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BANKING SECTOR AND CENTRAL BANK IN DEVELOPING COUNTRIES: THE CASE OF IRAN USING A DSGE MODEL

Abstract

Banking sector as one of the most important sector in developing countries plays a major role in the economic stability of the countries. In this paper and with the help of DSGE model we investigate the importance of banking system and the role of central bank in shifting economic shocks across the society.

The analysis of the effects of oil and financial shocks on real variables of the economy indicates that the adopted model is well-matched with theoretical expectations and facts. Results of the model endorse the importance of the banking sector in reassigning the impact of the shocks and we also show that liquidity injections by central bank relieve financial instability in the short run.

JEL CLASSIFICATION: G21, E43, C69A.
KEYWORDS: INTERBANK MARKET, PROBABILITY OF DEFAULT, MONETARY POLICY, CAPITAL ADEQUACY, DSGE MODEL.

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1. Introduction

Financial markets have a significant role in funding investments and are considered the backbone of economic development in developing countries. The empirical evidence associated with the recent financial crisis has also implied a significant role of financial sector in shifting monetary policy toward the real sector of the economy and major cause of business cycle (Jermann and Quadrini 2009). To better understand the sources of economic fluctuation and design an effective economic policy, we separately examine the role of financial intermediaries in both money and capital markets.

Whereas short term financing through money markets is the main objective of commercial banks and credit institutions, capital markets are considered to be the main source of financing long term funding for productive activities in manufacturing and services industries.

Despite the recent progress to enhance the scope of capital markets in Iran, Central Bank and the banking system as a whole remains to be the leading source of fund for the entire economy. In other words banking system performs two distinct functions.

Since all the deposits at commercial banks are insured by the Central Bank, and the Central Bank is influentially controlled by the government, on one hand the banking system is responsible for supply of money and allocation of deposits among semi-private commercial banks and on the other hand it takes an active role in payment management and distribution of funds among producers and investors. Consequently, financial surplus unit's main financial instruments for saving are banks' certificate of deposits (with regulated interest rate) and bonds issued either by the government or commercial banks and the deficit units' have no choice but to rely on the implemented policy of financial authorities regarding the allocation of funds. To this extent, any deficiency of funds in the financial markets coupled with an inefficient performance of policy makers leads to monetary shock and negative spill over to other sectors of the economy.

The main objective of this paper is to build a dynamic stochastic general equilibrium model with regarding banking sector and central bank role in financial crises. We introduce negative market book shock and negative oil shock and compare our simulation results to Iran data.

In this paper, section 2 presents literature review. Section 3 gives methodology. Section 4 presents the model. Conclusion provided at section 5.

2. **Literature review**

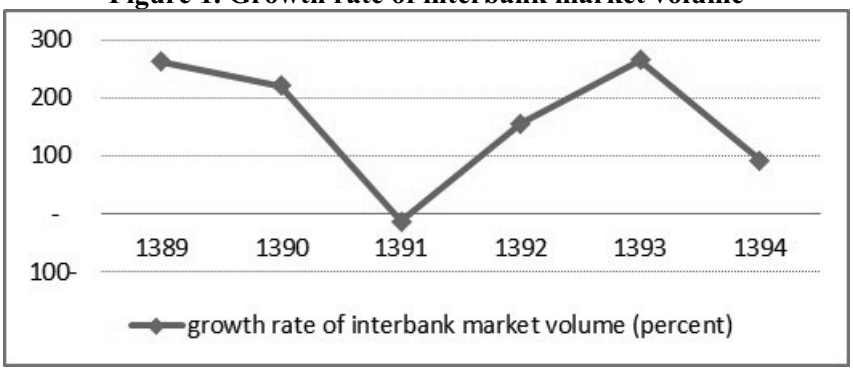
Over the past decade the relation between fiscal and monetary policies, role of banks as financial intermediaries and interbank market in transferring shocks to the real sector of the economy have become an important research field of research for academies and a very visible objective for policymakers.

An external economic shock is an event that causes a significant change within an economy, despite occurring outside of it. economic shocks are unpredictable and may typically impact either sides of the market, thus shifting economic shocks across society in Real Business Cycle (RBC) models is considered as for how the important economic variables affected by financial, market book and oil shocks (Medina 2005).

A major lesson of the financial crisis is that the interbank lending market is crucial for banks that face uncertainty regarding their liquidity needs. The interbank market funds, will reduce the overdraft of the central bank and reduce the cost of liquidity management, it also reduces inflationary effects of overdraft.

