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Interbank Market Failure and the Effects of the Basel III Regulations in a DSGE Model for Iran

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Abstract

In order to facilitate transactions among banks, the interbank market has been established in Iran since 2008. The primary objective of this market is to eliminate banking system liquidity deficiencies at a rate chosen by the Central bank of Iran. The importance of this rate is that it affects market interest rates through its effects on banks' balance sheets. Banks' balance sheets are also influenced by banking regulation, such as Basel regulations; thus, this study was aimed to investigate the effects of the interbank market in Iran by imposing Basel III regulations on the banking system. For this purpose, a dynamic stochastic general equilibrium model (DSGE) was designed that included the interbank market. The structural parameters of the designed model were estimated using the Bayesian method and the quarterly data on the period 2008-2015. Afterward, the effect of a positive interbank innovation on the economy's dynamics was examined. The results showed that an increase in the interbank rate led to instability in the economy. It was concluded that an increase in the liquidity and capital adequacy requirement, as mentioned in the Basel III regulations, would reduce the negative effects of interbank shocks on macroeconomic variables and the economy would naturally become more stable.

1. Introduction

The 2007-2008 financial crisis showed that the banking sector plays a significant role in transmitting shocks to the real economy. In this recent financial crisis, banks' balance sheets faced remarkable problems, as a result, the banks with excess liquidity refrained from transmitting funds to banks with liquidity deficiencies, resulting in a credit crunch that reduced the supply of loans and produced a big threat to the financial stability. (Brunnermeier , 2009; Puri et al., 2011; Acharya & Mora, 2015).

In an endeavor to preserve the financial stability, the Federal Reserve and European central bank decreased policy rates to near zero; moreover, in order to

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inject resources to the banking system and eliminate liquidity deficiencies, they bought private credit loans of commercial banks. In other words, the interbank market failure made central bank intervention warranted (Schuler & Corrado ,2016). This experience of the interbank market failure highlights its important role in crisis propagation.

The recent crisis also revealed something left unnoticed to the policymakers: The shortcomings in the financial system and the related regulations. Due to these shortcomings, the regulators have proposed new regulations to stabilize the financial sector. Accordingly, they have attempted to design new policy tools to eliminate potentially systemic risks in the banking system which have led to the designing of Basel III accord. Basel III is a new set of post-crisis improvement tools for banking regulation and risk management produced to attain financial stability. Its regulations target bank liquidity and capital adequacy requirements. There are two liquidity measures within the Basel III accord that focus on the interbank market; these include the liquidity coverage ratio (LCR) and the net stable funding ratio (NSFR) (Ibid). The concern underlying these liquidity ratios is that financial intermediaries might not have sufficient liquidity reserves when a liquidity shock occurs (Ahn et al.,2016).

The most significant benefit of the Basel III regulations is that this accord reduces the probability of occurring a systemic financial crisis, say, capital adequacy criteria, by encouraging banks to increase the quantity and quality of capital, thus making them more stable when a shock occurs. On the other hand, higher capital and liquidity requirements in the Basel III regulations impose remarkable costs on the banks. The capital requirement affects banks' funding costs and this, in turn, causes banks to decrease loan volumes.

A number of models, including DSGE models, have been used by the researchers to analyze the effects of these new regulations on the stability of the financial system and the whole economy. In an attempt to model the interbank market, the new generation of DSGE models is equipped with the banking sector (Harmanta et al., 2014). Tapping into the literature on this issue, the authors designed a DSGE model to suit Iran's economy so that they could evaluate the effects of interbank lending shocks with and without employing Basel III regulations. Iran's interbank market was established in 2008 and, now, plays a major role in providing resources to the banks with liquidity deficiencies. Moreover, the overnight rate is now determined in this market which has a central role in directing funds among banks. These interactions between the major policymaker, i.e. the Central Bank, and other players, i.e. the banks, in the interbank market affect the decision-making process of the economic agents, which are households, firms, and the government. Accordingly, to compute the overall effects of this market, one needs to design a general equilibrium model containing the behavior of all agents.

After estimating the structural parameters of the model using the Bayesian method, an interbank market shock was simulated and the effects of the shock on the dynamics of the macro variables were analyzed. Finally, the effects of the Basel III regulations on the dynamics of macroeconomic variables in the presence of an interbank shock were assessed.

The Basel accords have several prudential and necessary recommendations for the banks to have a strong and standard balance sheet. Since strengthening a balance sheet depends crucially on a bank's capital, most of these recommendations are devoted to compute and consider minimal capital adequacies in the banks. This issue was addressed in the DSGE model adopted in the present study.

This article is organized as follows. Section 2 presents some facts on Iran's interbank market. Section 3 summarizes the Basel Accords. Section 4 provides a short survey of the related literature. Section 5 describes model derivation. Section 6 reports the quantitative results of the interbank shock and its indications for the Basel III regulations. Finally, section 7 offers some conclusions.

2. Iran's Interbank Market

The interbank market is a part of the money market, in which banks with excess funds give a portion of their reserves to those with deficit funds for a short-term period (Shakeri & Ahmadian, 2014). In Iran, the interbank market was founded in 2008 with ten banks, and the volume of the market operations at that year was about 8500 billion Rials, which has grown over the years. Figures 1 and 2 show the interbank market growth and the volume of transactions, respectively. Increasing the volume of transactions influenced the banking system resources and, subsequently, expanded their liquidity.

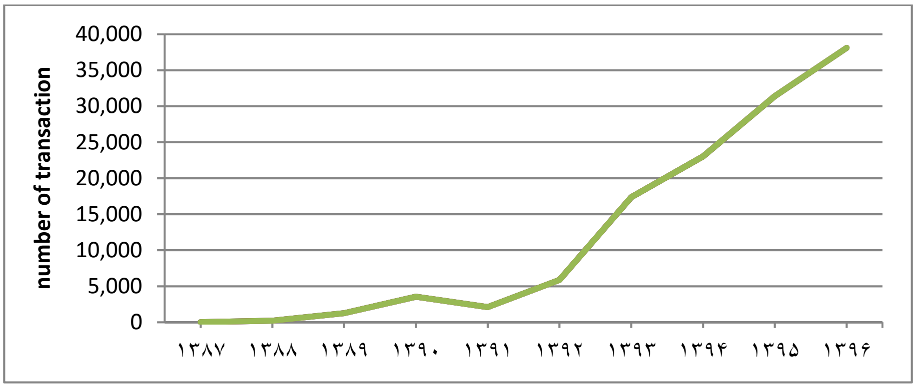

Figure 1. The interbank market growth trend (unit: number).
***Source**: Central Bank of the Islamic Republic of Iran*

