NBG Working Papers

WP 03/2020

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Cash Flow at Risk Assessment for the Banking Sector of Georgia*

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July 2020

Abstract

The aim of our study is to estimate the distribution of the profitability of the Georgian banking sector, in order to determine liquidity risk, for which we use Cash Flow at Risk (CFaR). In our estimation, we took into account possible nonlinear impact of monetary policy on banks' profit, which allows us also to estimate the neutral interest rate. According to our results, the relationship between bank profits on the one hand and short- and long-term interest rates on another is nonlinear indeed. In addition to median estimates, we also use quantile regression, which allows us to estimate tail risks. According to the results in a "normal" (median) situation, when interest rates are below neutral rate, decreasing policy rate reduces banks' profits, while if banks suffer from low liquidity (on a lower percentile), reduction of policy rate increases banks' profits. According to the quantile regression output, the relationship between bank profitability and yield curve is asymmetric. The results also show the dependence of bank liquidity risk on other macro variables. Estimates are made for the entire banking sector as well as for the two largest banks in Georgia.

JEL Codes: C21 C53, E52, G21.

Keywords: Quantile regression; Forecasting; Monetary policy; Bank profitability; CFaR

[*] We would like to thank Macroeconomics and Statistics Department at the NBG for their feedback. All errors and omissions remain with the authors.

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1 Introduction

The ability of a bank to meet its obligations without unexpected losses is determined by its liquidity. Liquidity management is a daily activity undertaken by banks, which involves cash flow monitoring and forecasting to maintain adequate liquidity. Maintaining this balance is very important, as depositors may require their obligations to be met when the bank in question cannot fully hand out the cash.

One of the causes of the Global Financial Crisis of 2008 was the shortage of liquidity, which, among many other factors, can be caused by the low-interest financing rate. When interest rates are low for a long time, banks take more risks (Gambacorta, 2009[i]). In the short run, low interest rates decrease the probability of default, but in the medium run, higher value of collateral and the search for yield lead to riskier lending by banks (loosening of lending standards). Increased credit risk threatens operating cash inflows (interest income). Increased credit risk is a danger to operating cash inflows (interest income). On the aggregate level, when interest rates are very low, the bank's resilience to liquidity risk decreases in the medium run.

In this paper, we empirically estimate the drivers of liquidity risk using the Georgian data of banks' cash flows (or profitability). More generally, the profitability of the banking system is an important factor for financial stability. The IMF working paper (Xu, Hu, and Das, 2019[ii]) describes this relationship, building a theoretical model and estimating it using the panel data. In particular, the relationship between systemic and idiosyncratic risks and the bank's profitability is quantitatively assessed. The authors conclude that, as profit is crucial to financial stability, it is important to determine the source of risks to banks' profits when making policy decisions and assess how risky the source of that profit is. This means identifying whether the profit comes from non-interest income, leverage or large-scale funding sources.

Reflecting the past developments in the financial markets and in the wake of the 2007-09 crisis, the Basel Committee has updated its Liquidity Risk Supervision and Management Regulations - "Liquidity Risk Management and Supervision". This document focuses on 5 key parts and 17 principles for liquidity risk management and supervision. Unlike in the early 2000s, since 2008, banks have been required to have sufficient liquidity in the form of high-quality liquid assets (see BCBS, 2008[iii]). Supervisors will also be required to take immediate action if banks face any difficulties. A bank must clearly formulate its liquidity risk tolerance to be consistent with its business strategy and role in the financial system, and must be able to handle stress in line with its liquidity risk tolerance[1]. To establish a credible process for determining, measuring, and monitoring liquidity risk, a bank must first develop an approach to plan cash flows.

Intraday bank liquidity risk management is one of the new and important approaches. By monitoring liquidity risk during the day, banks should ensure that payments and settlement obligations are met

[1] Basel committee introduced the liquidity tolerance term.

in a timely manner, in both normal and stressful environments. Banks will be required to conduct stress tests regularly to identify sources of liquidity risk and confirm that current risks are consistent with those identified in prior. Stress test results should be used to adjust the bank's liquidity management strategy, policy and position and develop an effective contingency plan.

An important notion for liquidity risk management is the Cash Flow at Risk (CFaR). The CFaR identifies the risk of loss, which implies a maximum loss of cash with a certain confidence level (mostly 5%). It represents a company's liquidity risk using a single number (determined by appropriate probability). In other words, it shows the maximum loss of cash flow with a specified probability. Risk is an asymmetric phenomenon. As various papers show (e.g. Kahneman and Tversky, 1979[iv]), people are more likely to respond to negative incentives than to positive stimuli. Therefore, when estimating the risk of loss, it is important to determine its probability distribution, as it should reflect this asymmetry.

When looking at this issue, cash flow to a bank is classified as an operating, investment or financial activity. Cash flow statement which uses this principle to sort cash flows, is a good indicator of a bank's financial soundness (Klumpes et al, 2009[v]). However, earning before taxes is usually used for such an analysis, and in this paper, we will also use this measure.

Cash Flow at Risk (CFaR) – unlike VaR, which determines market risk by predicting changes in the value of assets or an entire portfolio – is a measure of cash flow fluctuations over a certain period. An advantage of the CFaR method is the argument that the change in asset value (as seen in VaR) does not fully reflect cash flow fluctuations, which is very important for liquidity. CFaR shows exact maximum loss in cash flow with a certain degree of probability.

This approach was first developed for nonfinancial firms (Stein et al, 2001[vi]), where authors used cash flow to measure income (EBITDA - earnings before interest, taxes, depreciation and amortization) over assets. For the banking sector, mostly, the bank's profit is estimated via taking various determinants into account. However, with the aforementioned estimated relationship, it is already possible to assess the cash flow at risk.

As noted above, here we estimate risks to bank profit using different determinants for the economy of Georgia. As the monetary policy is one of the major determinants of banks' cash flows, we calculate the neutral interest rate based on the estimated relationship; as the results show, there is a nonlinear relationship between bank profits on the one hand and short and long term interest rates on another. Thus, when monetary policy is close to a neutral interest rate, policy rate increases have no significant impact on banks' earnings, but when it is too high, its additional hike reduces banks' profits (possibly due to lower demand for loans), while when it is too low, it reverting back to higher, more normal, levels increases profits (possibly due to interest margins un-squeezing). GEL depreciation has a negative effect on the banks' profits, which is explained by the deterioration of the quality of loans after depreciation (due to dollarization) and increase in importers' costs. Inflation has a positive effect on earnings, explained by increased demand for lending from firms and individuals due to rising prices. GDP growth has a positive effect on median estimates (as well as on all other quantile estimates as well).

More importantly, as noted, in addition to median estimates, we also use quantile regression, which allows us to take tail risks and elasticities of stress scenarios into account, in particular. According to the results in a "normal" (median) situation, when interest rates are below neutral rate, decreasing policy rate reduces banks' profits, while if banks suffer from low liquidity (on a lower percentile), reduction of policy rate now increases banks' profits. At the same time, on a lower percentile, GDP elasticity significantly decreases, while inflation elasticity changes and becomes negative. According to the quantile regression output, the relationship between bank profitability and yield curve is asymmetric.

