Financial (in)stability in Romania: the implications of Basel III

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Abstract

In this paper I propose a medium scale Dynamic Stochastic General Equilibrium model for emphasizing the effects of the new Basel III Agreement for Romania's financial stability. This model has similar structures as those developed by Walque et al. (2010) and Roger and Vlček (2011) but, combining their features, it results a more comprehensive framework.

First of all, I calibrated this model in order to obtain the deep parameters. After calibration, I used several shocks to conduct simulations for analyze if the model can capture the behavior of the economy. In the end of this study, I estimate the model using Bayesian techniques to match the data of the Romania's economy.

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I. Introduction

This paper reflects the impact that the new requirements of capital and liquidity will have on Romania's economy and financial system in particular once that Basel III Agreement will be implemented. The Basel III Agreement represents first of all an alternative for reaching a high degree of financial stability that can face the challenges of future economic and financial crises. This last Agreement completes the Basel II and Basel 2.5 frameworks, keeping the features that proved useful and proposing new features that will enlarge the cover area of the prudential supervision.

In November 2011, G20 leaders in Cannes called on jurisdictions to meet their commitment to implement fully and consistently Basel II and Basel 2.5 by end 2011, and Basel III, starting in 2013 and completing by 1 January 2019. In December 2010, Basel III was released and Committee members agreed to implement Basel III from 1 January 2013, subject to transitional and phase-in arrangements.[1] The actual crisis represents a research lab for Basel Committee and the two working papers - "Strengthening the Resilience of the Banking Sector" (henceforth referred to as 'Basel III') and "International Framework for Liquidity Risk Measurement, Standards and Monitoring" – represent the conclusions of the researchers, respective, the proposals for a higher degree of financial stability. The particularity of this last framework is that its implementation as an imposed requirement will be made in 2018/2019. Until then, starting from 2013, the proposed measures will act as recommendations and the indicators will be calculated only as informative measure for monitoring purposes. This strategy of implementation will support the banks, allowing them to gradually adapt to the new requirement, minimizing implementation costs. Instead, for researchers, this flexible implementation strategy makes more difficult to choose the common adaptation mechanism representative for whole financial system.

In Romania, financial stability is one of the several objectives of the central bank, the National Bank of Romania (NBR). In the 2011's Financial Stability Report, NBR reference

[1] BCBS (2012), p. 8.

at the impact produced by implementing Basel III agreement but concentrates only on a higher capital requirement. The conclusion of the report is that Romania's financial sector can easily adapt to these requirements because the banks' capitalization remains at a comfortable level of 14.2% (June, 2011). As a member of the European Union, Romania will implement the Basel III Agreement through Capital Requirement Directive (CRD IV). Therefore, in terms of progress in implementing the agreement, Romania fits with other European countries in the second stage according to the BIS report[2]: draft regulation published.[3]

In this study, the impact that transition from Basel II to Basel III will have on the financial environment is highlighted by a Dynamic Stochastic General Equilibrium model (DSGE) with the banking sector. This model highlights the links between financial sector and real economy variables, especially the channels through which decisions that ensure financial stability in the real economy spreads. Also, another reason for considering appropriate this model is the fact that financial sector has a sufficiently complex representation and can capture most of the requirements recommended by the Agreement.

The paper is organized as follows. In chapter II it describes the framework of Basel III going to review the new features, how to implement them and the costs and benefits of the new provisions. Chapter III will make a brief review of the literature dealing with this topic, referring in particular to groups of researchers from BIS: Macroeconomic Assessment Group (MAG) - which highlighted the financial costs of adopting new standards, and Long Economic Impact-term group (LEI), part of the Basel Committee for Banking Stability (BCBS) - whose efforts have been conducted to reflect the benefits of implementing new long-term requirements. Chapter IV contains a description of the model used for analysis. Chapter V is dedicated to the calibration of the model. Chapter VI contains a description of the simulations used to emphasize how model reacts when shocks occur. Chapter VII of this paper is concentrated on the estimation techniques used for obtaining the parameters that match the observed data and on the results of the estimation procedure. In Chapter VIII the last chapter of the book, I present the research findings and possible ways in which research

[2] *Idem,* p. 7

[3] Third compromise text (directive and regulation) published by the Danish Presidency on 28 March 2012

can be improved further. In Chapter VI, the last chapter of the book, I present the conclusions of this research I will mention several possible ways in which research can be further improved.

II. Basel III – Description

As I mentioned before, the Basel III Agreement consists of two framework documents. Each of these documents is referring to one of the main directions of activity of this Agreement: strengthening bank capital and providing liquidity in the financial system.

2.1. Capital requirements

The motivation that led to the increase in capital requirement was that the global banking system entered the crisis with an insufficient level of high quality capital. The crisis also revealed the inconsistency in the definition of capital across jurisdictions and the lack of disclosure that would have enabled the market to fully assess and compare the quality of capital across jurisdictions. A key element of the new definition of capital is the greater focus on common equity, the highest quality component of a bank's capital.

Following Basel III methodology, total regulatory capital will consist of the sum of the following elements[4]:

1. Tier 1 Capital (going-concern capital)

a) Common Equity Tier 1:

- Common shares issued by the bank that meet the criteria for classification as common shares for regulatory purposes (or the equivalent for non-joint stock companies);
- Stock surplus (share premium) resulting from the issue of instruments included Common Equity Tier 1;
- Retained earnings;
- Accumulated other comprehensive income and other disclosed reserves;

[4] BCBS (2011A) pp. 12-19.

- Common shares issued by consolidated subsidiaries of the bank and held by third parties (i.e. minority interest) that meet the criteria for inclusion in Common Equity Tier 1 capital;
- Regulatory adjustments applied in the calculation of Common Equity Tier 1;

b) Additional Tier 1
- Instruments issued by the bank that meet the criteria for inclusion in Additional Tier 1 capital (and are not included in Common Equity Tier 1);
- Stock surplus (share premium) resulting from the issue of instruments included in Additional Tier 1 capital;
- Instruments issued by consolidated subsidiaries of the bank and held by third parties that meet the criteria for inclusion in Additional Tier 1 capital and are not included in Common Equity Tier 1;
- Regulatory adjustments applied in the calculation of Additional Tier 1 Capital.

2. Tier 2 Capital (gone-concern capital)
- Instruments issued by the bank that meet the criteria for inclusion in Tier 2 capital (and are not included in Tier 1 capital);
- Stock surplus (share premium) resulting from the issue of instruments included in Tier 2 capital;
- Instruments issued by consolidated subsidiaries of the bank and held by third parties that meet the criteria for inclusion in Tier 2 capital and are not included in Tier 1 capital;
- Certain loan loss provisions;
- Regulatory adjustments applied in the calculation of Tier 2 Capital.

This definition of bank capital first has the role to establish a basis for calculating new indicators of solvency but also acts to separate the elements of capital depending on their solvency quality[5].

[5] For an ample description of the conditions of classification of capital see BCBS (2011A), section dedicated to new definition of capital.

Basel Committee's proposals regarding the establishment of new capital adequacy indicators (Form of Capital / Risk Weighted Assets) and how the actions will be implemented during the transition to Pillar I are summarized in the following table:

Table 1: Capital requirements under Basel III

Ratio/RWA	Basel II	Transitional arrangements						Basel III
	2012	2013	2014	2015	2016	2017	2018	2019
Common Equity Tier 1 (CET1)	2.00%	3.50%	4.00%	4.50%	4.50%	4.50%	4.50%	4.50%
Capital Conservation Buffer (CCB)					0,625%	1,250 %	1.875%	2.50%
Common Equity Tier 1 + CCB		3.50%	4.00%	4.50%	5.125%	5.75%	6.375%	7.00%
Regulatory Adjustments			20%	40%	60%	80%	100%	100%
Tier 1 Capital	4.00%	4.50%	5.50%	6.00%	6.00%	6.00%	6.00%	6.00%
Total capital	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%
Total capital + CCB		8.00%	8.00%	8.00%	8.625%	9.25%	9.875%	10.50%

At these indicators can be added also the countercyclical buffer, an indicator that ranges from 0% to 2.50% depending on the geographic profile where bank conducts its business.

The capital adequacy measures are applied to all internationally active banks to ensure that each bank maintains an appropriate level of capital relative to its own exposures. A number of the policy measures will have a particular impact on global systemically important banks (G-SIBs), given their business models have generally placed greater emphasis on trading and capital markets related activities, which are most affected by the enhanced risk coverage of the capital framework. The measures are included in a rules text published by Basel Committee in November 2011[6]. The Committee realizes that these policy measures are significant but are not sufficient to address the negative externalities posed by G-SIBs nor are they adequate to protect the system from the wider spillover risks of G-SIBs.