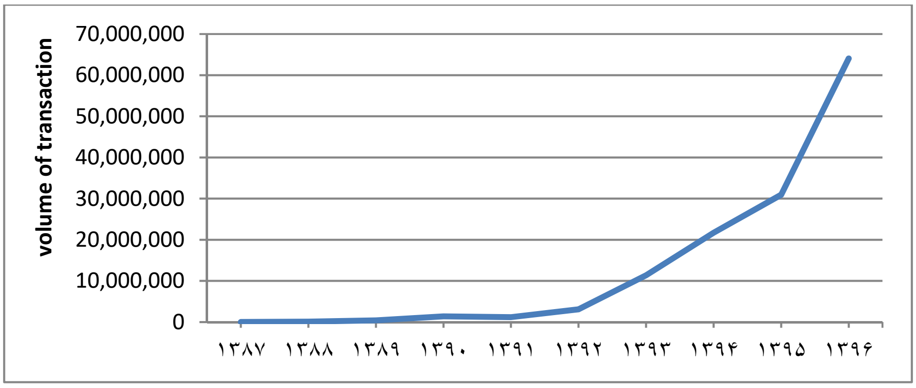

Figure 2. The volume of transactions (unit: thousand)
***Source**: Central Bank of the Islamic Republic of Iran*

3. Comparison of the Basel Accords

The Basel council of banking supervision is a global committee structured to create norms for banking regulation. This council has formed a series of exceptional policy recommendations known as the Basel Accords. The Basel Accords (Basel I, Basel II, and Basel III) refer to a collection of proposals concerning the banking industry regulations (Shakdwipee & Mehta, 2017).

The primary Basel Accord, known as Basel I, was finalized in 1988. It practically concentrates on credit risk and, also, characterizes the capital requirement and the structure of risk weights for the banks. Based on these standards, the assets of banks are arranged into four groups, including no risk (0%), low risk (20%), medium risk (50%), and high risk (100%). This accord proposed that the banks' capital holding should be equivalent to 8% of their risk-weighted assets. Despite the benefits of Basel I, its shortcomings are hard to ignore. For example, the capital adequacy in Basel I relies on credit risk while other risks, including market and operational risks, are ignored.

Due to these drawbacks, the Basel Council on Banking Supervision published a revised the framework and issued a new framework known as Basel II accord, in 2004. In Basel II, in order to compute the capital adequacy ratio (CAR), three risks, namely, credit, market, and operational risk, were recognized in the framework.

The Basel III regulations were published in 2010. The fundamental reason to introduce these standards was the financial crisis in 2008, which revealed the holes in the Basel II. This accord highlights the systemic risk in which the failure of one big institution may lead to the failure of one or more counterparts. Due to the fact that the capital under the Basel II was insufficient to cover another risk, the Basel III contains a new leverage ratio, capital protectors, market liquidity risk with new short-term and long-term liquidity ratios, and stress testing concentrating on stability (Ibid). Indeed, the Basel III presents two new capital protectors: A capital conservation buffer and a countercyclical capital buffer. Capital conservation buffer is an extra protector of 2.5% to relieve future concerns (Ghosh et al., 2013). This protector saves sufficient capital to make a buffer for the whole banking sector which can be used when a shock occurs.

In order to address the countercyclical capital buffer, banks should develop another time-varying capital protector (Ibid). The required extra capital varies between 0% and 2.5%. Thus, an expansion in the countercyclical capital buffer enhances banking resilience by increasing banks' ability to absorb shocks. Consequently, the Basel III obliges a higher and superior capital quality. The minimum aggregate capital is still 8%; however, due to extra buffers, the aggregate required capital is raised to 10.5%-13%.

In order to estimate the liquidity risk, the Basel III introduces two liquidity ratios, i.e. long-term ratio of the net stable funding (NSFR) and the short-term ratio of liquidity coverage (LCR). The aim of LCR is to guarantee that the high quality assets of a bank can quickly be changed into cash to satisfy its needs for liquidity for 30 days when the bank faces an intense liquidity stress situation (Boyao Li, 2016). Moreover, to relieve liquidity inconsistency in the longer run, banks must keep net stable funding ratio (NSFR).

4. A Short Review of Literature on the Interbank Market and the Regulations of Basel III

Edwards and Vegh (1997) showed how shocks to the banking system could affect employment and output. Due to the fluctuations in the bank credit, they investigated the anti-cyclical utilization of reserve requirements and noticed that this reserve could be used to protect the economy against the global business cycle.

De Walque et al. (2010) studied the interbank market and the regulatory segments in a DSGE model. The interaction among the system of banking, the real divisions of the economy, the significance of stabilizing the fiscal section, and regulatory guidelines are considered in this model. They indicated that the minimum capital requirement of the Basel I lessened the long-term output level while it enhanced the flexibility of the economy against shocks. However, they reported that the capital requirement of the Basel II increased the fluctuations of the business cycle.

Angelini et al. (2011) examined the long-term economic impact of the Basel III regulatory. Their results implied that, first, each percentage point increase in the capital ratio and the new liquidity regulation caused a 0.09% decrease in the level of steady-state output; secondly, the Basel III regulatory reduced output volatility.

Giri (2018) assessed the effects of a default on the European interbank market and its influence on the business cycle using a DSGE model. He showed that an interbank shock could avert resources from the interbank and deter lending to a safer government bond market.

Schuler and Corrado (2016) formed a model to study the impacts of macro-prudential tools on the banking sector and the economic dynamics. It became clear that when there was an increase in the liquidity requirement, the effects of an interbank market shock on both the nominal and the real variables decreased efficiently; however, an increase in the capital requirement only decreased the effect of an interbank shock on the nominal variables.

Mohebbi et al. (2017) analyzed the role of the banking system in transferring shocks in Iran's economy by modeling a DSGE model with interbank market and considering the endogeneity of the default probability in the banking sector and firms. The results of their model cast light on the role of the Central Bank in reducing the shock impacts through injecting liquidity into the interbank market.

