

A Model of Asset and Liability Management and Monetary Shocks (DSGE Model)

**Ahmadian, Azam* and
Shahchera, Mahshid****

Received: 11/17/2014 Approved: 5/24/2015

Abstract

Asset-liability mismatch in balance sheet of banks shows serious challenges in banks because of the traditional methods of recording assets and liabilities at book value in Iran. The Central Bank of the country motivated and advised banks to take concrete steps in minimizing the mismatch in the asset-liability composition. This paper attempts to suggest a micro funded framework that can evaluate the role of asset and liability management in banking sector in business cycles through a DSGE model. In this paper, we use Bayesian method to estimate parameters and use national account and balance sheet data from 1981 to 2013. Results show that tightening monetary policy decreases the cost of ALM .On the other hand, raising required reserve requirement increases the cost of asset and liability management; technology shock leads to decrease of asset and liability

* Researcher, Monetary and Banking Research Institute, azam_ahmadyan@yahoo.com

** Faculty member, Monetary and Banking Research Institute

management cost, and the costs of ALM affects interest rate. Then, the increase of the cost of ALM leads to increase of interest rate.

Key words: *Banks, Asset and liability management, Financial shocks, Monetary policy.*

JEL Classification: *E31, O42*

1. Introduction

Banking sector is an important part of entrepreneurship and economic development in every country. In the developing countries, including Iran, the regulatory regime, on the operations and supervision of banks and financial institutions, did not allow much competition in the financial system. The interest rates are controlled by the Central bank. The balance sheet management does not show many problems since the income is accounted for on the basis of off balance sheet and central bank persuades banks to minimize the incompatibility of assets and liabilities of banks.

Taking one step ahead, the banks focus on integrated balance-sheet management and all the relevant factors which affect appropriate balance sheet composition. Therefore, various components of balance sheet are analyzed in the assessment of strengths of a bank. The earlier approach of managing deposits, loans and advances has no much relevance. The basic difference in earlier approach and dynamic approach can be described by focusing on value addition, analysis of different scenarios, comprehensive risk and dynamic approach of balance sheet evaluation in the present ALM system.

The ALM is defined as “managing both assets and liabilities simultaneously for the purpose of minimizing the adverse impact of interest rate movement, providing liquidity and enhancing the market value of equity”. It is also defined as “planning a procedure which accounts for all assets and liabilities of a bank by rate, amount and maturity.”

There has been remarkable progress over the past ten years in the specification and estimation of dynamic stochastic general equilibrium (DSGE) models. The method for success of DSGE models mendacities their ability to combine rich structural macro models with numerical algorithms and simulation techniques. Woodford (2009) has investigated an emerging macroeconomic consensus today that embodies five elements: (i) the notion

that macroeconomic models should incorporate a coherent set of inter temporal general-equilibrium foundations; (ii) that quantitative policy advice should be based on econometrically validated structural models; (iii) that expectations should be modeled as rational and endogenous with respect to monetary policy; (iv) that real disturbances and nominal rigidities are important sources of short-and medium run fluctuations; and (v) that monetary policy is effective, especially as a means of controlling inflation.

So in this article, the asset and liability management is designed in the context of dynamic stochastic general equilibrium model to study and analyze the real effects. We modify some of the latest DSGE models on banking to fit the Iranian context. So far, this strand of research can be divided into papers that introduce a variety of financial assets with differing returns [e.g. Christiano et al. (2010) or Goodfriend and McCallum (2007)], and those that assume a banking sector under monopolistic competition, resulting in a mark-up of banking interest rates over the policy rate and a sluggish interest rate adjustment [e.g. Gerali et al. (2010)]. We found that neither of these approaches suits the unconventional monetary policy in Iran. Following the work of Chen et al. (2012), Wang (2011) and Chen et al. (2011), who investigate a partial equilibrium model for the banking sector when credit and interest rates are regulated by the central bank, we implement their partial-equilibrium modeling work in a fully specified DSGE framework to analyze the effect on inflation and output.

The overall structure of the paper is as follows: Section 2 and 3 present methodology and literature review. Section 4 presents the model. The parameter estimation is represented in section 5 and the Section 6 shows Impulse-response Function. The conclusion is described in the final section.

2. Methodology of Asset and Liability Management

Asset and liability management (ALM) indicates the optimal investment of assets for achieving current goals and future liabilities. The role of ALM is

the combination of risks and benefits for assets and liabilities. The more traditional view of managing risks separately surveys the risk type. This research shows that there are gains from managing risks at the global level (Rosen and Zenios, 2006). Among the different risks faced by an institution (such as market, credit, liquidity, operational, and business risk), ALM focuses on financial risks [SOA, (2003)].

ALM is the ongoing process of formulating, implementing, monitoring and revising strategies related to assets and liabilities to reach an organization's financial objectives, given the organization's risk tolerances and other constraints. Although short-term risks arising from the possibility that an institution's assets will not cover its short-term obligations are essential, ALM is usually conducted from a long-term perspective. ALM is considered a strategic regulation as opposed to a tactical one (Choudhry, 2007).

Therefore, ALM sets out a long-term position for investing assets and covering liabilities, whether at a single future point in time, or over multiple future periods.

The benefits of ALM are rather obvious: an understanding of the company's overall position in terms of its obligations; comprehensive strategic management and investment in view of liabilities; the ability to quantify risks and risk preferences in the ALM process; better training for future uncertainties; and, ideally, gains in efficiency and performance from the integration of asset and liability management. Recognizing these benefits, banks and other institutions have implemented their own ALM methodologies. Despite the widely accepted benefits of ALM, the associated challenges may avoid an institution from adopting an ALM framework. These difficulties focus on implementation of ALM. First, each institution has its particular objectives, risk tolerances, and constraints, and it would be difficult to devise an optimization algorithm that would realistically account

for these specific characteristics when evaluating portfolio allocation decisions. Second, long-term strategic decision making may be delayed because of factors whose forecasts may not be available to the institution. Third, risk preferences and their changes over time must be translated into mathematical language, which is far from trivial. Finally, a reasonable ALM model must cover all its different components (assets, liabilities, goals, institutional and policy constraints, etc.)

Managing all of these difficulties is too hard (Romanyuk, 2010). Then, asset-liability management refers to the method by which an institution manages its balance sheet in order to allow for alternative interest rate and liquidity. Banks and other financial institutions provide services which expose them to various risks. Asset liability management is an approach that provides institutions with a defense that makes such risks acceptable. Asset-liability management models enable institutions to measure and monitor risk, and provide suitable strategies for their management.

Asset-liability management includes not only a formalization of this understanding, but also a method to quantify and manage these risks. Further, even in the absence of a formal asset-liability management program, the understanding of these concepts is of value to an institution as it provides a true picture of the risk. Asset-liability management is a first step in the long-term strategic planning process. Therefore, it can be considered as a planning function for an intermediate term. In a sense, a variety of aspects of balance sheet management deal with planning as well as direction and control of the levels, changes and mixes of assets, liabilities, and capital (Romanyuk, 2010).

Asset-liability management (ALM) is the process of planning, organizing, and controlling asset and liability volumes, maturities, rates, and yields in order to decrease interest rate risk and maintain an acceptable profitability level. ALM allows managers to be proactive and anticipate change, rather than reactive to unanticipated transformation. Then, managers must always analyze the impact that any ALM decision will have on the

liquidity position of the institution. Liquidity is affected by ALM decisions in the maturity structure of the assets and liabilities which can change the cash requirements and flows. Change of interest rates could affect liquidity. If savings rates are depressed, clients might take out their funds and liquidity decreases. Higher interest rates on loans could make it difficult for some clients to meet interest payments, causing a liquidity shortage. The objective of ALM is to keep up a match in the terms of assets with their funding sources in order to reduce interest rate risk.

