Journal of Money and Economy
Vol. 9, No.1 Winter 2014

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 policyr*

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 als defi ed as pplaiii gg 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 a d ttat dii gg s simultaneuulsy miii mizes t e bakk's fragility wwigg t withdrawal risk and maximizes the value added by the bank in relationship-lending. They also examine the impact of interbank competition on the bakk'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 NIB[1] 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:

$$\Big|_{x\cong 0}^{\clubsuit} (\varepsilon^h)^s E_t \left\{ \frac{(c_t)^{10\varpi_c}}{10\varpi_c} \; 0 \; \frac{N_t^{1.\varpi_n}}{1.\varpi_n} \; . \; \frac{1}{10M}\left[\frac{M_t^h}{P_t}\right]^{10M} \right\} \qquad (1)$$

Where ε 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. ϖ_c denotes inverse of the elasticity of inter- temporal substitution of consumption ϖ_N is inverse of elasticity of inter-temporal substitution of labor, M is elasticity of liquidity at household. They are subject to the budget constraint:

$$m_t^h \; . \; c_t \; . \; d_t \; . \; i_t \cong w_t N_t \; . \; (1. \; r_{t01}^d)\frac{d_{t01}}{\sigma_t} \; . \; r_t^k k_t \; . \; \frac{m^h_{t01}}{\sigma_t} \; . \; t_t \; . \; \frac{\sigma_t^f}{p_t} \; . \; \frac{\sigma_t^b}{p_t} \qquad (2)$$

Where w_t is the real wage, t_t is tax, $1. \; r_t^d$ is the interest rate of deposit, $D_t \cong \int_0^1 D_{jt} d_t$ is deposit and $d_t \cong \frac{D_b}{P_b}$, σ_t^f is profit of production sector and

σ_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. γ is a constant rate of depreciation and the last term is a capital adjustment cost function specified in standard fashion, μ_k denotes an adjustment cost parameter. $k_{t.1}$ can be obtained as:

$$k_{t.1} \cong (1 0 \gamma) k_t \,.\, i_t \, 0 \frac{\mu_k}{2} \left(\frac{k_{t.1}}{k_t} 0 1\right)^2 k_t \tag{3}$$

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 Dxit-Stieglitz method.

$$Y_t \cong \left[\int_0^1 Y_{jt}^{\left(\frac{\tau 0 1}{\tau}\right)} d_j \right]^{\frac{\tau}{\tau 0 1}} \qquad \tau \succ 1 \tag{4}$$

Where Y_{jt} is intermediate good, and τ 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:

$$Y_{jt} \cong \left[\frac{P_{jt}}{P_t} \right]^{0\tau} Y_t \tag{5}$$

Price for final good is:

$$P_t \cong \left(\int_0^1 P_{jt}^{10\tau} d_j \right)^{\frac{1}{10\tau}} \tag{6}$$

c. Intermediate Producer

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

$$Y_{jt} \cong A_t N_{jt}^{10\delta} K_{jt}^{\delta} \tag{7}$$

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

$$A_t \cong \upsilon_A A_{t01} .\ (10\ \upsilon_A)\bar{A} .\ \eta_{A,t} \quad \upsilon_A \angle +0,1, \ , \ \eta_{t,A} \mid N +0, \varpi_{\eta_{t,A}} , \tag{8}$$

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

$$\varphi_t \cong (10\ \upsilon_\varphi)\bar{\varphi} .\ \upsilon_\varphi \varphi_{t01} .\ \eta_{\varphi,t} \quad \upsilon_\varphi \angle +0,1, \ \eta_{t,\varphi} \mid N +0, \varpi_{\eta_{t,\varphi}} , \tag{9}$$

and L_{jt} (loan) is:

$$L_{jt} \cong \varphi_t + P_{jt} r_t^k K_{jt} .\ P_{jt} W_t N_{jt} , \tag{10}$$

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

$$PAC_t^j \cong \frac{\mu_f}{2}\left[\frac{P_{jt}}{(\bar{\sigma})P_{jt01}} 01\right]^2 Y_t \tag{11}$$

Where $\mu_f \propto 0$ is adjusted cost parameter, $1.\ \sigma_t$ is inflation rate, Y_t is total production. The marginal cost is:

$$mc_{jt} \cong \frac{\left[\varphi_t(1.\ r_t^l)w_t\right]^{10\delta} + \varphi_t(1\ \ r_t^l)r_t^k ,^{\delta}}{\delta^{\delta} + 10\delta ,^{10\delta} A_t} \tag{12}$$

Firms maximize profit through:

$$\sigma_{jt}^{f} \cong P_{jt} Y_{jt} \; 0 \; P_t mc_t Y_{jt} \; 0 \; PAC_t^{j} \tag{13}$$

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 $\frac{v_{kcb}}{2}(L_t \; 0 \; L_t^{cb})^2$.