The paper is organized as follows: the second part constitutes a review of the literature, covering the impact of monetary policy on bank cash flows and bank sector profitability estimates for other countries. The third part briefly outlines an econometric approach that includes quantile regression and empirical results. The last chapter sums up the conclusions, while the appendices provide technical details.

2 Literature review

2.1 Impact of monetary policy on bank profits

Monetary policy is one of the major determinants of banks' cash flows, and given its nonlinear nature, we must discuss this effect separately. Monetary policy can be characterized by short-term interest rates and yield curve. It has a significant impact on interest rate term structure: a central bank directly determines short-term interest rate, while also influencing long-term rates by affecting the market participants' expectations of short-term rate and trading long-term securities.

The literature does not clearly identify the effects of a monetary policy on bank profits, as there are several channels of influence that may operate in opposite directions and the significance of each one depends on the situation. Table 1 presents an incomplete list of papers assessing the impact of monetary policy on banks' profit.

Table 1. Literature on monetary policy impact on banks' profit (Zimmermann K., 2017[vii])

Author	**Influence**	**Period**
Hancock (1985)	Positive	1973-78 (18 banks, USA)
Demirgüç-Kunt and Huizinga (1999)	Positive	1988-95 (80 Countries)

English (2002)	Ambiguous	1979-01 (10 OECD countries)
Borio et al. (2015)	Positive	1995-12 (109 banks)
Busch and Memmel (2015)	Negative - SR; Positive - LR	1968-13 (Germany)
Alessandri and Nelson (2015)	Negative - SR; Positive - LR	1992-09 (44 banks, the UK)
Sääskilahti (2016)	Positive	2005-14 (181 banks, Finland)
Scheiber et al. (2016)	Does not influence	2007-16 (3 countries)
Claessens et al. (2017)	Positive	2005-13 (3385 banks)
English et al. (2012)	Negative	1997-2007 (355 banks, USA)
Aharony et al. (1986)	Negative	73 banks, USA

Note: SR - short-term rate; LR - Long-term rate.

According to a study by Zimmerman (2019)[viii], the impact of a monetary policy on banks is state-dependent. Profit elasticity (sensitivity) to the monetary policy rate depends on the share of deposits in the bank's liabilities and the share of mortgages in total loans. In particular, the author estimates that, an increase in the interest rate has a negative effect on the bank's profit when the share of mortgage loans is high, which is explained by the long-term character of these types of loans and the reduction in the slope of the yield curve. The high share of deposits reduces this effect.

Kohlscheen et al. (2018)[ix] discusses the key determinants of bank profitability in 19 emerging countries based on 534 bank balance sheets. According to the results, higher long-term interest rates increase profitability, while higher short-term interest rates decrease profits due to raising funding costs. They also find that, in normal times, credit growth is more important for profitability than GDP growth. This implies that financial cycles predict bank profits more accurately than business cycles. They also show that the increase in sovereign risk premium reduces bank profit, emphasizing that credible fiscal framework that promotes financial stability is crucial to bank profit. English (2012)[x] describes monetary policy impact and direction as ambiguous.

Ampudia et al. (2019)[xi] describes nonlinear impact of a monetary policy on banking sector, discussing the relationship between European bank equity value and interest rates in different periods. Under low, but positive, interest rates, unexpected negative changes in interest rates will have a positive impact on bank stock prices during a "normal" (pre-crisis) period, and this effect is stronger during a crisis. This impact changes direction during the period of negative interest rates (after the crisis) - an unexpected decrease of monetary policy rate reduces bank stock prices. This reversal is stronger for banks that rely more on deposit funding.

For predicting profitability of the banking sector as whole and two large banks of Georgia, we rest our analysis on Borio et al. (2015)[xii]. This paper differs from others and presents a nonlinear impact of a monetary policy on bank profit, based on a theoretical model. Authors use data from 109 banks in 14 developed countries for 1995-2012. According to the results, there is usually a positive relationship between bank profitability and the level of the short-term interest rates and the slope of a yield curve. This implies that the positive impact of interest rates on net interest income outweighs the negative one. The negative effect is an increase in loan loss provisions and a decrease in non-interest income. According to the study, this relationship is nonlinear and the nonlinearity is stronger at lower interest rates. As a result, if interest rates are already high, then their additional growth will no longer increase bank profitability and may even reduce it after a certain point.

This paper describes four key mechanisms for transferring interest rate impact on bank profits. These include a „retail deposits endowment effect ", a „capital endowment effect ", a „quantity effect "(that compensates price effect – or interest rate effect) and the dynamic effect of the transition between equilibria, which also includes the revaluation lags and credit loss accounts.

The retail deposits endowment effect implies that the rate on deposits is lower than the market interest rate, which can be explained by the banking sector's oligopolistic structure and transaction benefits. The tightening of a monetary policy will increase bank interest income, as the lending rates increase more than deposit rates (on current accounts), according to Drechsler et al. (2018)[xiii], who argues that during maturity transformation, banks have less interest rate risk. The deposits endowment effect was a major source of income in times of high inflation, when competition between banks and the banking and non-banking sectors was low (the 1970s). In the post-crisis period, when interest rates were very low, deposit rates could not drop to zero, and interest rates on deposits would only change slightly when interest rates fell (Borio et al, 2015).

As for the "capital endowment effect", it is the special case of the deposit effect. No interest is paid on equity capital. Therefore, when interest rates fall, the return on assets (which is covered by capital) decreases. Quantitatively, this effect is smaller than in case of deposits, since capital is a small share of the total assets.

The change in market interest rates also has a quantitative effect, which means an impact on the number of bank loans and deposits. Elasticity of demand on loans is higher than elasticity on deposits. Consequently, when interest rates rise sufficiently, it is possible to reduce the volume of loans and hence deposits. Therefore, above a certain interest rate, the bank's interest income will start to decline. This value is determined by the elasticities of demand for loans and for deposits toward interest rates in the general equilibrium (a description of the relevant small model is presented in the appendix of Borio et al, 2015).

The slope of the yield curve is one of the determinants of interest income of banks. In particular, steep curve has a positive effect on interest income. However, part of this income is temporary. This is explained by the fact that if all bank's liabilities are issued at market rates, then the only component that will make a profit is term premium. After some time, market interest rates will be equal to forward rates. This means that a negative term premium, which may also be the result of a quantitative easing policy, is a loss for the bank's profit.

The change in the slope of the yield curve also has a quantitative effect. In particular, the demand for a mortgage is more elastic towards the change of the slope than the demand for medium-term deposits. It has to be mentioned, that after a point, an increase in slope results in a decrease in bank profit. This point is determined by the elasticities of loans demanded and deposits supplied to the market rates in general equilibrium.

As for interest rates and non-interest income, there is no direct link between them. However, higher interest rates are likely to result in lower non-interest income and offset the positive effect discussed above. The non-interest income includes three main variables: the effect of securities valuation, hedging by derivatives, and commissions and fees.

The effect of securities valuation implies decrease in the price of a bank's securities portfolio due to the increase in interest rates. As for profit / loss accounting, it depends on accounting conventions. The loss is directly reflected in the income statement if the securities are adjusted for market value, will move into equity and have an impact when sold. This effect is temporary and is associated with the changes in interest rate.