Iran's interbank market was established in 2008, initially with 10 members but today has 18 members. Statistical research shows considerable growth from 2008 to 2015 which indicates banks' reliance on each other's surplus funds in short term.

Figure 1. Growth rate of interbank market volume



Source: Central Bank of Iran

Sargent and Wallace (1981) showed that the monetary policy cannot reduce inflation in the short and the long term without major changes in

fiscal policy, in other words; they raised the dominance of fiscal policy in which fiscal authorities compensate their budget deficits by issue debt securities and realizing that monetary authorities do not have the power to control inflation. If monetary authorities impose tighter monetary policies to control the inflation, the interest rate will rise and the deficit will increase further due to the government's financial obligations. Depending on the method of deficit financing, the economy may face even higher inflation than before.

After the banking crisis started in 2007, the importance of a relationship between the banking sector and the real sector was more apparent than ever before. Therefore transmission of shocks from the banking sector to the real sector was entered into the DSGE modeling. In the literature on closed economy models, the two main ways in which an active banking system is incorporated into DSGE models with financial friction, is through the external finance premium proposed in Bernanke, Gertler and Gilchrist (BGG 1999) or through Collateral constraint tied to real estate values for entrepreneurs proposed in Iacoviello (2005). Gerali et al. (2010), Smets and Wouters (2007) designed DSGE models based on the framework of the banking sector, the households and firms, While the banking sector and financial intermediaries receive deposits from households and supply credit to firms. Iacoviello (2011) introduces a banking sector with one bank and focuses on how financial shocks (repayment shocks) affect an economy with patient and impatient households.

This group of studies has not addressed the role of the interbank markets as the balance sheet shocks transmitted to the real economy, but the effect of shocks as banks' default shocks on the real sector has been discussed. The results represent reduced credit supply and thus reduce economic growth.

De Walque and et al (2010), are considered Interbank market and regulatory sectors at DSGE. In this model, they have considered the interaction between the banking system and the real sector of the economy and importance of stabilizing the financial sector and regulatory policy. The model is calibrated against real US data and used for simulations. they show that Basel regulation reduces the steady state but improves the resilience of the economy to shocks and that moving from Basel I to Basel II is procyclical.

Goodhart et al. (2005), this paper proposes a model to assess risk for banks. Its main innovation is to incorporate endogenous interaction among banks, where the actual risk an individual bank bears also depends on its

interaction with other banks and investors. they develop a two-period general equilibrium model with three active heterogeneous banks, incomplete markets, and endogenous default. The model is calibrated against UK banking data and therefore can be implemented as a risk assessment tool for regulators and central banks.

Dib (2010) the author proposes a micro-founded framework that incorporates an active banking sector into a dynamic stochastic general-equilibrium model with a financial accelerator. He evaluates the role of the banking sector in the transmission and propagation of the real effects of aggregate shocks and assesses the importance of financial shocks in U.S. business cycle fluctuations. The banking sector consists of two types of profit maximizing banks that offer different banking services and transact in an interbank market. Loans are produced using interbank borrowing and bank capital subject to a regulatory capital requirement. Banks have monopoly power, set nominal deposit and prime lending rates, choose their leverage ratio and their portfolio composition, and can endogenously default on a fraction of their interbank borrowing. Because it is costly to raise capital to satisfy the regulatory capital requirement, the banking sector attenuates the real effects of financial shocks, reduces macroeconomic volatilities, and helps stabilize the economy. The model also includes two unconventional monetary policies (quantitative and qualitative easing) that reduce the negative impacts of financial crises.

Goodfriend and McCallum (2007) and Christiano et al. (2007) formulate quantitative models to assess the relevance of a detailed banking sector (and hence the importance of distinguishing among the various short term interest rates) for monetary policy. Gerali et al. (2010) augment these papers by introducing imperfect competition among banks.

All the papers mentioned above use homogeneous banks and the interbank market either collapses or amounts to a connection with the central bank. But Giri (2014) has considered two types of banks. Banks are faced with shortage liquidity for credit supply and thus borrowing from the interbank market and giving credit to the real sector, the second group of banks that have excess funds, lend to interbank and invest less risky assets such as bonds. Results suggest that Credit shocks in the interbank market have reduced the supply of loans from the banking sector to the real sector of the economy, and then has reduced Investment and economic growth.

The followings are the two studies about Iran’s economic bank sector in a DSGE model.

ShahHosseini (2013) in her Ph.D. thesis investigated inter relationship between the banking system and real variable of macroeconomics in Iran and developed a DSGE model considering the banking sector as an intermediary and its performance on banks with different shocks. Addition of banking sector in DSGE model and its experimental evaluation reveals that this sector has an important role in Iran's real business cycles. They noticed that existing monetary shock effects in non-performing loans shows that such loans lead to decreasing the efficiency of monetary shocks.

