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The Role of Financial Frictions in Iran's Business Cycles: A DSGE Approach

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Abstract

Before the incidence of the financial crisis in 2008, the financial sector was ignored in the most of business cycles analyses. It was assumed that the financial sector played no independent role in describing business cycle fluctuations and followed the real part of the economy. In recent years, modeling financial frictions have been much considered in business cycles literature. The present study aimed to investigate the role of financial friction in Iranian's business cycles. For this purpose, a dynamic stochastic general equilibrium (DSGE) model is designed based on the structural features of the Iranian economy and is estimated by using Bayesian method and seasonal data during 1370q1- 1395q4 (1991q2-2017q1). The results indicated that the consideration of financial sector in the model increased our understanding of business cycles fluctuations and financial shocks played an influential role in explaining business cycles fluctuations. Further, based on the results of the present study, the persistence of the effect of financial shocks was more compared to the supply and demand sector shocks.

Keywords: Business Cycles, Financial Frictions, DSGE Model, Bayesian Estimation.

JEL Classification: E22, E32, E44, C11.

1. Introduction

Although emerging new macroeconomics is accompanied with emphasizing the importance of financial markets role, the role has been disregarded gradually. For example, Fisher and Keynes (1933) were among the first researchers which emphasized the role of financial markets in the incidence of the Great Depression. However,

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the role of financial markets was gradually ignored in explaining fluctuations and business cycles. The famous hypothesis of "capital structure irrelevance" by Modigliani and Miller and overemphasis on efficient financial markets caused little attention to be paid to the importance of the financial sector in explaining macroeconomic fluctuations unintentionally. In this regard, it is worth noting that the lack of effectiveness of financial market conditions on the real part of the economy as the common characteristic of business cycles models such as IS-LM and real business cycles models. In economics literature, some researchers such as Bernanke and Gertler (1989), Carlstrom and Fuerst (1997), and Kiyotaki and Moore (1997) identified the role of financial markets in the fluctuations of the real economy from the late 1980s. It should be noted that before the incidence of financial crisis (2008), the financial sector ignored in most standard business cycle models.

Identifying and understanding the effective factors on the incidence and sustainability of business cycles, as one of the main branches of macroeconomics, is significantly considered in the economic literature. The main question raised here is which variables play a major role in the occurrence of business cycles, or whether the persistence of the periods of recession and boom is related to different variables. The present study aimed to investigate the role of financial frictions in the business cycles of the Iranian economy. Specifically, the role of financial sector shocks in the incidence of business cycles is investigated by adding financial sector to a standard dynamic stochastic general equilibrium model.

In the present study, the collateral constraint and financial intermediation approach are used to modeling financial sector. Compared to other studies, the unique and distinct features of the present study are: 1) modeling housing supply side; 2) breakdown the firm needs for funds into two portions of working capital and fixed capital loan; 3) modeling direct investment activity of banks; and 4) estimating the model using Bayesian technique and seasonal data of Iranian economy. The two main questions addressed in this study are how much the financial shocks plays a role in explaining business cycles fluctuations and whether the sustainability of financial shocks can be compared to the shocks of the supply and demand sector or not.

The present study is organized as follows: Section 2 briefly reviews the related research on modeling financial sector in business cycles models. Section 3 introduces the dynamic stochastic general equilibrium model. Section 4 presents the empirical data, as well as the results of Bayesian estimation of the proposed model in the previous section. Section 5 analyses the empirical evidence resulted from the model. Finally, the last section concludes the study.

2. Literature Review

The term "financial friction" refers to the financial market limitations (market imperfection) in the financing process. In situation of the market imperfection, there is no possibility to exchange state-contingent asset. As a result, some of the intra-temporal and inter-temporal exchanges between economic agents are faced with restrictions. Therefore, the economic agents cannot predict or delay their expenditures (for consumption or investment) or to be insured against risky events (smooth the way of their consumption or investment). The imperfection of financial market causes major constraints on access to financial resources for economic agents, particularly entrepreneurs and manufacturers. The existence of these restrictions can both exacerbate the effects of exogenous shocks on the real economy and also, can affect the economics activities as endogenous shocks.

There are three major approaches in modeling macro-financial linkages including Costly State Verification, Collateral constraint, and financial intermediation. Costly State Verification (CSV) was first proposed by Townsend (1979) in which the financial frictions affect external resource costs. The most influential studies in this area were conducted by Bernanke and Gertler (1989), Carlstrom and Fuerst (1997), and Bernanke, Gertler, and Gilchrist (1999). The collateral constraint approach models the financial frictions from the limited access to the external resources. The study of Hart and Moore (1994) is one of the pioneering studies in this field. Further, Kiyotaki and Moore (1997) and Iacoviello (2005) investigated the collateral constraint model in the framework of general equilibrium models. In the third approach, it is assumed that the two agents of lender and borrower are indirectly communicated with each other through financial intermediaries. In addition, the evidence of financial crises indicated that the financial intermediaries such as banks play an influential role in the financial sector and the transmission of financial shocks. Thus, modeling financial intermediaries is the prerequisite for the correct understanding of financial sector interactions. The studies of Gerali et al. (2010) and Gertler and Kiyotaki (2010) are regarded as the important research in this area.

Given that in the present study, a combination of the collateral constraint and financial intermediation approach has been used to model the financial sector friction, two recent and influential studies in this area are briefly reviewed. Based on micro foundation, Gerali et al. (2010) modeled the banking system in a dynamic stochastic general equilibrium model in which banks have three distinct characteristics. First, banks have market power in loan and deposit markets and determine different interest rates for households and firms. Second, banks are faced with the cost of adjusting retail interest rates, and finally banks are seeking to comply with the capital adequacy limits. The main results of this study indicate that banks have a dual role in business cycles fluctuations. On the one hand, financial intermediation leads to the protection of economic agents from the interest rate changes, and in some way plays the role of the stabilizer of the fluctuations resulted from the non-financial sector. On the other hand, the banking sector could lead to more fluctuations in the real sector due to shocks from the credit market and procyclicality of this sector.

Iacoviello (2015) focused on the role of financial shocks in the business cycle of the American economy, by Bayesian estimation of a dynamic stochastic general equilibrium model. In this study, the effect of financial frictions on the bank, firm and household agents are modeled and the effects of financial stocks are investigated and compared to the other common shocks in business cycles models (demand and supply shocks). The three shocks of the financial sector include the redistribution shock (the transmission of wealth from savers to borrowers at the time of default), credit crunch (change in loan-to-value ratio), and asset price shocks. Based on the results, the financial shocks play a crucial role in explaining the US business cycle, as empirical evidence suggests that two-thirds of gross domestic product (GDP) decline during the 2007-2009 downturn was due to financial shocks. Further, financial frictions have an influential role in explaining other US recession periods.

3. Model Design

The overall framework of the proposed model is borrowed from Jermann and Quadrini (2012) and Iacoviello (2015). The main components of the model are the household, the manufacturing goods firm, the housing construction firm, the banking system and the central bank. As mentioned above, the collateral constraint and financial intermediation approach are used in order to model financial friction in the present study. Regarding the selection, we can refer to two important issues. First, in Iranian economy, the difference in the interest rates of banking loan is negligible for most borrowers and the structural conditions of the financial sector are not consistent with the Costly State Verification (CSV) model. Second, the financial system of Iranian economy is bank-based and banking credit are the major contributor in financing firms. In the present study, frictions of the financial sector are considered as the main components of the model. In line with the conditions of the Iranian economy, where households sector use a small share of banking system loans (less than 10%), firms are assumed to be the main applicants of external financial resources. In the following, we describe the behavior of each of the components of the dynamic stochastic general equilibrium model.