In addition to meeting the Basel III requirements, global systemically important financial institutions must have higher loss absorbency capacity to reflect the greater risks that they pose to the financial system. The additional loss absorbency requirements are to be met with a progressive Common Equity Tier 1 (CET1) capital requirement ranging from 1% to 2.5%, depending on a bank's systemic importance. For banks facing the highest G-SIB surcharge, an additional loss absorbency of 1% could be applied as a disincentive to increase materially their global systemic importance in the future.

The Basel III Pillar I, along with another two key reforms will complete the Basel III Capital Framework. Those are Pillar 2 – Risk management and Supervision and Pillar 2 – Market discipline.

2.2. Liquidity requirements

Basel III framework, unlike his predecessors, suggests a new direction for a healthier financial environment that is minimizing liquidity risk. Even though in terms of solvency banks show a healthy image, recent events have shown us that a strategy allocation of assets and liabilities oriented on satisfactory yields but with low degree of liquidity can generate disastrous imbalances when on markets is establishing panic.

For liquidity risk supervision, the Committee has developed two standards that have separate but complementary objectives. The first standard is Liquidity Coverage Ratio (LCR)[7] and has the objective to promote the short-term resilience of the liquidity risk profile of banks by ensuring that they have sufficient high-quality liquid assets to survive a significant stress scenario lasting 30 calendar days. The second standard is the Net Stable Funding Ratio (NFSR)[8] that has a time horizon of one year and has been developed to

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[6] BCBS (2011B) p.3.

[7] $LCR = \frac{Stock\ of\ high-quality\ liquid\ assets}{Total\ net\ cash\ outflows\ over\ the\ next\ 30\ calendar\ days} \geq 100\%$

[8] $NFSR = \frac{Available\ amount\ of\ stable\ funding}{Required\ amount\ of\ stable\ funding} > 100\%$

capture structural issues to provide a sustainable maturity structure of assets and liabilities. The objective of the Net Stable Funding Ratio standard is to promote resilience over a longer time horizon by creating additional incentives for banks to fund their activities with more stable sources of funding on an ongoing basis.[9]

Both the LCR and the NSFR will be subject to an observation. After an observation period beginning in 2011, the LCR, including any revisions, will be introduced on 1 January 2015 and the NSFR, as well including any revisions, will move to a minimum standard by 1 January 2018.

The new capital and liquidity requirements represent the alternative that the Commission proposes to meet future challenges that the global financial system will be subjected. Implementation of Basel III gave rise to clashes of ideas that put in balance the costs and benefits for financial systems still affected of the slow return from the recent economic crisis.

III. Literature review

This paper embodies a Dynamic Stochastic General Equilibrium model with an endogenous and heterogeneous banking sector that that allows bank regulations following de Walque et al. (2010) and Roger and Vlček (2011). The principal advantage of DSGE modeling for this particular research field is that it can provide a coherent framework for policy discussion and analysis by capturing the dynamic relationships among different macroeconomic variables while being grounded in microeconomic theory. Nevertheless, DSGE models have limitations. Prime among these is that they may be too stylized to fully capture the dynamics of the data. Moreover, fitting DSGE models to observable data is still quite challenging, even when using sophisticated econometric and statistical methods.[10]

First of all, this model starts from a real business cycle (RBC) model with a shock in total-factor productivity (TFP) but it leaves soon the Kydland and Prescott (1982) setting by

[9] BCBS (2010), p. 25.
[10] MAG (2010) p. 26-27

introducing a banking sector. In this type of setting, the Modigliani and Miller (1958) theorem doesn't holds anymore meaning that financial and credit market conditions aren't irrelevant and can affect the real economy.

This model is part of a larger group of models that assess the relevance of a detailed banking sector for monetary policy and supervision as in Goodfriend and McCallum (2007), Christiano et al. (2009) and Gerali et al. (2009). The papers mentioned before use homogenous banks and the interbank market either collapses or amounts to a connection with the central bank. De Walque et al. (2010) argues that this setting where the absence of a true interbank market and the lack of heterogeneity obscures the relationships between banks cannot be used to emphasize how a financial system will react at changes in regulatory measurements proposed by a supervisory authority or by central bank.

The main cores of researchers studying the issue of financial stability in the spirit of Basel III are the Macroeconomic Assessment Group (MAG) under the patronage of Bank for International Settlements (BIS) and Long-term Economic Impact Group (LEI) as part of the Basel Committee Banking stability (BCBS). For work of the MAG, the study of Roger and Vlček (2011) made an important contribution by introducing in a DSGE model both the new features imposed by Basel III: changes in capital and liquidity requirements. In most DSGE models, the notion of liquidity is not well established. However, Kiyotaki and Moore (2008) have started incorporating this notion of liquidity into New Keynesian DSGE models[11].

The Macroeconomic Assessment Group uses a broad range of models developed for policy analysis in central banks and international organizations (semi-structural large-scale models, reduced-form VAR-type models, DSGE models). The use of the DSGE models in MAG's works is considered an alternative approach because MAG members, as a complement to the estimates from the standard policy models, investigated how alternative modeling techniques represented by DSGE models and reduced-form estimation could be applied to the issues under consideration.

[11] *Idem,* p 48.

IV. The model

4.1. Households

The households consists of a continuum of j agents that are facing a intertemporal utility maximization process choosing consumption $C_t(j)$ and leisure $1 - N_t(j)$. As is often the case in RBC literature, I used a logarithmic Bernoulli utility function for consumption and for leisure. I also imposed a target in deposits $D_t^l(j)$ over their long run optimal level (steady state) through a quadratic disutility term. The household maximization program is:

$$\max_{N_t, C_t} \sum_{s=0}^{\infty} \beta^s E_t \left[\mathcal{U}(C_{t+s}(j)) + \bar{m} \ln(1 - N_{t+s}(j)) - \frac{\chi}{2} \left(\frac{D_{t+s}^l(j)}{1 + r_t^l} - \frac{D^l(j)}{1 + r^l} \right)^2 \right]$$

under the budget constraint:

$$p_t C_t(j) + p_t \frac{D_t^l(j)}{1+r_t^l} = p_t w_t(j) N_t(j) + p_{t-1} D_{t-1}^l(j) + \pi_t^f(j) + \pi_t^{ff}(j) + (1 - v_b) p_{t-1} \pi_{t-1}^b(j) + (1 - v_l) p_{t-1} \pi_{t-1}^l(j)$$

where p_t is the price level, r_t^l is the real rate for deposits , w_t is the real wage, $\pi_t^f(j)$ is the profit of the j-th intermediate production firm, $\pi_t^{ff}(j)$ is the profit of the j-th final good production firm. $(1 - v_b) p_{t-1} \pi_{t-1}^b(j)$ and $(1 - v_l) p_{t-1} \pi_{t-1}^l(j)$ represents the nominal profits redistributes by the merchant bank and the deposit bank to the households-shareholders.

4.2.1. Intermediate production firms

Intermediate production firms represent a continuum of j agents that produce intermediate goods using capital $K_t(j)$ and labor $N_t(j)$ as inputs and ϵ_t as total factor productivity. As in de Walque et al. (2010), the firms are facing costs for defaulting but are not excluded from the market. Costs are both pecuniary (higher search costs for obtaining new loans represented by the parameter γ) and also non pecuniary (disutility or 'social stigma' represented by the parameter d_f). The j-th intermediate production firm maximization program is represented by:

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

under the constraints:

$$K_t(j) = (1 - \tau)K_{t-1}(j) + \frac{L_t^b(j)}{1 + r_t^b}$$

$$\pi_t^f(j) = \epsilon_t p_t^w \bar{\mathcal{F}}(K_t(j), N_t(j)) - p_t w_t(j) N_t(j) - \alpha_t(j) p_t L_{t-1}^b(j) \\ - \frac{\gamma}{2}\Big((1 - \alpha_{t-1}(j)) p_{t-1} L_{t-2}^b(j)\Big)^2$$

The first constraint represents the law of motion for capital $K_t(j)$. Capital depreciates at a rate τ and firms borrow from Merchant bank $L_t^b(j)$ at a price $\frac{1}{1+r_t^b}$ to refill their capital stock. The interest rate is predetermined meaning it is fixed at the borrowing time t and not at the repayment time $t+1$. This assumption is based on the fact that, when borrow, firms know their interest rate at the date they sign the contract with bank. Moreover, without this predetermination, the endogenous default choice would be irrelevant because it would be totally offset by an increase in interest rate. In reality, firms may also finance investments with own funds but this is beyond the scope of this paper so I assume that intermediate production firms finance investments only through credit.

The second constraint defines profit of the intermediate production firm $\pi_t^f(j)$. Firms pay a wage $w_t(j)$ to their workers and choose what proportion of their previous period credit $L_{t-1}^b(j)$ to reimburse, knowing that they will have to pay in the future a quadratic search cost on any defaulted amount. They sell the intermediate productions $\bar{\mathcal{F}}$ to the final production firms at price p_t^w and they pay their costs at final price p_t.