Mehregan and Daliri (2011) investigated banks reaction to monetary policies based on a DSGE model by using Quarterly data between years (1991-2009). In this study, they designed DSGE frameworks with respect to intermediaries to investigate the thinking of investors and loan seekers in society, through the monetary shocks.

The results suggest that monetary shocks will increase nominal variables such as wages, prices, and interest rate.

3. Methodology

DSGE models are built on microeconomic foundations and emphasize agents' intertemporal choice. The dependence of current choices on future uncertain outcomes makes the models dynamic and assigns a central role to agents' expectations in the determination of current macroeconomic outcomes. In addition, the models' general equilibrium nature captures the interaction between policy actions and agents' behavior.

These models can help to identify sources of fluctuations, forecast and predict the effects of policy changes, and perform counterfactual experiments. They also allow establishing a link between structural features of the economy and reduced form parameters, something that was not always possible with the large scale of macroeconomic models. Given the difficulty of constructing accurate DSGE models, most Central banks still rely on traditional marc econometric models for short-term forecasting.

In this paper, we investigate the importance of banking system with endogenous default probabilities and examine the role of the central bank as a stabilizing factor by injecting funds in the market to alleviate financial fluctuation. We have used a modified model of Gregory de Walqe, Olivier Pierrard and Abdul-Aziz Rouabah (Olivier Pierrard 2008). In their model, banking system provides loans to firms in order to satisfy their capital requirements for new investments. On the other hand, banks acquire their

funds through household's deposits and pay a fixed interest rate, until end of the contract.

In this paper, banks are divided into two groups, one those who have excess liquidity and the other those who have liquidity deficit. In this situation the first group of banks provides loans to the second group through an interbank market and also interbank rate can change during the time. To allow for the presence of credit risk, we introduce the endogenous probability of default for firms and banking sector.

Also, all sectors (households, firms, and banks) either maximize utility or profits subject to their budget constraint. Capital requirements rules should be observed as a commitment for banks and a Central bank has the authority to interfere in the interbank market.

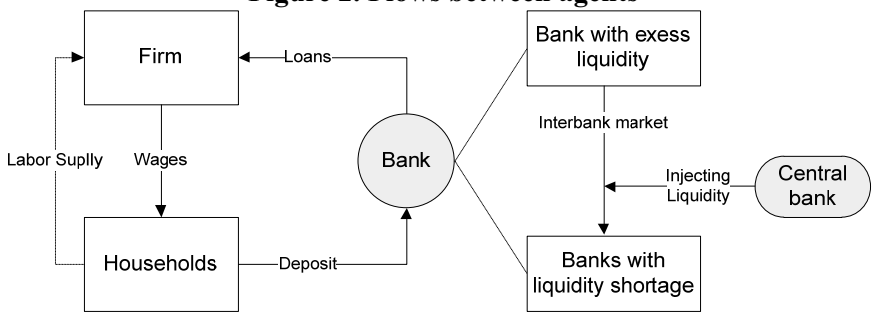
3.1 Developing a DSGE Model Considering Banking Sector with respect to Iran's Economy

To adjust for a more realistic situation in developing countries, contrary to usual assumption of classical RBC models we are not assuming perfect competition in capital markets. We also added oil production based on available oil reserves and quota set by OPEC, as an exogenous variable in AR (1) format.

Based on the historical evidence (in Iran economy) there is no possibility of default for households depositor, in other words, there is no risk for household's deposits. Reserves and assets requirements of the banks are controlled by a supervisory authority.

Therefore there are 5 sectors (households, firms, banks, the central bank, and oil) in the model. We can illustrate the relation of these sectors as follows:

Figure 2. Flows between agents



3.1.1 Firms

The Primary objective of firms is to acquire a number of loans needed to maximize their profit as an (Elul 2008). Even though there is a possibility for firms to default their loans, they must pay some high pecuniary and non-pecuniary costs. Pecuniary costs include penalties which they have to pay for non-performing loans and non-pecuniary costs are those of loss of reputation and credits for future loans.