5. Model Specification and Estimation

As discussed earlier, the interbank market and its related regulations have important implications for the policymakers. To have a general view of these implications, one should design a model which includes all agents influenced by this market. Households are affected because the interest rate has a key role in the consumption and saving decisions leading to some changes in the supply of labor hours and investment spending (production factors). By a change in the factors pertinent to production, the production level fluctuates around its long-run trend that brings business cycles. These cycles lead to variations in the inflation rate; therefore, the economy experiences periods of boom and recessions. These days policymakers face economics fluctuations that force them to manipulate the interbank market rate and policy tools. As a result, all parts of the economy are influenced by interbank interest rate and its associated regulations. This interplay between the macroeconomic variables and the interbank market necessitates the designing of a general equilibrium model which includes the above-mentioned agents. Therefore, in this section, all parts of such a model are explained.

5.1 Household

There are a continuum number of households that wish to maximize their utility function, as expressed in equation (1). In this equation, c_t denotes the consumption level. The working hours in the final goods-producing firms is shown by l_t^s, and the hours devoted to work in banks is indicated by m_t^s, where $0 \leq l_t^s + m_t^s \leq 1$. The household decision problem maximizes all the period utility functions:

$$maxE_0 \sum_{t=0}^{\infty} \beta^t (log(c_t) + \emptyset log(1 - l^s{}_t - m^s{}_t)) \tag{1}$$

where $0 < \beta < 1$ is the discount factor of the representative household, and $\emptyset$ is the shock of the labor supply. The household faces three constraints: First of all, it faces "money in advance" constraint as expressed in the following formula (Goodfriend et al., 2007):

$$c_t = v \frac{D_t}{P_t} \tag{2}$$

where D_t stands for household deposits at banks, and the velocity of money is indicated by v. The second constraint is the household budget constraint that can be shown as follows:

$$c_t + \frac{B_t}{P_t} + \frac{D_t}{P_t} - \frac{L_t}{P_t} + \frac{e_t}{P_t} + I_t \leq w_t\,(l_t^s + m_t^s) + (1 + R_{t-1}^B)\frac{B_{t-1}}{P_t} + (1 + R_{t-1}^D)\frac{D_{t-1}}{P_t} - (1 + R_{t-1}^L)\frac{L_{t-1}}{P_t} + (1 + R_{t-1}^e)\frac{e_{t-1}}{P_t} + \left(r_t^k z_t K_{t-1} - \square(z_t)K_{t-1}\right) + \pi_t - tax_t \tag{3}$$

where w_t is the real wage and is supposed to be paid equally in both the banking and the production sectors. B_t denotes the government bond with the nominal interest R_t^B. The non-financial firms' and banks' dividend is shown by π_t. Lump-sum tax transfers are shown by tax_t, and e_t is the bank equity holding that pay the return R_t^e . D_t is the deposit with nominal interest R_t^D. K_t is the quantity of physical capital, $0 < z_t \leq 1$ is the capital utilization rate, and $\psi(z_t)$ is the cost of capital utilization.

At the beginning of period t, financial markets are open to households, and they can allocate their wealth over holding deposits (D_t), bond (B_t), unit of bank equity (e_t), and unit of investment (I_t). Therefore, a household's expenditure in the period t is expressed by the subscript t, and the income from the last period holding is expressed by the subscript t-1.

The third constraint is capital accumulation (Cristiano et al.,2005):

$$K_t = (1 - \delta)K_{t-1} + I_t\left[1 - S\left(\frac{I_t}{I_{t-1}}\right)\right] \tag{4}$$

where the depreciation rate is shown by δ, and $S(.)$ is the investment adjustment cost. Household maximizes the utility function subject to budget constraint, "money in advance" constraint, and capital accumulation, where the corresponding Lagrangian multiplier are λ_t and μ_t, respectively. The first-order conditions for maximizing the utility function with respect to consumption, labor force, deposits, bonds, investment, capital utilization rate and capital are as follows:

$$\frac{1}{c_t} = \square_t \tag{5}$$

$$w_t\,\square_t = \frac{\emptyset}{1 - l^s{}_t - m^s{}_t} \tag{6}$$

$$E_t\,\Lambda_{t,t+1}(1 + R_t^B) = 1 \tag{7}$$

In which $\Lambda_{t,t+1} \equiv E_t\,\beta\left\{\frac{\lambda_{t+1}\;P_t}{\lambda_t\,P_{t+1}}\right\}$.

$$E_t\;\beta\left\{\frac{c_t\;P_t}{c_{t+1}\,P_{t+1}}\right\}(1 + R_t^B) = 1 \tag{8}$$

$$-\square_t + \square_t - \square_t S\left(\frac{I_t}{I_{t-1}}\right) - \square_t I_t \frac{1}{I_{t-1}}\acute{S}\left(\frac{I_t}{I_{t-1}}\right) + \beta E_t\,\square_{t+1}\left(\frac{I_{t+1}}{I_t}\right)^2 \acute{S}\left(\frac{I_{t+1}}{I_t}\right) = 0 \tag{9}$$

$$r_t^k - \acute{\omega}(z_t) = 0 \tag{10}$$

$$E_t\beta^{t+1}\left[\square_{t+1}(r_{t+1}^k z_{t+1} - \psi(z_{t+1})) + \square_{t+1}(1 - \delta)\right] - \beta^t\square_t = 0 \tag{11}$$

$$q_t = \frac{\square_t}{\square_t} = \beta E_t\left[\frac{\square_{t+1}}{\square_t}(r_{t+1}^k + q_{t+1}(1 - \delta)\right] \tag{12}$$

where q_t is the marginal Q- Tobin. Moreover, the first-order condition working hour at a bank is as follow:

$$\frac{(1-\alpha)}{m_t}\left(\frac{1}{\square_t} - c_t - \frac{L_t}{P_t}(R_t^L - R_t^D)\right) = 0 \tag{13}$$

5.2 Non-Financial Firms

Intermediate firms produce goods and services in a monopolistic competitive market and hire workers as well as capitals to produce intermediate goods which will be used for producing the final goods. The problem of intermediate firms is to maximize profit as shown in the following equation:

$$\Pi_t^F(i) = Y_t(i) - w_t l_t(i) - r_t^k K_{t-1}(i) \tag{14}$$

where $Y_t(i)$ is an individual firm's output with a Cobb-Douglas form as presented below:

$$Y_t(i) = Al_t k_{t-1}^{\eta} l_t(i)^{1-\eta} \tag{15}$$

where η is the production elasticity of capital, and $Al_t$is the level of total factor productivity, which follows an AR(1) process: $al_t = \rho_a al_{t-1} + \epsilon_{a.t}$; where, $al_t = Log(Al_t)$ and $\epsilon_{a.t}$ is technology shock.