3.1 Household

The economy consists of a set of similar households which are represented by the index i ∈ [0.1]. The representative household gains utility from consumption of goods c_t, consumption of housing services $H_{h.t}$ and holding real money balance $\frac{M_t}{p_t}$, and suffers disutility by supplying labor n_t. Due to the separation of the production sector, it is assumed that the household supplies the labor force both for goods sector $n_{p.t}$ and the housing sector $n_{h.t}$. The intertemporal utility function of the representative household is as follows:

$$E_0 \sum_{t=0}^{\infty} \beta_h^t \Bigg[S_{d.t} (\log(c_t - \xi c_{t-1}) + \phi\, S_{h.t} \log(H_{h.t})) + \frac{1}{(1-\zeta)} (\frac{M_t}{p_t})^{1-\zeta} - \frac{{n_t}^{1+\sigma_n}}{1+\sigma_n} \Bigg] \quad (1)$$

where, the parameter β_h represents the discount factor of the household and the parameter ξ measures the household consumption habit $(0 < \xi < 1)$. The parameters σ_n and ζ indicate the inverse of Frisch elasticity of labor and the inverse of interest elasticity of the demand for real money balance, respectively. Further, the parameter of ϕ denotes the housing share in household preferences. Two types of demand shock is considered here: The shock of the total demand $S_{d.t}$, which simultaneously affects the utility of consumption of goods and the utilization of housing services, and the shock of housing demand $S_{h.t}$, which only affects the utility of housing services utilization. These shocks are modeled as a first-order autoregressive process.

In what follows, the household budget constraint is reviewed. As it was already mentioned, it is assumed that households are net savers, and hold a part of the available resources as a bank deposit B_t in each period. In additions, it is assumed that households are the shareholders of the firms and banks. In this case, available resources to the household include the income from the supply of labor force to goods sector $W_{p.t} n_{p.t}$, the income resulted from supply of labor force to housing sector $W_{h.t} n_{h.t}$, the gross return of bank deposits $(1 + r_{h.t-1})\, B_{t-1}$, the money balance of the previous period plus the dividend of manufacturing goods firm $D_{p.t}$, the dividend of the housing construction firm $D_{h.t}$, and the dividend of the banks $D_{b.t}$. A part of these resources is spent on current consumption expenditure, investment in bank deposits and investment in the housing sector, and the remainder is held as money balances. Based on this description, the household budget constraint is as follows:

$$P_t\ c_t + B_t + P_t^H\ (H_{h.t} - (1-\delta)\ H_{h.t-1}) + M_t \leq W_{p.t} n_{p.t} + W_{h.t} n_{h.t} + (1 + r_{h.t-1})\ B_{t-1} + M_{t-1} + D_{p.t} + D_{h.t} + D_{b.t} \tag{2}$$

In the above equation, the variables P_t and P_t^H represent the general level of prices and housing prices, respectively. Further, the variable $r_{h.t}$ implies the rate of interest on bank deposits. The parameter δ denotes the depreciation rate. By dividing the above equation with the general level of prices P_t, the household's budget constraint in real term obtained (It should be noted that the lowercase Latin letters denote the real value of the corresponding variables):

$$c_t + b_t + p_t^H\ (H_{h.t} - (1-\delta)\ H_{h.t-1}) + \frac{M_t}{P_t} \leq w_{p.t} n_{p.t} + w_{h.t} n_{h.t} + \left(\frac{1 + r_{h.t-1}}{1 + \pi_t}\right) b_{t-1} + \frac{M_{t-1}}{P_t} + d_{p.t} + d_{b.t} + d_{h.t} \tag{3}$$

where the variable π_t denotes the inflation rate, and the variable $p_t^H = P_t^H / P_t$ represents the real price of the housing. By maximizing the intertemporal utility function of the household subject to the budget constraint, the first-order conditions for the consumption, the labor supply to the goods manufacturers, the labor supply to housing builders, bank deposits, housing demand, and the demand for real balances are obtained as follows, respectively:

$$\frac{S_{d.t}}{(c_t - \xi c_{t-1})} - \beta_h\ \xi\ \frac{S_{d.t+1}}{(c_{t+1} - \xi c_t)} - \lambda_t = 0 \tag{4}$$

$$-n_{p.t}^{\sigma_n} + \lambda_t w_{p.t} = 0 \tag{5}$$

$$-n_{h.t}^{\sigma_n} + \lambda_t w_{h.t} = 0 \tag{6}$$

$$-\lambda_t +\ \beta_h\ \lambda_{t+1}\ \left(\frac{1 + r_{h.t}}{1 + \pi_{t+1}}\right) = 0 \tag{7}$$

$$(S_{d.t}\ \ S_{h.t})\frac{\phi}{H_{h.t}} - \lambda_t\, p_t^H +\ \beta_h\,(1-\delta)\,\lambda_{t+1}\, p_{t+1}^H = 0 \tag{8}$$

$$\left(\frac{M_t}{p_t}\right)^{-\zeta} - \lambda_t\ + \beta_h\ \frac{\lambda_{t+1}}{(1+\pi_{t+1})} = 0 \tag{9}$$

The variable λ_t in the above equations implies the Lagrange multiplier of the household budget constraint.

3.2 Manufacturing Goods Firm

In this section, the condition of the manufacturing goods firm is described. This group of firms is indicated by index $j \in [0.1]$. The three main production inputs of firms are machinery capital $k_{p.t}$, housing capital $H_{p.t}$ and the labor force $n_{p.t}$. The production function of this group of firms is defined as the Cobb–Douglas production function with constant return to scale:

$$q_t = S_{z.t}\ \left(k_{p.t-1}^{\alpha k}\ \ H_{p.t-1}^{\alpha h}\ \ n_{p.t}^{\beta}\right)\quad .\quad \beta = 1 - \alpha k - \alpha h \tag{10}$$

Where, the parameters αk and αh indicate the share of machinery capital and housing capital in the total production, respectively. Further, the variable $S_{z.t}$ implies technology shock, which is modeled as a first-order autoregressive process.

The firm's activity faces two basic constraints including the limitation of borrowing resources and the budget constraint. Typically, firms need external resources to continue working (working capital loans) and carry out development projects (fixed capital loan). In most business cycle models, the working capital is defined as intertemporal due to the insignificant share of working capital resources from the total external financing of firms. That's why; firstly, an increase or decrease in the working capital does not affect existing resources for fixed capital loan and secondly, there is no interest cost. Given that the share of working capital loan from the total banking loan of Iran is more than 50%, the working capital loan is defined in such a way that an increase (decrease) in the amount of working capital loans reduces (increases) the available resources for fixed capital loan one by one, in addition working capital loan is subject to paying interest cost.