Interest rate risk hedging is very important for the bank that is implemented through interest rate swaps. As a rule, banks 'liabilities are shorter than assets' and have a smaller revaluation interval. The bank pays a fixed rate and receives a floating rate. When the interest rates and the slope of the yield curve increases lead to an increase in earnings (which depends on the floating rate), which reinforces the income effect on the interest rate margin. However, in fact hedging is only partial.

Fees and charges represent more than a half of total non-interest income (credit lines, transactions services). It is difficult to explain the effect of interest rates on it, although it is easy to see that the increase in interest rates reduces this component of income because of the reduction in loans. It follows, that the relationship between interest rate and bank profit is neither straightforward nor linear. Different channels of transmission are more important in different conditions. Thus, to estimate this non-linear relationship is of great interest to both financial supervision and commercial banks themselves.

2.2 CFaR estimates for other countries

Cash Flow at Risk (CFaR) defines a risk of loss, which implies a maximum loss of cash with a certain significance level. This indicator has been applied to industrial enterprises since the 1990s

(Oxelheim, Wihlborg, 1987[xiv]). Different approaches have been refined over the years (there were top down, bottom up). Andren et al (2005) study presents a risk-based cash flow at risk model. This approach was used to assess the liquidity risk of the Norwegian company Norsk Hydro, taking the variability of cash flows into account in accordance with different changes in risk.

In the working paper "Estimating Liquidity Risk Using the Exposure-Based Cash-Flow-at-Risk Approach: An Application to the UK Banking Sector" Yan et al (2013) applied this approach to assesses the cash flow at risk of the banking sector of the United Kingdom.

The fluctuations of banks' cash flow depend on the banks' savings / investment activity and on the changes in interest rates. Consequently, interest rates on 3-month interbank loans and interest rates on 10-year Treasury bills are identified as a risk factor. The index of asset price volatility and European swap spreads are used to describe the capital and derivatives markets, as banks have options and swaps in their asset portfolio. In addition, the United Kingdom Securities Index (UB) and the US Asset-Backed Securities Index (ABS) are used for reflecting the derivatives market risk. The market liquidity index (LQ) and repo spreads (Repo spreads – the difference between yields on three-month Gilt Repos and on three-month UK treasury bills) are used to represent funding opportunity. For exchange rate risks, the British pound exchange rates towards the US dollar and euro are included. The risks for banks may also arise from the local macroeconomic situation, for which inflation and GDP growth are the banks' macroeconomic risk determinants. Totally they use eleven factors: short-term interest rate, long-term interest rate, securities market index (UB), asset price volatility index, European swaps spread, market liquidity index, repo spread, exchange rates with EUR and USD, inflation and real GDP Growth. Due to the high correlation with other variables, the US Securities Index (ABS) is no longer used. According to the results, the aggregate increase in the short-term interest rates on the banking sector will have a positive effect, while the long-term interest rate impact is significant for some banks only; asset price fluctuations and swaps spread with the EU countries have a negative effect, while the increase in the securities market index positively affects banks' profit growth. The assessment of the distribution of cash flow at risk is the main novelty, as it represents valuable information about additional risks and helps improve the management of liquidity risk.

3 Econometric approach / the model

To estimate the nonlinear linkages described above and forecast a profit of the banking sector of Georgia, we use the Borio et al (2015) methodology, applying the following equation (a brief description of the theoretical model that follows this article is shown in Appendix 1):

$$Y_t = \delta Y_{t-1} + a_0 r_t + a_1 r_t^2 + \beta_0 \theta_t + \beta_1 \theta_t^2 + \gamma \sigma_t + \varphi c_t + \varepsilon_t$$

Where: Y_t denotes bank's profit; r_t - interbank short-term loan rate; θ_t- the slope of the yield curve; σ_t – variance of the interbank loan rate (to describe uncertainty of financial conditions); c_t - includes macroeconomic indicators, such as GDP growth, inflation, and nominal exchange rate depreciation (GEL / USD). Square terms are introduced to signify nonlinear linkages. We used a quantile regression method for a more in-depth evaluation of the relationship (Koenker and Bassett, 1978[xv]).

3.1 Quantile regression

Quantile regression is used to estimate the conditional quantile function. Unlike the least squares method, which minimizes the sum of squared residuals and estimates the conditional mean function, quantile regression estimates conditional quantile function. As Mosteller and Tukey (1977)[xvi] note, just like the mean gives us an incomplete picture of the distribution, so does the regression curve gives correspondingly incomplete picture of the entire distribution.

The standard least squares method links the explanatory and dependent variables with the conditional expectation (mean) function. However, it is also interesting to observe what the relationship in this function looks like at different points of the conditional distribution of the variable. Quantile regression is used for this very purpose.

The slope of the median observation regression was initially estimated in 1760 (Ruđer Josip Bošković) and used to determine the length of the Earth's equator. It was developed before the least squares method (1805). Subsequently, a quantile regression analysis was developed in 1978[xvii] to estimate the quantile conditional function - a model where the quantile conditional distribution of the dependent variable is described as a function of the explanatory variable. In other words, quantile regression can explain heterogeneous dependence.

Quantile level is the probability (or proportion of the population) associated with the quantile. The quintile is often denoted by the Greek τ letter, and the conditional quantile of the corresponding Y is denoted by $Q_Y(\tau|X)$. The quintile level is the probability $\Pr[Y \leq Q_Y(\tau|X)|X]$ and the quintile is the value of Y below that the population proportion is τ. In the quantile regression, we estimate the β_τ coefficients by minimizing the absolute value of the quantile-weighted residuals:

$$\widehat{\beta_\tau} = arrgmin_{\beta_\tau \in \mathbb{R}} \sum_{t=1}^{T-h} (\tau \mathbb{I}_{(y_{t+h} \geq x_t \beta)} |y_{t+h} - x_t \beta_\tau| + (1-\tau) \mathbb{I}_{(y_{t+h} < x_t \beta)} |y_{t+h} - x_t \beta_\tau|)$$

$\mathbb{I}_{(.)}$ is an “indicator function”. The value defined by the regression is the quantile of y_{t+h} conditional on x_t:

$$\hat{Q}_{y_{t+h|}|x_t}(\tau|x_t) = x_t \hat{\beta}_\tau$$

It is possible to show that $\hat{Q}_{y_{t+h|}|x_t}$ is a consistent linear estimation of the quantile of the function y_{t+h}. The quantile regression differs from the least squares method by two major properties: it minimizes the absolute value of the residuals, and takes different weights for the different quantiles, depending on whether the residual is above or below the quantile. In the least squares estimation the mean $E(Y|X)$ is not invariant to the monotonic transformation of the data, while applying quantile regression $Q_Y(\tau|X)$ is invariant to the monotonic transformation. The least squares method is sensitive to extreme values, while the quantile regression is stable.

3.2 Empirical results

In our estimations we use real GDP, consumer price index, nominal exchange rate GEL/USD, interest rate on Tbilisi interbank loans (up to 7 days), slope of the yield curve (as long-term interest rate proxy), short-term interest rate fluctuations (as indicator for financial uncertainty) and total bank assets. The data is a monthly frequency for 2013-2018. We use banks' net profit before taxes as a measure of profitability. The results obtained via the least squares method are presented in Table 2, while the results obtained by the quantile regression are presented in Table 3 and Figure 1.