In order to set the ALM position in the institution, banks should have effective liquidity management plans in place. And must be able to identify the core or stable deposit base in the institution and match that against longer-term assets to reduce the interest rate risk. A stable deposit includes the equity, certificates of deposit with penalties for early withdrawal, retirement savings, savings with a stated purpose, and regular savings accounts with small balances.

Then, managers must be able to identify the minimum net margin (gross income – cost of funds) necessary to fund financial costs, operating expenses, and contributions to capital.

3. Literature Review

There are good studies relating to asset-liability management in banks. The Basel Committee on Banking Supervision (2001) planned and formulated a broad supervisory framework and suggested required standards for best practices in the supervision mechanism of banking system. This framework also suggested setting up of risk and capital management requirements to ensure adequate capital reserve for various risks exposure for the process of lending and borrowing operations. It assumes that banks need to hold larger capital amount for greater exposure of risks. This will ensure solvency and stability for banking system. The Basel II standards (2004) focused on

international standard for the amount of capital to be maintained by banks as a protection against various risks they come across in the banking business. It concludes that; the greater risk the bank is exposed, the greater the amount of capital the bank requires holding for ensuring solvency and stability.

Giri (2014) discusses that, if banks have liquidity shortage, they borrow from Interbank to manage asset and liability. For this purpose, he has considered two types of banks. Banks which are faced with liquidity shortage for credit supply and thus borrow from the interbank market and give credit to the real sector; and the second group of banks that have excess funds, lend to interbank and invest in less risky assets such as bonds. Results suggest that credit shocks in the interbank market, has reduced the supply of loans from the banking sector to the real sector of the economy, and then has reduced investment and economic growth. On the other hand, the credit shock in the interbank market raises the interest rates of credit at the interbank market.

Memmel and Schertler (2009) suggested that recent developments in risk transfer instruments, changes in business models due to new technologies, and changes in prudential regulations may have reduced the dependency of banks on assets and liabilities. Their findings describe how the asset-liability dependency for German universal banks behaved over the period 1994 to 2007 without claiming to provide in-depth insights into what have caused these changes in the degree of dependency. Their findings show that the overall dependency between assets and liabilities has decreased in the last 14 years for all three sectors of universal banks (private commercial banks, savings banks, cooperative banks). This overall decline is related to selected asset and liability positions only: It can be attributed to a lower dependency of long-term loans to non-banks and to a lower dependency of short-term deposits, while other positions, such as savings account, did not contribute as much to the overall decline. Their findings also indicate that the decline is most pronounced for those groups of banks within each banking sector that intensively use derivatives instruments.

Song and Thakor (2007) address a fundamental question in relationship-banking: Why do banks that make relationship loans finance themselves primarily with core deposits and when would it be optimal to finance such loans with purchased money? They show that not only relationship loans are informational opacity and illiquid, but they also require the relationship between the bank and the borrower to endure the bank to add value. However, the informational opacity of relationship-loans gives rise to endogenous withdrawal risk that makes the bank fragile. Core deposits are an attractive funding source for such loans because bank provides liquidity services to core depositors and this diminishes the likelihood of premature deposit withdrawal, thereby, facilitating the continuity of relationship-loans. That is, they show that banks will wish to match the highest value-added liabilities with the highest value added loans and that doing so simultaneously minimizes the bank's fragility owing to withdrawal risk and maximizes the value added by the bank in relationship-lending. They also examine the impact of interbank competition on the bank's asset-liability matching and extract numerous testable predictions.

Zawalinska (1999) examined various approaches to ALM by commercial banks in Poland. He elaborated results of the empirical survey of ALM and risk management techniques applied by banks in Poland. The survey was conducted in 1999. The analysis shows that privatization of banks contributes to the improvement of efficiency and to better risk management. It creates a favorable climate for implementation of more advanced risk management and measurement techniques. The size of the Polish private banks has also a positive effect on diverse methodology and sophistication of risk management. The analysis implies the need for a further consolidation of Polish financial institutions. Therefore, this paper strengthens arguments in the support of accelerated privatization and consolidation of the Polish banking system.

Samuel (2011) used a goal programming model to examine the asset and liability management in relation with profitability by financial institution taking into account the specific characteristics of Ghanaian financial environment. The ultimate aim is to identify the best possible strategy to manage the composition of financial institution's assets and liability by controlling the various types of business strategies to maximize profitability. The model contributes to specific goals and constraints. It also tests the sensitivity of financial institution performance for different risk taking strategies environment. To be able to achieve the objectives of this research, a study targets all 27 NIB¹ branches in the country by randomly interviewing functional managers from 7 branches in the country from Eastern Region and Greater Accra and in addition, five years financial reports from the headquarters were fully analyzed to draw conclusion about the subject. It recommended that in view of the importance of asset-liability management, banks should implement ALM techniques that should be subjected to periodic update and view to meet the goals and objectives of portfolio management.

Entrop et al. (2009), provide a comprehensive analysis of the valuation and interest rate risk measurement in the risk-neutral valuation framework of Jarrow and Van Deventer (1998). They apply 6 term structure models and 4 interest rate pass-through models and estimate the value and interest rate risk of 13 non-maturing product categories for up to 400 German banks on an individual bank level for each of these 24 model combinations. They find that the choice of the term *structure* and the *pass-through* model is of limited importance for the valuation of non-maturing banking products. For ranking banks according to the interest rate risk of their products the pass-through process is of specific relevance. When the level of the interest rate risk is to be estimated, an advanced term structure model should be chosen additionally.

1. National Investment Bank

4. Structure of the Model

As pointed out by Giri (2014), we assume that banking sector confronts with shortage of liquidity and borrow from interbank. Chen et al. (2012) assumed that banks do manage asset and liability in spite of costs it involves. The central bank of Iran fixes interest rate in the banking system, reserve requirement and influences the credit supply via window guidance. We use three of them in the model.

a. Households

Households are constrained and decide the amount of consumption, the amount of labor they wish to supply to the production sector, and the amount of liquidity according to the following utility function:

$$\sum_{x=0}^{\infty} (\beta^h)^s E_t \left[\frac{(C_t)^{1-\sigma_c}}{1-\sigma_c} - \frac{N_t^{1+\sigma_n}}{1+\sigma_n} + \frac{1}{1-\vartheta} \left(\frac{M_t^h}{P_t} \right)^{1-\vartheta} \right] \tag{1}$$

Where β is inter temporal discount factor, C_t denotes real consumption, N_t is supply of labor in goods sector, M_t^h is the liquidity at households. σ_c denotes inverse of the elasticity of inter- temporal substitution of consumption σ_N is inverse of elasticity of inter-temporal substitution of labor, ϑ is elasticity of liquidity at household. They are subject to the budget constraint:

$$m_t^h + c_t + d_t + i_t = w_t N_t + (1+r_t^d) \frac{d_{t-1}}{\pi_t} + r_t^k k_t + \frac{m_{t-1}^h}{\pi_t} + t_t + \frac{\pi_t^f}{p_t} + \frac{\pi_t^b}{p_t} \tag{2}$$

Where w_t is the real wage, t_t is tax, $1+r_t^d$ is the interest rate of deposit,

$D_t = \int_0^1 D_{jt} d_t$ is deposit and $d_t = \frac{D_b}{P_b}$, π_t^f is profit of production sector and

π_t^b is profit of banking. k_t is quantity of capital, i_t is investment. As Agenor et al. (2012), we suppose, investment is added to capital stock at beginning of period and creates future capital stock. δ is a constant rate of depreciation and the last term is a capital adjustment cost function specified in standard fashion, φ_k denotes an adjustment cost parameter. k_{t+1} can be obtained as:

$$k_{t+1} = (1 - \delta)k_t + i_t - \frac{\varphi_k}{2} \left(\frac{k_{t+1}}{k_t} - 1 \right)^2 k_t \quad (3)$$