Firms that tend to maximize profit are subjected to the production function. The first-order conditions of (14) with respect to capital and labor lead to the following equations for the marginal cost and labor wage rate, respectively:

$$MC_t(i) = \frac{w_t}{(1-\eta)l(i)_t^{-\eta} Al_t\, k_{t-1}^{\eta}} \tag{16}$$

$$w_t = (1-\eta)Al_t\, k_{t-1}^{\eta} l_t^{-\eta} \tag{17}$$

We assumed the Calvo model (Calvo, 1983) for intermediate firms price setting, in which there are two groups of firms: The first one, i.e. $1 - \Theta$, includes those firms that can determine the optimal prices to maximize their profit. The second group, i.e. Θ, consists of those that cannot re-optimize their price and simply index their price to the last period inflation:

$$P_t = (\pi_{t-1})^{\rho_\pi} P_{t-1} \tag{18}$$

where π_t is inflation, and ρ_π indicates the degree of indexation to the past inflation rate. The profit optimization problem can be written as follows:

$$max\ E_t \sum_{k=0}^{\infty} (\beta\Theta)^k \frac{\square_{t+k}}{\square_t}\left\{\left[\prod_{s=1}^{k} (\pi_{t+s-1})^{\rho_\pi} \frac{P_t(i)}{P_{t+k}} - mc_{t+k}\right] Y_{t+k}(i)\right\} \tag{19}$$

$s.t$

$$Y_t(i) = \left[\prod_{s=1}^{k} (\pi_{t+s-1})^{\rho_\pi} \frac{P_t(i)}{P_{t+k}}\right]^{-\epsilon} Y_t \tag{20}$$

Solving this problem yields hybrid new–Keynesian Philips curve as follows:

$$\hat{\pi}_t = \frac{\rho_\pi}{1+\beta\rho_\pi}\hat{\pi}_{t-1} + \frac{\beta}{1+\beta\rho_\pi} E_t\hat{\pi}_{t+1} + \frac{(1-\Theta)(1-\beta\Theta)}{\Theta(1+\beta\rho_\pi)}\widehat{mc}_t \tag{21}$$

5.3 Retailers

The intermediate goods $Y_t(i)$ are bought at the nominal price $p_t(i)$ by the retailers; they produce the final goods (Y_t) using Dixit-Stiglitz index:

$$Y_t = \left[\int_0^1 Y_t(i)^{1-\epsilon} di\right]^{1/_{1-\epsilon}} \tag{22}$$

where ϵ is fixed substitution elasticity among intermediate goods. Retailers' objective function is to maximize the profit function, resulting in the following demand for the intermediate goods:

$$Y_t(i) = \left(\frac{p_t(i)}{p_t}\right)^{-\epsilon} Y_t \tag{23}$$

Substituting (23) into (22) yields the total price level:

$$P_t = \left(\int_0^1 P_t(i)^{1-\epsilon} di\right)^{\frac{1}{1-\epsilon}} \tag{24}$$

5.4 Commercial Banks[1]

In the interbank market, commercial banks give loans to each other. Banks resources are provided by the household deposits and they can borrow from the interbank market. Any bank with probability ½ belongs either to a group of banks with surplus funds specified as lender in the interbank or denoted as the borrower of the interbank. The profit function (Π_t) of a representative commercial bank can be written as follows:

$$\Pi_t = \left(R_t^L - R_t^f\right)\frac{L_t}{p_t} - w_t m_t + V_t \tag{25}$$

where, banks receives interest rate R_t^L from lending and bears costs of lending, R_t^f; it employs workers, m_t with real wage w_t. The third term in the right hand side of equation (25) is bank position in the interbank market (V_t), which defines as:

$$V_t = \frac{1}{2} V_t^I + \frac{1}{2} V_t^{II} \tag{26}$$

where V_t^I is the profit of the lending banks and V_t^{II} is the profit of the borrowing banks in the interbank market. The interest rate paid to depositors (R_t^D) and the regulatory requirements determine the costs of finance (R_t^f). Regulatory requirements include the reserve requirement ratio, rr, and capital requirement ratio(k). The liquidity requirements are defined as the ratio of reserves to deposits: $Res_t = rr\, D_t$. Banks should hold a minimum level of capital proportional to the loan, i.e. $e_t \geq kL_t$, in which k stands for the ratio of capital requirement.

A bank can receive a part or the whole of its reserves (Res_t) if it puts its bonds (γB_t) to the central bank as collateral or sells them to the central bank. On the other hand, if a bank has excess reserves and decides to deposit this excess in the central bank; then, it can receive an interest rate (R^P), on its reserves. Therefore, there is a difference between being financed from the central bank or from the interbank market, named as the interbank financing premium (IFP). The cost of bank financing can be measured as follows:

$$R_t^f = R_t^D + (rr + k\zeta)R_t^p + (\Delta_s IFP_s)_t \tag{27}$$

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[1] - The model specification is based on Schuler and Corrado (2016).

where ζ shows the equity risk premium (ERP). $R_t^e = \zeta R^P$ shows the return of equity. Since most of the Iranian banks have low profitability, we assumed that the parameter ζ in the Iran banking system was smaller than 1; in other words, the cost of financing was thought to be more than the return on banks assets.

For a given efficiency Q, banks employ labor in order to monitor the allocated loans:

$$\frac{L_t}{P_t} = Qm_t^{1-\alpha} \tag{28}$$

By maximizing the bank's profit (equation (25)), and using equation (28), a bank's demand for monitoring work can be obtained, where the optimal loan provision is dependent on the loan rate spread over the loan provision marginal costs:

$$R_t^L - R_t^f = \frac{vw_t m_t}{(1-\alpha)c_t} \tag{29}$$

The loan rate is determined at the beginning of each period and it depends on the bank financing costs. The interbank loans also require monitoring that is denoted by m_t^{IB} .

$$\frac{L_t^{IB.S}}{P_t} = (m_t^{IB})^{1-\alpha} \tag{30}$$

Equation (30) can be rearranged and re-written as:

$$m_t^{IB} = (\frac{L_t^{IB.S}}{P_t})^{\frac{1}{1-\alpha}} \tag{31}$$

The profit of the lending bank in the interbank market is defined as follows:

$$V_t^I = (R_t^{IB} - R_t^f)\frac{L_t^{IB.D}}{P_t} - (1-\Phi)W_t m_t^{IB} \tag{32}$$

where Φ is the degree of trust between banks; there is no cost of trust if $\Phi = 1$, and if $\Phi < 1$, the distrust cost emerges between the banks. Moreover, the interbank loan rate is denoted by R_t^{IB}, and $L_t^{IB.D}$ shows the volume of the interbank loan. The real supply for the interbank loans $(\frac{L_t^{IB.S}}{P_t})$ can then be determined by what is presented below:

$$\frac{L_t^{IB.S}}{P_t} = \left[\frac{(1-\alpha)(R_t^{IB} - R_t^p)}{(1-\Phi)w_t}\right]^{\frac{1-\alpha}{\alpha}} \tag{33}$$

Thus, supplying the interbank loan is dependent on the net revenue $(R_t^{IB} - R_t^p)$ and the distrust among banks ($\Phi < 1$) if it exists.