4.2.2 Final production firm (the retailer) and market

The final production firms also represent a continuum of j continuum agents that use the intermediate production to create final goods. They are monopolistically competitive firms with staggered price setting of the Calvo type with perfect indexation as in Christiano et al. (2005). The final goods producer j maximizes profit $\pi_t^{ff}(j)$, choosing price p_t^* and demand for intermediate goods:

$$\max_{\mathcal{F}_t(j),p_t^*} \sum_{s=0}^{\infty} E_t\left[\beta^s \xi_p^s \{p_t^* X_{ts} \mathcal{F}_t(j) - p_t^w \overline{\mathcal{F}_t}(j)\}\right]$$

under the constraints:

$$X_{ts} = \begin{cases} \pi_t \cdot \pi_{t+1} \cdot \pi_{t+2} \cdot \ldots \cdot \pi_{t+s-1} & for\ s \geq 1 \\ 1 & for\ s = 0 \end{cases}$$

$$\mathcal{F}_t(j) = \left(\frac{p_t(j)}{p_t}\right)^{-\frac{1+e^p}{e^p}} \mathcal{F}_t$$

The production function is linear, simply transforming intermediate production to final goods, $\mathcal{F}_t(j) = \overline{\mathcal{F}_t}(j)$, meaning that the retailers are just "branders" as in Gerali et al. (2008). The retailers are buying the intermediate goods from firms at price p_t^w and differentiate it at no cost. Each retailer then sells his final product, applying a markup over the intermediate price and taking into account the demand that it faces characterized by constant price elasticity e^p among types of goods.

In each period, a firm faces a constant probability $1 - \xi_p$ of being able to reoptimize its nominal price:

$$p_t = \left[(1 - \xi_p)(p_t^*)^{\frac{1}{1+e^p}} + \xi_p(\pi_{t-1} p_{t-1})^{\frac{1}{1+e^p}}\right]^{1+e^p}$$

The ability to reoptimize its price is independent across retailers and time. If a firm can reoptimize its price, it does so before the realization of the time t growth rate of money. Retailers that cannot reoptimize their price simply index to lagged inflation:

$$p_t(j) = \pi_{t-1} p_{t-1}(j)$$

Let p_t^* denote the value of $p_t(j)$ set by retailer that can reoptimize the price at time t. I preferred this notation that does not depend on j based on the fact that all firms that can reoptimize their price choose the same price, as other studies revealed[12].

$$\pi_t^{ff}(j) = p_t(j)\mathcal{F}_t(j) - p_t^w \overline{\mathcal{F}_t}(j)$$

The market consists in a continuum of fully competitive distributors. These distributors have the role to aggregate demand by minimizing total costs:

$$\min_{\mathcal{F}_t(j)} \int_0^1 p_t(j)\mathcal{F}_t(j)\, dj$$

under the constraint:

$$\mathcal{F}_t = \left(\int_0^1 \mathcal{F}_t(j)^{\frac{1}{1+e^p}}\, dj \right)^{1+e^p}$$

The demand function for final goods $\mathcal{F}_t(j)$ is derived from this optimization problem.

4.3 The financial system

The financial system resembles the setting proposed by de Walque et al. (2010): it is composed by a bank that borrows from interbank market and lends the intermediate production firms, a bank that receives deposits from households and lends the interbank market, a central bank that sets the interest rate on interbank market and conducts liquidity operations, and a supervisory authority that fixes the capital and liquidity requirement[13].

[12] Christiano et al. (2005), p. 11

[13] In Romania, the central bank conducts the monetary policy and also has the role of supervisory authority, but, to make it clear, I preferred to disaggregate these two roles.

4.3.1 Bank borrowing from the interbank market (merchant bank)

The representative risk-averse merchant bank choose fund allocation from amongst aggregated loans to intermediate goods firms L_t^b, market book B_t^b, borrowing D_t^{bd} from interbank market and own funds F_t^b, as well as the repayment rate on the past borrowing so as to maximize the sum of all expected payoffs. The payoff is represented by a concave function of profits, a disutility from default and a utility from the difference between own funds and particular required funds. The particular required funds can be different from the rate of required funds set by the supervisory authority (targeted rate)[14]. As for firms, the defaulters are not excluded but instead are imposed both pecuniary and non-pecuniary costs, where d_δ represents the non-pecuniary cost and ϖ^b represents the pecuniary cost. The merchant bank maximization program is:

$$\max_{\delta_t, D_t^{bd}, L_t^b, B_t^b, F_t^b} \sum_{s=0}^{\infty} E_t\left[\beta^s \left\{\ln\left(\pi_{t+s}^b\right) - d_\delta\left(1-\delta_{t+s}\right) + d_{F^b}\left(F_t^b - k\left[\overline{w}_t L_t^b + \widetilde{w} B_t^b\right]\right)\right\}\right]$$

under the constraints:

$$F_t^b = (1-\xi_b)F_{t-1}^b + \frac{p_{t-1}}{p_t} v_b \pi_{t-1}^b$$

$$\pi_t^b = \alpha_t L_{t-1}^b + \frac{D_t^{bd}}{1+i_t} - \delta_t D_{t-1}^{bd} - \frac{L_t^b}{1+r_t^b} - \frac{\varpi^b}{2}\left((1-\delta_{t-1})D_{t-2}^{bd}\right)^2 + \zeta_b(1-\alpha_{t-1})L_{t-2}^b + (1+\rho_t)B_{t-1}^b - B_t^b$$

with ξ_b, ζ_b and $v_b \in [0,1]$. First constraint states that at every period, banks devote an exogenous fraction v_b of nominal profits to own funds. Furthermore, a small fixed proportion ξ_b from the own funds are put in an insurance fund managed by a public authority. The insurance mechanism is very important in calculating the endogenous repayment rates because this allows banks to recover a fraction ζ_b of the firm's defaulted amount. The second constraint defines the bank's period real profit. The bank borrows D_t^{bd} on the interbank market at a price $\frac{1}{1+i_t}$. It chooses a fraction δ_t of past borrowing it wants to pay back, knowing that next period it will face a quadratic search cost on the defaulted amount. Banks

[14] This is further detailed in section dedicated to supervisory authority.

also invest B_t^b in securities (market book) represented by government bonds B_t^{gov} and common shares $(1-s_g)B_t^b$, where s_g is the share of government bonds. The expected return of the market book is a stochastic AR(1) process:

$$\rho_t = (\rho)^{1-\rho_\rho}(\rho_{t-1})^{\rho_\rho} exp(-u_t^\rho)$$

where ρ is the equilibrium return, ρ_ρ is the persistence and u_t^ρ is a normally distributed shock. The supervisory authority fixes $\overline{w}_t$ and $\widetilde{w}$ the respective weights on loans and on the market book. In addition, $\overline{w}_t$ vary over time as I further illustrate in the supervisory authority section.

4.3.2 Bank lending to the interbank market (deposit bank)

The representative risk–averse deposit bank choose fund allocation from amongst loans to the interbank market D_t^{bs}, market book B_t^l, aggregated deposits from households D_t^l and own funds F_t^l from profit maximization. As the merchant banks, they derive the utility d_{F^l} from the buffer of own funds above the targeted capital requirement.

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

under the constraints:

$$F_t^l = (1-\xi_l)F_{t-1}^l + \frac{p_{t-1}}{p_t}v_l\pi_{t-1}^l$$

$$\pi_t^l = \delta_t D_{t-1}^{bs} + \frac{D_t^l}{1+r_t^l} - D_{t-1}^l - \frac{D_t^{bs}}{1+i_t} + \zeta_l(1-\delta_{t-1})D_{t-2}^{bs} + (1+\rho_t)B_{t-1}^l - B_t^l$$

with ξ_l, ζ_l and $v_l \in [0,1]$ as well as in the case of the merchant bank. The first constraint is the law motion of own funds that are increased each period by a share v_l of nominal profits that are not redistributed to households. Furthermore, a small fixed proportion ξ_l from the own funds are put in an insurance fund managed by a public authority. The second constraint represents the bank's real profit π_t^l. Deposit bank finance form households' aggregated deposits at a price $\frac{1}{1+r_t^l}$ and credit the interbank market with a price $\frac{1}{1+i_t}$. A fraction ζ_l of the defaulted amount (by the defaulting merchant banks) is paid back to the deposit bank from the insurance fund managed by public authority. Because the deposits are guaranteed by a government fund, I assume that deposit banks never default and the households' deposits are fully paid. The deposit banks also have a market book investment with payoff $(1 + \rho_t)B_{t-1}^l - B_t^l$ with the same return as merchant banks, ρ_t. For simplicity, I assumed that $B_t^l = B_t^b$.

4.4 Central bank

The central bank, as in Roger and Vlček (2011), sets the interbank rate according to a common Taylor type rule of the form:

$$i_t = \phi_i i_{t-1} + (1 - \phi_i)(\bar{\imath} + \Delta p_t + \phi_p(\Delta p_t))$$

with parameters ϕ_i and ϕ_p representing the persistance and the aggresiveness of monetary policy so that $\phi_i < 1$, and $\phi_p > 1$. $\bar{\imath}$ represents the steady state value for interbank rate and $\Delta p_t = \ln p_t - \ln p_{t-1}$ is the inflation.