The firm faces constraints in raising funds. As previously mentioned, the collateral constraint approach was used to model the borrowing constraints of firms in this study. We can refer to the studies of Kiyotaki and Moore (1997) and Iacoviello (2005) as one of the pioneers of this approach. The firms operate in uncertainty conditions and are affected by various external shocks. At the beginning of the period, the firm proceeds to acquire the banking loan although the return of the productive activity is determined at the end of the period. If the firm's rate of return is lower than the interest rate of the bank's facility, the firm may not be willing to repay the principal and interest of the loan borrowed from the banking system. Therefore, in a debt contract, there should be executive enforcement for the firm to adhere to the contract terms. One of the common approaches to solving this problem is to collateralize the durable assets such as land, buildings, and machinery by the firm. In other words, the maximum resources which a firm can raise through external financing $L_{p.t}$ are equal to the proportion of the firm's value of assets. Thus, the borrowing constraint of the firm can be represented as follows:

$$L_{p.t} = L_{v.t} + L_{w.t} \leq S_{L.t} \left[\theta^K P_t k_{p.t} + \theta^H P_t^H H_{p.t} \right] \quad (11)$$

where $L_{v.t}$ and $L_{w.t}$ refer to fixed capital loan and working capital loan, respectively. It is worth noting that the working capital loan is defined as a percentage of labor costs. The parameters θ^K and θ^H represent the maximum ratio of borrowing funds to the value of the company durable assets, which is regarded as the loan-to-value ratio (LTV) in the economic literature. The loan-to-value ratio is generally determined by policymaking institutions and is between zero and one. The variable $S_{L.t}$ which indicates a stochastic shock implies a sudden change in the availability of economic agents to external resources. This variable is known as the financial shock in the economic literature.

It is noteworthy that in addition to the budget constraints and borrowing resources constraints, there is limitation for the firm to change its capital structure. The capital structure is the combination of debt and equity which is used to financing a company. In general, one can claim that either the change of equity (an increase or a decrease in capital) or the variation of debt level is costly for the firm. This adjustment cost causes difficulty for restructuring the firm capital in dealing with the changing financial conditions. As the study of Jermann and Quadrini (2012), the adjustment cost for changes of the dividend is considered as follows:

$$\mathrm{X}_{p.t} = \frac{\kappa}{2}\left(D_{p.t} - \overline{D_P}\right)^2 \qquad (12)$$

Where the parameter κ denotes the adjustment cost scale of the dividend and $\overline{D_P}$ represents the amount of dividend in a steady state.

Regarding the budget constraint, the payments of the firm in each period include dividends, the wage cost of the labor force, investment costs in machinery, investment costs in the building, the cost of repayment of previous-period loans, and the cost of dividend adjustment. On the other hand, revenues from sales of current-period products and new borrowing resources constitute resources of the firm. Based on this description, the budget constraint of the manufacturing goods frim is as follows:

$$\begin{aligned} D_{p.t} + W_{p.t}n_{p.t} + (1 + r_{l.t-1})L_{p.t-1} + P_t\, k_{p.t} + P_t^H\, H_{p.t} \\ + \mathrm{X}_{p.t} \\ \le (1-\delta)\, P_t\, k_{p.t-1} + (1 \\ - \delta)\, P_t^H\, H_{p.t-1} \quad + P_t\, q_t + L_{p.t} \end{aligned} \qquad (13)$$

In the above equation, the variable $r_{l.t}$ denotes the interest rate of banking loan. It is worth noting that the depreciation rate δ for machinery and housing capital is assumed to be the same. By dividing the above equation with the general level of prices P_t, the firm budget constraint in real term is achieved:

$$d_{p.t} + w_{p.t}n_{p.t} + \left(\frac{1 + r_{l.t-1}}{1 + \pi_t}\right) l_{p.t-1} + k_{p.t} + p_t^H\, H_{p.t} + \chi_{p.t} \\ \leq (1-\delta)k_{p.t-1} + (1-\delta)\, p_t^H\, H_{p.t-1} + q_t \\ + l_{p.t} \tag{14}$$

The problem of representative firm can be defined as maximizing the sum of discounted dividend payments subject to budget and borrowing constraints. Therefore, the objective function of firm is as follows:

$$E_0 \sum_{t=0}^{\infty} \beta_p^t \left[d_{p.t}\right] \tag{15}$$

where the parameter β_p denotes the discount factor of the firm. If the variables $\gamma_{p.t}$ and $\mu_{p.t}$ indicate the Lagrange multiplier of the budget constraint and the constraint of borrowing funds, the first-order conditions of the optimization problem of the firm for dividend, labor force, machinery capital, capital housing and borrowing resources can be written as follows:

$$1 - \gamma_{p.t}\left[1 + \kappa\left(d_{p.t} - \overline{d_p}\right)\right] = 0 \tag{16}$$

$$\gamma_{p.t}(1 - \alpha_k - \alpha_h)\left(\frac{q_t}{n_{p.t}}\right) - \beta_p\, \gamma_{p.t+1} \left(\frac{1 + r_{l.t}}{1 + \pi_{t+1}}\right) w_{p.t} \\ - \mu_{p.t}\, w_{p.t} = 0 \tag{17}$$

$$-\gamma_{p.t} + \beta_p\, \gamma_{p.t+1}\left[\alpha_k \left(\frac{q_{t+1}}{k_{p.t}}\right) + (1-\delta)\right] + \theta^K\, S_{L.t}\, \mu_{p.t} = 0 \tag{18}$$

$$-\gamma_{p.t}\, p_t^H + \beta_p\, \gamma_{p.t+1}\left[\alpha_h \left(\frac{q_{t+1}}{H_{p.t}}\right) + (1-\delta)\, p_{t+1}^H\right] \\ + \theta^H\, S_{L.t}\, \mu_{p.t}\, p_t^H = 0 \tag{19}$$

$$\gamma_{p.t} - \beta_p\ \gamma_{p.t+1}\left(\frac{1 + r_{l.t}}{1 + \pi_{t+1}}\right) - \mu_{p.t}\ = 0 \tag{20}$$

3.3 Housing Construction Firm

As it was already mentioned, due to the multiple roles of housing in the model of the present study such as household consumption inputs, manufacturing inputs of firms and the role of collateral in credit market, the supply side of the housing is modeled. The studies of Davis and Heathcote (2005), and Iacovielli and Neri (2010) can be referred to as influential studies that model the housing supply. The three main elements of the housing cost are land, and residential structures and labor force costs. Thus, the production function of housing is considered as Cobb–Douglas with a constant return to scale:

$$q_{H.t} = S_{zh.t}\ \left(xh_t^{\alpha x}\ \ lh_t^{\alpha l}\ n_{h.t}^{1-\alpha x-\alpha l}\right) \tag{22}$$

where xh_t, lh_t and $n_{h.t}$ indicate the input of the residential structures, the land, and the labor force, respectively. The variable $S_{zh.t}$ represents the technology shock which follows a first-order autoregressive process. Further, the parameters αx and αl represent the input share of the residential structures and the land in the production function of the housing. In addition, the housing construction firm uses external financing like the manufacturing goods firm. Therefore, the housing construction firm faces a borrowing constraint. It is worth noting that the loan of housing construction firms is defined intertemporal in such a way that at the beginning of the period, the firm raise recourse to finance the costs of residential structures and the labor force, also at the end of the period, the loan is repaid. On the other hand, the land is considered as the collateral asset of these firms. In this case, the collateral constraint of the housing construction firm is as follows:

$$L_{H.t} = P_t\ xh_t + W_{h.t}\ n_{h.t} \leq S_{Lh.t}\ [\theta^{Lh}\ P_t^l\ lh\ _t] \tag{22}$$