The profit of the interbank-borrower is measured as follows:

$$V_t^{II} = (R_t^L - R_t^{IB})\frac{L_t^{IB.D}}{P_t} - w_t m_t^{II} \tag{34}$$

The net revenue $(R_t^L - R_t^{IB})$ is earned by the interbank-borrower, and it faces the (extra) cost of loan monitoring ($w_t m_t^{II}$). Therefore, the interbank loan demand can be derived as follows:

$$\frac{L_t^{IB.D}}{P_t} = \left[\frac{(1-\alpha)(R_t^L - R_t^{IB})}{w_t}\right]^{\frac{1-\alpha}{\alpha}} \tag{35}$$

By merging (33) and (35), the interbank rate condition can be determined by the following equation:

$$R_t^{IB} = R_t^P + \frac{1-\Phi}{2-\Phi}(R_t^L - R_t^P) \tag{36}$$

In the case of trust among the banks, ($\Phi = 1$), there will be no monitoring cost and the interbank rate (R_t^{IB}) equals the policy rate (R_t^P). However, a negative shock to Φ=1 splits the interbank rate from the policy rate. Here, $\mathrm{A}2_t$ is defined as the interbank market shock with an AR(1) process: $a2_t = \rho_2 a2_{t-1} + v_t$. Since this shock indicates a lower level of trust among the banks, it could possibly be defined as interbank finance premium (IFP):

$$A2_t = (\Delta_s IFP_s)_t \tag{37}$$

where the overnight transactions are indicated by s. Thus, the bank funding costs can be assessed by what follows:

$$R_t^f = R_t^D + (rr + k\zeta)R_t^P + A2_t \tag{38}$$

Reducing transactions in the interbank market causes a decline in the loan supplied by banks and this affects household optimal decision rule (13) through money in advance constraint which together results in the following equation:

$$W_t = \frac{(1-\alpha)}{m_t}\left(\frac{1}{\square_t} - c_t - R_t^P\left(\frac{Res_t}{P_t} + \frac{\zeta e_t}{P_t}\right) - \frac{L_t}{P_t}A2_t\right) \tag{39}$$

This means that the shock of loan monitoring will reduce refinancing in the interbank market. The reduction in the total loan from the supply can be written as:

$$\frac{L_t}{P_t} = \frac{(L+\Delta_s L_s^{IB})_t}{P_t} \tag{40}$$

in which $\Delta_s L_s^{IB}$ shows the change of the interbank loan size in the overnight market. It can be re-written as:

$$\frac{(L+\Delta_s L_s^{IB})_t}{P_t} = Qm_t^{1-\alpha} \tag{41}$$

by substituting the term referring to the shock

$$\frac{L_t}{P_t} = Qm_t^{1-\alpha} + \frac{A2_t}{\epsilon_{IB}} \tag{42}$$

where ϵ_{IB} is the elasticity of the interbank loan reaction following a change in the interbank rate. The external finance premium can be presented as:

$$R_t^L - R_t^f = \frac{vw_t m_t}{(1-\alpha)c_t} \tag{43}$$

The equation shows how reduces with an increase in the refinancing rate $(R_t^f + \Delta_s IFP_S)$ could lead to a decrease in loan supply.

5.5 Government

Governments seek to balance their budgets, and it is assumed that there are three methods for financing government expenditures: Taxes, government bonds, and borrowing from the central bank. Accordingly, the government expenditures can be defined as follows:

$$G_t + (1 + r_{t-1})\frac{B_{t-1}}{P_t} = T_t + \frac{B_t}{P_t} + \frac{(GD_t - GD_{t-1})}{P_t} \tag{44}$$

where the real government expenditure is denoted by G_t, and $(GD_t - GD_{t-1})$ is the net government debt to the central bank.

5.6 Central Bank

Since the interest rate is not a policy tool in Iran, the Central Bank monetary rule can be written in terms of money growth. By definition, the monetary base (MB_t) equals the total international reserves of the central bank (FA_t) and the government debt to the central bank (GD_t):

$$MB_t = FA_t + GD_t \tag{45}$$

If we define MO_t as the growth rate of money, then:

$$MO_t = Ln(MB_t) - Ln(MB_{t-1}) \tag{46}$$

Thus, the central bank monetary rule can be written as follows:

$$\widehat{MO}_t = \rho\, \widehat{MO}_{t-1} + \Phi_\pi\, \hat{\pi}_t + \Phi_c \hat{c}_t + a\, 3t \tag{47}$$

where $\Phi_\pi < 0$ and $\Phi_c < 0$ are reactions of the central bank to inflation and consumption gap, respectively, and a3t shows the monetary shock that follows an autoregressive AR(1) process given by $a3_t = \rho_3 a3_{t-1} + \varepsilon_t$ with $|\rho_3| < 1$.

5.7 Market-Clearing Conditions

Households maximize their utility by choosing c_t , ${l^s}_t$, ${m^s}_t$, $B_t . L_t$, and K_t. Given its cost, the optimal price (P_t^*) is chosen by the intermediate firm (i). Through a maximum profit combination of intermediate goods ($Y_t(i)$), the retail firm provides market clearing Y_t. By lending to households (L_t), receiving funds in the deposits form (D_t), and transacting extra funds in the interbank market (L_t^{IB}), the commercial banks maximize their profits. Thus, market clearing can be written as:

$$Y_t = C_t + I_t + G_t \tag{48}$$

$$\square B_t + (1 - \square) B_t = B_t \tag{49}$$

$$l_t^s = l_t \tag{50}$$

$$m_t^s = m_t \tag{51}$$

5.8 Model Estimation

In this paper, the Bayesian method and seasonal data on consumption, inflation rate, deposit, deposit rate, loan rate, and loan over the period of 2008-2015 were used to estimate the structural parameters. The values of the steady-state of the variables are presented in table 1, and the estimated results are reported in table 2.