The interbank equilibrium is set via liquidity injections. The liquidity injections are driven through a simplified McCallum rule that is complementary with the Taylor rule:

$$M_t = v(i_t - \bar{\imath})$$

, because when the interbank rate is set higher than its equilibrium value, the central bank injects the needed liquidity and when the interbank rate is set lower than its equilibrium value, the central bank absorbs the excess liquidity from interbank market. Parameter v helps the connection between denominated liquidity injections and interest rate expressed in percentage points.

4.5 Supervisory authority

The supervisory authority sets the capital and the liquidity requirements and the weights associated with risk categories of assets. As I said before when I discussed about banks' utility of the buffer of own funds above the achieved capital requirement, banks can consider a different level of capitalization that maximize their utility. In Romania, the level of capitalization is sensitive higher than required ratio so I assumed the achieved level of capital that generates utility for banks follows the adjusting equation:

$$k_t = \delta_k k_{t-1} + (1 - \delta_k)k^* + req_k$$

where δ_k is the persistency, k^* is the targeted ratio imposed by Basel III and req_k represents the capital requirement stochastic shock.

As in Macroeconomic Assessment Group work, an increase in the liquidity requirement is modeled as an increase in holding of government bonds. The liquidity requirement follows the same type of process like the targeted capital requirement:

$$B_t^{gov} = \delta_B B_{t-1}^{gov} + (1 - \delta_B)B^{gov*} + B_t^{gov} req_l$$

where δ_B is the persistency, B^{gov*} is the steady state value for government bonds in market book and req_l represents the liquidity requirement stochastic shock.

The supervisory authority also sets the weights associated with risk categories of assets. For simplicity, I assume the weight of market book $\widetilde{w}$ is fixed and is the same for merchant and deposit banks. Because of the endogenous default rates, I choose dynamic weights for loans to firms and for interbank credit meaning that the weights adjust when the expected future associated default rate changes.

The weight for loans to firms $\overline{w}_t$ depends on the evolution of firms' repayment rate and the weight for interbank loans $\overline{\overline{w}}_t$ depends on the evolution of merchant banks' repayment rate:

$$\overline{w}_t = \overline{w} E_t \left[\left(\frac{\alpha_t}{\alpha_{t+1}} \right)^{\eta} \right]$$

$$\bar{\bar{w}}_t = \bar{\bar{w}} E_t \left[\left(\frac{\delta_t}{\delta_{t+1}} \right)^{\eta} \right]$$

with $\eta > 0$.

V. Calibration

The model is calibrated on average historical data from 2007Q1 to 2011Q4.[15] I calibrate the banking sector using aggregate balance sheet of the monetary financial institutions and also I used the real interest rates for loans, deposits and interbank transactions. The calibration of the real sector is made using seasonal adjusted macro-financial data from national account.

5.1 The real sector

The production function $\bar{\mathcal{F}}(K_t(j), N_t(j)) = K_t(j)^{\mu} N_t(j)^{1-\mu}$is a Cobb-Douglas function with $\mu = 1/3$, and the productivity shock ϵ_t is normalized to 1. I assumed that the capital stock is 10 times higher than the production, $\frac{K_t(j)}{\bar{\mathcal{F}}_j} = 10$, and the depreciation rate of capital is $\tau = 3\%$. The ratio of the credit loss is about 5% so I choose a repayment rate of 95%. As in de Walque et al. (2010), I assume that default cost for intermediate production firms represents on average 0.6% of intermediate output. The consumption is set to 81% of intermediate output to match the data.

The probability of price reoptimization is 25% ($\xi_p = 75\%$) meaning that final good producing firms choose to change their price once a year. Also, the markup over the intermediate production price is set at 5% above it.

5.2 The banking sector

The banking sector is calibrated to match the implied ratios of the aggregated balance sheet. The steady state values for the quarterly interest rates are set at 2.8% for borrowing interest rate, 1.6% for interbank interest rate and 1.4% for deposit interest rate. These values

[15] The data used are described in Appendix 1.

are close to the quarterly 2007 – 2011 data (2.45%, 1.32%, and 1.26%). The deposit interest rate of 1.4% implies a discount factor of $\beta = \frac{1}{1+r_t^l} = 0.986$. I assume that the quarterly return on market book is $\rho = 5\%$. This return is significantly higher than the return of the government bonds (approx. 1% quarterly) but we can expect that banks also have higher-yield securities.

The aggregate balance sheet of the Romanian monetary institution is displayed in Appendix A. A key element of the calibration is the fact that some variables are stock in data and flow in model: households' deposits and production firms' loans. Because the lack of data, I assumed that the volume of loans and the volume of deposits are smaller than the observed data. In other words, imposed $D_t^l/L_t^b = 1.165$ and $D_t^{bd}/L_t^b = D_t^{bs}/L_t^b = 0.64$. Finally, I also imposed a market book for each bank equal to 50%: $B_t^b = B_t^l = 0.5 \cdot L_t^b$ and a 50% share of government bonds in total market book ($B^{gov}/B^b = 50\%$)[16].

According to the current Basel agreement, the minimum own funds requirement is set to 8% of risk-adjusted assets. I assumed as de Walque et al. that the loans to firms weight is $\bar{w} = 80\%$ and the market book weight is $\widetilde{w} = 120\%$ (weights ranging from 0 to 150%). For the interbank weight I assumed a lower value of $\bar{\bar{w}} = 10\%$ because of the central bank liquidity interventions that lower risk.

The allocation of profits is the same for both banks: 50% of their profits go to households ($v_l = v_b = 50\%$). To maintain the own funds stationary, I assumed that banks pay about 6% to the insurance fund ($\xi_b = 6\%$ and $\xi_l = 6.5\%$) in exchange for 80% of the defaulted amount ($\zeta_b = \zeta_l = 80\%$).

From all these implied values for ratios and parameters I was able to infer the values for the default cost parameter for intermediate production firms γ and the correspondent disutility parameter d_f, the default cost parameter for merchant banks ϖ^b and the correspondent disutility parameter d_δ. I also was able to infer the values for the utility parameters of own funds buffer d_{F^b} and d_{F^l}.[17]

[16] This is probably a high share but it helps illustrating better the reaction to liquidity requirement
[17] The implied ratios and the parameters used can be found in Appendix B

VI. Simulations

The simulations conducted have the purpose to check if the model is able to reproduce some well-known results of the economic theory. Using DYNARE v4 with MATLAB R2010A, I simulate business cycle moments, nominal frictions of intermediate goods price and final goods price, market book return volatility and, the most important, changes in financial stability related requirements.

Simulations of business cycle are driven by an autoregressive total factor of productivity shock $\epsilon_t = (\epsilon_{t-1})^{\rho_\epsilon} exp(u_t^\epsilon)$ with persistency $\rho_\epsilon = 0.8$, $u_t^\epsilon \sim \mathcal{N}(0, \sigma_\varepsilon^2)$ and $\sigma_\varepsilon^2 = 0.01$. This approach is standard in RBC literature.

The market book return volatility is simulated through a autoregressive shock $\rho_t = (\rho)^{1-\rho_\rho}(\rho_{t-1})^{\rho_\rho} exp\left(-u_t^\rho\right)$ with autoregressive parameter $\rho_\rho = 0.5$ and normally distributed innovations $u_t^\rho \sim \mathcal{N}(0, \sigma_\rho^2)$, $\sigma_\rho^2 = 0.01$.

Nominal frictions are simulated through two distinct processes. First I assume that the first order condition obtained from the maximization program of the final good producers representing a partially forward-looking Phillips curve:

$$\Delta p_t = \frac{1}{1+\beta}\Delta p_{t-1} + \frac{\beta}{1+\beta}\Delta p_{t+1} + \frac{(1-\xi_p)(1-\xi_p\beta)}{\xi_p(1+\beta)}\ln\left(\frac{Markup_p p_t^w}{p_t}\right) + e_t^p$$

is driven by normally distributed innovations $e_t^p \sim \mathcal{N}(0, \sigma_p^2)$, with $\sigma_p^2 = 0.4\%$. I choose this value for σ_p^2 because it generates an approximately 1% change in final prices. The second process is a intermediate production price shock. p_t^w is a simple normally distributed shock $p_t^w \sim \mathcal{N}(\overline{p^w}, \sigma_w^2)$ with mean $\overline{p^w} = 1$ and variance $\sigma_w^2 = 0.01$. It is unnecessary that these two shocks to be correlated simply because p_t^w is integrated in the process of Δp_t.