In the above equation , θ^{Lh} indicates the loan-to-value ratio of the land of and P_t^l denotes housing prices. The variable $S_{H.t}$ represents the shock of the loan to value ratio (financial shock) for housing builders. In the empirical evidence section, the effects of financial stocks are discussed in detail. In what follows, we examine the budget constraints of the housing construction firm. Given that the wage of the labor force and the cost of residential structures are provided by financing, the payments of the firm in each period are the dividend $D_{h.t}$, the cost of land $P_t^l\ lh_t$, principal and interest of the banking loan $(1+r_{l.t})L_{H.t}$, and the dividend adjustment cost $\mathrm{X}_{H.t}$. In this case, the firm budget is as follows:

$$D_{h.t} + P_t^l\, lh_t + (1+r_{l.t})(P_t\, xh_t + W_{h.t}\, n_{h.t}) + \mathrm{X}_{H.t} \leq P_t^H\, q_{H.t} \tag{23}$$

The adjustment cost of dividend is defined as $\frac{\kappa}{2}\,(D_{h.t} - \overline{D_h})^2$. By dividing the above equation with the general level of prices, the budget constraint in real term is obtained:

$$d_{h.t} + p_t^l\, lh_t + (1+r_{l.t})\,(xh_t + w_{h.t}\, n_{h.t}) + \chi_{H.t} \leq p_t^H\, q_{H.t} \tag{24}$$

In the above equation, the variable p_t^l represents the real price of housing. It should be noted that the supply of land is assumed to be fixed and normalized to a value of 1. The housing construction firm's optimization problem is defined by determining the optimal amount of control variables in order to maximize the discounted dividend subject to budget and borrowing constraints. In the following, the first-order conditions of this maximization are presented for the dividend, residential structures input, land input, and the input of labor force, respectively:

$$1 - \gamma_{h.t}\left[1 + \kappa\left(d_{h.t} - \overline{d_h}\right)\right] = 0 \tag{25}$$

$$\gamma_{h.t}\, \alpha x\, p_t^H \left(\frac{q_{H.t}}{xh_t}\right) - (1+r_{l.t})\,\gamma_{h.t} - \mu_{h.t} = 0 \tag{26}$$

$$\gamma_{h.t}\, \alpha l\, p_t^H \left(\frac{q_{H.t}}{lh_t}\right) - \gamma_{h.t}\, p_t^l + \theta^{Lh}\, S_{Lh.t}\, \mu_{h.t}\, p_t^l = 0 \tag{27}$$

$$\gamma_{h.t}\,(1 - \alpha x - \alpha l)\, p_t^H \left(\frac{q_{H.t}}{nh_t}\right) - \gamma_{h.t}\,(1 + r_{l.t})\, w_{h.t} - \mu_{h.t}\, w_{h.t} = 0 \tag{28}$$

Where the variables $\gamma_{h.t}$ and $\mu_{h.t}$ indicate the Lagrangian multiplier of the budget constraint and borrowing constraint, respectively.

3.4 Banking System

As manufacturing goods firms, banks seek to maximize their value (the sum of the discounted future dividends). The main task of the bank (commercial type) is financial intermediation, however, the scope of the bank's activities is not limited to this field. The range of bank activities in various countries has remarkable differences. For example, in some countries, the permission of direct investment has been given to banks up to a certain amount while banks have no right to engage in direct investment in some countries. In Iran, according to Article 34 of the Monetary and Banking Law and the instructions for the investment of credit institutions (approved on 21/3/2007), the investment activities of banks and credit institutions is allowed in accordance with the determined limits. Thus, in modeling the behavior of the banking system for the Iranian economy, the intermediary activities and direct investment (entrepreneurship) are considered. In line with these two main activities of banks, there are two limitations including capital adequacy constraint, and entrepreneurship constraint. In addition to these two constraints, banks are required to hold legal reserves at the central bank.

Based on the financial leverage of the bank's intermediary activity and the problem of representative due to the asymmetric information problem, the intermediary activity of the bank faces a limited capital adequacy. In other words, the bank capital should not be less than a percentage of the bank assets. This percentage, known as "capital adequacy", is set by the monetary supervisor based on Basel Committee Standards 2 and 3, and the ratio is more than 8%. In this regard, a cost function is used to model the limitation of capital adequacy. If the asset of the bank is considered as the balance of lending l_t, the accumulated direct investment in firms $k_{b.t}$, and the legal reserves rr b_t (rr denotes the legal reserves ratio), and the only debt of the bank is household deposits b_t, then the cost function of the violating the capital adequacy ratio is defined as follows:

$$\psi_{c.t} = \frac{\varphi_C}{2}\left(\Omega - \left(\frac{cap_t}{l_t + k_{b.t}}\right)\right)^2 (l_t + k_{b.t}) \quad . l_t = l_{p.t} + l_{H.t} \tag{29}$$

Where, the parameters Ω and φ_C denote the minimum ratio of capital adequacy and the cost scale of non-compliance with capital adequacy limits, respectively. Further, the variable cap_t represents the capital of the bank ($l_t + k_{b.t} - (1 - rr)\ b_t$). By replacing the capital of the bank in the above equation, we have:

$$\psi_{c.t} = \frac{\varphi_C}{2}\left(\Omega - 1 + (1 - \mathrm{rr})\left(\frac{b_t}{L_t + k_{b.t}}\right)\right)^2 (l_t + k_{b.t}) \tag{30}$$

Based on the instructions for the investment of credit institutions, the bank capital accumulated in companies and other firms should not exceed 40% of the bank's base capital. In the following, in order to model the restriction on the direct investment of banks, a cost function is defined as:

$$\psi_{k.t} = \frac{\varphi_k}{2}\left(\frac{k_{b.t}}{cap_t} - \Theta\right)^2 cap_t \tag{31}$$

The parameter Θ shows the permitted limit of direct investment of banks and the parameter φ_k represents the cost scale of the violating the direct investment constraint.

Banks are faced with budget constraints, in addition to the two constraints of capital adequacy and entrepreneurship. The bank's payments in each period are the dividend, the principal and interest of the previous period deposits, the new lending, the new direct investment, changes in the legal reserves, the cost of non-compliance with the capital adequacy ratio $\psi_{c.t}$, the cost of non-accordance with direct investment limit $\psi_{k.t}$, and dividend adjustment cost $\chi_{b.t}$. On the other hand, the new deposits and the principal and interest from the previous period's loans along with the return of the direct investment are the available resources of banks. It should be noted that the return rate of the direct investment of bank is assumed equal to the capital's rate of return in the production function of the manufacturing goods firm. Therefore, the budget constraint of the bank is as follows:

$$d_{b.t} + \left(\frac{1 + r_{h.t-1}}{1 + \pi_t}\right) b_{t-1} + l_t + k_{b.t} + rr\left(b_t - \frac{b_{t-1}}{1 + \pi_t}\right) + \psi_{c.t} + \psi_{k.t} + \chi_{b.t} \leq b_t + \left(\frac{1 + r_{l.t-1}}{1 + \pi_t}\right) l_{t-1} + (1 + r_{k.t}) k_{b.t-1} \quad (32)$$