Firm's Objective function:

$$\max_{N_t, L_t^b, \alpha_t} \sum_{s=0}^{\infty} E_t[\tilde{\beta}_{t+s}\{\pi_{t+s}^f - d_f(1-\alpha_{t+s})\}] \tag{3.1}$$

Subject to:

$$Kt = (1-\tau)K_{t-1} + \frac{L_t^b}{1+r_t^{b\prime}} \tag{3.2}$$

$$\pi_t^f = \epsilon_t F(K_t, N_t) - w_t N_t - \alpha_t L_{t-1}^b - \frac{\gamma}{2}\left((1-\alpha_{t-1})L_{t-2}^b\right)^2 \tag{3.2}$$

$$\bar{\beta}_{t+s} = \beta^s \frac{uc_{t+s}}{uc_t} \tag{3.4}$$

Equation (3.2) is the law of motion for capital. Capital K_t depreciates at a rate τ and firms borrow at a price $1/1+r_t^b$ to refill their capital stock.

Equation (3.3) defines profit (π_t^f). The firms produce goods using capital

and labor as input, and ε is a total factor productivity shock. They pay a wage w_t to workers and reimburse their previous period borrowing (L^b_{t-1}). They choose what proportion α_t of their previous borrowing they want to repay, knowing that they will have to pay tomorrow a quadratic search cost on any defaulted amount. At the end have to say that firms owned by households.

3.1.2 Banks with liquidity shortage

This kind of banks holds loans L^b_t to firms, market book B^b_t,, borrowing D^{bd}_t from interbank market, D^b_t deposits from households and own funds F^b_t and with respect to the current rates they maximize profits. As for firms sector, defaulters are not excluded but have both non pecuniary and pecuniary costs (Goodhart et al. 2005).

It is noticeable that the second terms in banks maximization profit function indicate positive utility for the buffer of own funds above the minimum capital requirements imposed by the financial supervisory authority which fixes the coverage ratio of risky assets with respective of weights.

The bank with liquidity shortage maximization function is:

$$\max_{\delta t, D^{bd}_t, L^b_t, B^b_t, F^b_t} \sum_{s=0}^{\infty} E_t\left[\tilde{\beta}_{t+s}\left\{\ln(\pi^b_{t+s}) - d_\delta(1-\delta_{t+s}) + d_{F^b}(F^b_t - k\left[\overline{w}_t L^b_t + \widetilde{w} B^b_t\right])\right\}\right] \quad (3.5)$$

Subject to:

$$F^b_t = (1-\xi_b)F^b_{t-1} + \upsilon_b \pi^b_t \quad (3.6)$$

$$\pi^b_t = \alpha_t L^b_{t-1} + \frac{D^{bd}_t}{1+i_t} - \delta_t D^{bd}_{t-1} - \frac{L^b_t}{1+r^b_t} - \frac{\omega^b}{2}\left((1-\delta_{t-1})D^{bd}_{t-2}\right)^2 + \zeta_b(1-\alpha_{t-1})L^b_{t-2} + \frac{D^b_t}{1+r^l_t} - D^b_{t-1} + \rho^b_t, \quad (3.7)$$

Equation (3.6) states that funds are increased each period by the share υ_b of profits that are not redistributed to the households-shareholders. Furthermore, a small fixed proportion ξ_b of the own funds are put in an insurance fund managed by a public authority.

Equation (3.7) defines a period profit. The bank borrows D_t^{bd} on the interbank market at a price $1/1+i_t$. It chooses the fraction δ_t of the past borrowing it wants to pay back, knowing that it will have to pay a quadratic search cost on her defaulted amount.

Because of the existence of the insurance fund, the bank is able to recover a fraction ζ_b of the firms' defaulted amount.

3.1.3 Banks with surplus funds

This kind of banks hold: loans L_t^l to firms, market book B_t^l, lending D_t^{bs} from interbankmarket, D_t^l deposits from households and own funds F_t^l and with respect to the current rates they maximize profits.

Due to holding capital adequacy higher than supervisory standards this bank gains positive utility because of not being exposed to liquidity risk.

Since the bank with surplus fund is the only source of lending, the probability of default is indicated with negative sign.

The bank with surplus liquidity maximization function is:

$$\max_{D_t^{bs},D_t^l,B_t^l.F_t^l} \sum_{s=0}^{\infty} E_t\left[\tilde{\beta}_{t+s}\left\{\ln\left(\pi_{t+s}^l\right) + d_{F^l}(F_t^l - k\left[\bar{\bar{w}}D_t^{bs} + \tilde{w}B_t^l\right])\right\}\right] \quad (3.8)$$

Subject to:

$$F_t^l = (1 - \xi_l)F_{t-1}^l + \upsilon_l\pi_t^l, \quad (3.9)$$

$$\pi_t^l = \delta_t D_{t-1}^{bs} + \frac{D_t^l}{1+r_t^l} - D_{t-1}^l - \frac{D_t^{bs}}{1+i_t} + \zeta_l\left(1 - \delta_{t-1}\right)D_{t-2}^{bs} + \alpha_t L_{t-1}^l - \frac{L_t^l}{1+r_t^b} + \zeta_b(1 - \alpha_{t-1})L_{t-2}^l + \varphi_t^l, \quad (3.10)$$

Equation (3.9) displays the own funds dynamic. Own funds are increased each period by the share υ_l of profits that are not redistributed to the households shareholders. Furthermore, a small fixed proportion ξ_l of the own funds are put in an insurance fund managed by a public authority.