Simulations of changes in financial stability related requirements are driven by two distinct uncorrelated processes of capital requirement and liquidity requirement. These simulations are almost similar with Roger and Vlček (2011) framework. The capital requirement process has two different shock components: a deterministic shock in the targeted component, meaning that the future values of this variable are known according to Basel III[18], and a stochastic shock that influence the achieved capitalization level. The stochastic shock req_k is normally distributed, $req_k \sim \mathcal{N}(0, \sigma_k^2)$ with $\sigma_k^2 = 0.01$. This variance can be interpreted as a variance of achieved capitalization level generated by bank's own decisions.

Regarding liquidity requirements, I used the same technique as Roger and Vlček: I assumed that government bonds level is shocked with normally distributed innovations $req_l \sim \mathcal{N}(0, \sigma_B^2)$ having $\sigma_B^2 = 0.25$. Multiplying the shock with the value of government bonds, I actually obtained a 25% increase of the government bonds, the same as in the scenario used by Macroeconomic Assessment Group.

The results of the simulations are found in the Appendix C in the form of the impulse response functions. The impulse response functions are plotted only for the stochastic shocks of the capital and liquidity requirements because the other shock only were used to provide the consistency for the framework.[19] To emphasis on relevance of the deterministic shock of the capital requirement, I also included a 10 year forecast where both stochastic and deterministic disturbances can be observed.

As a general result, the reactions of the macroeconomic and financial variables are in respect with economic sense. More than that, from the impulse response functions, we can observe that capital requirement stochastic shock has little negative effect on gross domestic product and also a negative impact on the interbank market. The liquidity requirement has a negative impact on own funds and a negative impact followed in next quarter by a positive one on gross domestic product.

VII. Estimation

I have extended further the research of this field than de Walque et al. (2010) or Roger and Vlček (2011) by estimating several parameters that I consider important for this framework. I estimated the following parameters:

[18] Basel III Agreement proposes an increase of the capital requirements from 8% to 10.25%

[19] These results are also important but I choose not to distract the reader's attention form the main objectives of this paper.

- disutility or 'social stigma' of default for intermediate production firms d_f;
- disutility or 'social stigma' of default for merchant banks d_δ;
- the search costs parameter for obtaining new loans by intermediate production firms γ;
- the pecuniary cost parameter for obtaining new interbank loans by merchant bank ϖ^b;
- the utility parameters of own funds buffer for merchant bank d_{F^b};
- the utility parameters of own funds buffer for deposit bank d_{F^l};
- the persistency of the targeted capital requirement δ_k;

7.1 Data

I used only three data series to match the observed variables: nominal gross domestic product, nominal capital and reserves of financial institutions and nominal interbank deposits. The small number of series can be explained by the fact that the model contains only six shocks and are estimated only seven parameters, others being calibrated. The series have quarterly frequency and range from 2000Q1 to 2011Q4 meaning that there are 48 observations for every series. All the data are expressed in national currency and where denominated by 10^{11}.

The GDP series was downloaded from EUROSTAT database and was already seasonal adjusted. The source of the own funds series (capital plus reserves) is the NBR database and the series was transformed from monthly frequency to quarterly frequency by choosing the observation at the end of every quarter. The interbank deposits series has the same source as own funds, the NBR database, and also was transformed from monthly frequency to quarterly frequency by choosing the average of the monthly observations of a quarter.

7.2 Prior distributions

For parameters that are defined on $(0,1)$ range I choose a Beta distribution and for parameters that are defined on $(0, \infty)$ I choose an Inverse Gamma distribution:

- d_f is Inverse Gamma distributed with mean 0.12 and variance 0.01;
- d_δ is Inverse Gamma distributed with mean 5.59 and variance 0.05;
- γ is Inverse Gamma distributed with mean 72 and variance 0.1;
- ϖ^b is Inverse Gamma distributed with mean 406 and variance 0.05;
- d_{F^b} is Inverse Gamma distributed with mean 4.83 and variance 0.05;
- d_{F^l} is Inverse Gamma distributed with mean 5.66 and variance 0.05;
- δ_k is Beta distributed with mean 0.97, 0.01, 0.1;

7.3 Estimation procedure

As estimation procedure I used the Bayesian technique of estimation. Griffoli (2010) argues that Bayesian estimation fits the complete, solved model, opposed to GMM estimation which is based on equilibrium relationships. Another advantage of the Bayesian techniques is the consideration of priors which work as weights in estimation process so that posterior distribution avoids peaking at false points where likelihood peaks.

As in Griffoli's DYNARE User Guide (2010), Bayesian estimation routine is described as follows:

- First, priors are described by a probability density function of the form $p(\theta_{\mathcal{M}}|\mathcal{M})$ where $\mathcal{M}$ stands for model and $\theta_{\mathcal{M}}$ represents the parameter of the model.
- Second, the likelihood function describes the density of the observed data, given the model and its parameters: $\mathcal{L}(\theta_{\mathcal{M}}|Y_t,\mathcal{M}) \equiv p(Y_t|\theta_{\mathcal{M}},\mathcal{M})$ where Y_t are the t observations. The likelihood function is evaluated with the Kalman filter.
- The posterior density is given by:

$$p(\theta_{\mathcal{M}}|Y_t,\mathcal{M}) = \frac{p(Y_t|\theta_{\mathcal{M}},\mathcal{M})p(\theta_{\mathcal{M}}|\mathcal{M})}{p(Y_t|\mathcal{M})}$$

  where $p(Y_t|\mathcal{M})$ is the marginal density of the data conditional on the model.
- The posterior kernel that corresponds to the numerator of the posterior density:

$$p(\theta_{\mathcal{M}}|Y_t,\mathcal{M}) \propto p(Y_t|\theta_{\mathcal{M}},\mathcal{M})p(\theta_{\mathcal{M}}|\mathcal{M}) \equiv \mathcal{K}(\theta_{\mathcal{M}}|Y_t,\mathcal{M})$$

  is simulated using the Metropolis-Hastings algorithm.

The Metropolis-Hastings algorithm implements the following four steps: First, it chooses a starting point θ^0, where this is typically the posterior mode. Second, it draws a $proposal\,\theta^*$ from a jumping distribution $J(\theta^*|\theta^{t-1}) = \mathcal{N}(\theta^{t-1}, c\Sigma_{\mathrm{m}})$, where Σ_{m} is the inverse of the Hessian computed at the posterior mode. Third, it computes the acceptance ratio: $r = \frac{p(\theta^*|\mathcal{M})}{p(\theta^{t-1}|\mathcal{M})} = \frac{\mathcal{K}(\theta^*|Y_t,\mathcal{M})}{\mathcal{K}(\theta^{t-1}|Y_t,\mathcal{M})}$. Finally it accepts or discards the $proposal\,\theta^*$ according to the following rule: $\theta^t = \begin{cases} \theta^* & with\,probability\,\min(r,1) \\ \theta^{t-1} & otherwise \end{cases}$. The steps (2), (3) and (4) are repeated in a loop.

For posterior distributions' simulation I used for Metropolis-Hastings chains with 100,000 draws each and tuned the scale parameter to 0.9 so as to obtain an acceptance ratio of 0.27.

7.4 Results

The results of the estimation are summarized in the table below[20]:

Table 2: Estimation results

Parameter	Prior mean	Posterior mean	Confidence interval (90%)		Prior PDF	Prior standard deviation
d_f	0.05	0.1362	0.1180	0.1559	Inverse Gamma	0.01
d_δ	3.6	3.9996	3.6508	4.3292	Inverse Gamma	0.05
γ	79	97.4546	86.0744	103.2842	Inverse Gamma	0.1
ϖ^b	506	689.8866	655.4378	723.4556	Inverse Gamma	0.05
d_{F^b}	4.83	4.3827	4.0758	4.7015	Inverse Gamma	0.05
d_{F^l}	5.66	5.0892	4.8734	5.2860	Inverse Gamma	0.05
δ_k	0.5	0.5016	0.4847	0.5183	Beta	0.01

Estimation of the deep parameters using Bayesian techniques showed that the disutility of firms default is higher than the calibrated value. The search costs parameter for

[20] The impulse response functions can be found in Appendix D.

obtaining new loans by intermediate production firms γ and the pecuniary cost parameter for obtaining new interbank loans by merchant bank ϖ^b also have larger estimated values than calibration. Another parameter that I estimate is the persistency of the capital requirement and the result was a high persistency of 50.16%.

The impulse response functions for the output are all significantly. The estimated impact of a capital requirement shock illustrated a decrease in gross domestic product of near 0.01% and a decrease in the nominal own funds of 0.43%. The estimated impact of the liquidity requirement on output is a decrease with more than 2% but this is higher than the anticipated answer because of the high share of government bonds held in banks portfolio that I assumed. These responses are in line with the results obtained by MAG.

VIII Conclusions

In this dissertation paper, I propose a dynamic stochastic general equilibrium model with a heterogeneous banking sector, endogenous default rates and nominal frictions that emphasize the role of supervisory authority in the pursuit of financial stability. I tried to develop a more comprehensive framework than the models that I used as basis by adding several new features described above in detail. I did this because I agree with the point of view of de Walque et al. (2010) arguing that a consistent framework for financial stability analysis must account for all linkages and diffusion processes, not only between financial and non-financial sectors, but also within the financial sector itself.