According to the results (Table 2), the banking sector's profitability is positively affected by the short-term and long-term interest rates, although this relationship is nonlinear (concave). In particular, when the monetary policy rate is low, the increase in the rates increases the banks' profits. When monetary policy is close to neutral, the policy rate increase has no significant impact on bank profits, and when it is high enough, additional growth reduces bank profits. Thus, we can determine the neutral interest rate – the breakeven point at which positive impact changes to negative is within the 6% range.

Exchange rate depreciation has a negative effect on bank's profit, which is explained by the reduction in loans due to dollarization and the possible increase in importers' expenses. The negative relationship between the exchange rate and bank's cash flow appears not only in the median estimation but in other percentiles as well (Table 3). Inflation increases bank's operating costs, but rising prices also increases revenues for banks as a result of increased demand for lending from firms and individuals. Overall, a 1 percentage point increase in inflation will boost the bank's annual profit by 1.4%. Real GDP growth has a positive effect on bank assets and profitability. According to our estimations, the growth positively affects profitability using the median and all other percentiles estimations as well. The profit is the most elastic in response to the interest rate on interbank lending rate and least elastic to the exchange rate depreciation.

As mentioned above, we present the median estimates of elasticities as well as quantile regression results. Applying the elasticities from the quantile regression enables us to assess the impact of explanatory variables on profitability on different percentiles. This allows us to take the tail risks and the respective elasticities into account, in particular during the times of stress.

The total assets are statistically significant on low percentile (10%), while for percentile above 20% - the short-term and long-term interest rates and their quadratic values, the real GDP growth and the depreciation in nominal exchange rate are statistically significant explanatory variables. At a low percentile, the profitability of the banking system is convex towards the short-term interest rate and the slope of the yield curve, while this function is concave in case of median estimates. This means that under normal (median) conditions, decreasing the interest rate below the neutral level reduces banks' profits, while during liquidity shortage periods (at a lower percentile), decreasing the interest rate below the neutral level actually increases bank profits, on average.

At the same time, at the lower percentile the elasticity to GDP significantly decreases, while the elasticity to inflation changes and becomes negative. According to the symmetry test, the relationship between bank profitability and yield curve is asymmetric (Table 6), which is also apparent from quantile results.

The estimations for two different banks, the results of the quantile regression of the Bank of Georgia (Table 4 and Figure 2) and TBC Bank (Table 5 and Figure 3) are similar to the results for overall banking sector, with one significant difference. For example, at a low percentile the profit of the Bank of Georgia retains concave with respect to the short-term interest rate and the slope of the yield curve - like a median estimate. This means that during liquidity stress, while the stimulus from the central bank increases the profitability of the banking sector, it decreases the profit of that particular bank. The reason may be that, there is less risk of a big outflow of deposits from a systemically important bank and, as a result, the necessity of the liquidity supply from the central bank is lower. This relationship, however, is not entirely constant on the different percentiles. As shown in Table 7, there is an asymmetric relationship between the Bank of Georgia's profit on one hand and the slope of yield curve and the short-term interest rate on the other. According to the estimation results for TBC Bank, its profit is asymmetric with respect to long-term and short-term interest rates (Table 8).

In conclusion, we show the estimations of the banks' profits for different quintiles. Figure 4 presents the estimated profit of the banking sector by the least squares method and quantile regressions for 10^{th} and 90^{th} percentiles. Given the asymmetric nature of banks' profits, it is very important to evaluate the links on low percentile. It gives the possibility to design liquidity management plan based on the evaluations on low percentiles and ensures sustainability of this plan towards liquidity shocks with some confidence level (90% in our case).

4 Conclusion

In this study, we evaluate the profitability of the banking system for Georgia; we took into account the non-linear impact of monetary policy and thus we were able to estimate a neutral interest rate; applying the quantile regression estimation enabled us to assess the impact of systemic risk and different stress scenarios. In particular, we evaluated the profit of the banking system as a function of interest rates and macroeconomic variables, taking the nonlinear relationship of dependent variable with the interest rates into account. In addition to the median estimates, we used quantile regression method, which allowed us to take tail risks and therefore elasticities in stress scenarios into account. In the "normal" (median) conditions, below the neutral rate, decrease in interest rate reduces banks' profits; while during the liquidity shortages (at a lower percentile) below the neutral rate, decrease in interest rate increases banks' profits. In addition, at the lower percentile the elasticity to GDP decreased significantly, while the elasticity to inflation changed and became negative. According to the symmetry test, the relationship between bank profitability and yield curve is asymmetric (table 6), which is also apparent from quantile results.

As for individual banks, from the results of the estimated equation for the Bank of Georgia, the monetary policy impact is nonlinear and the neutral interest rate is in the range of 5.3-6%. For the TBC Bank, profit depends on the short-term interest rate, and this impact is positive. While the long-term interest rate has a nonlinear effect. We hope that the approach presented here will help banks to assess liquidity risk and manage liquidity more easily. However, a short data remains the key obstacle and may lead to some inaccuracies in the presented estimates.

Appendix 1 - tables and figures

Table 2. Estimation of the banking sector profitability, least squares method

Dependent Variable: Profit (EBITDA)				
Method: Least Squares				
Date: 10/19/18 Time: 16:17				
Sample (adjusted): 2013M01 2018M08				
Included observations: 68 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
θ	15.81	14.02	1.13	0.26
θ^2	-1.22	1.09	-1.12	0.27
Short-term rate	32.65	23.56	1.39	0.17
Short-term rate ^2	-2.88	2.01	-1.44	0.16
SD-Short-term rate	9.24	16.50	0.56	0.58
Log of Total Assets	57.71	28.15	2.05	0.05
GDP growth	3.32	1.58	2.09	0.04
Inflation(-1)	1.43	2.05	0.70	0.49
Ex Rate dep	-0.96	0.37	-2.64	0.01
R-squared	0.64	Mean dependent var		59.83
Adjusted R-squared	0.56	S.D. dependent var		33.97
S.E. of regression	22.55	Akaike info criterion		9.25
Sum squared resid	27464.65	Schwarz criterion		9.71
Log likelihood	-300.53	Hannan-Quinn criter.		9.43
F-statistic	7.54	Durbin-Watson stat		2.26
Prob(F-statistic)	0.00			