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: $C_t = \frac{1}{2}(\mu_d[(1-\kappa_t)D_t]^2 + \mu_l L_t^2 + \mu_e Dc_t^2)$. Hence the representative bank seeks to maximize the discounted sum of cash flows:

$$\sum_{t=0}^{\infty} \varepsilon^t E_t \left\{ \begin{array}{l} (1+r_t^l)L_t - L_{t+1} - (1+r_t^c)Dc_t + Dc_{t+1} - (1+r_t^d)D_t \\ + (1-\kappa_t)D_{t+1} - (1+r_t^i)Di_t + Di_{t+1} \\ - \frac{\nu_{kcb}}{2}(L_t - L_t^{cb})^2 - \frac{1}{2}(\iota_d[(1-\kappa_t)D_t]^2 + \iota_l L_t^2 - \iota_e Dc_t^2) \end{array} \right\} \quad (14)$$

subject to a balance sheet constraint,

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

Where D_i and κ_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 substittt i of t e bakk's balance sheet snnctraitt i rr ofit ftttc i profit function changes to:

$$\begin{array}{l} \sigma_t^b = (r_t^l - r_t^i)L_t - (r_t^c - r_t^i)DC_t - [r_t^d - (1-\kappa_t) r_t^i D_t] \\ - \frac{K_{kcb}}{2}(L_t - L_t^{cb})^2 - \frac{1}{2}\{\iota_d[(1-\kappa_t)D_t]^2 + \iota_l L_t^2 + \iota_e Dc_t^2\} \end{array} \quad (16)$$

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:

$$r_t^l = r_t^i + \iota_l L_t + \nu_{lcb}(L_t - L_t^{cb}) \quad (17)$$

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

$$r_t^d = (1-\kappa_t) r_t^i - \mu_d((1-\kappa_t)^2 D_t \quad (19)$$

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 $r_t^i \cong r_t$,.

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

Borrowing from interbank is:

$$d_t^i \cong (d_{t01}^i)^{\iota_{di}^{di}} (y_t)^{\iota_{di}^{y}} \tag{20}$$

and borrowing from central bank is:

$$dc_t \cong (dc_{t01})^{\iota_{dc}^{dc}} (\sigma_t)^{\iota_{dc}^{\sigma}} \tag{21}$$

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:

$$(1. \; r_t) \cong \left[\frac{1. \; r_{t01}}{1. \; \bar{r}}\right]^{\upsilon_r} \left(\frac{1 \; \sigma_t}{1 \; \bar{\sigma}}\right)^{\upsilon_\sigma} \left(\frac{y_t}{\bar{y}}\right)^{\upsilon_y} \eta_{r,t} \tag{22}$$

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:

$$\kappa_t \cong \sigma_t^{\iota_\kappa^\sigma} \kappa_{t01}^{\iota_\kappa^\kappa} \eta_{t,\kappa} \tag{23}$$

ι_κ^σ and ι_κ^κ 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

$$l_t^{cb} \cong 0(1 0 \mu_l^{cb})(\mu_l^{\sigma}\sigma_t \,.\, \mu_l^{y} y_t) \,.\, \mu_l^{cb} l_{t01}^{cb} \tag{24}$$

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, μ_l^{σ} and μ_l^{y} determine the strength of the reaction with respect to inflation and output, while μ_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:

$$g_t \cong t_t \,.\, or_t \,.\, m_t \, 0 \, \frac{m_{t01}}{\sigma_t} \tag{25}$$

Tax is: $t_t \cong \gamma_t^{\mu_t^y}$ (26)

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

$$or_t \cong \upsilon_{or} or_{t01} \,.\, (10\, \upsilon_{or})\bar{or} \,.\, \eta_{or,t} \qquad \eta_{t,or} \mid N \mp 0, \varpi_{\eta_{t,or}}\,, \tag{27}$$

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

g. Market Clearing

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

$$y_t \cong c_t \,.\, i_t \,.\, g_t \,.\, AC_t \tag{28}$$

Equilibrium in liquidity market is:

$$m_t \cong m_t^h \,.\, d_t \tag{29}$$

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 μ_k, is 8.6. Adjusted cost of inflation μ_σ, 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:

$$\log(X_t) \cong c \ . \ \upsilon \log(X_{t01}) \ . \ \eta_{x_t} \tag{30}$$

Where υ is Autoregressive Coefficient and its standard deviation of η_{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
ϖ_c	0.93	Author calculations
ϖ_n	0.63	Author calculations
M	0.87	Author calculations
γ	0.024	Solving model
τ	4.33	Mark-up 30%
ε	0.97	Solving model
δ	0.78	Author calculations
υ_A	0.65	Appropriate structure of model
υ_{or}	0.60	Author calculations
υ_{pi}	0.89	Author calculations
υ_{mio}	0.82	Author calculations
υ_y	0.46	Author calculations
υ_{φ^i}	0.65	Author calculations
ι_κ^σ	0.062	Author calculations
ι_κ^κ	0.83	Author calculations
μ_{di}	0.46	Author calculations
μ_{di}^y	0.347	Author calculations
μ_{dc}^{dc}	0.55	Author calculations
μ_k	8.6	Agenor et al. (2012)
μ_t^{yc}	2.08	Author calculations
υ_r	0.80	Author calculations
μ_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: Auhhors’ calculaooos

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).

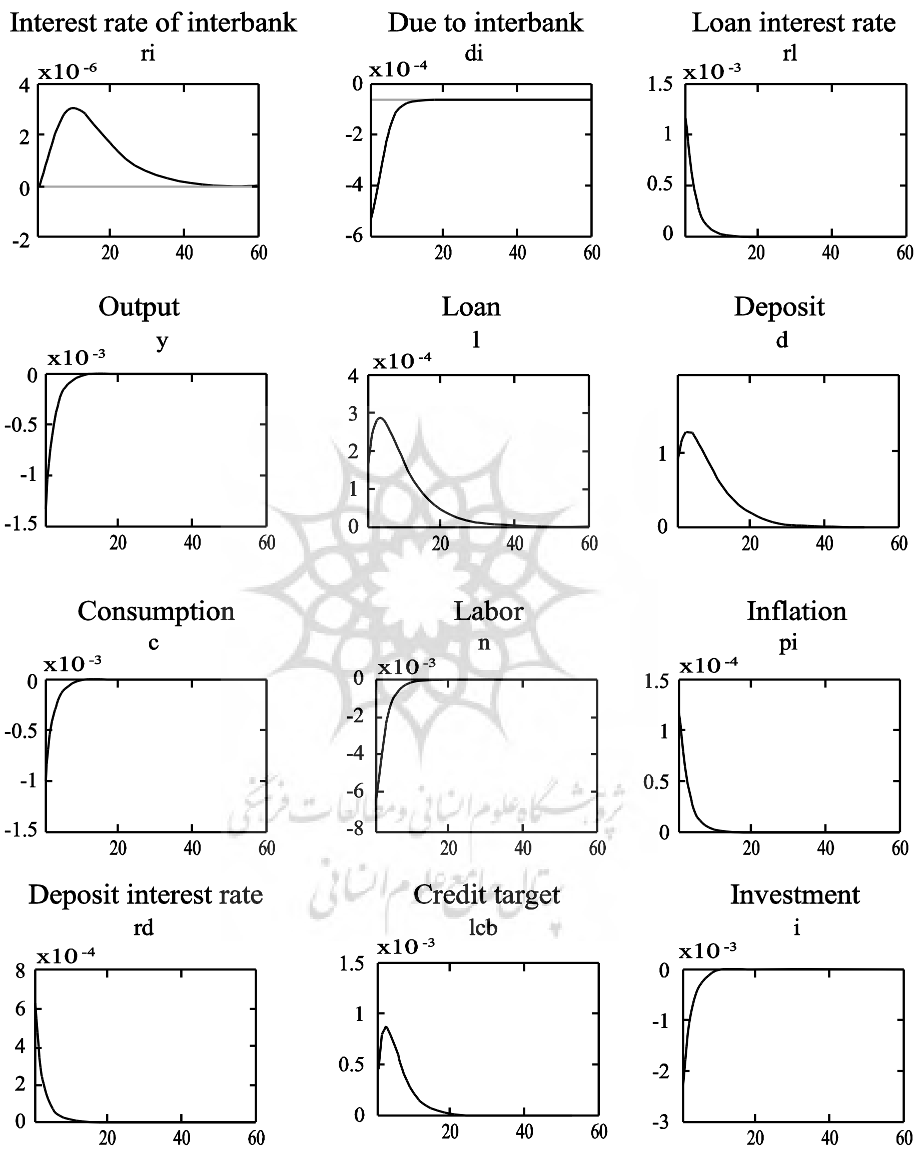
6.1 Financial shock

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

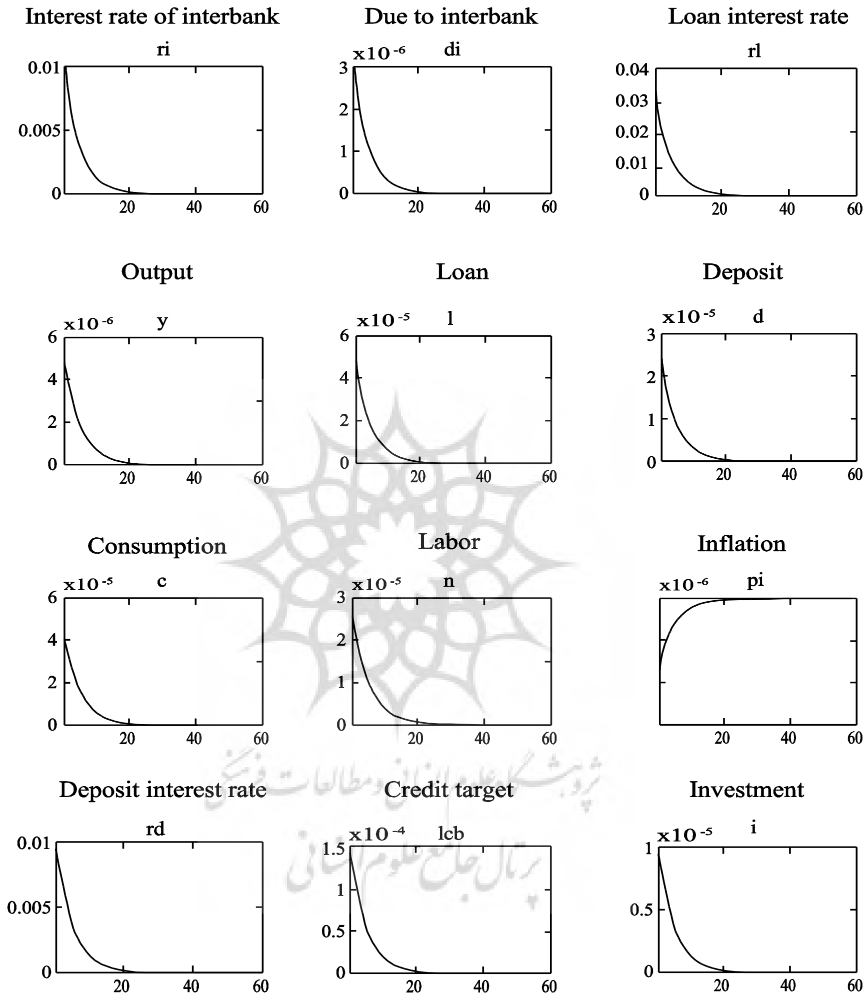


6.2. Monetary policy shock

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 bakkts 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 Usigg of uuuesuuld'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