The characteristics of this model regarding capital and liquidity requirements were modeled to resemble with those proposed by Macroeconomic Assessment Group so I was able to compare results with those obtained by other researchers. This model showed that, with a representation of a true interbank market, the interbank flows are affected when the capital and liquidity requirements are changing, in another words, it illustrates the fact that banks, as parts of a financial system, will concentrate more on their balance sheets and less on interconnection of the system.

As direct costs, the new requirements will have small negative impact on output, a result that could be anticipated mainly because of high degree of capitalization. Regarding the true level of liquidity in the system, I cannot make any further remark, except the fact that a reallocation of funds to market book despite loans produces a small negative impact because of the small share of market book in aggregated balance sheet.

This framework obviously has many limitations. First of all, as in the papers already mentioned, I modeled a closed economy. In Romania, foreign equity and also external assets and liabilities play an important role that is uncovered by this model. The second important direction in which the model can be developed is introducing a non-bank financial sector because, nowadays, when banking credit is constrained, alternative credit channel represented by non-bank financial entities had grown to a significant level. The third important area in which the model is lacking is the undifferentiated households that do not include a very specific credit product: loans for consumption. Even with the same model structure, this study can be improved by including more observable data series and by gathering data that reflects the flows of aggregated balance sheet elements.

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Appendix

A. Data

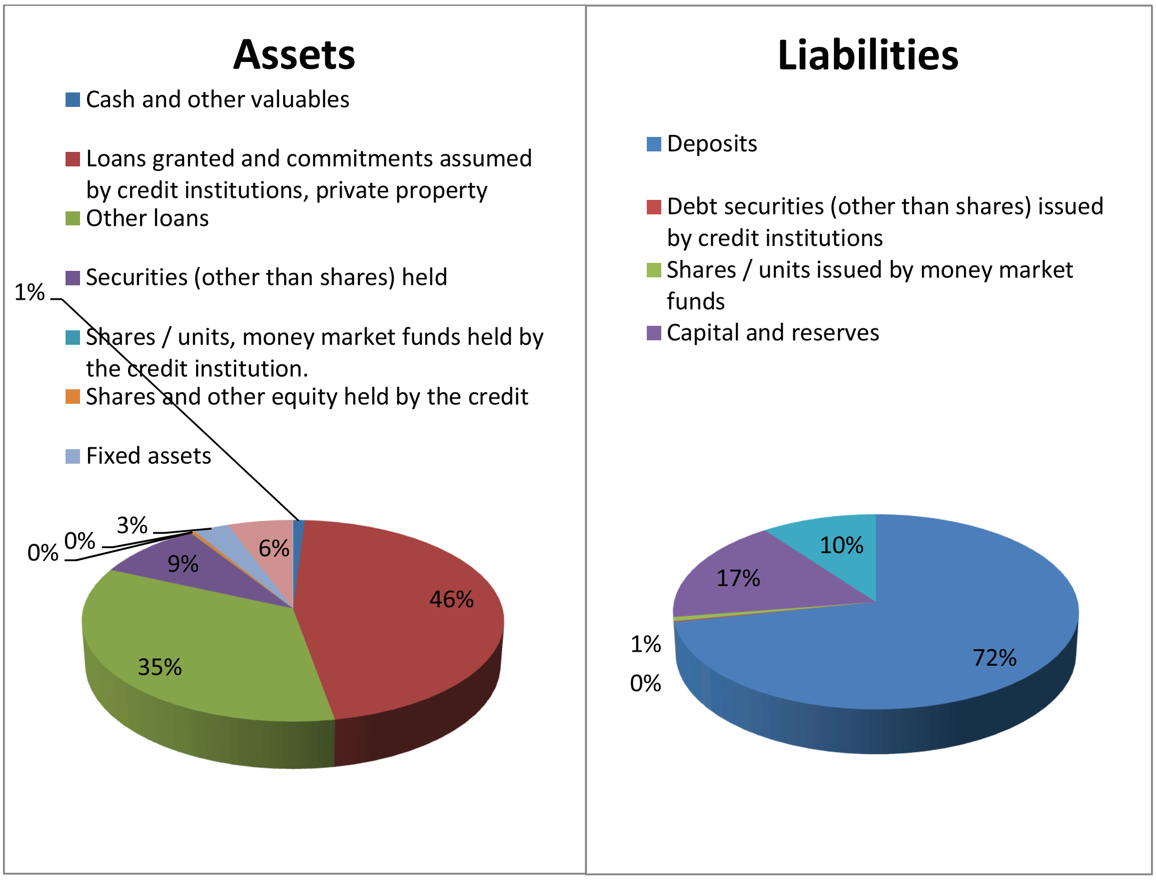
In calibration process I used the following data series from 2007Q1 – 2011Q4:

- **Credit to firms**: monthly frequency, source: aggregated financial balance sheet, NBR;
- **Total deposits**: monthly frequency, source: aggregated financial balance sheet, NBR;
- **Interbank deposits**: monthly frequency, daily average, source: interbank statistics, NBR;
- **Market book**: sum of securities (other than shares) held, shares / units, money market funds held by the credit and shares and other equity held, monthly frequency, source: aggregated financial balance sheet, NBR;
- **Own funds**: defined as capital plus reserves, monthly frequency, source: aggregated financial balance sheet, NBR;
- **Lending rate (real)**: deflated by CPI, quarterly compounded, monthly frequency, source: monetary and financial indexes, NBR;
- **Interbank rate (real)**: average of ROBOR3M and ROBID3M, deflated by CPI, quarterly compounded, monthly frequency, source: interbank statistics , NBR;
- **Borrowing rate (real)**: deflated by CPI, quarterly compounded, monthly frequency, source: monetary and financial indexes, NBR;
- **Default rate for firms (bad loans)**: monthly frequency, source: credit risk statistics, NBR;
- **Consumption**: seasonal adjusted, quarterly frequency, source: EUROSTAT;
- **Gross Domestic Product:** seasonal adjusted, quarterly frequency, source: EUROSTAT;

In estimation process I used the following data series from 2000Q1 – 2011Q4 (48 observations):

- **Gross Domestic Product:** seasonal adjusted, quarterly frequency, source: EUROSTAT;
- **Own funds**: defined as capital plus reserves, quarterly frequency, source: aggregated financial balance sheet, NBR;
- **Interbank deposits**: monthly frequency, daily average, source: interbank statistics, NBR;

Figure 1: The aggregated balance sheet for Romanian banking sector, average 2007-2011



B. *The implied ratios, steady state variables and calibrated parameters*

Table 3: Implied ratios

$\frac{C}{\mathcal{F}} = 0.81$	$\frac{\mathcal{F}}{K} = 0.1$
$\frac{tpc^f}{\mathcal{F}} = 0.003$	
$\frac{D^l}{L^b} = 1.16$	$\frac{F}{B} = 1.2$
$\frac{B^b}{L^b} = 0.5$	$B^b = B^l$
$D^{bd} = D^{bs}$	$\frac{D^{bd}}{L^b} = 0.64$

Table 4: Steady state

$r^b = 11.68\%$	$C = 0.725$
$r^l = 5{,}8\%$	$N = 0.2$
$i = 6.56\%$	$\pi^f = 0.0314$
$L^b = 0.2754$	$D^l = 0.3209$
$D^{bd} = 0.0561$	$D^{bs} = 0.0561$
$F^b = 0.0902$	$F^l = 0.0252$
$B^b = 0.1377$	$B^l = 0.1377$
$\pi^b = 0.0106$	$\pi^l = 0.0033$
$B^{gov} = 0.0688$	
$\alpha = 94.863\%$	$\delta = 99.786\%$

Table 5: Calibrated parameters

$\mu = 0.333$	$\tau = 0.03$	$\zeta_b = 80\%$	$\zeta_l = 80\%$	$\rho = 20\%$
$v_b = v_l = 50\%$	$\xi_b = 6\%$	$\xi_l = 6.5\%$	$k = 8\%$	$\chi = 0.5$
$\overline{\overline{w}} = 10\%$	$\overline{w} = 80\%$	$\widetilde{w} = 120\%$	$\delta_k = 0.5$	$\delta_B = 0.6$
$\phi_i = 0.8$	$\phi_p = 1.2$	$\rho^p = 0.5$	$\xi_p = 0.75$	$Markup_p = 1.05$
$s_{gov} = 0.5$	$\eta = 0.5$	$\bar{r} = 6.4\%$	$\beta = 0.986$	$v = 5$
$\overline{m} = 3.2853$		$\gamma = 79.7963$		$w^b = 502.9814$
$d_{F^b} = 9.5996$	$d_{F^l} = 12.2114$	$d_f = 0.0454$	$d_\delta = 3.6418$	