Table 3. Banking profitability estimates by quantile regression

	Quantile	Coefficient	Std. Error	t-Statistic	Prob.
θ	0.1	-7.9	20.0	-0.4	0.7
	0.2	0.0	21.0	0.0	1.0
	0.4	24.8	19.8	1.2	0.2
	0.6	31.3	18.2	1.7	0.1
	0.8	25.0	26.5	0.9	0.4
θ ^2	0.1	0.4	1.6	0.2	0.8
	0.2	-0.2	1.7	-0.1	0.9
	0.4	-1.9	1.5	-1.2	0.2
	0.6	-2.1	1.4	-1.5	0.1
	0.8	-2.1	2.1	-1.0	0.3
Short-term rate	0.1	-18.1	28.3	-0.6	0.5
	0.2	-10.5	33.7	-0.3	0.8
	0.4	40.3	30.8	1.3	0.2
	0.6	30.6	32.3	0.9	0.3
	0.8	29.9	52.8	0.6	0.6
Short-term rate ^2	0.1	1.2	2.3	0.5	0.6
	0.2	0.3	2.7	0.1	0.9
	0.4	-3.4	2.6	-1.3	0.2
	0.6	-2.2	2.8	-0.8	0.4
	0.8	-3.0	5.0	-0.6	0.5
SD-Short-term rate	0.1	-0.1	13.7	0.0	1.0
	0.2	6.1	15.9	0.4	0.7
	0.4	6.2	19.4	0.3	0.8
	0.6	-4.2	21.1	-0.2	0.8

	0.8	18.2	30.0	0.6	0.5
Log of Total Assets	0.1	42.5	25.9	1.6	0.1
	0.2	55.2	28.4	1.9	0.1
	0.4	66.0	33.0	2.0	0.1
	0.6	75.2	34.2	2.2	0.0
	0.8	69.1	35.5	1.9	0.1
GDP growth	0.1	0.9	1.8	0.5	0.6
	0.2	2.1	1.8	1.1	0.3
	0.4	3.1	1.7	1.8	0.1
	0.6	3.2	1.7	2.0	0.1
	0.8	2.9	3.7	0.8	0.4
Inflation(-1)	0.1	-1.8	2.6	-0.7	0.5
	0.2	-1.4	3.0	-0.5	0.6
	0.4	0.9	2.5	0.3	0.7
	0.6	-0.1	2.4	0.0	1.0
	0.8	6.6	3.2	2.1	0.0
Ex Rate dep	0.1	-0.3	0.6	-0.4	0.7
	0.2	-0.3	0.7	-0.4	0.7
	0.4	-1.3	0.6	-2.1	0.0
	0.6	-1.3	0.4	-3.1	0.0
	0.8	-1.4	0.5	-2.9	0.0

Figure 1. Quantile regression coefficients (banking sector)

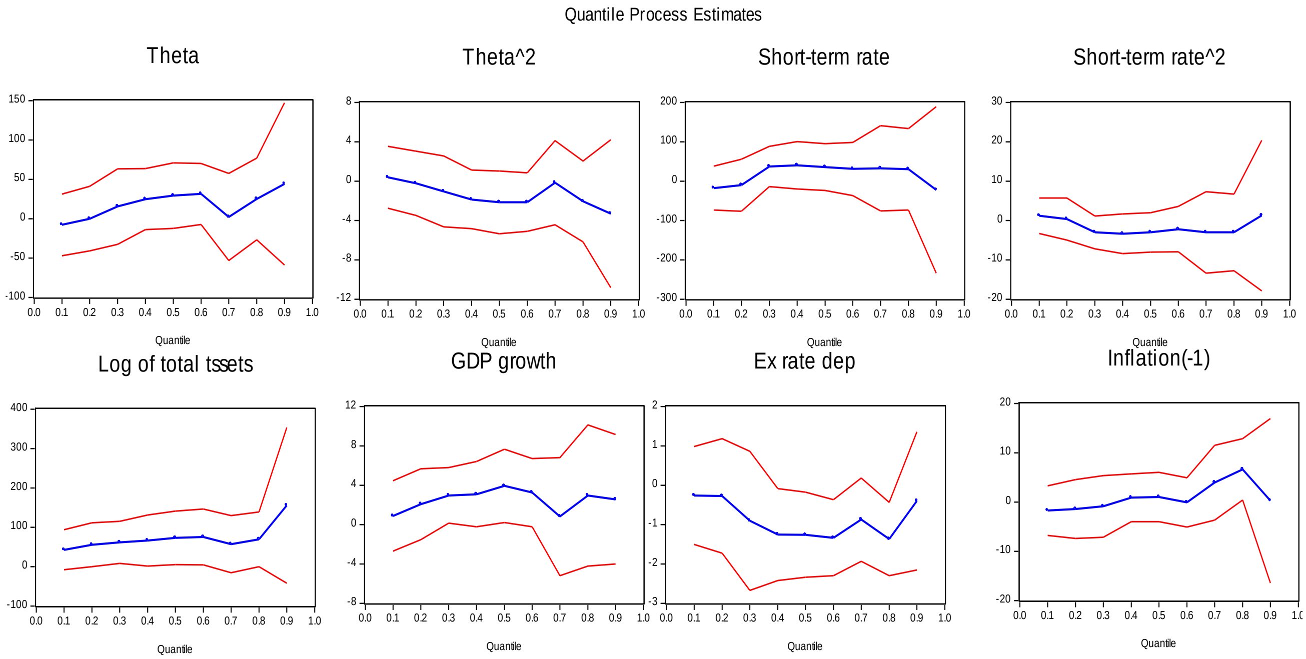


Table 4. Bank of Georgia, profit estimation, quantile regression coefficients

	Quantile	Coefficient	Std. Error	t-Statistic	Prob.
θ	0.2	2.7	16.3	0.2	0.9
	0.4	2.5	11.0	0.2	0.8
	0.5	4.2	9.7	0.4	0.7
	0.6	5.2	10.7	0.5	0.6
	0.8	15.0	10.2	1.5	0.1
θ ^2	0.2	-0.1	1.3	-0.1	0.9
	0.4	-0.2	0.8	-0.3	0.8
	0.5	-0.4	0.7	-0.6	0.6
	0.6	-0.5	0.8	-0.6	0.5
	0.8	-1.3	0.8	-1.6	0.1
Short-term rate	0.2	65.0	15.8	4.1	0.0

	0.4	34.7	17.9	1.9	0.1
	0.5	31.3	18.1	1.7	0.1
	0.6	29.2	20.2	1.4	0.2
	0.8	18.8	21.1	0.9	0.4
Short-term rate^2	0.2	-5.4	1.3	-4.1	0.0
	0.4	-3.0	1.5	-2.0	0.0
	0.5	-3.0	1.5	-1.9	0.1
	0.6	-2.8	1.8	-1.6	0.1
	0.8	-1.7	1.8	-0.9	0.4
SD-Short-term rate	0.2	11.8	13.3	0.9	0.4
	0.4	9.3	11.0	0.8	0.4
	0.5	17.1	10.3	1.7	0.1
	0.6	19.3	11.2	1.7	0.1
	0.8	4.3	10.4	0.4	0.7
Log of Total Assets	0.2	3.7	25.1	0.1	0.9
	0.4	8.6	24.2	0.4	0.7
	0.5	13.7	19.2	0.7	0.5
	0.6	12.9	18.3	0.7	0.5
	0.8	18.5	19.3	1.0	0.3
GDP growth	0.2	2.0	2.0	1.0	0.3
	0.4	1.3	0.9	1.4	0.2
	0.5	1.4	0.9	1.6	0.1
	0.6	1.4	0.9	1.6	0.1
	0.8	1.6	0.9	1.8	0.1
Inflation(-1)	0.2	2.3	1.9	1.2	0.2
	0.4	2.2	1.7	1.3	0.2