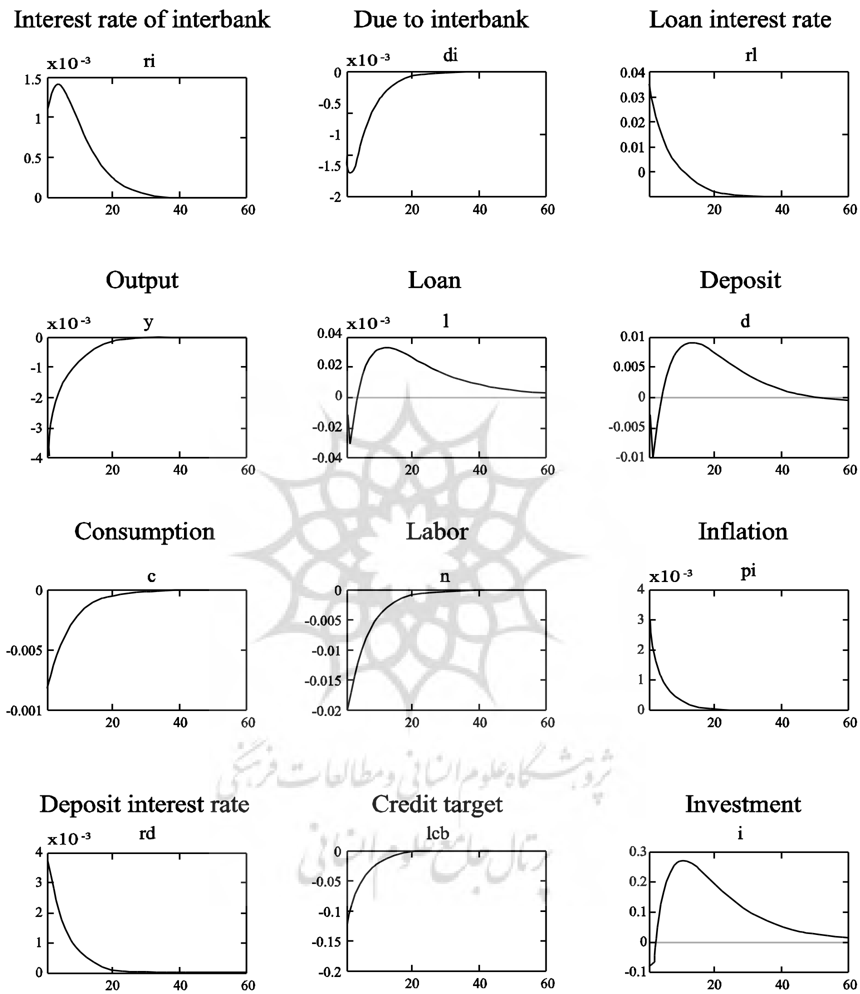
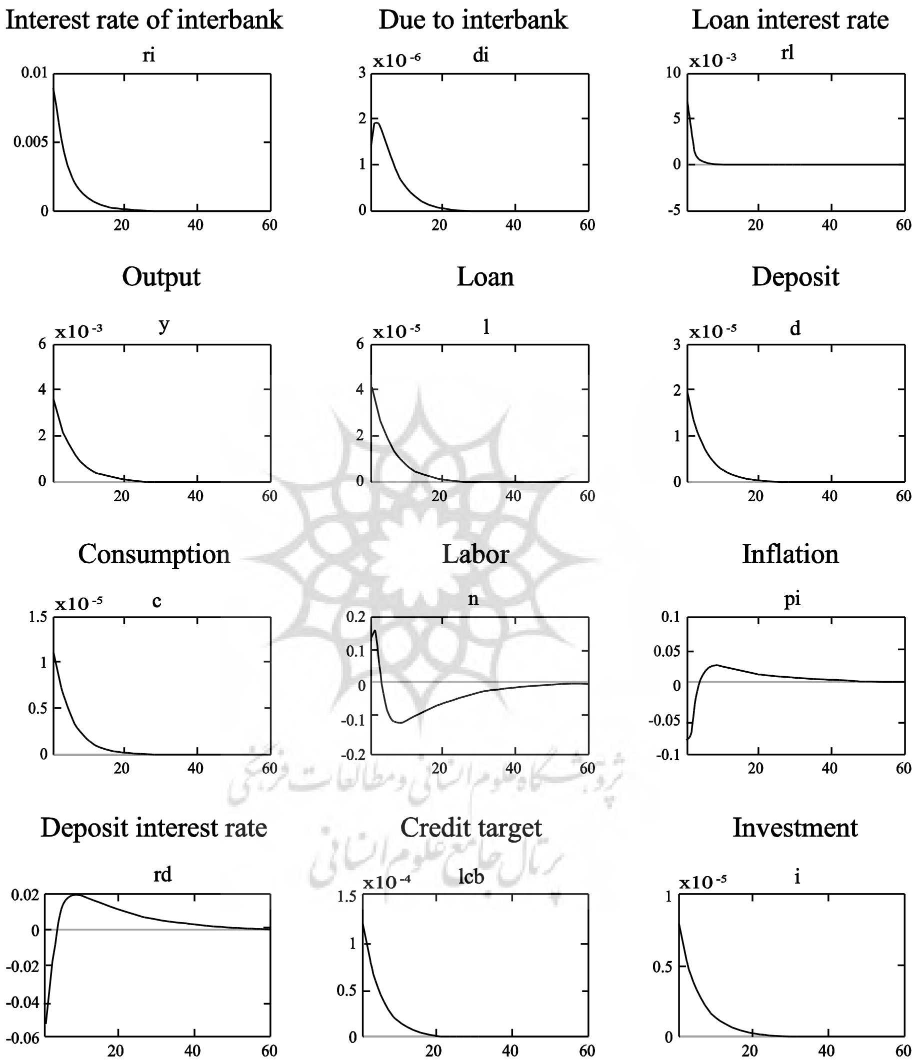


Figure 4: Technology Shock



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 Keynesia DGG model t catt rr e IRAN's vvvcvvevvinnla 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

C e Q C e a d Gerlac (1111)11TTe Implemett ati of nnne tary iiil cy i Cii ”a” *Working paper* in the second annual international conference on the Chinese economy, Hong Kong Institute for Monetary Research mimeos.

C e iayygg ii chael kkkke a d ii chael taet z (2222)22MMarket a d Non-market Monetary Policy Tools in a Calibrated DSGE Model for Mainla d Cii ”a” Bakk of nnnla d OII T Itst ittt e frr 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 Rtst ag (0000)00iii nanciali facrtt s ytt ecgggmlc’ fllcl iai t’”””s ll *Working Paper* Series 1192, European Central Bank.

Entrop, Oliver; Krombach, Arne; Memmel, Christoph; Wilkens, Marco, (9999)999Nnn-maturing Assets and Liabilities of Banks: Valuation and Risk Measrr emett *Working Paper* April 2009, the Deutsche Bundesbank.