C. *Impulse response functions*

Figure 2: Capital requirement shock

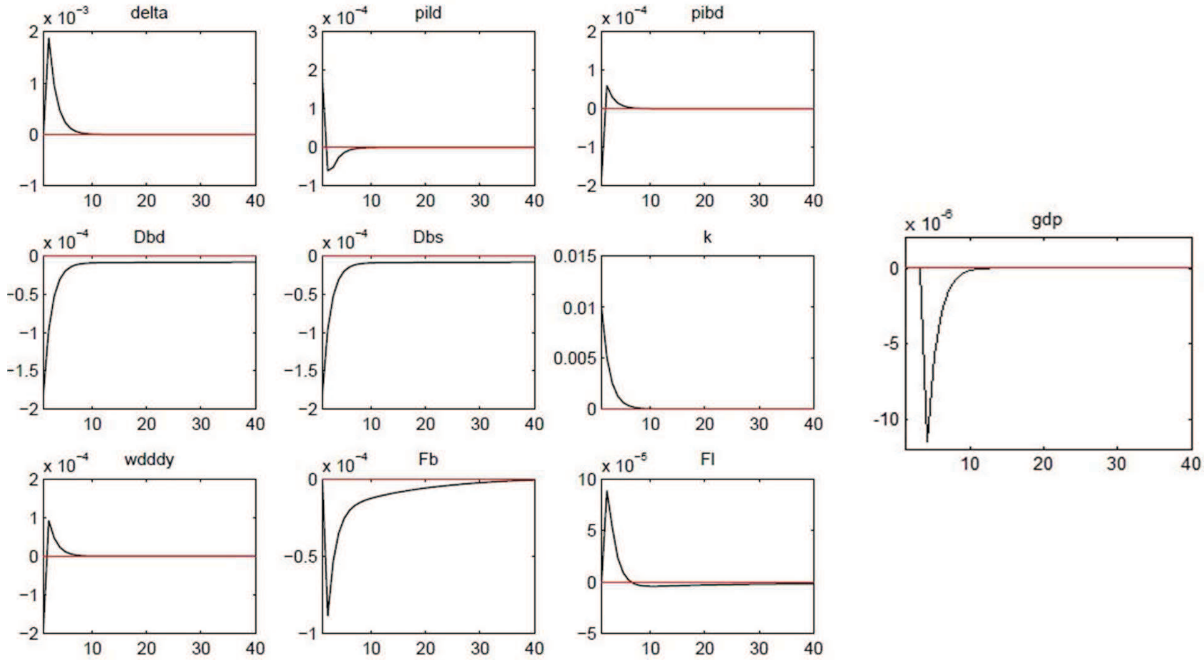


Figure 3: Liquidity requirement shock

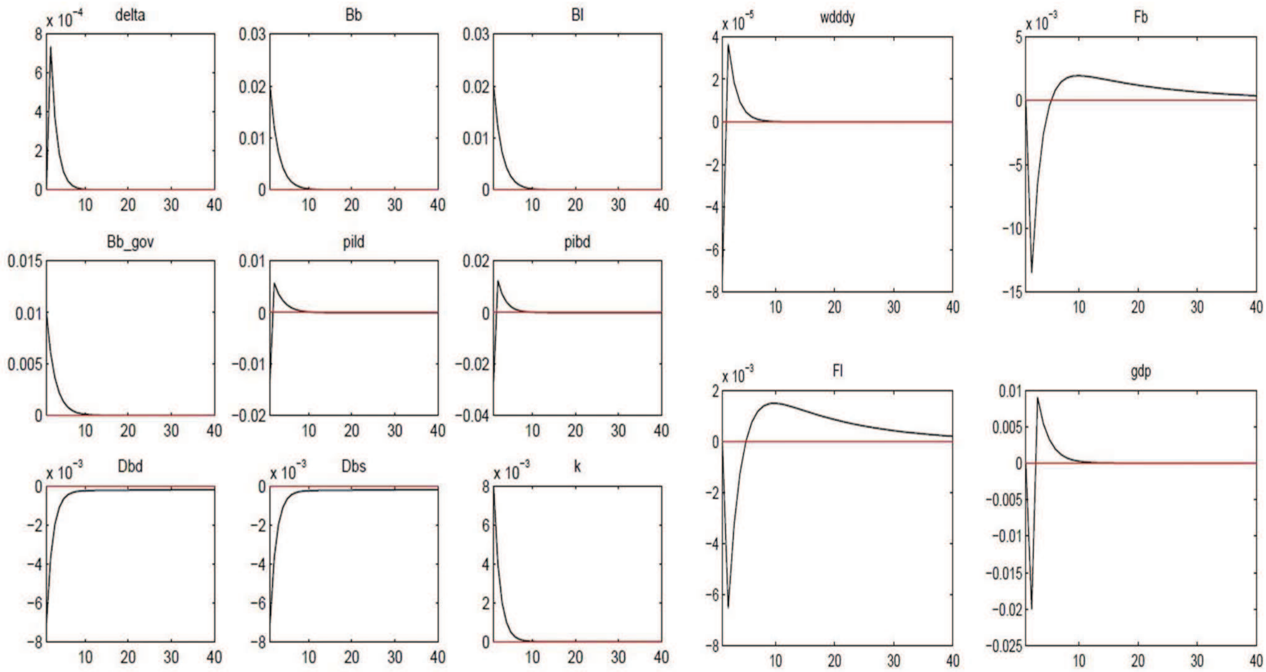
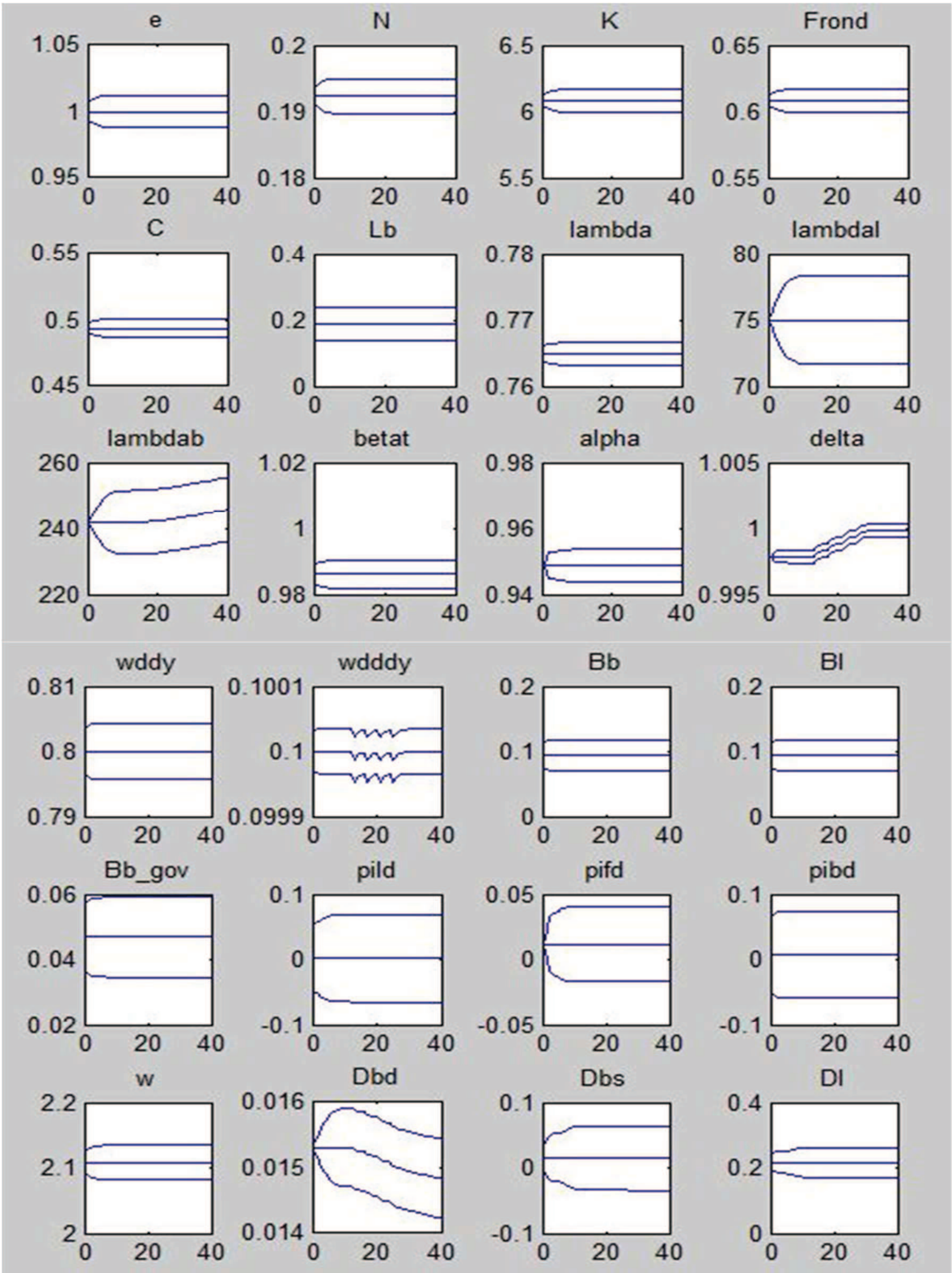
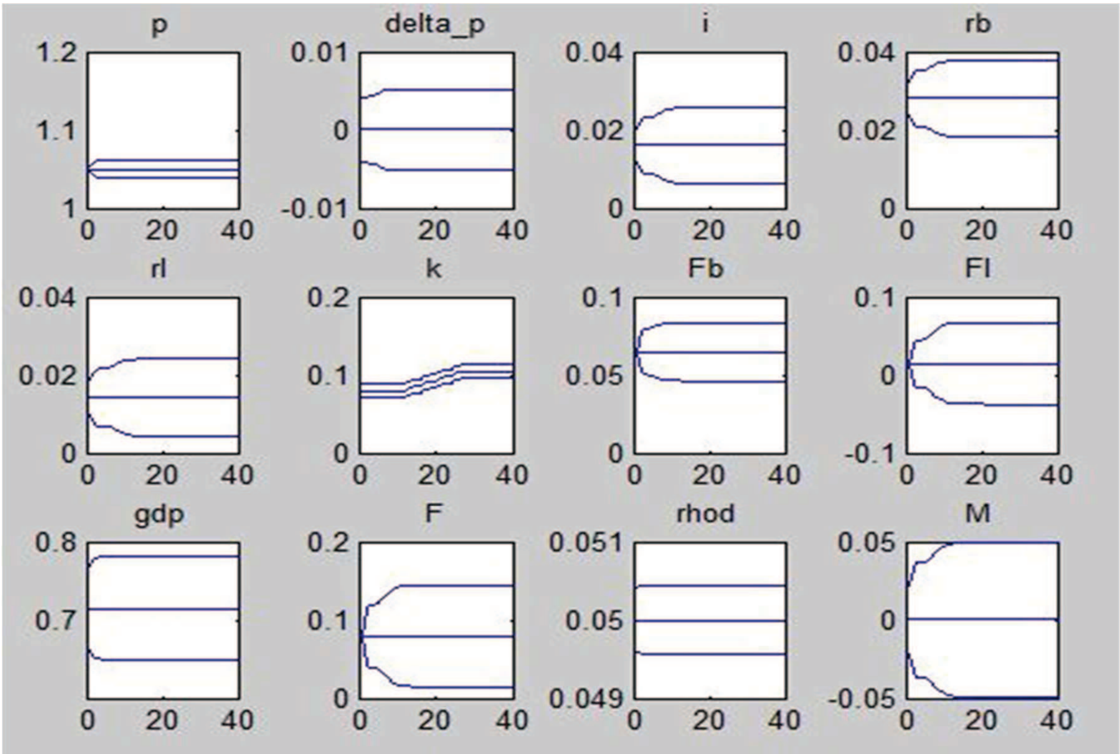