We obtain first order conditions with respect to c_t , N_t , d_t , m_t^h , k_t in Appendix A.

b. Final Good Producer

Final good producer buys intermediate goods that are shown with j , and produce final good by using Dixit-Stieglitz method.

$$Y_t = \left(\int_0^1 Y_{jt}^{\frac{\theta-1}{\theta}} d_j \right)^{\frac{\theta}{\theta-1}} \quad \theta > 1 \quad (4)$$

Where Y_{jt} is intermediate good, and θ is constant elasticity of substitution between intermediate goods. Final good producers try to determine their purchases of intermediate goods according to differ prices in order to determine maximum profit. Demand function for different product by any intermediate producer can be obtained:

$$Y_{jt} = \left(\frac{P_{jt}}{P_t} \right)^{-\theta} Y_t \quad (5)$$

Price for final good is:

$$P_t = \left(\int_0^1 P_{jt}^{1-\theta} d_j \right)^{\frac{1}{1-\theta}} \quad (6)$$

c. Intermediate Producer

Production sector, characterized by monopolistic competition and Rotemberg pricing, adopts a standard Cobb-Douglas production function with capital k_t , and labor N_t , subject to productivity shocks:

$$Y_{jt} = A_t N_{jt}^{1-\alpha} K_{jt}^{\alpha} \quad (7)$$

Where $\alpha \in (0,1)$ is elasticity of production with respect to capital:

$$A_t = \rho_A A_{t-1} + (1-\rho_A) \bar{A} + \varepsilon_{A,t} \quad \rho_A \in (0,1), \quad \varepsilon_{t,A} \approx N(0, \sigma_{\varepsilon_{t,A}}) \quad (8)$$

A_t is technology shock and \bar{A} is steady rate of A_t . At the beginning of every period, each of cost of capital stock and labor. γ_t is:

$$\gamma_t = (1-\rho_\gamma) \bar{\gamma} + \rho_\gamma \gamma_{t-1} + \varepsilon_{\gamma,t} \quad \rho_\gamma \in (0,1) \quad \varepsilon_{t,\gamma} \approx N(0, \sigma_{\varepsilon_{t,\gamma}}) \quad (9)$$

and L_{jt} (loan) is:

$$L_{jt} = \gamma_t (P_{jt} r_t^k K_{jt} + P_{jt} W_t N_{jt}) \quad (10)$$

They pay r_{jt}^l which is interest rate of loan. Adjustment costs of firms is:

$$PAC_t^j = \frac{\varphi_f}{2} \left(\frac{P_{jt}}{(\bar{\pi}) P_{j,t-1}} - 1 \right)^2 Y_t \quad (11)$$

Where $\varphi_f \geq 0$ is adjusted cost parameter, $1+\pi_t$ is inflation rate, Y_t is total production. The marginal cost is:

$$mc_{jt} = \frac{[\gamma_t (1+r_t^l) w_t]^{1-\alpha} (\gamma_t (1+r_t^l) r_t^k)^\alpha}{\alpha^\alpha (1-\alpha)^{1-\alpha} A_t} \quad (12)$$

Firms maximize profit through:

$$\pi_{jt}^f = P_{jt} Y_{jt} - P_t mc_t Y_{jt} - PAC_t^j \quad (13)$$

Then obtain first order conditions with respect to, k_{jt} , N_{jt} and P_{jt} (See Appendix A).

d. Commercial Banks

The banking sector of the model in this paper, is based on the partial equilibrium models of He and Wang (2011) and Chen et al. (2011, 2012) of a Chinese banking sector and Gerali et al. (2010), who implemented a banking sector in a DSGE framework. More precisely, we embed those ingredients from the first two papers that are needed to analyze Iranian monetary policy in the banking system introduced in Gerali et al. (2010). However, we believe that the banking sector determines the demand function for deposits and due to central bank and the supply function for loans, takes all interest rates as given (instructed).

The inter-temporal optimization is a problem. A representative commercial bank chooses the amount of loans and deposits, due to central bank dc_t , and borrowings from the interbank market di_t . In addition, banks are constrained by the guidelines of the monetary authority. We assume that deviations of actual credits from the target of the central bank L_t^{cb} has costs that are shown by $\frac{\kappa_{kcb}}{2} (L_t - L_t^{cb})^2$.

Asset liability mismatch in balance sheet of banks in Iran, has posed serious challenges. They have not enough deposit to extend credit and assets and liabilities have not the same maturity. Assets often are long-term but liabilities are short-term. Therefore, asset-liability mismatch has costs for banks. Moreover, we assume banks gather deposit and supply credit, and then if they have not enough deposit, they borrow from central bank to manage asset and liability. So asset and liability management has a cost that we assume it as quadratic management costs for loans, deposits, and

borrowing from central bank: $C_t = \frac{1}{2}(\phi_d [(1-\eta_t)D_t]^2 + \phi_l L_t^2 + \phi_e Dc_t^2)$. Hence the representative bank seeks to maximize the discounted sum of cash flows:

$$\sum_{t=0}^{\infty} \beta^t E_t \left\{ \begin{aligned} &(1+r_t^l)L_t - L_{t+1} - (1+r_t^c)Dc_t + Dc_{t+1} - (1+r_t^d)D_t \\ &+(1-\eta_t)D_{t+1} - (1+r_t^i)Di_t + Di_{t+1} \\ &-\frac{\kappa_{kcb}}{2}(L_t - L_t^{cb})^2 - \frac{1}{2}(\phi_d [(1-\eta_t)D_t]^2 + \phi_l L_t^2 - \phi_e Dc_t^2) \end{aligned} \right\} \quad (14)$$

subject to a balance sheet constraint,

$$Di_t + (1-\eta_t)D_t + Dc_t = L_t \quad (15)$$

Where D_i and η_t represent net borrowings from the interbank market and the required reserve ratio, and $r_t^i, r_t^c, r_t^l, r_t^d$ represent the interbank interest rate, central bank interest rate, loan interest rate and deposit interest rate.

By substitution of the bank's balance sheet constraint in profit function, profit function changes to:

$$\begin{aligned} \pi_t^b &= (r_t^l - r_t^i)L_t - (r_t^c - r_t^i)Dc_t - [r_t^d - (1-\eta_t)r_t^i]D_t \\ &-\frac{\kappa_{kcb}}{2}(L_t - L_t^{cb})^2 - \frac{1}{2}\{\phi_d [(1-\eta_t)D_t]^2 + \phi_l L_t^2 + \phi_e Dc_t^2\} \end{aligned} \quad (16)$$

In an optimum environment, the amount of loans, deposits, borrowing from central bank and interbank market are chosen, so that marginal benefits from these assets are equalized to the opportunity costs of holding them:

$$r_t^l = r_t^i + \phi_l L_t + \kappa_{kcb}(L_t - L_t^{cb}) \quad (17)$$

$$r_t^c = r_t^i - \phi_e Dc_t \quad (18)$$

$$r_t^d = (1-\eta_t)r_t^i - \phi_d ((1-\eta_t)^2 D_t) \quad (19)$$

According to 17 and 18, opportunity costs for loans and borrowing from central bank are given by the sum of the interbank interest rate, management

costs and costs for deviating from the central bank loan target. Equation 19 illustrates that the opportunity costs for deposits depend on the interbank market rate, and the management costs for deposits. We follow Gerali et al. (2010) and assume arbitrage ensures that the interbank rate equals the policy rate ($r_t^i = r_t$).