Gerali, Andrea; Neri, Stefano; Sessa, Luca & Signoretti, M. Federico (2010). Credit a d bakkigg i a DGG model of t e err area omooocœ *Working Paper*, 740, Bank of Italy, Economic Research and International Relations Area.

GwHtlr ,,, (eeee) ee fffsef fii ecbaii l market matter frr bisi ness cycle fluctuation? An estimated DSGE model with financial frictions for the euro area Uii verita oolitecii ca delte marche Dirar timett di ici ezze *Economiche e Sociali, Quaderni di ricerca* n. 398.

Goofdrie d a d B T McCallum (7777)7Tkkak kgg a d itt erest rates i mttte ary oolicy analysis: A qtatt ttative explrr ati *Journal of Monetary Economics*, 54, 1480 1507.

He D a d H Wagg (1111)1 tuula -Track Interest Rates and the Conduct of Monetary uuukcy i Cii ”a”” *Working Papers* 212011, Hong Kong Institute for Monetary Research.

Jarrow, R., and D. Van Deventer, (1998). TThe arbitrage- free valuation and gedgigg of dema d soodects a d credit card lnans *Journal of Banking and Finance*, 22, 249-272

Memmel C A rcrer rler (9999)9TT e dependencn of t e bakks’ assets a d liabilities: evidence from Germayy *Discussion Paper*, Series 2: Banking and Financial Studies, No 14/2009.

Romayykk R (0000)00AAessALiability Magagemett : A Overvie *Working Paper* in bank of Canada.

ose D a d A Zeii s (6666)6Ettt errr ise-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 (1111)1TTT e Effects of asset liability managemett rr ofitability of tat innla ivvestmett bakk i t e e Juabegg miii cipality A *Thesis* submitted to the institute of distance learning, KWAME NKRUMAH 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.

iiic ety of Actrar ies (OOA) (3333)33rrr ofessinnla Actrar ial iiiec alty 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-iia bility matcii gg rr oblem *The Review of Financial Studies*, Vol. 20, No: 5.

Zawalikska K (9999)99AAessAa d iia bility managemett T e itst ittt innla approach to ALM by commercial banks in Poland: a special focus on risk managemett *Center for Social and Economic Research*, Warsaw, Studies & Analyses CASE Nr 185.

Appendix A: First order condition

1. Household

$$\frac{\div\ell}{\div c_t} \cong \varepsilon^t + c_t ,^{0\varpi_c} \; 0\, \varepsilon^t o_t \cong 0 \qquad \text{(A-1)}$$

$$\frac{\div\ell}{\div N_t} \cong 0\, \varepsilon^t N_t^{\varpi_n} \;.\; \varepsilon^t o_t w_t \cong 0 \qquad \text{(A-2)}$$

$$\frac{\div\ell}{\div d_t} \cong E_t \sim \; 0\, \varepsilon^t o_t \;.\; \varepsilon^{t.1}(\frac{1.\; r_t^d}{\sigma_{t.1}}) o_{t.1} \; \Upsilon \cong 0 \qquad \text{(A-3)}$$

$$\frac{\div\ell}{\div m^h{}_t} \cong E_t \sim \; \varepsilon^t (m^h{}_t)^{0M} 0\, \varepsilon^t o_t \;.\; \varepsilon^{t.1} \frac{o_{t.1}}{\sigma_{t.1}} \bullet \cong 0 \qquad \text{(A-4)}$$

$$\frac{\div\ell}{\div k_t} \cong 0\, o_t \left\{ 1.\; \mu_k \left[\frac{k_{t.1}}{k_t} 0\, 1 \right] \right\} .\; \varepsilon \sim o_{t.1} \left\{ r_{t.1}^k .\; 1 0\, \gamma\, 0 \frac{\mu_k}{2} \left[\frac{k_{t.2}^2 \, 0\, k_{t.1}^2}{k_{t.1}^2} \right] \right\} \Upsilon \cong 0 \qquad \text{(A-5)}$$

2. Entrepreneur

$$\frac{\div\ell}{\div k_t} \cong o_t A_t \delta N_{jt}^{10\delta} K_{jt}^{\delta\, 01} \; 0\, o_t^f r_t^k + 1.\; r_t^l , \cong 0 \qquad \text{(A-6)}$$

$$\frac{\div\ell}{\div N_t} \cong o_t A_t + 1 0\, \delta ,\, N_{jt}^{0\delta} K_{jt}^{\delta} \; 0\, o_t^f (1.\; r_t^l) w_t \cong 0$$