Equation (3.10) defines a bank profit. δ_t And α_t explain the portion of loan's to firms and interbank market that are not defaulted. This is important to say that, for this group of bank's there is no constraint in bank maximization profit function because there is no default for them.

3.1.4 Households

As an RBC standard models household maximizes their utility with respect to consumption and leisure. Also households try not to deviate from optimized amount of deposits.

The household's maximization function is:

$$\max_{N_t, C_t} \sum_{s=0}^{\infty} \beta^s E_t \left\{ u(C_{t+s}) + \bar{m} \ln(1 - N_{t+s}) - \frac{\chi}{2} \left(\frac{D^l_{t+s}}{1 + r^l_{t+s}} - \frac{D^l}{1 + r^l} \right)^2 \right\} \quad (3.11)$$

Subject to:

$$C_t + \frac{D^l_t}{1 + r^l_t} = w_t N_t + D^l_{t-1} + \pi^f_t + (1 - \upsilon_b)\pi^b_t + (1 - \upsilon_l)\pi^l_t \quad (3.12)$$

Hence households are the real owner of whole economy so in their budget constraint we assume firms, banks with surplus and shortage liquidity profit.

3.1.5 Central Bank (supervisory authority)

RBC Models assume that interbank market is always at Long run equilibrium although in short run the central bank may inject liquidity in market in order to restore equilibrium as well as decreasing financial shocks.

So we have:

$$M_t = D^{bd}_t - D^{bs}_t \quad (3.13)$$

Also money equilibrium follows McCallum rule:

$$M_t = \upsilon (i_t - \bar{\imath}) \quad (3.14)$$

In this equilibrium $\upsilon \geq 0$, this means when the rate of interbank market is higher than the long term equilibrium money will be injected into the interbank market[4].

In other hand if $\upsilon = 0$, there is no central bank intervention and the

[4] since $M_t = 0$ in the long run, $\bar{\imath}$ must be equal to the equilibrium value of the interbank rate, $\bar{\imath} = i$

interbank interest rate clears the interbank market[5].

In the other hand, since the central banks oversees the activities of banks in Iran, so it determine capital adequacy (minimum capital requirements) for banks with respect to Basel regulation. It also defines the weight of assets with respect to their risks. According to guidelines of Basel 1 committee all weights are constant $\bar{\omega}_{t=\bar{\omega}}$ whereas in Basel 2 Committee the measurement of credit risk is calculated strictly in a way that if probability of default is high then it should devote higher rates to cover the risk of such loans.

$$\bar{\omega}_t = \bar{\omega}\, E_t\left[\left(\frac{\alpha}{\alpha_{t+1}}\right)^{\eta}\right], \text{whereas } \eta > 0 \qquad (3.15)$$

3.1.6 Oil sector

An exogenous variable, OPEC quota of oil production, is introduced in the model in an AR (1) format.

$$\log(o_t) = (1 - p_0)\log(o) + p_0 \log(o_{t-1}) + e_{ot} \qquad (3.16)$$

Which "o" is stable oil production level and e_o is relative shocks that influence oil income equilibrium amounts accidently. We also assume that the entire production of oil is exported at global market price and treat the oil revenue as an exogenous variable.

3.2 Model

In solving DSGE model first, we optimize the behaviour of economic agents subject to the constraints to obtain the first order conditions. Then we analyze the amount of variable in steady state and evaluate standard deviation with respect to different shocks.

The symmetry assumption also applies to extract initial values of variables. That is; all households, firms, banks, the lender and the borrower shall make the same decisions.

It should be noted that all variables are steady state with respect to economic growth, in accordance with relationship $\widetilde{X} = x_t/\eta^t$.

[5] Because of the long run equilibrium in the interbank market, there is no distinction between central bank money and banks money. In the other words, interest and default rate apply to both types of funds.

We will explain more about sectors first order condition in next paragraph.