In the above equation $r_{k.t}$ implies the return rate of the direct investment of bank and is defined as follows:

$$r_{k.t} = (\alpha k)\left[\frac{q_t}{k_{p.t-1}}\right] - \delta \quad (33)$$

The objective function of the representative bank is defined as the manufacturing goods firm and the housing construction firm. By maximizing the objective function of the representative bank subject to the budget constraint, the first-order conditions for the dividend, bank deposits, lending and accumulated capital in the firms are as follows:

$$1 - \gamma_{b.t}\left[1 + \kappa\left(d_{b.t} - \overline{d_b}\right)\right] = 0 \quad (34)$$

$$(1 - rr)\,\gamma_{b.t} - \beta_b\,\gamma_{b.t+1}\left(\frac{1 + r_{h.t} - rr}{1 + \pi_{t+1}}\right) - \frac{\partial \psi_{c.t}}{\partial b_t} - \frac{\partial \psi_{k.t}}{\partial b_t} = 0 \quad (35)$$

$$-\gamma_{b.t} + \beta_b\,\gamma_{b.t+1}\left(\frac{1 + r_{l.t}}{1 + \pi_{t+1}}\right) - \frac{\partial \psi_{c.t}}{\partial l_t} - \frac{\partial \psi_{k.t}}{\partial l_t} = 0 \quad (36)$$

$$-\gamma_{b.t} + \beta_b \, \gamma_{b.t+1} \, (1 + r_{k.t+1}) - \frac{\partial \psi_{c.t}}{\partial k_{b.t}} - \frac{\partial \psi_{k.t}}{\partial k_{b.t}} = 0 \tag{37}$$

In the above equations, the variable $\gamma_{b.t}$ implies a Lagrange multiplier of budget constraint.

3.5 The Central Bank

Generally, the modeling of the central bank is performed through Taylor's rule in DSGE models for advanced economies. In economic literature, there is a relative consensus which the main purpose of the central bank is to control the general level of prices through the middle target of the interest rate. In Iranian economy, the central bank intervenes both in determining the interest rate as well as the amount of money in discretionary manner. In the present study, the banking system is responsible for determining interest rates, due to the modeling of financial frictions and it is assumed that the central bank plays its main role by determining the amount of money. Following the recent study by Komeijani and Tavakkolyan (2012), the rule of growth rate of the money volume is defined as follows:

$$gm_t = (gm_{t-1})^{\gamma_m} \left(\left(\frac{\pi_t}{\bar{\pi}}\right)^{\gamma_\pi} \left(\frac{q_t}{\bar{q}}\right)^{\gamma_q} \right)^{1-\gamma_m} e^{s_{m.t}} \tag{38}$$

In the above equation , $\bar{\pi}$ and $\bar{q}$ represent the values of the corresponding variables in a steady state and the parameters γ_π and γ_q indicate the reaction coefficients of the central bank in the face of the deviation of inflation and the level of production from their steady-state values. In addition, the variable $s_{m.t}$ implies a monetary policy shock.

3.6 Market Clearing Conditions

Market clearing in the goods market in accordance with the Walras' law is obtained by aggregating all the budget constraints of the model. The clearing conditions of the housing market can be displayed as follows:

$$i_{H.t} = H_t - (1 - \delta)\, H_{t-1} = q_{H.t} \qquad (39)$$

In the above equation, the variable $i_{H.t}$ indicates the housing investment demand. Further, the variable H_t denotes the total stock of the housing and is given by $H_{t-1} = H_{h.t} + H_{p.t}$.

In the present study, there are seven shocks including total demand shock, housing demand shock, the technology shock of the manufacturing goods firm's production function, the technology shock of the housing construction firm's production function, financial shock of the manufacturing goods firm, financial shock of the housing construction firm and monetary policy shock. The first six shocks are modeled in as an autoregressive process and monetary policy shock is considered as a stochastic variable with an independent and identical distribution (iid).

4. Data and Model Estimation

4.1 The Empirical Data

The designed model in the previous section is estimated by Bayesian inference and seasonally adjusted data[1] of the Iranian economy during 1370q1- 1395q4 [2]. The data used to estimate the model are private sector consumption, non-residential investment (fixed capital formation in machinery), residential investment (fixed capital formation in construction), gross domestic product (in order to adapt to the model, it is defined as the total expenditures of the consumption and investment), banking loan (non-government debt balance to the banking system), and inflation rate. The source of all data is the economic time series database of the Central Bank of the Islamic Republic of Iran. The variables of GDP, consumption, and investment are based on constant prices in 2004, and the variable of bank credit is divided by consumer price index (2004=100) to obtain the real value. Given that the variables in the model are defined as deviations from steady state, all variables except inflation rate are detrended using the Band Pass (BP) filter in order to compatible with the model.

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1. The raw data used are seasonally adjusted by using the X12 method.
2. The model is estimated using the Dynare program. The codes for estimating and simulating the model are available on request.

Specifically, the modified form of the Band Pass filter of Baxter and King (1999) proposed by Christiano and Fitzgerald (2003) is used. The advantage of this approach is inclusion the larger range of time series than the Baxter and King method, and the convergence to the optimal filter in the long run. Further, the inflation rate demeaned over the considered period. Fig. 1 shows the detrended and demeaned data

It is worth noting that in estimating the model of the present study, the measurement error is considered. In order to solve the problem of low accuracy in measuring empirical data and the existence of different types of abnormality in data, measurement error method is used (Pfeifer, 2014). In this method, the exogenous variables are defined in the model to the number of empirically observable variables, whose tasks are to adjust the measurement error. In the present study, the variance of the measurement error variables is considered equal to 20% of the variance of the empirical data.

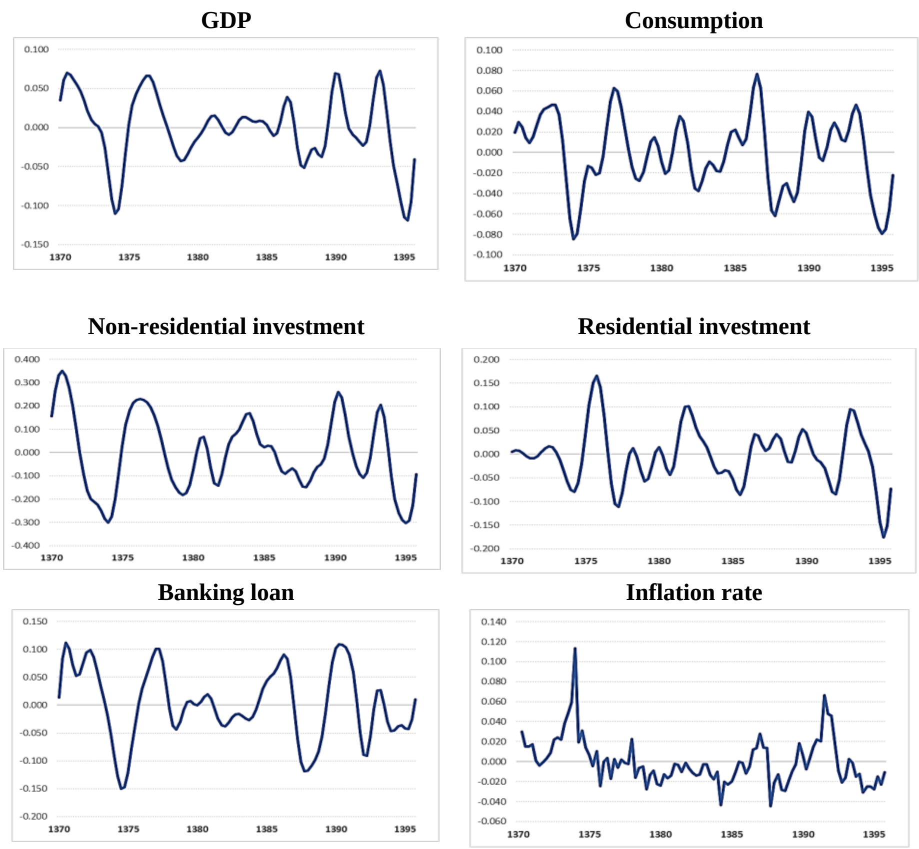

Figure 1: Detrended and Demeaned Data Used in Estimation

4.2 The Calibrated and Estimated Parameters

In what follows, we introduce the calibrated and estimated parameters as well as the prior and the posterior distributions of the estimated parameters. Normally, in estimating DSGE models, some parameters which determine the steady-state values of the endogenous variables of the model are not estimated and calibrated into the model. Table 1 shows the values of the calibrated parameters. Two issues are considered in the selection of discount factors. First, we see the flow of resources from the household to the bank and the firms. Second, the real interest rate in a steady state situation is close to 1%. The share of productive inputs is selected in such a way that the share of the consumption, non-residential and residential investment in a steady