$$\frac{\div\ell}{\div P_t} \cong \left\{ 1 0\, \tau .\; \tau \left[\frac{P_t}{P_{jt}} \right] mc_{jt} \bullet\, o_t \left[\frac{P_{jt}}{P_t} \right]^{0\tau} \frac{Y_t}{P_t} 0\, o_t \mu_f \left\{ \left[\frac{P_{jt}}{(\bar{\sigma}) P_{jt\,01}} 0\, 1 \right] \frac{Y_t}{(\bar{\sigma}) P_{jt\,01}} \bullet \right. \right.$$

$$.\; \varepsilon \mu_f E_t \left\{ o_{t.1} \left[\frac{P_{jt.1}}{(\bar{\sigma}) P_{jt}} 0\, 1 \right] Y_{t.1} \left[\frac{P_{jt.1}}{(\bar{\sigma}) P_{jt}^2} \right] \bullet \right. \cong 0 \qquad \text{(A-7)}$$

$$mc_{jt} \cong \frac{\left[\varphi_t (1.\; r_t^l) w_t \right]^{10\delta} + \varphi_t (1.\; r_t^l) r_t^k ,^{\delta}}{\delta^{\delta} + 1 0\, \delta ,^{10\delta} A_t} \qquad \text{(A-8)}$$

3. Commercial bank

$$\frac{\div\ell}{\div l_t} \cong (r_t^l \; 0 \; r_t^i) l_t \; 0 \, \mu_l l_t \; 0 \; \nu_{lcb}(l_t \; 0 \; l_t^{cb}) \cong 0 \qquad \text{(A-9)}$$

$$\frac{\div\ell}{\div d_t} \cong 0(r_t^d \; 0 \; (1\,0\,\kappa_t) r_t^i) \, 0 \, \mu_d (1\,0\,\kappa_t)^2 d_t \cong 0 \qquad \text{(A-10)}$$

$$\frac{\div\ell}{\div dc_t} \cong 0(r_t^c \; 0 \; r_t^i) \, 0 \, \mu_{dc} dc_t \cong 0 \qquad \text{(A-11)}$$

Appendix B. log linear of model

$$\tilde{w}_t \cong \varpi_c \tilde{c}_t \; . \; \varpi_n \tilde{N}_t \qquad \text{(B-1)}$$

$$\tilde{c}_t \cong \frac{\tilde{\sigma}_{t\,.\,1} \, 0 \, \tilde{r}_t^d}{\varpi_c} \; . \; \tilde{c}_{t\,.\,1} \qquad \text{(B-2)}$$

$$\tilde{m}_t^c \cong \frac{1}{M} + 0 \tilde{r}_t^d \; . \; \varpi_c \tilde{c}_t \, , \qquad \text{(B-3)}$$

$$\tilde{r}_{t\,.\,1}^k \cong \frac{\varpi_c}{1\,0\,\varepsilon(1\,0\,\gamma)} + \tilde{c}_{t\,.\,1} \, 0 \, \tilde{c}_t \, , \qquad \text{(B-4)}$$

$$\tilde{k}_{t\,.\,1} \cong (1\,0\,\gamma)\tilde{k}_t \; . \; \gamma \tilde{i}_t \qquad \text{(B-5)}$$

$$\tilde{N}_t \cong \tilde{k}_t \, 0 \tilde{w}_t \; . \; \tilde{r}_t^k \qquad \text{(B-6)}$$

$$\tilde{\sigma}_t \cong \left[\frac{\tau\,0\,1}{\mu_f} \right] m\tilde{c}_t \; . \; \varepsilon \tilde{\sigma}_{t\,.\,1} \qquad \text{(B-7)}$$

$$m\tilde{c}_t \cong + 1\,0\,\delta \, , + \tilde{w}_t \, , \, . \; \delta \tilde{r}_t^k \; . \; \tilde{r}_t^l \; 0 \, \tilde{A}_t \; . \; \tilde{\varphi}_t \qquad \text{(B-8)}$$

$$\tilde{y}_t \cong \tilde{A}_t \; . \; (1\,0\,\delta)\tilde{N}_t \; . \; \delta \, \tilde{k}_t \qquad \text{(B-9)}$$

$$\tilde{l}_t \cong \bar{\varphi}((\tilde{r}^k \ . \ \tilde{k}_t)\frac{\bar{r}^k\bar{k}}{\bar{l}} \ . \ \frac{\bar{w}}{\bar{l}}\tilde{w}_t) \ . \ \tilde{\varphi} \qquad \text{(B-10)}$$

$$\tilde{d}_t \cong \frac{\bar{l}}{\bar{d}(1 0 \bar{\kappa})}\tilde{l}_t \ . \ \frac{\bar{\kappa}}{\bar{d}(1 0 \bar{\kappa})}\tilde{\kappa}_t \ 0 \ \frac{d\bar{c}}{\bar{d}(1 0 \bar{\kappa})}d\tilde{c}_t \ 0 \ \frac{d\bar{i}}{\bar{d}(1 0 \bar{\kappa})}d\tilde{i}_t \qquad \text{(B-11)}$$