The central bank determined the reserve requirement ratio, which was on average 16.25% from 2008 to 2015. The minimum required CAR is 8%. In this study, it was 8% as well. The ζ parameter is characterized as the ratio of the average loan interest rate to either the average central bank policy rate or the average interbank market rate, which is on average 0.73.

Table 1. The value of steady state of a number of variables

Steady state	Definition	Reference	value
$\frac{\bar{C}}{\bar{Y}}$	Consumption ratio to non-oil production	research calculation	0.55
$\frac{\bar{I}}{\bar{Y}}$	Investment ratio to non-oil production	research calculation	0.31
$\frac{\bar{G}}{\bar{Y}}$	Government expenditure ratio to non-oil production	research calculation	0.13
$\frac{\bar{D}}{\bar{L}}$	Deposit ratio to loan	research calculation	1.35
$\frac{Res}{\bar{L}}$	Reserves ratio to loan	research calculation	0.21
$\bar{l}$	Steady state production firm's employment	research calculation	0.14
$\bar{m}$	steady state bank employment	research calculation	0.51

***Source**: Research findings*

Table2. The calculated parameters of the model

parameter	Definition	Reference	Prior amount	Posterior amount	Prior distribution	Standard error
η	concavity in production	Borghei & Mohammadi (2017)	0.360	0.3411	beta	0.04
α	concavity in loan	selected	0.220	0.2237	beta	0.02
c	steady state consumption	research calculation	0.550	0.5489	beta	0.01
β	discount factor	Motavaseli et al. (2011)	0.990	0.9902	beta	0.001
θ	share of firms without price reset	Tavakolian& Komeijani (2012)	0.500	0.4983	beta	0.01
ρ	smoothing in policy function	Taghipour & Esfahanian (2016)	0.410	0.4101	beta	0.01
Φπ	weight of inflation in policy function	Tavakolian& Komeijani (2012)	-1.070	-1.0705	normal	0.05
Φc	weight of consumption in policy function	Tavakolian& Komeijani (2012)	-2.350	-2.3347	normal	0.05
ψ	equity risk premium	research calculation	0.730	0.7299	beta	0.01

***Source**: Research findings*

Table (2) shows the estimated results of the parameters. To ensure the validity of the results, one should employ statistics associated with the Bayesian method, which compare prior and posterior distribution functions, as well as the Monte Carlo-Markov Chain statistic. The former statistic points out: 1) Posterior function should have a Normal-like distribution function, 2) the prior and posterior should look like each other with a minor difference, and 3) the posterior must have a single mode.

According to figure (3), all the prior and related posterior distributions have the mentioned characteristics.

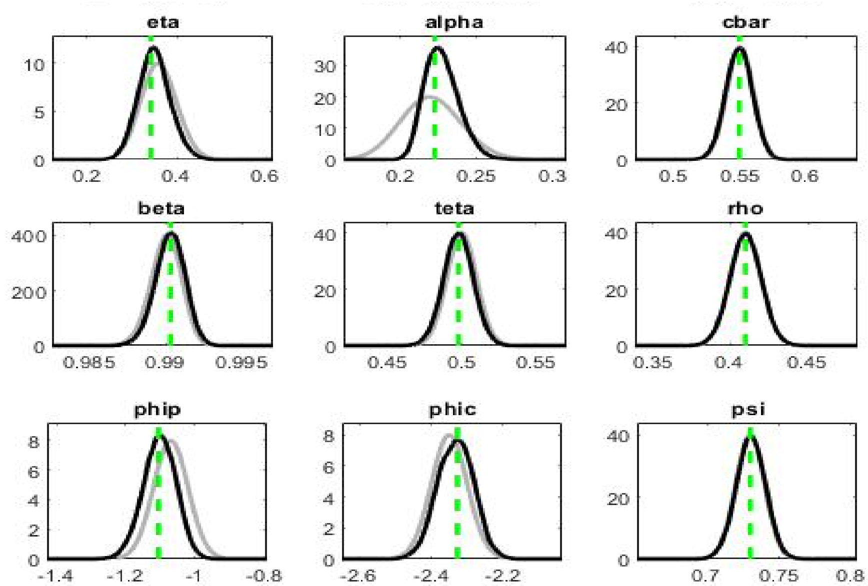

Figure 3. Priors and posterior distributions
***Source**: Research findings*

Monte Carlo-Markov chain (MCMC) statistic is used to verify the validity of the obtained results. MCMC is an important statistic to check overall validity of the Bayesian model. The red and blue lines show the above criteria including parameters inside and between the chains, respectively. These lines should be fairly stable, although some fluctuations in them are acceptable, and converge if they are to show accurate results.

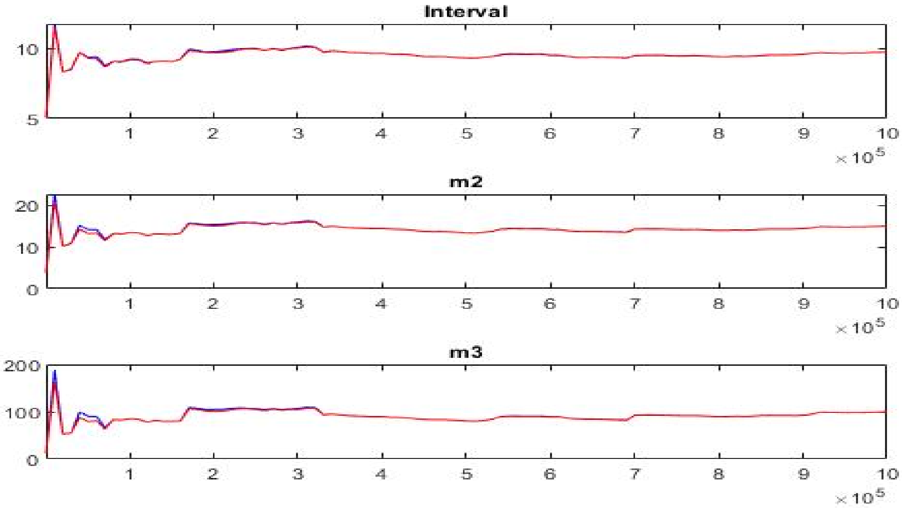

Figure 4. MCMC results
***Source**: Research findings*

6. Impulse Response Functions

The impulse response functions under a shock of interbank lending are presented in this section. To assess the importance of this market, the impact of a positive interbank innovation on the dynamics of the economy was simulated. The impulse response functions to a standard deviation interbank market interest rate are shown in figure 5. Interbank market shock pushes the surplus bank to request higher interest rates on their resources in the interbank market. As a consequence, the interbank loan shock raises the total cost of refinancing. The latter has an adverse effect on the loan supply. Higher interest rates discourage demand for credit, resulting in a reduction of loans provided by the of interbank which ultimately reduces the loan payment to households. The recession is propagated to the real economy through restriction on households' power to purchase and invest. As a result of the reduction in the households' purchases, inflation will reduce and the sales of firms will decrease. Accordingly, the amount of bank deposits will decline.