Table 1: Calibrated Parameters for Model

Parameter	Symbol	value
discount factor of the household	β_h	0.99
discount factor of the firms	β_p	0.95
discount factor of the bank	β_b	0.95
share of machinery capital in the production function of manufacturing goods firms	αk	0.3
share of housing capital in the production function of manufacturing goods firms	αh	0.1
loan-to-value ratio for machinery capital	θ^K	0.2
loan-to-value ratio for housing capital	θ^H	0.2
share of structures in the production function of housing construction firm	αx	0.3
share of land in the production function of housing construction firm	αl	0.2
loan-to-value ratio for housing construction firm	θ^L	0.5
legal reserve ratio	rr	0.1
capital adequacy ratio	Ω	0.08
direct investment limit	Θ	0.4
depreciation rate	δ	0.02

state situation is consistent with the average share of these inputs in the period of the present study. Loan-to-value ratios are selected in such a way that the total lending ratio to the gross domestic product (GDP) is not more than one. The parameters of the banking system are in accordance with the existing rules and regulations. Other parameters are calibrated equally to the common values in the literature of the dynamic stochastic general equilibrium models.

Other parameters of the model are estimated by using the Bayesian inference. Estimating the parameters of the model requires the determination of initial values and the choice of the prior distribution. The choice of the prior distribution of parameters is proportional to the features of the corresponding parameter and distribution characteristics. For example, the Beta distribution is characterized by three indicators of mean, standard deviation, and upper and lower limit. Therefore, this distribution is appropriate for estimating the parameters defined in the domain. However, the Gamma distribution is in the zero-infinity domain and is suitable for estimating parameters which can only have positive values. Further, in order to estimate the parameters having no specific limitation, normal distribution can be a suitable distribution. Table 2 presents the prior and posterior distribution of structural parameters of the model. In addition, the same information is presented for the parameters of autoregressive processes of model shocks in Table 3. It should be noted that the mean of prior distributions of monetary policy parameters are taken from the study of Komeijani and Tavakkolyan (2012). Furthermore, the mean of prior distributions of the cost scale parameters of the non-accordance with capital adequacy constraint φ_c and the non-accordance with the permitted limit of direct investment of banks φ_k are selected in such a way that the mentioned ratios are consistent with the empirical data of Iranian economy. Based on the calculations of the research, the capital adequacy ratio of the banking system and the ratio of total accumulated direct investment of banks to the capital of the banking system during 2008-2016 were approximately 7% and 60%, respectively. The average of other parameters is equal to the common values in the literature of dynamic stochastic general equilibrium models.

Table 2: Estimated Structural Parameters

Parameter	Prior distribution			Posterior distribution	
	Density	**Mean**	**St,dev**	**Mean**	**St,dev**
consumption habit parameter (ξ)	Normal	0.6	0.1	0.45	0.06
inverse of Frisch elasticity of labor (σ_n)	Normal	1.5	0.2	1.53	0.2
inverse of interest rate elasticity of the demand for real money balance (ζ)	Normal	2	0.2	1.9	0.18
autoregressive coefficient of monetary policy (γ_m)	Beta	0.5	0.1	0.53	0.09
reaction coefficient of central bank to inflation (γ_p)	Normal	-0.98	0.2	-1.48	0.14
reaction coefficient of central bank to GDP (γ_q)	Normal	-2.96	0.5	-0.24	0.16
cost scale of non-compliance with the capital adequacy (φ_c)	Gamma	5	1	4.07	0.97
cost scale of non-compliance with the direct investment limit (φ_k)	Gamma	0.5	0.1	0.5	0.1
cost scale of adjusting the dividend (κ)	Gamma	0.5	0.1	1.07	0.13

The posterior distribution of structural parameters has a relative adaptation with initial values of prior distributions. The average of household consumption habit parameter is obtained 0.45, which shows relative consumption responsiveness to changes in economic conditions. The results of the estimation of the reaction coefficients of the monetary policy indicate the importance of the inflation rate in the objective function of the central bank. Thus, the coefficient of the monetary policy reaction to the deviation of inflation (in absolute terms) is almost multiple of the coefficient of the monetary policy reaction to the production deviation. According to the expectation, the coefficient of both variables of the inflation and production rate in the reaction function of monetary policy is estimated to be negative. The mean of the posterior distribution of the cost scale parameter of the dividend adjustment cost of firms is almost two times more than the initial value of the prior distribution, which implies the importance of this cost in the objective function of firms. Further, the evidence of the estimation of model shock parameters suggests that financial and demand shocks have the highest and lowest persistence, respectively. In other words, the autoregressive coefficients of financial and demand shocks are estimated to be larger and smaller than other shocks, respectively. It should be noted that the convergence diagnostics and the prior and posterior distributions of the estimated parameters are presented in appendixes (A) and (B), respectively.

Table 3: Estimated Parameters of the Shock Processes

Parameter	Prior distribution			Posterior distribution	
	Density	Mean	St,dev	Mean	St,dev
autoregressive coefficient of total demand shock	Beta	0.9	0.1	0.87	0.05
autoregressive coefficient of housing demand shock	Beta	0.9	0.1	0.88	0.02
autoregressive coefficient of technology shock for manufacturing goods firm	Beta	0.9	0.1	0.93	0.02
autoregressive coefficient of technology shock for housing construction firm	Beta	0.9	0.1	0.84	0.04
autoregressive coefficient of financial shock for manufacturing goods firm	Beta	0.9	0.1	0.96	0.04
autoregressive coefficient of financial shock for housing construction firm	Beta	0.9	0.1	0.88	0.005
standard deviation of total demand shock	Inverse gamma	0.01	Inf	0.009	0.002
standard deviation of housing demand shock	Inverse gamma	0.01	Inf	0.004	0.001
standard deviation of technology shock for manufacturing goods firm	Inverse gamma	0.01	Inf	0.012	0.001
standard deviation of technology shock for housing construction firm	Inverse gamma	0.01	Inf	0.014	0.001
standard deviation of financial shock for manufacturing goods firm	Inverse gamma	0.01	Inf	0.004	0.000
standard deviation of financial shock for housing construction firm	Inverse gamma	0.01	Inf	0.013	0.001
standard deviation of monetary policy shock	Inverse gamma	0.01	Inf	0.005	0.001

5. Empirical Evidences

5.1 Business Cycles Moments

In this section, in order to check the compatibility and adaptation of the proposed model with empirical data, the data moments and the moments obtained from the model are compared. Two moments are considered; the relative standard deviation (the ratio of standard deviation of each variable to the standard deviation of gross domestic product) and the correlation of the variables with the gross domestic product. Table 4 presents the evidence obtained from the model and the empirical data. The evidence suggests that in actual data, the greatest relative standard deviation belongs to the non-residential investment. Further, the relative standard deviations of variables of non-residential investment, residential investment and banking loan are greater than one, meaning that the fluctuations of these variables are higher than the gross domestic product (GDP). In the simulated model, non-residential investment has the high relative standard deviations, and the standard deviation of variables of non-residential investment, residential investment and banking loan is higher than the standard deviation of gross domestic product. The correlation evidence of variables indicate that the correlation coefficients of all variables, other than the inflation rate, are positive in both empirical data and simulated data of the model. In general, there is an acceptable compatibility between the moments of actual data and the model.