Policy rate in Iran is the rate of bond issued by the central bank.

Borrowing from interbank is:

$$d_t^i = (d_{t-1}^i)^{\phi_{di}^{di}} (y_t)^{\phi_{di}^y} \quad (20)$$

and borrowing from central bank is:

$$dc_t = (dc_{t-1})^{\phi_{dc}^{dc}} (\pi_t)^{\phi_{dc}^\pi} \quad (21)$$

e. Central Bank

Monetary policy in Iran varies from conventional central banking in several respects. The central bank fixes lending and deposit rates, influences the credit supply via window guidance, and, in recent years has even used the reserve requirement ratio as a tool for fine-tuning monetary policy.

Central bank is able to set policy interest rate and reserve requirement. Policy interest rate is:

$$(1 + r_t) = \left(\frac{1 + r_{t-1}}{1 + \bar{r}} \right)^{\rho_r} \left(\frac{1 + \pi_t}{1 + \bar{\pi}} \right)^{\rho_\pi} \left(\frac{y_t}{\bar{y}} \right)^{\rho_y} \varepsilon_{r,t} \quad (22)$$

Where ρ_y, ρ_π, ρ_r are the weights assigned to the output, stabilization of inflation, and interest rate of previous period.

Reserve requirement is:

$$\eta_t = \pi_t^{\phi_{\eta}^\pi} \eta_{t-1}^{\phi_{\eta}^\eta} \varepsilon_{t,\eta} \quad (23)$$

ϕ_{η}^π and ϕ_{η}^η are weights assigned to inflation rate and reserve requirement at previous periods. In addition, the central bank influences the credit supply

via window guidance. The use of credit quotas is primarily directed at preventing excessive credit growth. Hence, we assume that the loan targets of the central bank follow a Taylor-type rule of the form

$$l_t^{cb} = -(1 - \varphi_l^{cb})(\varphi_l^\pi \pi_t + \varphi_l^y y_t) + \varphi_l^{cb} l_{t-1}^{cb} \quad (24)$$

According to 24, loans are restricted to slower growth if inflation or the output gap is positive, in order to cool down the economy. Moreover, φ_l^π and φ_l^y determine the strength of the reaction with respect to inflation and output, while φ_l^{cb} determines the persistence of the reaction. In a nutshell, the central bank tries to smooth real activity by smoothing loan growth.

f. Government and Oil Sector

Government is financed with tax (t_t), oil revenue (or_t) and money (m_t)
Government expenditure is:

$$g_t = t_t + or_t + m_t - \frac{m_{t-1}}{\pi_t} \quad (25)$$

$$\text{Tax is: } t_t = \varphi_t^y y_t \quad (26)$$

Where φ_t^y is a weight of output. Oil revenue shock is:

$$or_t = \rho_{or} or_{t-1} + (1 - \rho_{or}) o\bar{r} + \varepsilon_{or,t} \quad \varepsilon_{or,t} \approx N\left(0, \sigma_{\varepsilon_{or,t}}\right) \quad (27)$$

$o\bar{r}$ is oil revenue at steady state.

g. Market Clearing

At equilibrium, the output and liquidity market must clear. Equilibrium in output market is:

$$y_t = c_t + i_t + g_t + AC_t \quad (28)$$

Equilibrium in liquidity market is:

$$m_t = m_t^h + d_t \quad (29)$$

5. Estimation

a. Methodology and Stylized Facts

This paper uses Calibration to calibrate the structural parameters of the model. First, it obtains the first order condition and linearizes them, which are explained in Appendix A and B. Then it solves the model. The sample runs for the data in 1981-2013. We use central bank of Iran data base items, such as national account and balance sheet of banking system of Iran.

b. Calibrated Parameters

We fix some parameters, because they are either notoriously difficult to estimate or because they are better identified using other information. Adjusted cost of capital, adjusted cost of inflation, quadratic cost parameter of due to interbank and cost of non-replayed loans are in line with the literature [Agenor et al. (2012), Dib(2010)]. Adjusted cost of capital (φ_k) is 8.6. Adjusted cost of inflation (φ_π) is 4.26.

The weights assigned to the output, inflation stabilization, growth of money and interest rate of previous period, inflation rate and reserve requirement at previous period and output are estimated by Eviews according to the their functions. Parameters of shocks are estimated by Eviews according to the following equation:

$$\log(X_t) = c + \rho \log(X_{t-1}) + \varepsilon_{x_t} \quad (30)$$

Where ρ is Autoregressive Coefficient and its standard deviation of ε_{x_t} is used as a standard deviation of variable. Productivity shock is selected according to the appropriate structure of model. Distribution of parameters is selected based on the characteristics of parameters and features of the distribution.

Table 1: Calibrated Parameters

Parameters	Mean	Calibrated from
σ_c	0.93	Author calculations
σ_n	0.63	Author calculations
ϱ	0.87	Author calculations
δ	0.024	Solving model
θ	4.33	Mark-up 30%
β	0.97	Solving model
α	0.78	Author calculations
ρ_A	0.65	Appropriate structure of model
ρ_{or}	0.60	Author calculations
ρ_{pi}	0.89	Author calculations
ρ_{mio}	0.82	Author calculations
ρ_y	0.46	Author calculations
ρ_{y^i}	0.65	Author calculations
ϕ_n^π	0.062	Author calculations
ϕ_η^η	0.83	Author calculations
φ_{di}	0.46	Author calculations
φ_{di}^y	0.347	Author calculations
φ_{dc}^{dc}	0.55	Author calculations
φ_k	8.6	Agenor et al. (2012)
φ_t^{yc}	2.08	Author calculations
ρ_r	0.80	Author calculations
φ_f	4.26	Dib(2010)

We use comparison of mean, standard deviation and auto correlation to assess the model. Table 2 shows moments and table 3 shows auto correlation for some variables. The results show that the model simulates economy of Iran appropriately.

Table 2: Moments

	Standard deviation		mean	
	real	model	real	model
Gross domestic product	1.99	2.041	255027.13	254932.02
Inflation	2.12	2.15	17.5321	17.5328
Loan	1.64	1.56	16781.19	16797.98
Deposit	1.52	1.54	1602.74	1603.26

Source: Authors' calculations

We use Eviews to calculate autocorrelation for real variables, and then compare them with simulated figures. Results show real and simulated models are similar and the model is appropriate for the economy of Iran (see table 3).

Table 3: Autocorrelation and Simulated

	Simulated autocorrelation		Real autocorrelation	
	Second lag	First lag	Second lag	First lag
Gross domestic product	0.61	0.81	0.79	0.89
Inflation	0.37	0.07	0.42	0.08
Loan	0.72	0.78	0.72	0.87
Deposit	0.73	0.78	0.75	0.89