	0.5	3.4	1.4	2.4	0.0
	0.6	4.1	1.4	2.8	0.0
	0.8	2.8	1.4	2.0	0.0
Ex rate dep	0.2	-0.7	0.5	-1.3	0.2
	0.4	-0.3	0.3	-1.0	0.3
	0.5	-0.5	0.3	-2.0	0.0
	0.6	-0.6	0.2	-2.5	0.0
	0.8	-0.5	0.2	-2.7	0.0

Figure 2. Quantile regression coefficients, Bank of Georgia

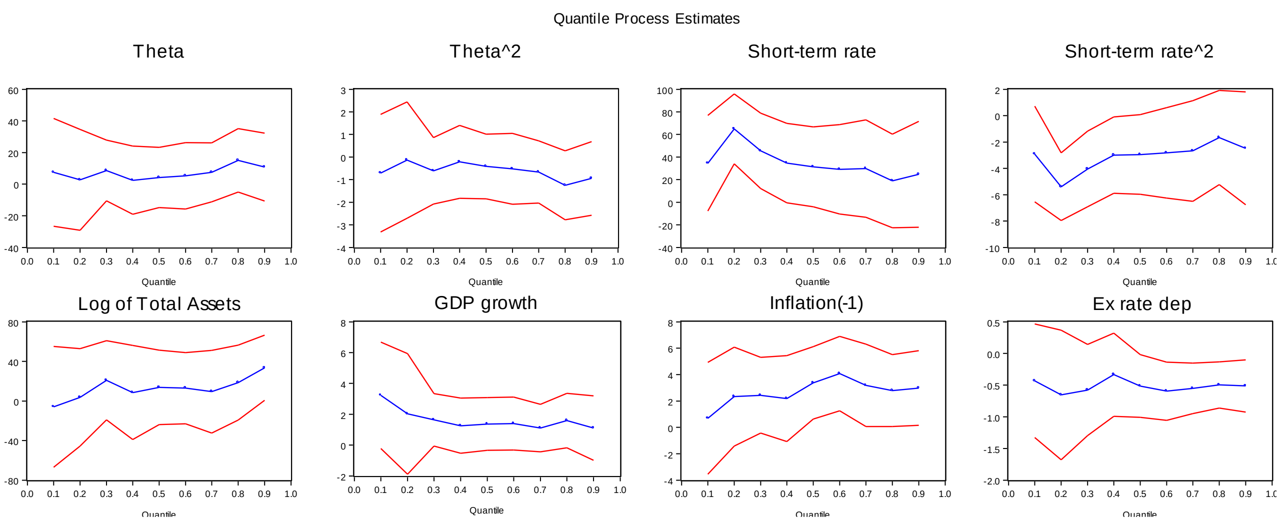


Table 5. TBC Bank, profit estimation, quantile regression coefficients

	Quantile	Coefficient	Std. Error	t-Statistic	Prob.
θ	0.2	-8.1	4.1	-2.0	0.1
	0.4	-4.8	3.2	-1.5	0.1
	0.5	-4.7	3.3	-1.4	0.2

	0.6	-2.8	3.4	-0.8	0.4
	0.8	0.3	3.2	0.1	0.9
θ ^2	0.2	0.7	0.4	1.8	0.1
	0.4	0.4	0.3	1.4	0.2
	0.5	0.4	0.3	1.3	0.2
	0.6	0.3	0.3	0.7	0.5
	0.8	-0.1	0.3	-0.2	0.8
Short-term rate	0.2	6.1	1.3	4.7	0.0
	0.4	5.6	1.0	5.7	0.0
	0.5	5.5	1.0	5.4	0.0
	0.6	5.1	1.0	4.9	0.0
	0.8	6.3	1.1	5.9	0.0
SD-Short-term rate	0.2	-12.0	5.0	-2.4	0.0
	0.4	-9.7	4.5	-2.2	0.0
	0.5	-9.2	4.5	-2.0	0.0
	0.6	-10.5	4.6	-2.3	0.0
	0.8	-21.4	5.3	-4.0	0.0
Ex rate dep	0.2	-0.1	0.3	-0.4	0.7
	0.4	-0.3	0.2	-1.6	0.1
	0.5	-0.2	0.2	-1.0	0.3
	0.6	-0.1	0.2	-0.6	0.5
	0.8	-0.1	0.2	-0.7	0.5

Figure 3. Quantile regression coefficients, TBC Bank

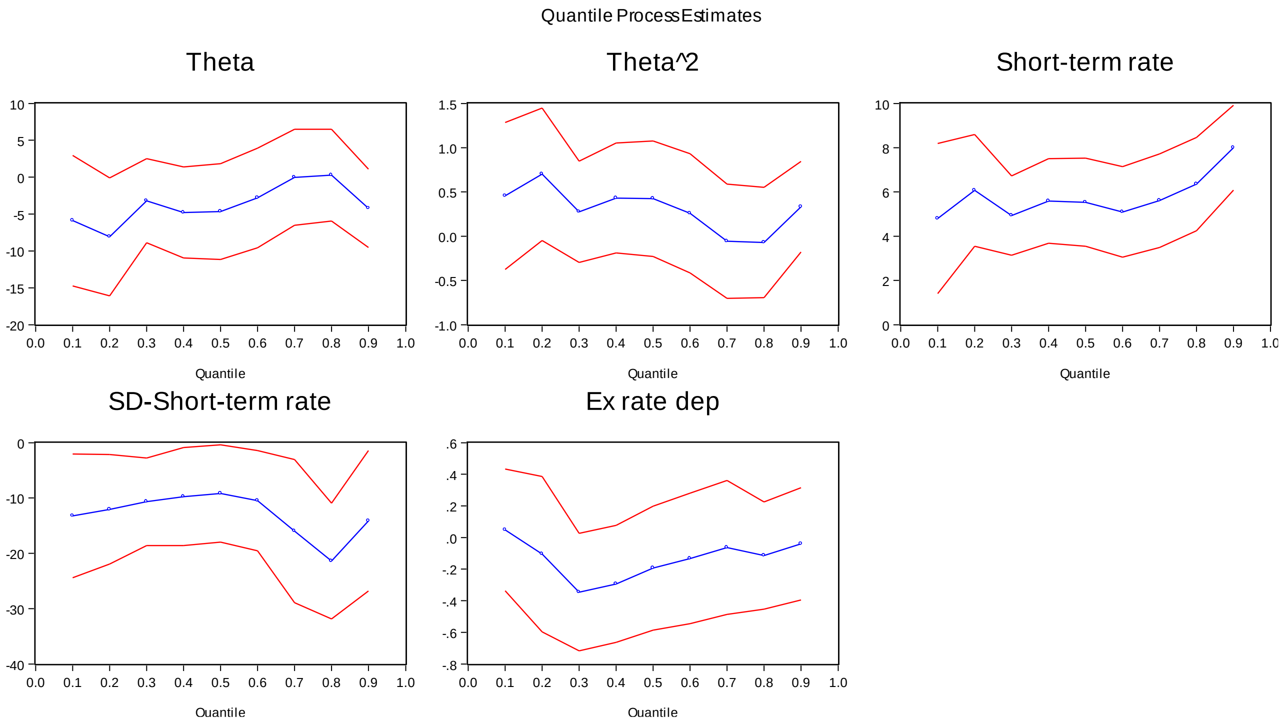


Table 6. Quantile symmetry test for the banking sector

Symmetric Quantiles Test

Restriction Detail: b(tau) + b(1-tau) - 2*b(.5) = 0

Quantiles	Variable	Restr. Value	Std. Error	Prob.
0.06, 0.94	θ	-78.29	54.20	0.1
	θ ^2	5.60	4.28	0.2
	Short-term rate	-34.97	89.21	0.7
	Short-term rate^2	1.00	7.53	0.9
	SD-Short-term rate	49.45	49.89	0.3
	Log of Total Assets	-30.58	113.10	0.8
	GDP growth	-4.82	4.57	0.3

