of DSGE models.

The results showed that increase liquidity in the economy causes to rise in output and inflation, investment and consumption as in usual New Keyenesian model. Variables respond to monetary policy of the CC model more than EFP model.

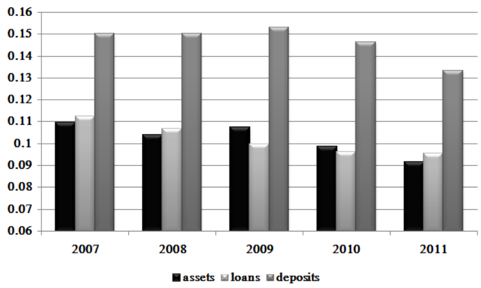
In addition, we compared the prediction power of the models. According to the results, MSPE of EFP model was equal to 0.001515 and

CC model was equal to 0.00377, therefore, we concluded that EFP model would be more promising than CC model.

Endnotes

1- Parvin et al. (2015) augmented that in the area of monetary policy, interest rate is regarded as a direct monetary instrument and required reserve ratio as an indirect monetary instrument which are enforced by the monetary authorities to the banking system and will affect its behavior. Results showed that the consequence of a positive interest rate shock is an increase in the output and a reduction in inflation and the consequence of shock relative to the required reserve ratio is a decrease in output and an increase in inflation.

[2]- Calculating the concentration indices indicate that Iranian banks have high concentration. The following figure shows the concentration indicator (Herfindahl Hirschman index HHI) on Iranian Banks in assets, loans and deposits:



3- erner index in Iran's banking industry is :

year	2000	2001	2002	2003	2004
Lerner ndex	0.062	0.106	0.563	0.503	0.339
year	2005	2006	2007	2008	2009
Lerner ndex	0.393	0.276	0.226	0.221	0.180

4- For more information, see Guntner (2009:6) or Guntner (2011:4)

5- Accordingly, the manager maximizes the present value, in terms of utility, of future expected profits to the household, subject to satisfying the demand for intermediate good j by the final goods producer: $k_{t-1}(j)^{\gamma} n_t(j)^{1-\gamma} \geq \left(\frac{P_t(i)}{P_t}\right)^{-\mu} y_t = y_t(j)$. The presence of the per-period loan rate r^l in the profit function (7) introduces a cost channel of monetary policy into the model. Via marginal costs, optimal firm behavior is directly affected by changes in the policy rate and thus the loan rate. For a theoretical analysis of the cost channel's relevance for monetary policy transmission and an overview of the related literature, see Henzel et al. (2009).

6- Both theoretical and empirical findings strongly support this assumption. See (Gerali et al., 2010:11)

7- we let the growth rate of money be a constant $\mu_t = M_t / M_{t-1}$

8- This assumption implies that in the steady state equilibrium households optimally choose to lend while entrepreneurs borrow.

9- After the nationalization of Iran banks, usury (interest) was abolished from the banking system. This approach continued till the approval of the Usury (Interest) Free Banking Law (UFBL-83). The UFBL-83 has replaced the conventional fixed interest rate with profit rate in banks' mobilization and allocation of financial resources. In accordance with this Law, concepts like deposit and deposit-taking were modified; therefore, the banks were authorized as attorney of their depositors to attract and utilize deposits for extending facilities within the framework of Islamic contracts. Banks' profit rates are determined by contracts. The contracts stipulated in the UFBL-83, by nature, are divided into Profit and Loss sharing (PLS) contracts and non-PLS contracts. Banks determine the minimum or the maximum lending rate for non-PLS contracts or contracts with fixed return (Komijani, 2011). So there are no interest rates in Iran’s Islamic banking and Banks have profit rate. See (Komijani, 2011).

10- Tobin (1969) defined q as the market value of firms divided by the replacement cost of the capital. If q is high, the market price of firms is high relative to the replacement cost of the capital, and new plant and equipment of the capital are cheap relative to the market value of business firms. Companies can then issue equity and get a high price for it relative to the cost of the plant and equipment they are buying. Thus investment spending will rise because firms can buy a lot of new investment goods with only a small issue of equity. An alternative channel for monetary transmission through equity prices occurs through wealth effects on consumption. This channel has been strongly advocated by Modigliani and his MIT-Penn-SSRC (MPS) model. In Modigliani's life-cycle model-explained very clearly in Modigliani (1971)-consumption spending is determined by the lifetime resources of consumers, which are made up of human capital, real capital and financial wealth. A major component of financial wealth is common stocks. When stock prices fall, the value of financial wealth decreases, thus decreasing the lifetime resources of consumers, and consumption should fall, since we have already seen that expansionary monetary policy can lead to an increase in stock prices and consumption (Mishkin, 1995; Andre´s and Arce, 2012).

11- However, in neoclassical models money does not influence real variables such as the real interest rate. Therefore increases in the money supply just forecast higher inflation and so the nominal interest rate rises as there is no liquidity effect only a Fisher effect (higher expected inflation). Therefore to generate the liquidity effect (lower nominal interest rates for higher money supply) we required enough non-neutrality that inflation expectations do not outweigh the liquidity effect. But, in new Keynesians models money influence real variables. Therefore increases in the money supply have Fisher effect and liquidity effect.

Mean squared error measures the expected squared distance between an estimator and the true underlying parameter. The mean squared prediction error measures the expected squared distance between what your predictor predicts for a specific value and what the true value is:

$\text{MSPE}(L)=E[\sum (g(xi)-\hat{g}(xi))^2]$.

It is thus a measurement of the quality of a predictor.

12- Mean squared error measures the expected squared distance between an estimator and the true underlying parameter. The mean squared prediction error measures the expected squared distance between what your predictor predicts for a specific value and what the true value is:

$\text{MSPE}(L)=E[\sum (g(xi)-\hat{g}(xi))^2]$.

It is thus a measurement of the quality of a predictor.

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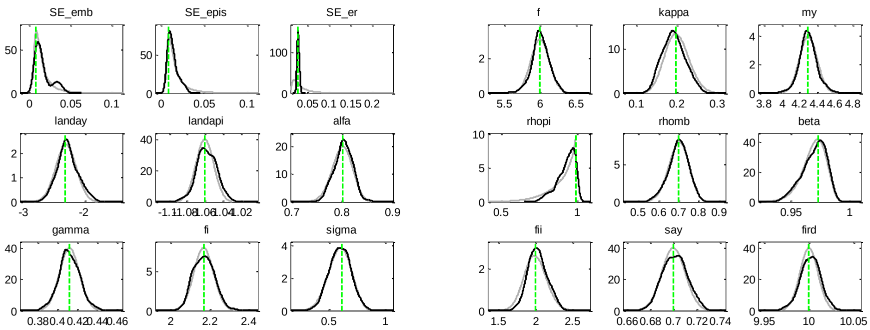
Appendix 1: Prior and Posterior Marginal Distributions in EFP Model



Appendix 2: Prior and Posterior Marginal Distributions in CC Model