Source: Authors' calculations

6. Impulse Responses

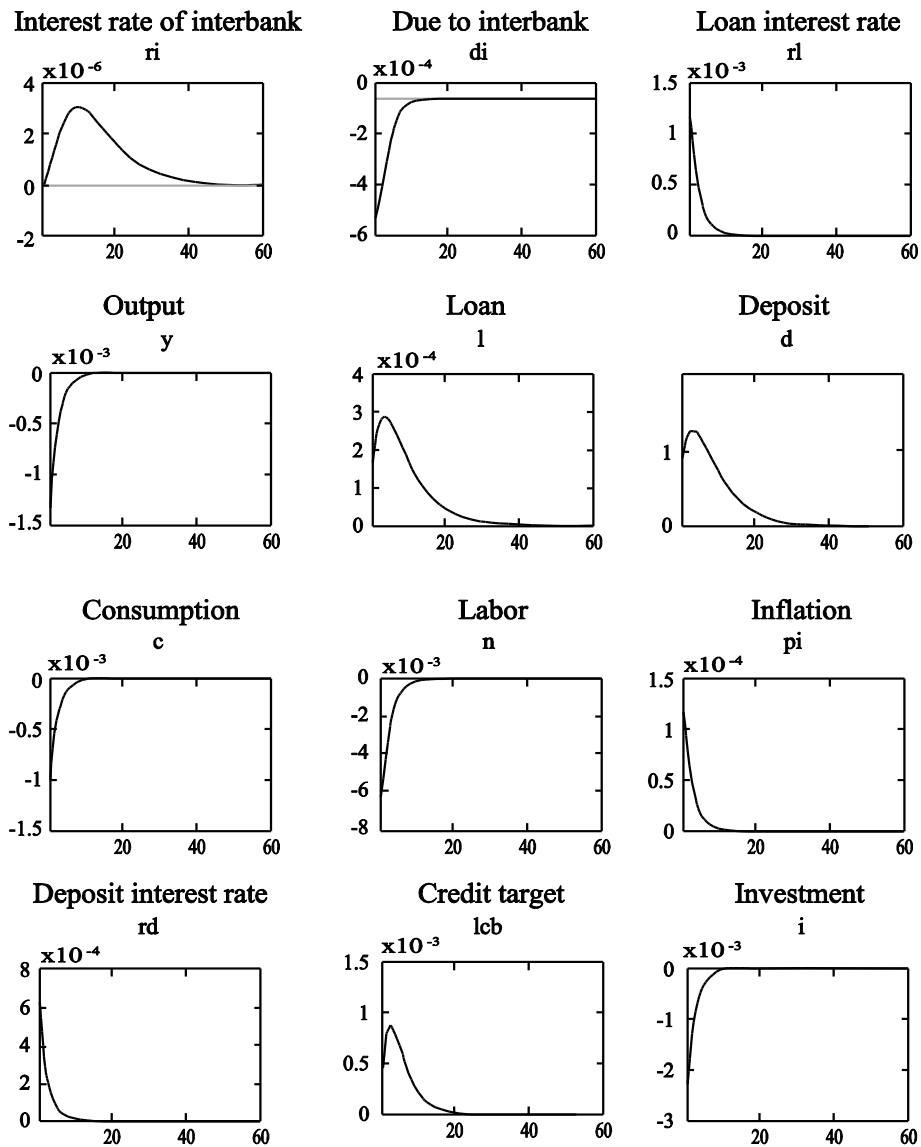
In this section we want to assess whether and how the transmission of shocks is affected by bank intermediaries in the context of the close economy with interbank. We consider three shocks. The first is financial shock, while the second is monetary policy shock (demand shock). The third is technology shock (supply shock).

6.1 Financial shock

According to the results, Figure One shows impulse response to financial shock. Producers finance cost of projects through loans. If costs of financing increase, investment and production reduce. Because of decrease of production, demand for labors and wage decrease, as a result, employment is reduced. Then, with lower wages, household consumption drops.

Central bank responses to increased production costs, according to the role of banking finance, and increases credit target and requires banks to increase the supply of credit. On the other hand, the supply-side inflation increase implies an increase in the policy rate, and consequently, income, consumption, investment, capital and employment decline. The higher real interest rate makes saving more attractive, so deposits increase. Moreover, entrepreneurs borrow to compensate their lower incomes.

The unconventional monetary policy tools differ strongly in their impact on the dynamics following a cost-push shock, but all of them have a dampening effect on inflation. In response, the interest rate corridor leads to a small increase, but from the second quarter onwards this effect is reversed. Interestingly, the dampening effect of the interest rate corridor does not imply strong effect on downturn in the output gap that might be expected due to the well-known output-inflation trade-off in New Keynesian models. Again, window guidance seems to be the most effective weapon against inflation, but comes at costs of a much stronger recession.

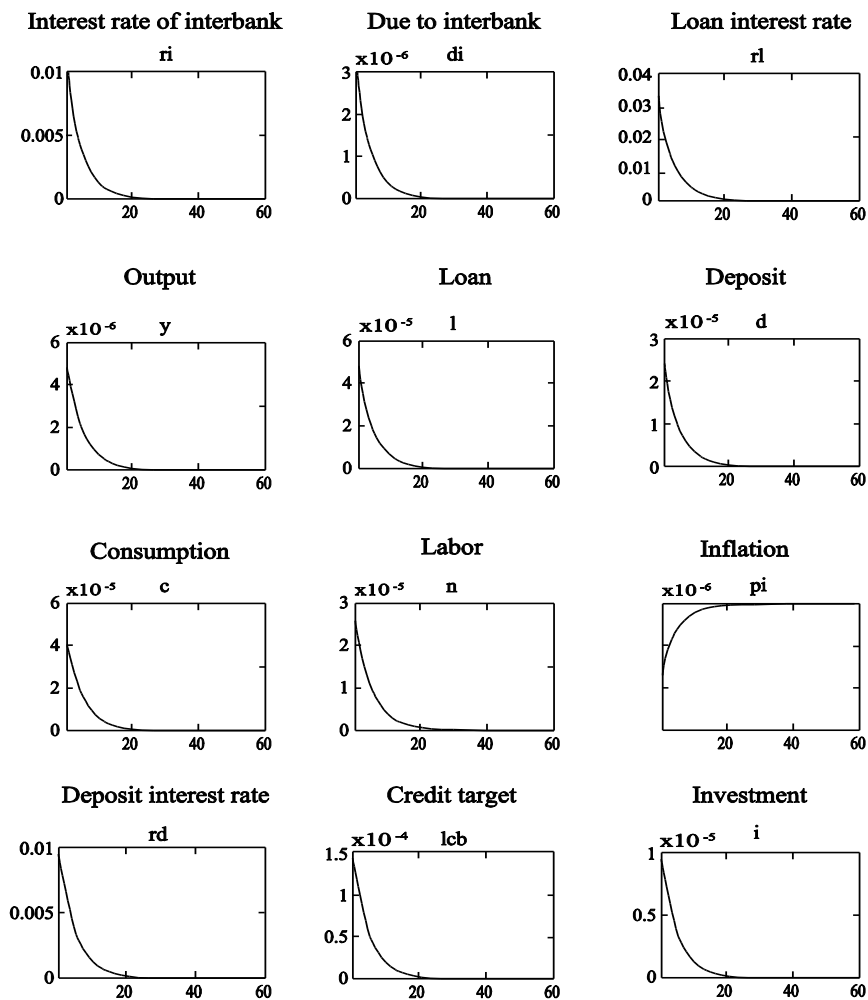
Figure 1- Finance shock

6.2. Monetary policy shock

This paper considers a tightening monetary policy in Iran. Two monetary policies are considered: Interest rate and required reserve. The role of the banking sector in the transmission of the monetary policy shock has been investigated by previous work by Christiano et al. (2007), Goodfriend , McCallum (2007) and Gerali et al. (2010). As discussed in Christiano et al. (2007) and Goodfriend and McCallum (2007), financial frictions enhance the amplitude of business cycles through three channels (borrowing constraint, financial accelerator and nominal debt) beside the traditional interest rate channel. With the existence of banks, the banking attenuator effect identified by Goodfriend and McCallum (2007) and Gerali et al. (2010) is another Channel to propagate business cycles. This paper is in accordance with Chen et al. (2012), He and Wang (2011) and Chen et al. (2011), who investigate a partial equilibrium model for the banking sector when credits and interest rates are regulated by the central bank. Here we are not going to highlight how each channel affects the transmission of monetary policy shock, but focus on the role of the banking sector.