Investment and capital volume will decrease once the loan supply is reduced. The consumption will increase initially and then decreases. The impact of the interbank market shock on output is oscillatory.

When borrowing loans from the interbank market becomes more expensive, banks try to use their reserves at the central bank; thus, the amount of bank reserves decreases.

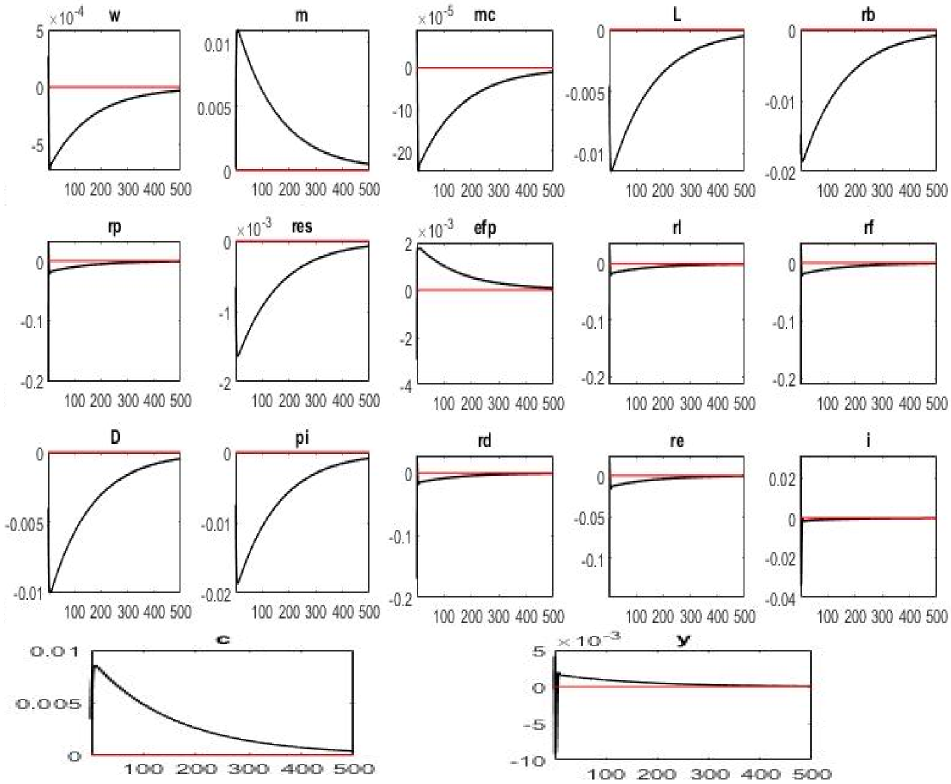

Figure 5. impulse response function under an interbank shock
***Source**: Research findings*

In this paper, two macro prudential instruments, i.e. the reserve requirement ratio (a proxy for liquidity requirement) and capital adequacy, have been introduced. Based on these two tools, two scenarios are specified in the next section: In the first scenario, the reserve requirement ratio increased from 16.25% in the base model to 20%; in the second scenario, the capital adequacy requirement ratio raised from 8% in the base model to 10.5%.

6.1 Scenario One: Increasing the Liquidity Requirement

In this subsection, the effect of the interbank market shock is studied under two different values for liquidity requirement. The assigned values are 16.25% and 20%, which are compared in figure 6. It can be observed that an increase in the liquidity ratio affects both financial and real variables. The main point derived from this simulation is that a higher liquidity ratio can significantly decrease the effect of the interbank loan shock significantly. In other words, amending the balance sheet by considering Basel regulations will ease the negative effects of interbank shock. The impulse response shows that a higher liquidity ratio leads to more sustainable responses from the model variables.