$$\tilde{d}_t^i \cong \iota_{di}^{di}\tilde{d}_{t01}^i \ . \ \iota_{di}^{y} y_t \qquad \text{(B-12)}$$

$$\tilde{dc}_t \cong \iota_{dc}^{dc} d\tilde{c}_{t01} \ . \ \iota_{dc}^{\sigma}\tilde{\sigma}_t \qquad \text{(B-13)}$$

$$\tilde{r}_t^l \cong \frac{\bar{r}_i}{\bar{r}^l}\tilde{r}^i{}_t \ 0 \ \nu_{lcb}\frac{\bar{l}^{cb}}{\bar{r}^l}\tilde{l}_t^{cb} \ . \ \frac{\mu_l \ . \ \nu_{lcb}}{\bar{r}^l}\bar{l}\tilde{l}_t \qquad \text{(B-14)}$$

$$\tilde{r}_t^d \cong (\frac{\bar{r}_i}{\bar{r}^d} \ . \ \frac{2\mu_d\bar{d}(1 0 \bar{\kappa})}{\bar{r}^d})\tilde{\kappa}_t \ . \ \frac{(1 0 \bar{\kappa})\bar{r}^i}{\bar{r}^d}\tilde{r}_t^i \ 0 \ \frac{\mu_d\bar{d}(1 0 \bar{\kappa})^2}{\bar{r}^d}\tilde{d}_t \qquad \text{(B-15)}$$

$$\tilde{r}_t^{dc} \cong \frac{\bar{r}^i}{\bar{r}^{dc}}\tilde{r}_t^i \ 0 \ \frac{\mu_{dc}\bar{dc}}{\bar{r}^{dc}}d\tilde{c}_t \qquad \text{(B-16)}$$

$$\tilde{r}_t \cong \upsilon_r\tilde{r}_{t01}. \ \upsilon_\sigma\tilde{\sigma}_t \ . \ \upsilon_y\tilde{y}_t \ . \ \eta_{r,t} \qquad \text{(B-17)}$$

$$\tilde{\kappa}_t \cong \iota_\kappa^\sigma\tilde{\sigma}_t \ . \ \iota_\kappa^\kappa\tilde{\kappa}_{t01} \ . \ \eta_{t,\kappa} \qquad \text{(B-18)}$$

$$\tilde{l}_t^{cb} \cong 0\frac{(1 0 \mu_l^{cb})}{\bar{l}^{cb}}(\mu_l^\sigma\tilde{\sigma}_t \ . \ \mu_l^y\tilde{y}_t) \ . \ \frac{\mu_l^{cb}}{\bar{l}^{cb}}\tilde{l}_{t01}^{cb} \qquad \text{(B-19)}$$

$$\tilde{g}_t \cong \frac{\bar{t}}{\bar{g}}\tilde{t}_t \ . \ \frac{o\bar{r}}{\bar{g}}o\tilde{r}_t \ . \ \frac{\bar{m}}{\bar{g}}(\tilde{m}_t \ 0 \ \tilde{m}_{t01} \ . \ \tilde{\sigma}_t) \qquad \text{(B-20)}$$

$$\tilde{t}_t \cong \iota_t^y\tilde{Y}_t \qquad \text{(B-21)}$$

$$\tilde{y}_t \cong \frac{\bar{c}}{\bar{y}}\tilde{c}_t \; . \; \frac{\bar{i}}{\bar{y}}\tilde{i}_t \; . \; \frac{\bar{g}}{\bar{y}}\tilde{g}_t \qquad \text{(B-22)}$$

$$\tilde{m}_t \cong \frac{\bar{m}^h}{\bar{m}}\tilde{m}_t^h \; . \; \frac{\bar{d}}{\bar{m}}\tilde{d}_t \qquad \text{(B-23)}$$

$$\tilde{\varphi}_t \cong \upsilon_\varphi \tilde{\varphi}_{t01} \; . \; \eta_t^\varphi \qquad \text{(B-24)}$$

$$\tilde{A}_t \cong \upsilon_A \tilde{A}_{t01} \; . \; \zeta_t^A \qquad \text{(B-25)}$$

$$o\tilde{r}_t \cong \upsilon_{or} o\tilde{r}_{t01} \; . \; \eta_{or} \qquad \text{(B-26)}$$

$$\mathrm{r}_t^{\mathrm{r}} \cong \frac{\bar{\mathrm{r}}}{\bar{\mathrm{r}}^{\mathrm{t}}}\bar{\mathrm{r}}_t \qquad \text{(B-27)}$$