Tightening monetary policy has two effects on banks. First, because of the raising policy interest rate, interest revenue increases and banks attract more deposits. The raising of deposit leads to a further increase in credit, then cost of ALM decreases and loan and deposit rate decrease. As a result, investment and output increase and inflation decreases. Entrepreneurs increase wage, then income of household, labor and consumption increase. Second, rising in policy rates will increase the interbank market interest rate, leading to investment and output increase.

Figure 2: Interest Rate Shock



Central bank increases required reserve. Rising reserve requirement, usually aims at short term cash management, affects banking and this change leads to increase bank's reserve at the central bank and interbank interest rate. On the other hand, rising in required reserve, leads to falling deposit in bank and decreases operational costs. Then, loan declines in response to drop of deposits, and also, profit of bank declines. Fall of deposit and loan, increase cost of asset and liability management, which leads to deposit rate increase. As a result, financing, investment and output decrease because inflation rises in response to the fall in output (See Figure 3).

6.3. Technology shock

Figure 4 shows the impacts of positive technology shock on the economy of Iran. Since the production becomes more efficient, output rises. The supply of goods increases, thus reducing the price of the goods. The technology innovation reduces marginal costs and inflation, which leads to a drop in loan rate. Households raise their savings and entrepreneurs borrow more. Because of the rising savings, the marginal product of labor increases so that the aggregate capital increases. Entrepreneurs borrow more and create more product and labor force and wage will increase. Increase in wage, leads to rising of household's income. Household will increase savings and consumption. The rising in consumption leads to a rising demand for goods, leading to rising inflation. Central bank decreases credit ceiling, then loan and investment and output will increase. By increase of deposit and loan, costs of asset and liability management decrease, then it requires, loan and deposit rate to decrease.

Figure 3: Reserve Requirement Shocks

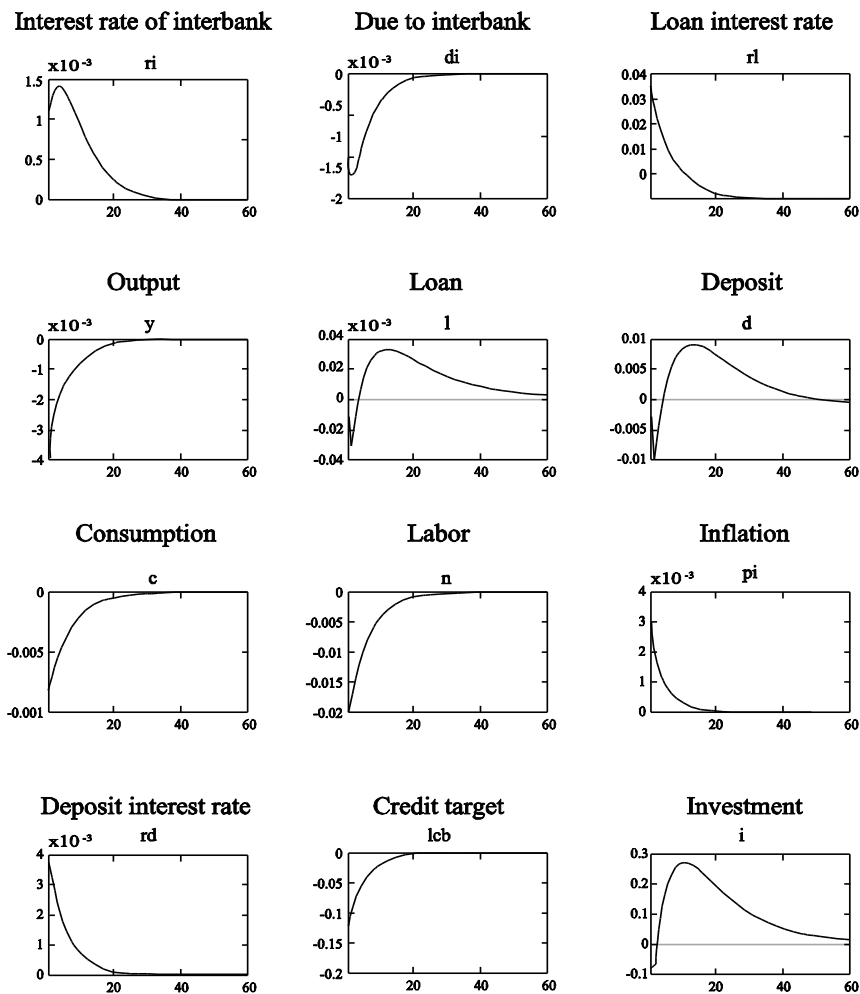
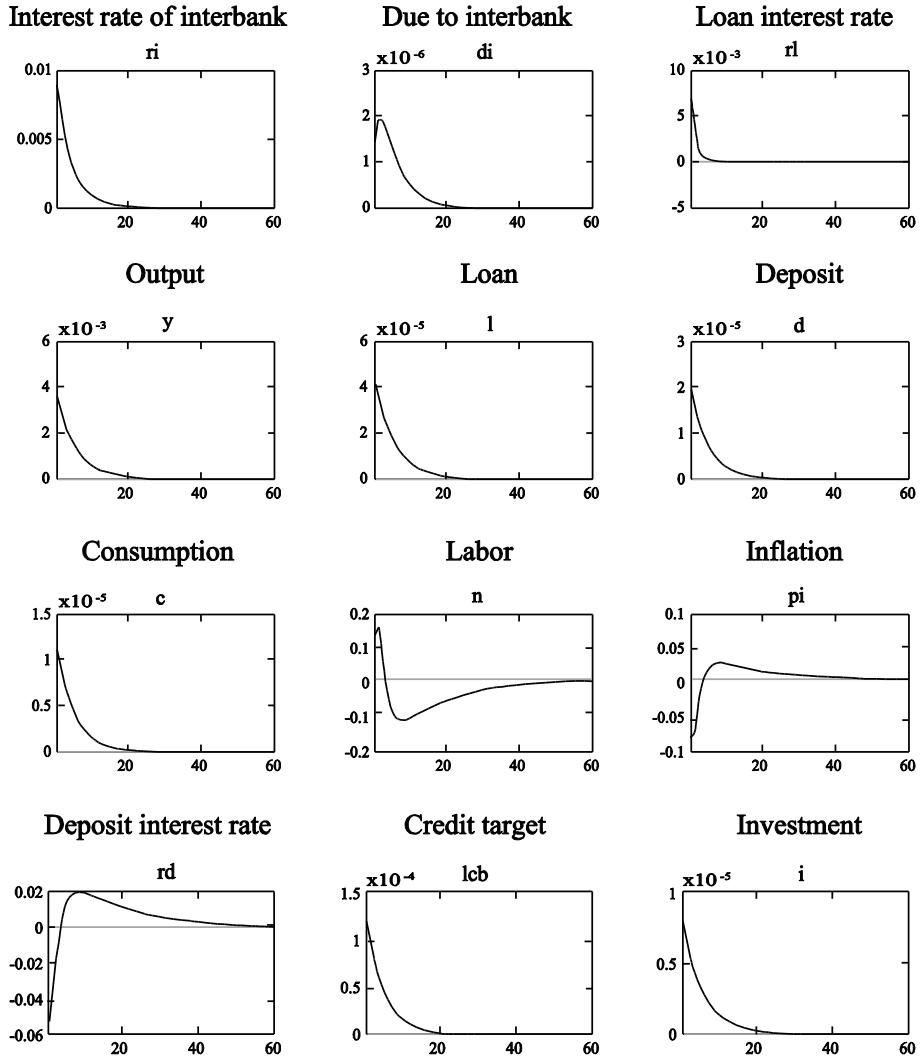


Figure 4: Technology Shock



7. Concluding Remarks

This paper suggests a micro framework that combines a banking sector with a DSGE model. This model evaluates the role of asset and liability management in active banking sector in business cycles and the contribution of financial shocks, monetary policy, and technology shock to the economy fluctuations in Iran. On the other hand, this paper improves a New Keynesian DSGE model to capture IRAN's unconventional monetary policy toolkit.