Table 4: Moments of Actual Data and Estimated Model

Variable	Relative standard deviation		Correlation with the GDP	
	Data	Model	Data	Model
GDP	1	1	1	1
consumption	0.81	0.88	0.77	0.82
non-residential investment	3.67	3.66	0.87	0.52
residential investment	1.36	1.2	0.54	0.32
banking loan	1.47	1.11	0.64	0.6
inflation rate	0.53	0.67	-0.06	-0.23

5.2 The Importance of Financial Frictions

In this section, in order to investigate the importance of financial frictions, the historical decomposition of the estimated model in response to financial shocks is presented. Fig. 2 presents the empirical data along with simulated data in response to the financial sector shocks. For each of the variables, the solid blue line shows the empirical data (in detrended and demeaned form) and red dotted line with star marks displays the model simulation in response to financial shocks (the financial shock of the manufacturing goods firm, and the financial shock of the housing construction firm). The historical decomposition of the model indicates that the explanatory power of the financial shocks is higher for residential investment, banking loan,

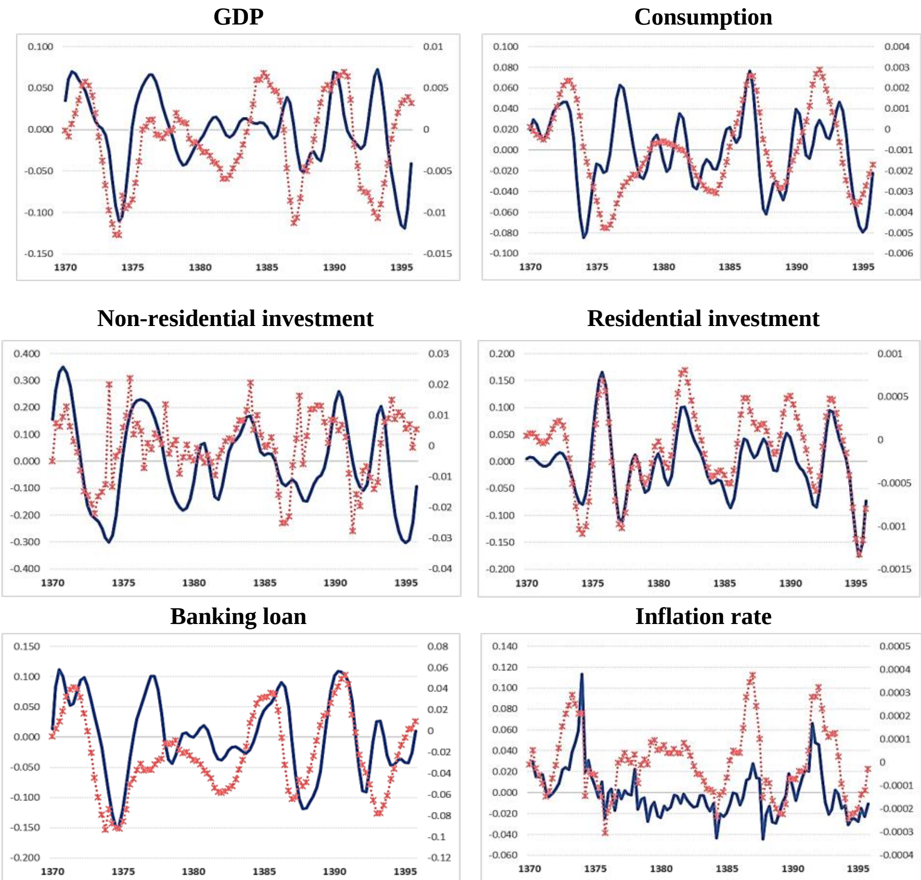

Figure 2: Historical Decomposition of Estimated Model in Response to the Financial Shocks

inflation rate, consumption, gross domestic product (GDP) and non-residential investment. The correlation coefficient of actual data and simulated data for the mentioned variables equals to 0.91, 0.72, 0.62, 0.39, 0.37 and 0.33, respectively. Generally speaking, the evidence suggests that there is a high degree of consistency between the actual data and simulated data in response to financial shocks. Based on the results, the financial shocks can explain a significant part of fluctuations of the business cycle of the Iranian economy.

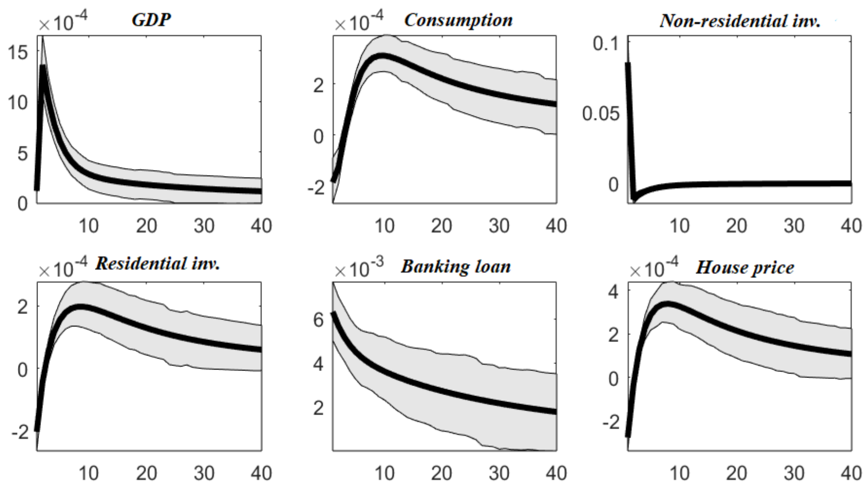

Figure 3: Impulse Responses to Financial Shock of Manufacturing Goods Firm

5.3 Impulse Response Functions

In this section, the impulse response functions of financial stocks are discussed and the persistence of these shocks is compared. Fig. 3 illustrates the response of various model variables to the shock of the loan-to-value ratio (LTV) of the manufacturing goods firms. Due to the positive impact of the loan-to-value ratio, firms can acquire more external resources, a part of which is spent on investing. Based on the evidence of this study, bank lending and non-residential investment have a positive and relatively rapid response. An increase in the investment and production lead to rise in the consumption. However, the response of the consumption variable in compared to other variables has more delay, which partly due to modeling household consumption habits. Other evidence suggests that residential investment and housing prices initially had a negative reaction, although it offset the initial reduction after a few periods, due to the reduction of external resources available to the housing construction firms.

Figure 4 represents the impulse response functions of the model variables to the financial shock of the housing construction firms. The evidence shows that investment in this sector increased due to the more access to external resources. In contrast, investment in the production sector declined due to the reduction of resources available to manufacturing goods firms. Generally, the effect of residential investment is higher and the GDP has also risen in response to a positive financial shock. In general, the impulse response functions of the model indicate that a positive (negative) financial shock leads to a rapid increase (decrease) in GDP.