3.2.1 First order conditions:

$$\varepsilon_t \tilde{F}_{N_t} = \widetilde{w}_t \tag{3.17}$$

$$\varepsilon_t \tilde{F}_{K_t} = \lambda_t - E_t\left[\tilde{\beta}_{t+1}(1-\tau)\lambda_{t+1}\right] \tag{3.18}$$

$$\frac{\lambda_t}{1+r_t^b} = E_t\left[\tilde{\beta}_{t+1}\alpha_{t+1} + \tilde{\beta}_{t+2}\gamma(1-\alpha_{t+1})^2\tilde{L}_t^b\right] \tag{3.19}$$

$$\tilde{L}_{t-1}^b = E_t\left[\tilde{\beta}_{t+1}\gamma(1-\alpha_t)(\tilde{L}_{t-1}^b)^2\right] + d_f \tag{3.20}$$

Equation (3.17) explain the marginal productivity of labor and wages.

Equation (3.18) also explains the marginal production of capital which is difference of today shadow prices and shadow discounted value tomorrow.

Equation (3.19) says that the shadow value of capital today is equal to its discounted expected cost.

Equation (3.20) equalizes the marginal cost of paying back today to the discounted marginal search cost of tomorrow plus the marginal disutility term.

$$\lambda_t^b D_{t-1}^{bd} = E_t\left[\tilde{\beta}_{t+1}\lambda_{t+1}^b \widetilde{w}^b(1-\delta_t)^2\right] + d_\delta \tag{3.21}$$

$$\frac{\lambda_t^b}{1+i_t} = E_t\left[\tilde{\beta}_{t+1}\lambda_{t+1}^b\delta_{t+1} + \tilde{\beta}_{t+2}\lambda_{t+2}^b\widetilde{w}^b(1-\delta_{t+1})^2 D_t^{bd}\right] \tag{3.22}$$

$$\frac{\lambda_t^b}{1+r_t^b} = E_t\left[\tilde{\beta}_{t+1}\lambda_{t+1}^b\alpha_{t+1} + \zeta_b\tilde{\beta}_{t+2}(1-\alpha_{t+1})\right] - d_{F^B}k\overline{w}_t \tag{3.23}$$

$$d_{F^b}\upsilon_b = \left(\lambda_t^b - \frac{1}{\pi_t^b}\right) - E_t\left[\tilde{\beta}_{t+1}(1-\xi_b)\left(\lambda_{t+1}^b - \frac{1}{\pi_{t+1}^b}\right)\right] \tag{3.24}$$

Equation (3.21) is the trade-off between paying back today and paying a cost tomorrow.

Equation (3.22) and (3.23) are Euler equations respectively for borrowing

(from the interbank market) and lending (to firms).

$$\frac{\lambda_{t+1}^{l}}{1+r_t^l} = E_t\left[\tilde{B}_{t+1}\lambda_{t+1}^{l}\right] \tag{3.25}$$

$$\frac{\lambda_t^l}{1+i_t} = E_t\left[\tilde{B}_{t+1}\lambda_{t+1}^{l}\delta_{t+1} + \zeta_l\tilde{B}_{t+2}(1-\delta_{t+1})\right] - d_{F^l}\tilde{k}\bar{w}_t \tag{3.26}$$

$$d_{F^l}\upsilon_l = \left(\lambda_t^l - \frac{1}{\pi_t^l}\right) - E_t\left[\tilde{\beta}_{t+1}(1-\xi_l)\left(\lambda_{t+1}^l - \frac{1}{\pi_{t+1}^l}\right)\right] \tag{3.27}$$

Equation (3.25) and (3.26) are Euler equations for respective deposits (from households) and loans.

$$\frac{U_{c_t}}{1+r_t^l} = \beta E_t\left[U_{c_{t+1}}\right] - \chi\left[\frac{D_t^l}{1+r_t^l} - \frac{\bar{D}^l}{1+r^l}\right] \tag{3.28}$$

$$\frac{\bar{m}\tilde{C}_t}{1-\tilde{N}_t} = \widetilde{w}_t \tag{3.29}$$

Equation (3.28) is Euler equation for consumption augmented with the deposit target term and equation (3.29) is the labor supply first order condition.

Also all shocks in the model in equations (3.30) and (3.31) are in format AR(1) as below:

$$log\ \varepsilon_t = \rho_\varepsilon + log(\varepsilon_{t-1}) + u_t^\varepsilon \tag{3.30}$$

$$log\ \rho_t = (1-\rho_\rho)\ log\ \rho + \rho_\rho\ log(\rho_{t-1}) + u_t^\rho \tag{3.31}$$

For an empirical analysis of the model, the equilibrium values of endogenous variables directly derived from these nonlinear equations system and rewritten in terms of parameters.