We find that credit quotas are important as the interest-rate corridor distorts the efficient reactions of the economy. Moreover, the choice of a particular monetary policy tool or an appropriate combination of instruments depends on the source of the shock.

This paper implies that asset and liability management has a cost for banking system that affects finance, monetary policy and technology shocks. We find that finance shock leads to increase of interest rate of loan. Then, banking system increases credit. On the other hand, interest rate of deposit and deposits increase. These increasing of deposit and loan, decreases cost of asset and liability management.

Tightening monetary policy raises policy interest rates. Because of the rising policy interest rate, interest revenue increases and banks attract more deposits. The raising of deposit leads to a further increase in credit, then cost of ALM decreases and loan and deposit rates decrease.

On the other hand, rising in required reserve, leads to fall of deposit in bank and decreases operational costs. Then, loan declines in response to drop of deposit and also profit of bank declines. Fall of deposit and loan, increase cost of asset and liability management.

Technology shock leads to increase of deposit and loan. With increase of deposit and loan, cost of asset and liability management decreases, then it requires, loan and deposit rate to decrease.

This paper suggests that banks play the main role in reducing the effects of uncertainty. Further study will include risk modeling of banks and the role of asset and liability management in risk management.

Reference

Chen, H., Q. Chen, and S. Gerlach, (2011). “The Implementation of Monetary Policy in China”. *Working paper* in the second annual international conference on the Chinese economy, Hong Kong Institute for Monetary Research mimeos.

Chen, Qianying, Michael Funke and Michael Paetz, (2012). “Market and Non-market Monetary Policy Tools in a Calibrated DSGE Model for Mainland China”, Bank of Finland, BOFIT, Institute for Economies in Transition, *BOFIT Discussion papers* 16/2012.

Choudhry, M. (2007). *Bank Asset and Liability Management: Strategy, Trading, Analysis*. Singapore. John Wiley & Sons.

Christiano, L., R. Motto, and M. Rostagno, (2010). “Financial factors in economic fluctuations”. *Working Paper* Series 1192, European Central Bank.

Entrop, Oliver; Krombach, Arne; Memmel, Christoph; Wilkens, Marco, (2009).” Non-maturing Assets and Liabilities of Banks: Valuation and Risk Measurement”, *Working Paper* April 2009, the Deutsche Bundesbank.

Gerali, Andrea; Neri, Stefano; Sessa, Luca & Signoretti, M. Federico (2010). “Credit and banking in a DSGE model of the euro area”, *Economic Working Paper*, 740, Bank of Italy, Economic Research and International Relations Area.

Giri, F. (2014). "Does interbank market matter for business cycle fluctuation? An estimated DSGE model with financial frictions for the euro area". Univerita politecnica delte marche. Dipartimento di Scienze Economiche e Sociali, *Quaderni di ricerca* n. 398.

Goodfriend, M. and B. T. McCallum (2007). "Banking and interest rates in monetary policy analysis: A quantitative exploration," *Journal of Monetary Economics*, 54, 1480–1507.

He, D. and H. Wang (2011). "Dual-Track Interest Rates and the Conduct of Monetary Policy in China," *Working Papers* 212011, Hong Kong Institute for Monetary Research.

Jarrow, R., and D. Van Deventer, (1998). "The arbitrage- free valuation and hedging of demand deposits and credit card loans", *Journal of Banking and Finance*, 22, 249-272

Mommel, Ch., A. Schertler, (2009). "The dependency of the banks' assets and liabilities: evidence from Germany", *Discussion Paper*, Series 2: Banking and Financial Studies, No 14/2009.

Romanyuk, R. (2010). "Asset-Liability Management: An Overview". *Working Paper* in bank of Canada.

Rosen, D. and S. A. Zenios, (2006). "Enterprise-Wide Asset and Liability Management." *Hand-book of Asset and Liability Management*, Vol. 1: Theory and Methodology, Chapter 1, edited by S. A. Zenios and W. T. Ziemba. Amsterdam: Elsevier.

Samuel, Gyekyi, (2011). "The Effects of asset liability management on profitability of national investment bank in the new Juabeng municipality". A *Thesis* submitted to the institute of distance learning, KWAME NKRUHMAH university of Science and technology in the partial fulfillment of the requirement for an award of the degree of Commonwealth executive masters of business administration.

Society of Actuaries (SOA), (2003). "Professional Actuarial Specialty Guide: Asset- Liability Management." Available at <www.soa.org/library/professional-actuarial-specialtyguides/professional-actuarial-specialtyguides/2003/september/spg0308alm.pdf>.

Song, F., Thakor, A., (2007), "Relationship banking, fragility, and the Asset-Liability matching problem", *The Review of Financial Studies*, Vol. 20, No: 5.

Zawalinska, K., (1999). "Asset and Liability management. The institutional approach to ALM by commercial banks in Poland: a special focus on risk management", *Center for Social and Economic Research*, Warsaw, Studies & Analyses CASE Nr 185.

Appendix A: First order condition

1. Household

$$\frac{\partial \ell}{\partial c_t} = \beta^t (c_t)^{-\sigma_c} - \beta^t \lambda_t = 0 \quad (\text{A-1})$$

$$\frac{\partial \ell}{\partial N_t} = -\beta^t N_t^{\sigma_n} + \beta^t \lambda_t w_t = 0 \quad (\text{A-2})$$

$$\frac{\partial \ell}{\partial d_t} = E_t \left\{ -\beta^t \lambda_t + \beta^{t+1} \left(\frac{1+r_t^d}{\pi_{t+1}} \right) \lambda_{t+1} \right\} = 0 \quad (\text{A-3})$$

$$\frac{\partial \ell}{\partial m_t^h} = E_t \left\{ \beta^t (m_t^h)^{-\theta} - \beta^t \lambda_t + \beta^{t+1} \frac{\lambda_{t+1}}{\pi_{t+1}} \right\} = 0 \quad (\text{A-4})$$

$$\frac{\partial \ell}{\partial k_t} = -\lambda_t \left[1 + \varphi_k \left(\frac{k_{t+1}}{k_t} - 1 \right) \right] + \beta \left\{ \lambda_{t+1} \left[r_{t+1}^k + 1 - \delta - \frac{\varphi_k}{2} \left(\frac{k_{t+2}^2 - k_{t+1}^2}{k_{t+1}^2} \right) \right] \right\} = 0 \quad (\text{A-5})$$

2. Entrepreneur

$$\frac{\partial \ell}{\partial k_t} = \lambda_t A_t \alpha N_{jt}^{1-\alpha} K_{jt}^{\alpha-1} - \lambda_t^f r_t^k (1+r_t^l) = 0 \quad (\text{A-6})$$

$$\frac{\partial \ell}{\partial N_t} = \lambda_t A_t (1-\alpha) N_{jt}^{-\alpha} K_{jt}^{\alpha} - \lambda_t^f (1+r_t^l) w_t = 0$$

$$\frac{\partial \ell}{\partial P_t} = \left\{ 1 - \theta + \theta \left(\frac{P_t}{P_{jt}} \right) m c_{jt} \right\} \lambda_t \left(\frac{P_{jt}}{P_t} \right)^{-\theta} \frac{Y_t}{P_t} - \lambda_t \varphi_f \left\{ \left(\frac{P_{jt}}{(\bar{\pi}) P_{jt-1}} - 1 \right) \frac{Y_t}{(\bar{\pi}) P_{jt-1}} \right\} \quad (\text{A-7})$$

$$+ \beta \varphi_f E_t \left\{ \lambda_{t+1} \left(\frac{P_{jt+1}}{(\bar{\pi}) P_{jt}} - 1 \right) Y_{t+1} \left(\frac{P_{jt+1}}{(\bar{\pi}) P_{jt}^2} \right) \right\} = 0$$

$$m c_{jt} = \frac{\left[\gamma_t (1+r_t^l) w_t \right]^{1-\alpha} \left(\gamma_t (1+r_t^l) r_t^k \right)^{\alpha}}{\alpha^{\alpha} (1-\alpha)^{1-\alpha} A_t} \quad (\text{A-8})$$