	Inflation(-1)	-2.09	5.88	0.7
	Ex rate dep	1.74	1.38	0.2

Table 7. Quantile symmetry test for the Bank of Georgia

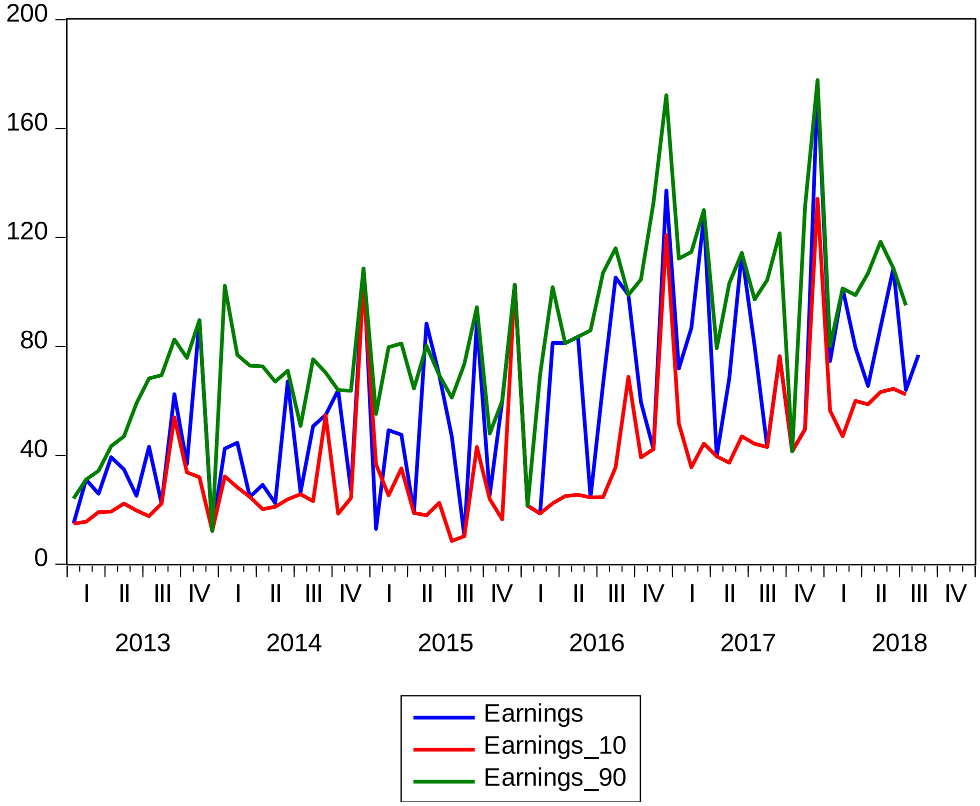
Equation: BOG Symmetric Quantiles Test Restriction Detail: b(tau) + b(1-tau) - 2*b(.5) = 0				
Quantiles	Variable	Restr. Value	Std. Error	Prob.
0.30, 0.70	θ	35.23	15.53	0.02
	θ ^2	-2.88	1.20	0.02
	TIBR7	31.95	21.48	0.14
	TIBR7^2	-3.14	1.89	0.10
	TIBR7_SD12	-2.91	13.61	0.83
	LTOT_ASSETS_BOG	25.68	24.04	0.29
	DY_Y	2.56	1.30	0.05
	DP_Y(-1)	2.05	1.96	0.30
	DE_Y	-0.34	0.36	0.35

Table 8. Quantile symmetry test for the TBC Bank

Equation: EQ22_TBC_Q Symmetric Quantiles Test Restriction Detail: b(tau) + b(1-tau) - 2*b(.5) = 0

Quantiles	Variable	Restr. Value	Std. Error	Prob.
0.30, 0.70	θ 1	6.13	4.28	0.15
	θ ^2	-0.63	0.43	0.14
	Short-term rate	-0.54	1.33	0.69
	Short-term rate ^2	-8.32	6.73	0.22
	SD- Short-term rate	-0.02	0.27	0.94
	Log of Total Assets	5.19	14.44	0.72
	GDP growth	-4.94	17.57	0.78
	Inflation(-1)	-6.56	10.27	0.52
	Ex rate dep	0.26	10.17	0.98

Figure 4. Banking sector profit, median and quantile estimates (90th and 10th percentile)



Appendix 2 - the model

Borio et al (2015) present a simplified version of the Monti-Klein model to describe oligopolistic competitive markets among banks. Unlike the original (Monti-Klein) model: 1. The notion of marginal cost of maturity transformation and the minimum capital requirement are introduced; 2. Equation for loan loss provision is introduced. The model includes cases of monopolistic and perfectly competitive markets as well.

The model is based on two basic assumptions: 1. the bank is a traditional intermediary (trading income and service payment not included) and 2. derivative hedge costs are included in net interest margin. Demand for loans is described by the decreasing demand function $l = l(L)$, where L denotes the amount of loan demanded from the borrower, and l denotes the corresponding interest rate on loans. The first-order partial derivative of the loan demand function is negative. The deposit supply function $d = d(D)$ is increasing (where D denotes the amount of deposits, d - the corresponding interest rate), though it is not very sensitive to interest rate fluctuations, as the banking sector is an oligopolistic market. This means that the value of the first-order derivative of this function ($d'_D(D)$) is not large.

The cost function for N identical banks is linear and separable (which implies that there is no joint cost for loan and deposit when bank intermediates):

$$C_j = \gamma_F + \gamma_L L_j + \gamma_D D_j \quad (1)$$

Where, L_j , D_j are j bank loans and deposits, γ - corresponding positive parameters. The bank can lend and borrow at a competitive market at market rate r. The market, in this case, combines both inter-bank loans and other securities (banks own loans, government and corporate securities). Assuming these instruments are substitutes. The model determines the net value of the bank's balance sheet. This market exogenously determines marginal revenues and costs, which define the amount of loans and deposits, net operating costs.