Figure 4: Forecast




p
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delta_p
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Fb
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gdp
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rhod
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M
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D. Estimation results

Figure 4: Prior and posterior distributions

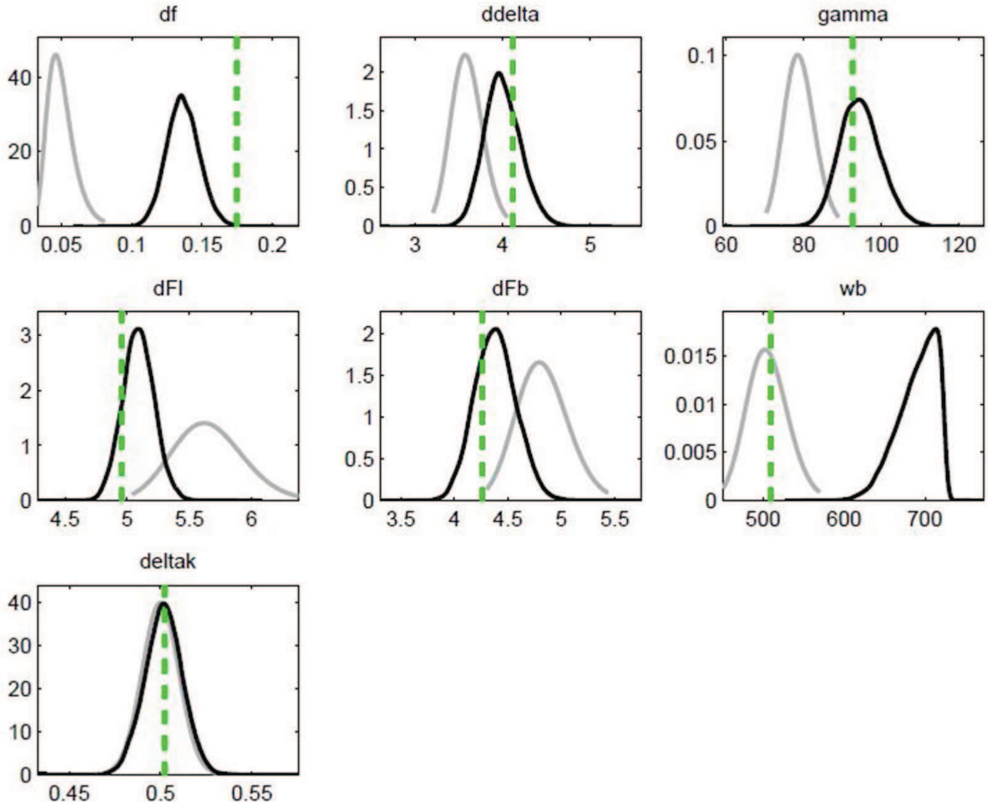
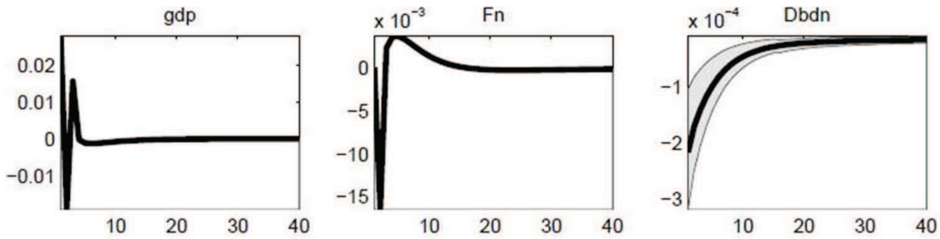
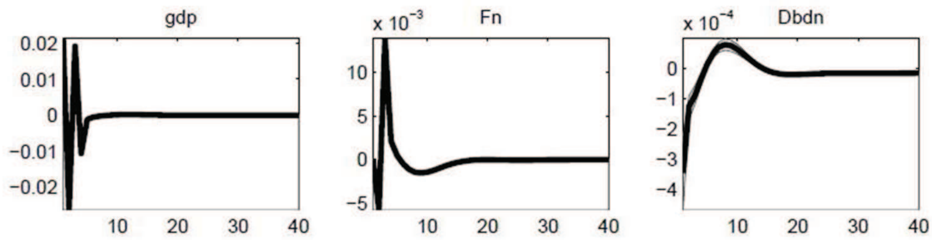


Figure 5: Bayesian IRF

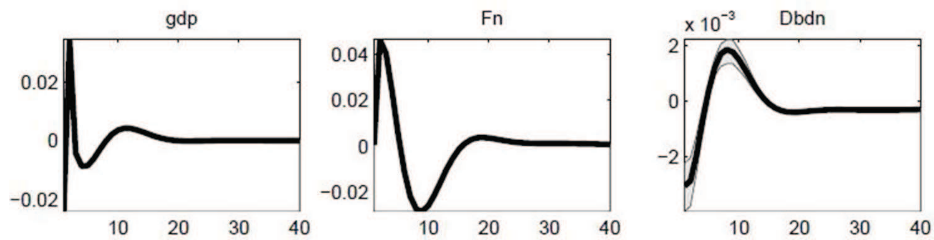
- Total factor productivity shock



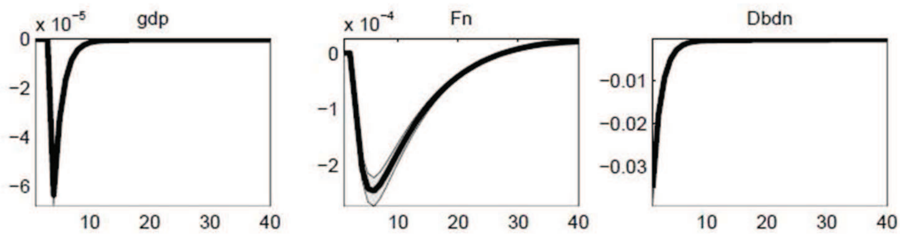
- Intermediate production shock



- Final production price shock



- Capital requirement shock



- Liquidity requirement shock