3. Commercial bank

$$\frac{\partial \ell}{\partial l_t} = (r_t^l - r_t^i)l_t - \varphi_l l_t - \kappa_{lcb}(l_t - l_t^{cb}) = 0 \quad (\text{A-9})$$

$$\frac{\partial \ell}{\partial d_t} = -(r_t^d - (1 - \eta_t)r_t^i) - \varphi_d(1 - \eta_t)^2 d_t = 0 \quad (\text{A-10})$$

$$\frac{\partial \ell}{\partial dc_t} = -(r_t^c - r_t^i) - \varphi_{dc} dc_t = 0 \quad (\text{A-11})$$

Appendix B. log linear of model

$$\tilde{w}_t = \sigma_c \tilde{c}_t + \sigma_n \tilde{N}_t \quad (\text{B-1})$$

$$\tilde{c}_t = \frac{\tilde{\pi}_{t+1} - \tilde{r}_t^d}{\sigma_c} + \tilde{c}_{t+1} \quad (\text{B-2})$$

$$\tilde{m}_t^c = \frac{1}{g} (-\tilde{r}_t^d + \sigma_c \tilde{c}_t) \quad (\text{B-3})$$

$$\tilde{r}_{t+1}^k = \frac{\sigma_c}{1 - \beta(1 - \delta)} (\tilde{c}_{t+1} - \tilde{c}_t) \quad (\text{B-4})$$

$$\tilde{k}_{t+1} = (1 - \delta)\tilde{k}_t + \delta \tilde{i}_t \quad (\text{B-5})$$

$$\tilde{N}_t = \tilde{k}_t - \tilde{w}_t + \tilde{r}_t^k \quad (\text{B-6})$$

$$\tilde{\pi}_t = \left(\frac{\theta - 1}{\varphi_f} \right) m \tilde{c}_t + \beta \tilde{\pi}_{t+1} \quad (\text{B-7})$$

$$m \tilde{c}_t = (1 - \alpha)(\tilde{w}_t) + \alpha \tilde{r}_t^k + \tilde{r}_t^l - \tilde{A}_t + \tilde{\gamma}_t \quad (\text{B-8})$$

$$\tilde{y}_t = \tilde{A}_t + (1 - \alpha)\tilde{N}_t + \alpha \tilde{k}_t \quad (\text{B-9})$$

$$\tilde{l}_t = \bar{\gamma}((\tilde{r}^k + \tilde{k}_t) \frac{\bar{r}^k \bar{k}}{\bar{l}} + \frac{\bar{w}}{\bar{l}} \tilde{w}_t) + \tilde{\gamma}_t \quad (\text{B-10})$$

$$\tilde{d}_t = \frac{\bar{l}}{\bar{d}(1-\bar{\eta})} \tilde{l}_t + \frac{\bar{\eta}}{\bar{d}(1-\bar{\eta})} \tilde{\eta}_t - \frac{d\bar{c}}{\bar{d}(1-\bar{\eta})} d\tilde{c}_t - \frac{d\bar{i}}{\bar{d}(1-\bar{\eta})} d\tilde{i}_t \quad (\text{B-11})$$

$$\tilde{d}_t^i = \phi_{di}^{di} \tilde{d}_{t-1}^i + \phi_{di}^y y_t \quad (\text{B-12})$$

$$\tilde{dc}_t = \phi_{dc}^{dc} d\tilde{c}_{t-1} + \phi_{dc}^\pi \tilde{\pi}_t \quad (\text{B-13})$$

$$\tilde{r}_t^l = \frac{\bar{r}_i}{\bar{r}^l} \tilde{r}_t^i - \kappa_{lcb} \frac{\bar{l}^{cb}}{\bar{r}^l} \tilde{l}_t^{cb} + \frac{\varphi_l + \kappa_{lcb}}{\bar{r}^l} \bar{l}_t \quad (\text{B-14})$$

$$\tilde{r}_t^d = \left(\frac{\bar{r}_i}{\bar{r}^d} + \frac{2\varphi_d \bar{d}(1-\bar{\eta})}{\bar{r}^d} \right) \tilde{\eta}_t + \frac{(1-\bar{\eta})\bar{r}^i}{\bar{r}^d} \tilde{r}_t^i - \frac{\varphi_d \bar{d}(1-\bar{\eta})^2}{\bar{r}^d} \tilde{d}_t \quad (\text{B-15})$$

$$\tilde{r}_t^{dc} = \frac{\bar{r}^i}{\bar{r}^{dc}} \tilde{r}_t^i - \frac{\varphi_{dc} \bar{dc}}{\bar{r}^{dc}} d\tilde{c}_t \quad (\text{B-16})$$

$$\tilde{r}_t = \rho_r \tilde{r}_{t-1} + \rho_\pi \tilde{\pi}_t + \rho_y \tilde{y}_t + \varepsilon_{r,t} \quad (\text{B-17})$$

$$\tilde{\eta}_t = \phi_\eta^\pi \tilde{\pi}_t + \phi_\eta^\eta \tilde{\eta}_{t-1} + \varepsilon_{t,\eta} \quad (\text{B-18})$$

$$\tilde{l}_t^{cb} = -\frac{(1-\varphi_l^{cb})}{\bar{l}^{cb}} (\varphi_l^\pi \tilde{\pi}_t + \varphi_l^y \tilde{y}_t) + \frac{\varphi_l^{cb}}{\bar{l}^{cb}} \tilde{l}_{t-1}^{cb} \quad (\text{B-19})$$

$$\tilde{g}_t = \frac{\bar{t}}{\bar{g}} \tilde{t}_t + \frac{o\bar{r}}{\bar{g}} o\tilde{r}_t + \frac{\bar{m}}{\bar{g}} (\tilde{m}_t - \tilde{m}_{t-1} + \tilde{\pi}_t) \quad (\text{B-20})$$

$$\tilde{t}_t = \phi_t^y \tilde{Y}_t \quad (\text{B-21})$$

$$\tilde{y}_t = \frac{\bar{c}}{\bar{y}} \tilde{c}_t + \frac{\bar{i}}{\bar{y}} \tilde{i}_t + \frac{\bar{g}}{\bar{y}} \tilde{g}_t \quad (\text{B-22})$$

$$\tilde{m}_t = \frac{\bar{m}^h}{\bar{m}} \tilde{m}_t^h + \frac{\bar{d}}{\bar{m}} \tilde{d}_t \quad (\text{B-23})$$

$$\tilde{\gamma}_t = \rho_\gamma \tilde{\gamma}_{t-1} + \varepsilon_t^\gamma \quad (\text{B-24})$$

$$\tilde{A}_t = \rho_A \tilde{A}_{t-1} + \xi_t^A \quad (\text{B-25})$$

$$o\tilde{r}_t = \rho_{or} o\tilde{r}_{t-1} + \varepsilon_{or} \quad (\text{B-26})$$

$$r_t^r = \frac{\bar{r}}{\bar{r}^t} \bar{r}_t \quad (\text{B-27})$$