Hence by calibration of parameters, all variables calculate based on primary values which this provides to solve model Dynare Software in nonlinear form.

3.2.2 Market Clearing Condition

$$F = F^b + F^l \tag{3.32}$$

$$\pi = \pi^b + \pi^l \tag{3.33}$$

$$gdp = c + \tau k + \zeta_b F^b + \zeta_l F^l \tag{3.34}$$

3.3 Calibration

We have 12 parameters as illustrated in the following table. The required ratio to the model calibration is calculated by annual data from years 1972-2016 issued by the central bank of Iran.

Table 1. Calibrated parameter values

Num	Parameters	Symbol	Data	Sources
1	Discount factor	β	0.98	Romero Villarreal (2007)
2	Capital share	μ	0.412	Shahmordi and Ebrahimi (2011)
3	Optimal ratio of capital adequacy	κ	-	Based on a scenario
4	Capital Depreciation share	τ	0.042	Shahmordi and Ebrahimi (2011)
5	Firm default cost	γ	75.4	De Walque et al. (2010)
6	Bank default cost	ω	679	De Walque et al. (2010)
7	Legal reserve	ξ	0.10	Central bank of Iran
8	Bank default Disutility	d_δ	6.67	Lawrence Christiano (2007)
9	Firm default Disutility	d_f	0.05	Lawrence Christiano (2007)
10	Deposit gap disutility	χ	0.01	Author calculations
11	Leisure utility	$\bar{m}$	1.936	Marc Hafstead and Josephine Smith (2012)

Table 2. Calibrated ratio

Num	Symbol	Data	Definition
1	$\frac{\mathrm{D^l}}{L^{\mathrm{b}}}$	0.96	The ratio of consumer deposit to loans to firm
2	$\frac{\pi^F}{F}$	0.12	The ratio of firm profit to production
3	$\frac{C}{F}$	0.55	The ratio of consumption to firm production
4	$\frac{tpcf}{\mathrm{F}}$	0.05	The ratio of total penalty costs for banks to firms

3.4 Model Evaluation

We simulated the model By Using the parameters estimated in previous studies and with Dynare software.

In DSGE model, parameters are calibrated and used in the model. Then based on the information provided by equilibrium condition, we simulate variables through average and standard deviation.

For this purpose we demonstrate the average and standard deviation of consumption, GDP, wages, interbank rate and production variable in table No3.

Table 3. mean and standard deviation of variables

Variable Name	Mean		Standard deviation	
	Model	Data	Model	Data
Consumption	0.422	0.43	0.016	0.014
GDP	0.633	0.647	0.025	0.008
Production	0.635	1.62	0.025	1.62
Wage	2.118	2.139	0.080	0.027
Interbank Rate	0.006	0.63	0.002	0.008

Source: Author calculations

As we can see from the above table, comparing the findings of the model with the real data, indicate the relative success of the model.

Another criterion which indicates the model is well evaluated is

comparing auto correlation coefficient with simulated model variables.

Table 4: autocorrelation of variables

Variable	Data autocorrelation		Model autocorrelation	
	First order	Second order	First order	Second order
Consumption	0.989	0.971	0.928	0.948
GDP	0.968	0.936	0.917	0.785
Firm production	0.968	0.936	0.892	0.850
Wage	0.986	0.912	0.910	0.877
Interbank Rate	0.770	0.580	0.811	0.665

Source: Author calculations

The amount of auto correlation coefficient and simulated values from models results are similar to each other.

3.5 Impulse Response Function

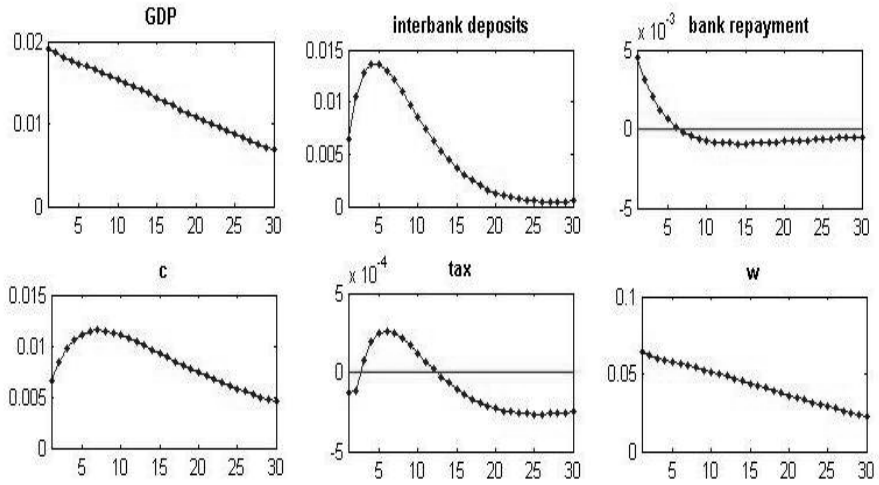
To evaluate our model further, we analyzing impulse response function of endogenous variables to stochastic shocks.