In the model banks has a maturity mismatch between deposits and loans, which causes the interest rate risk for the bank. The bank can reduce this risk by derivatives - at the appropriate cost. For simplicity, we assume that the cost $\psi(\theta)\, L_j \geq 0$ is positively related to the slope of the yield curve ($\psi'_\theta \geq 0$). When interest rates on deposits are not equal to market interest rates, we can expect that the incentive of the maturity transformation will increase as the slope of the yield curve increases – on the back of the maturity premium. If the loans are only short-term and there is no maturity mismatch, then $\psi(\theta) = 0$ and we come to the standard (Monti-Klein) model. The net interest income of the bank is described by the following equation:

$$NII_j = \big(l - \psi(\theta)\big)L_j + rM_j - dD_j \quad (2)$$

For simplicity, the model assumes that bank capital equals the minimum capital requirement K_j and is a function of loans. This can be explained by assuming that capital requirements are risk weighted, any securities held by the bank have zero risk and derivatives are not included. This means that the capital amount of the loan is proportional to loans $K_j = \rho L_j$ (3) and $0 < \rho < 1$

Loan collateral (P_j) is equal to μ portion of the loan. This share depends on the likelihood of the borrower's default, that increases when interest rate increase (with the increase in the market interest rate and the slope of the yield curve):

$$P_j = \mu(r, \theta) L_j \ (4)$$
$$\mu'_r > 0, \mu'_\theta > 0.$$

If the banks do not involve in the maturity activities, then

$$\mu'_\theta = 0$$

Since the model is static, the collateral is incurred to the borrower as soon as the loan is issued. The balance sheet of the bank j is written in the following equation:

$$R_j + L_j + M_J = D_j + K_j \quad (5)$$

Where $R_j = \alpha D_j$ and $\alpha > 0$

The bank makes decision on the amount of D deposits and L loans to maximize profits, subject to restrictions (3) - (5).

The above optimization problem is written as:

$$\max_{L_j D_j} \pi_j = \left[l\left(L_j + L_{-j}\right) - \tau\right]L_j - \left[d\left(D_j + D_{-j}\right) - \omega\right]D_j \qquad (7)$$

Where $-j$ index denotes all banks except j bank, and $L_{-j} = \sum_{h=1,h\neq j}^{N} L_h$, $D_{-j} = \sum_{h=1,h\neq j}^{N} D_h$. At the same time:

$$\tau = (1-\rho)r + \mu(r,\theta) + \psi(\theta) + \gamma_L > 0,$$

$$\omega = (1-\alpha)r - \gamma_D.$$

As the costs are additive, the bank's decision problem is separable: the optimal deposit rate and hence the amount are independent of the loan market characteristics; Accordingly, the optimal loan rate and the corresponding volume are also independent of the deposit market characteristics. The impact of the interest rate on the deposits and loans market come from the first order condition of the optimization problem and from the assumption of symmetry of equilibrium.

$$l(L^*) = \frac{\tau}{1-\frac{1}{N\varepsilon_L(L^*)}}, \qquad d(D^*) = \frac{\omega}{1+\frac{1}{N\varepsilon_D(D^*)}} \ (8)$$

Where $\varepsilon_L(L^*)$ and $\varepsilon_D(D^*)$ denote the elasticities of demand on loans and supply of deposits curves, respectively. Assuming that loan demand and deposit supply functions have constant elasticity, using the implicit- function theorem and equations (8), we obtain the equations:

$$\frac{\partial L^*}{\partial r} = \frac{1-\rho+\mu_r'}{l_L'(L^*)(1-\frac{1}{N\varepsilon_L})} < 0, \ \frac{\partial D^*}{\partial r} = \frac{1-\alpha}{d_D'(D^*)(1+\frac{1}{N\varepsilon_D})} > 0, \ (9)$$

If the elasticity of demand for loans is greater than $\frac{1}{N}$ $\left(\varepsilon_L > \frac{1}{N}\right)$, then $l_L'(L^*) < 0$, given the first inequality of (9), the amount of loans decreases when interest rate increases. The condition $\varepsilon_L > \frac{1}{N}$ is easily satisfied if the number of banks is large enough and competition between them is high.

The second derivative in (9) is positive: the supply of deposits for high d increases $(d_D'(D^*) > 0)$. If deposits are inelastic to interest rates on deposits ($\varepsilon_D \approx 0$), then they are less sensitive to market interest rates ($\frac{\partial D^*}{\partial r} \approx 0$). Similarly, we can estimate the impact of the changes in the yield curve on the equilibrium amount of loans and deposits.

$$\frac{\partial L^*}{\partial \theta} = \frac{\psi_\theta' + \mu_\theta'}{l_L'(L^*)(1-\frac{1}{N\varepsilon_L})} < 0, \frac{\partial D^*}{\partial \theta} = 0$$

An increase in the monetary policy rate positively affects borrowing costs and deposit rates as well; an increase of the slope of the yield increases lending rates and does not affect the deposit rate. Also, to describe the impact on net interest income and collateral ((2) and (4) equations), taking into account (8) - (10) and (3) - (5) constraints we get:

$$\frac{\partial NII_j}{\partial r} = \frac{1}{N\varepsilon_L - 1}\left[(1 - \rho + N\varepsilon_L \mu_r')L^* - \frac{N\varepsilon_L(1 - \rho + \mu_r')}{l_L'(L^*)}\eta\right] + \frac{1 - \alpha}{(N\varepsilon_D + 1)}\left[D^* + \frac{N\varepsilon_D}{d_D'(D^*)}\lambda\right]$$

$$\frac{\partial NII_j}{\partial \theta} = \frac{1}{N\varepsilon_L - 1}[(\mu_\theta' \, N\varepsilon_L + \psi_\theta')L^* + \frac{(\psi_\theta' + \mu_\theta')N\varepsilon_L}{l_L'(L^*)}\eta]$$

Where

$$\eta = l(L^*) - (1 - \rho)r - \psi(\theta) > 0$$

is the mark up on loans costs, and $\lambda = r(1 - \alpha) - d(D^*) > 0$ is the mark-down of the deposit rate compared to the marginal funding costs.

Given that $\frac{\partial NII_j}{\partial r}$ is positive and linear with respect to r, it follows that NII is a quadratic function with respect to r. However, the inflection point depends on the size of the elasticities and the capital requirements. In particular, it is concave with respect to r, if the demand for loans is elastic with respect to change in the lending rate ($l_L'(L^*)$ is low) and the supply of deposits is inelastic with respect to the change in the deposit rate ($d_D'(D^*)$ is high). This is quite a realistic assumption, since the bank is more monopolistic in the deposit market than in the lending market.

The second equation can be written as: $\frac{\partial NII_j}{\partial \theta} = \nu_0 + \nu_1\theta$ where $\nu_0 > 0$, and the sign of ν_1 is ambiguous. For its analytical form, consider as a function:

$$\nu_1 = \frac{2(\mu_\theta' \, N - \psi_\theta')(\mu_\theta' + \psi_\theta')}{l_L'(L^*)(1 + N)^2}$$

Taking into account that $l_L'(L^*) < 0$, $\nu_1 < 0$, when $N > \psi_\theta'/\mu_\theta'$. This implies that the relationship between net interest income and the slope of the yield curve is ambiguous and depends on the structural parameters of the model: $\frac{\partial NII_j}{\partial \theta}$ is negative (NII is concave with respect to θ), when ν_1 is negative and $N > \psi_\theta'/\mu_\theta'$. That implies that the marginal cost of derivatives contract ψ_θ' is quite low or the degree of competition N is very high. In opposite case, the function is convex.

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