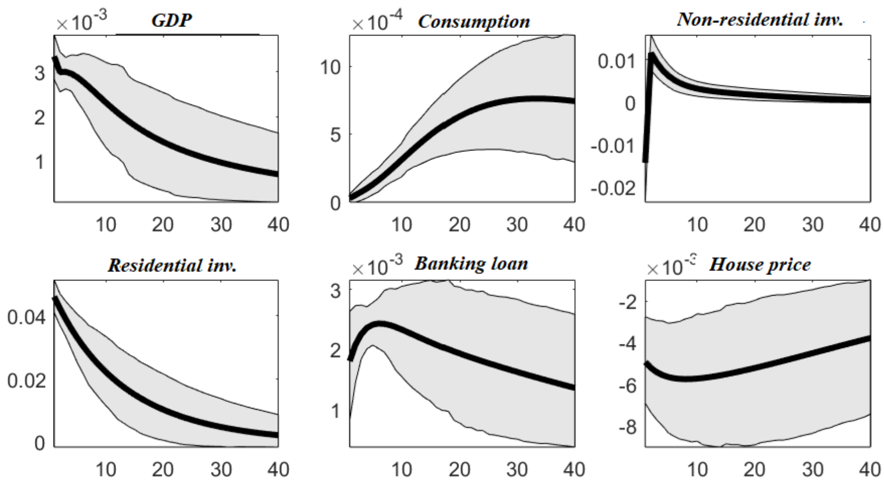

Figure 4: Impulse Responses to Financial Shock of Housing Construction Firm

In the following, we specifically discussed the durability of the effects of financial shocks compared to supply and demand shocks. In order to evaluate the sustainability of different shocks, a ratio is defined, which is the sum of the effects of a shock on the variable in the first ten years (long-term period) to the sum of the effects of the same shock on the variable in the first five years (short-term period). The higher the ratio is, the more likely is the durability of the effects of shock. Table 5 reports the sustainability ratio defined for supply and demand shocks and financial shocks. Based on the results, the persistence of financial sector shocks is relatively higher compared to supply-side shocks (productivity shocks) and demand-side shocks (total demand and housing demand shocks). Based on other evidence, the lowest and highest durability of the effects of different shocks are related to the non-residential investment and the consumption variable, respectively.

Table 5: Sustainability Ratio for the Different Shocks

Variable	Total demand shock	Housing demand shock	Technology shock of manufacturing goods firm	Financial shock of manufacturing goods firm	Financial shock of housing construction firm
GDP	1.25	2.31	1.41	1.35	1.39
consumption	1.21	1.44	1.59	1.78	3.31
non-residential investment	0.78	0.82	0.88	0.94	1.45
residential investment	0.46	1.37	1.47	1.65	1.17
banking loan	1.38	1.6	1.8	1.56	1.67

6. Conclusion

The present study aimed to investigate the role of financial frictions in the business cycles of the Iranian economy. For this purpose, a dynamic stochastic general equilibrium model (DSGE) is designed which is consistent with the structural characteristics of the financial sector. The main components of the model are the household, the manufacturing goods firms, the housing construction firm, the banking system and the policy maker (or the central bank). In the proposed model, financial resources are provided for firms by bank intermediation from the household sector. The supply of housing is endogenously modeled in this study and the direct investment activity of banks is considered in the model. The model is estimated by using the Bayesian technique and detrended and demeaned data of Iranian economy. The obtained evidence from the Bayesian estimation of the model suggests that there is an acceptable adaptation between the moments of empirical data and simulated data of the model. The results of the historical decomposition of the model showed that the financial shocks explained almost completely the fluctuations of residential investment and banking credit, as well as a large part of the fluctuations of GDP, consumption, and residential. In general, the results indicated the importance of modeling the financial sector in understanding the fluctuations of the business cycle.

The results of impulse response functions of the model variables in the face of financial shocks denote that a positive financial shock leads to an increase in GDP and consumption. Further, a positive financial shock can result in increasing the lending, although the share of lending in goods sector and housing sector increases or decreases depending on the type of financial shock. Finally, the results of the final part of the study indicated that the effect of financial stocks are more sustainable than supply and demand shocks.

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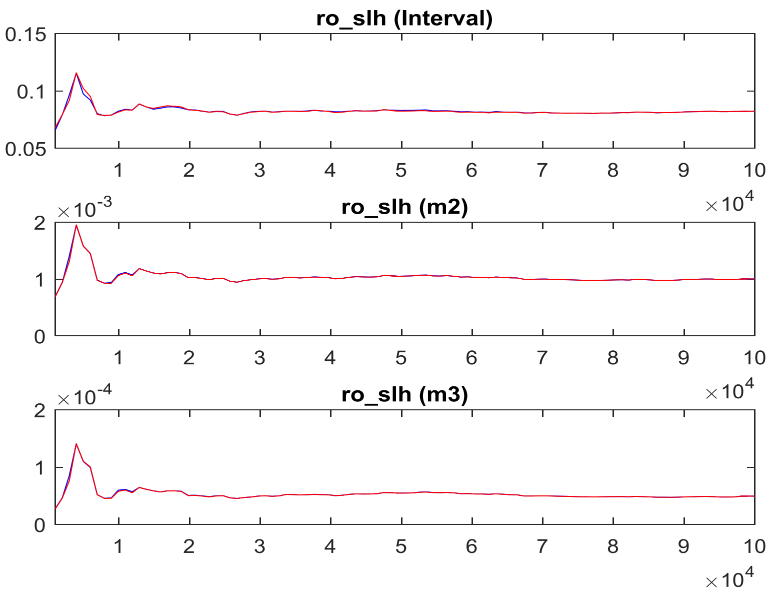
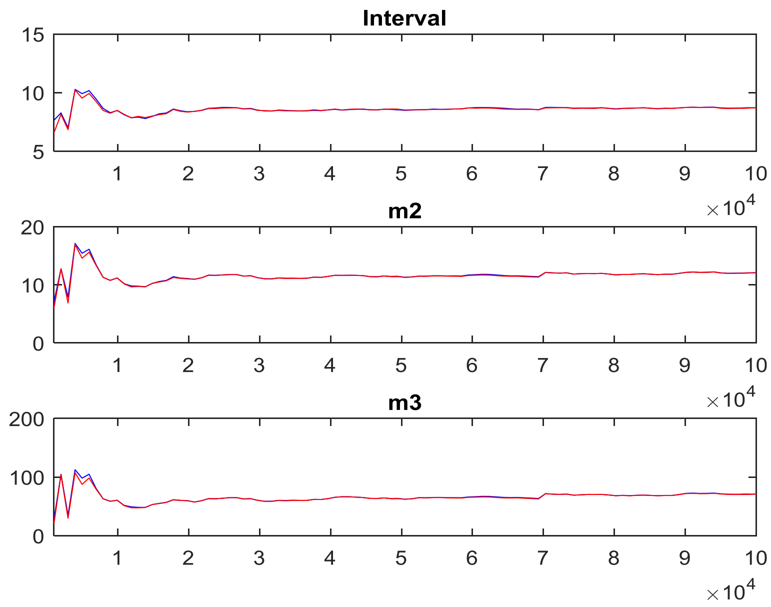
Appendix A: Convergence Diagnostics





Appendix B: Priors and Posterior Distributions