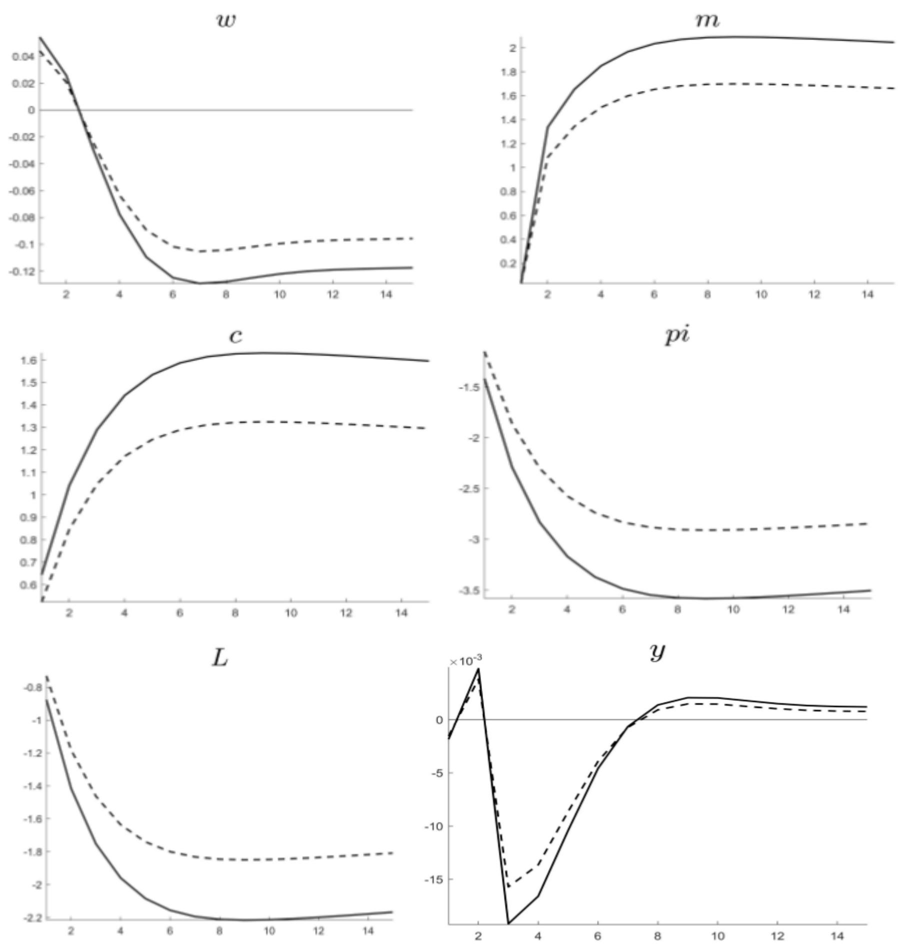

Figure 6. Impulse response from 1% shock to the interbank rate under 16.25% (Solid) and 20% (Dashed) liquidity ratio.

***Source**: Research findings.*

6.2 Scenario Two: Increasing Capital Adequacy

In this section, the effect of changing the capital adequacy under the interbank market shock is examined. Figure 7 shows the analysis under two values: A value of 8% CAR and a value of 10.5%. Under Basel considerations, capital conservation buffer is 2.5% plus minimum equity-to-asset ratio, which is 8%. The results from the simulation revealed that imposing capital requirements had dampened the strength of the macroeconomic variables reactions. Put differently, imposing capital requirements reduced the volatility of variables and acted as a shock absorber. Thus, one can conclude that the financial stability can be improved by considering Basel equity requirements.

Therefore, it can be suggested under the Basel III measures, including higher capital and liquidity requirements, the banks show more resilience to the interbank shock by reducing the volatility of the bank variables and macroeconomic variables. It means that this policy instrument can bring about a more stable economic and financial system.

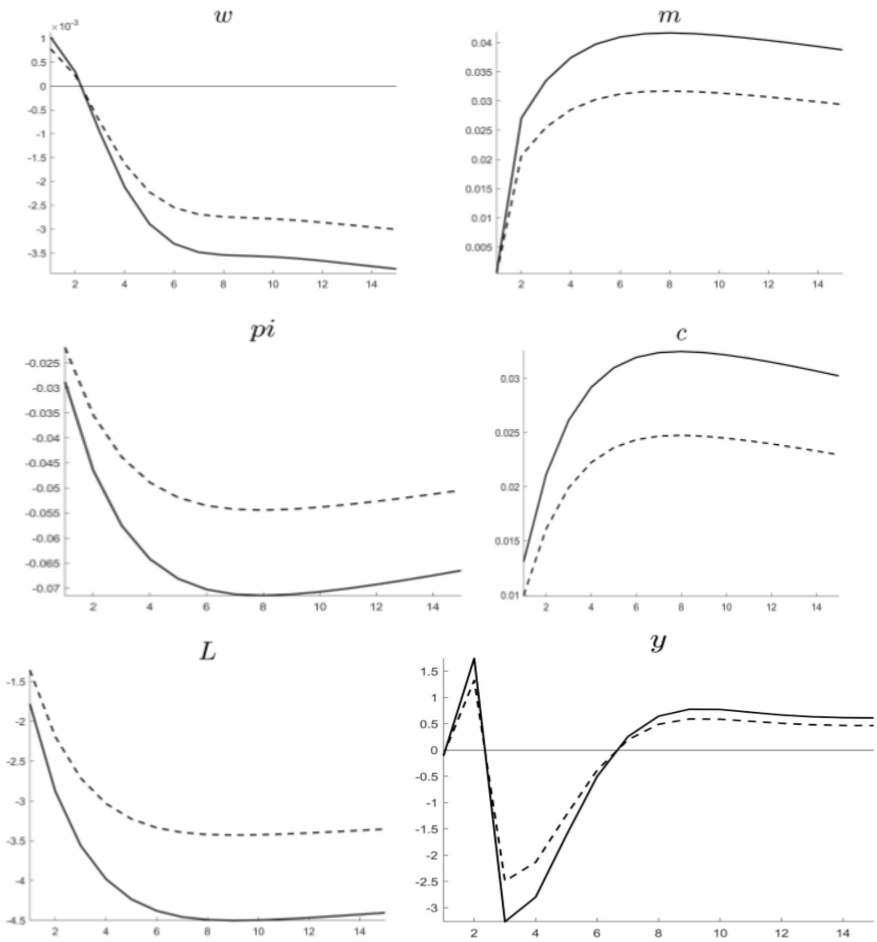

Figure 7. Impulse response from 1% shock to interbank rate under 8% (solid) and 10,5% (dashed) equity ratio.
***Source**: Research findings.*

7. Concluding Remarks

The interbank market was established in Iran in 2008. It was aimed to compensate for the liquidity deficiencies of the banks by transmitting funds to financial intermediaries. To evaluate the shocks of this market, a DSGE model was designed, which contained all the element of the economy. It should be emphasized that in the present study the effects of the interbank shocks were subjected to changes in the banking regulations. The most important package of banking regulations came from the Basel accords, which have several considerations and recommendations on liquidity requirements and capital adequacy, among others. These were the points that were carefully examined in this study.

The designed model formulated the behavior of households, firms, the banking system, government, and the central bank. Solving the objective function of these agents resulted in some structural equations, which were then used to measures the effects of Basel regulation on macroeconomic variables through the interbank market.

The analysis and results of this study show that the effects of the interbank shock on macroeconomic variables will be restricted if Basel considerations are imposed on the banking system by increasing the liquidity requirement and the capital adequacy ratio. In other words, if the regulator imposes Basel considerations on the banking system; then, the effects of interbank shock will decline due to the point that the Basel accord aims to remove the structural problems in the banks' balance sheets by levying some considerations on the financial ratios. These recommended ratios create a buffer around the banking system financial statements, thereby reducing the detrimental effects of shocks on the banking performance and macro variables. Based on the findings of this study, and given that the banking system in Iran is vulnerable to macro shocks and that these shocks can adversely affect the performance of banking system, the banks are encouraged to employ Basel recommendations. This accommodation can not only make the banking system less vulnerable but also facilitate the manipulation or acceptance of the macro variables.

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