3.5.1 Oil shock

A negative oil shock, (lower price and or lower exports) creates a liquidity shortage in interbank market which may lead to firm's default and lower profits for banks. As the interest rate increase, we may see lower investment and GDP. We can also see as a result of a drop in GDP because of the negative oil shock, wages decreasing.

In the other hand, because of a negative oil shock, in the short run taxes increases to compensate the negative effects.

Figure 3: Effects of negative oil shock



Source: Author calculations

3.5.2 Negative Market book shock and role of Central Bank

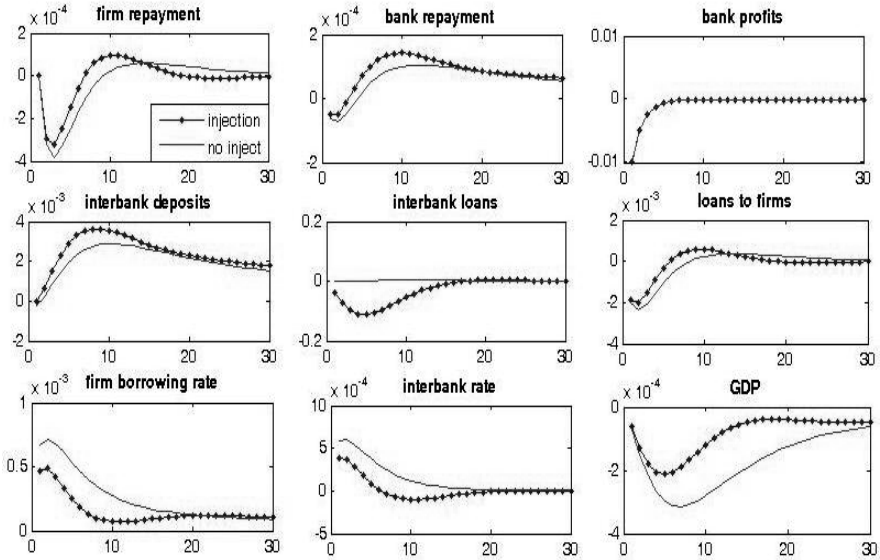
As a result of negative market book shock as we can see in the figures, interbank deposits will shrink and we will have equilibrium in a higher rate of the interbank market. In the other hand, loan's to firm reduce from bank sector and also default rate of banks and firms increases, thus GDP decreases.

In this section, we can clearly see the relation between the banking sector and real variable of the economy.

To determine the role of the central bank against negative shocks across the society, we consider a situation where the central bank injects liquidity in order to confront the negative shocks mentioned above.

As we can see in the figures, the amount of loan's to firm increases and default rate of banks and firm will be improved, so as a result in the short run, liquidity intervention by central have its own positive effects, but in the long run, liquidity interventions increase the persistence of the shock-negative- effects on economic activity.

Figure 4: Effects of negative market book shock



Source: Author calculations

4. Conclusions

In this paper, we introduce a dynamic stochastic general equilibrium model (related to the RBC literature) with a heterogeneous banking sector and endogenous default rate.

The purpose of this paper is to design a DSGE model for Iran (as a developing country) including a banking sector with an interbank market, and probability of loan defaults by the borrowers. We also investigate the role of central bank and importance of banking sector in reducing the impact of various exogenous and endogenous economic shocks on business cycles. A special attention has been paid to the presence of revenue from exports of oil based on allocated quota by OPEC as an exogenous variable in an AR (1) format.

Specifying the model according to the results from Comparison of the torque of the model and simulated autocorrelation variables with the real data; indicate the relative success of the model in simulating Iran's economy.

It is concluded that intermediary sector (banking sector) have an important role in transferring shocks to the economy and the Central Bank through monetary expansions can be very significant in lessening the impact of negative shocks especially in short run.

This model is relatively simple and could be extended along several directions. an extension to a New-Keynesian framework especially for developed countries would make it possible to study the effectiveness of central bank's policy to reduce inflation.

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