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MODELLING PROFITABILITY OF BANKS BY USING DYNAMIC PANEL DATA ESTIMATION METHOD

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Abstract

Purpose *– to find and assess connection between banking sector profitability and real economy data, using panel data, and to display analysis capabilities of dynamic panel data estimation methods.*

Design/methodology/approach – *a panel, or longitudinal data set, consists of a sequence of observations, repeated through time on a set of statistical units. Panel data and their estimation methods are frequently used in various economic research, as it gives more information than pure cross-section or time series data.*

Findings *– dynamic panel data estimation methods are used to study relationship between income statement items (net interest income, net fee and commission income and operating expenses) and macroeconomic variables. Model estimation shows that included macroeconomic variables are significant and there is interaction between banks profitability and real economy. Net interest income are found to be dependent on real investment and short term interest rate, net fee and commission income reacts to changes in real gross domestic product (GDP) and operating expenses are connected to real GDP and compensation per employee.*

Practical implications *– the model is used to estimate income statement items changes after the external forecasted macroeconomic impact. The forecasts indicate that banks profitability reacts to changes in macroeconomic situation.*

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***Keywords*:** *panel data methods, macroeconomic impact, bank profitability, financial and real economy interaction.*

***Research type*:** *case study.*

1. Introduction

After the latest financial crisis in 2008, many central banks and financial supervisory authorities declared that ensuring financial stability is one of the main objectives. Therefore, macroeconomic stress testing has become a popular tool in assessing the current financial situation in a country and its ability to withstand extreme, but possible shocks.

Stress testing frameworks have been developed constantly since more and more experience is gained. Quagliariello (2009) gave an overview of macroeconomic stress testing methodologies and their applications. Many stress tests are designed to evaluate credit losses of a bank after macroeconomic shock and to assess its capital requirement. The main focus is given on modelling credit losses or liquidity risk. Though, bank operating revenues are a major determinant of financial sources, which can be used to account credit losses and maintain operations. This part was not included in the early stress tests (Jakubík and Heřmánek, 2008). Only recently, models of bank profitability have been usually incorporated in stress testing (Deutsche Bundesbank, 2010; Burrows *et al*., 2012).

Furthermore, bank revenue also determines lending capacity and has a time variation pattern. In such way effecting economy, bank revenue may strengthen or weaken business cycle. Therefore, it is useful to understand the connections between bank profitability and real economy data.

There are relatively few studies on this topic, and many research analyse only net interest margin separately from stress testing contest. The purpose of this study is to find and assess the relationship between Lithuanian banking sector income statement items and macroeconomic data, and to use these equations to determine bank revenue after macroeconomic stress event.

Net interest income, net fee and commission income and operating expenses are analysed, because these are the main components of banking activity. Net interest income is the dominant component of income in Lithuanian banking sector. Lately, net fee and commission income have become more important, as low interest rates puts pressure on interest income. The last operating income item consists of trading income, but this component is very volatile, therefore, it is difficult to assess stable relationship with macroeconomic data.

This paper is structured as follows. In the next section, a brief overview of related literature is presented. Section 3 describes methodology and data used in the study. The results are presented and discussed in section 4 and conclusions are given in section 5.

2. Related works of profitability modelling

Some of the relevant literature tries to estimate the determinants of the net interest margin, which is the difference between the mean of loan rates and the mean of funding rates. Examples of such studies include Demirgüç-Kunt and Huizinga (1999), Claeys and Van der Vennet (2004). In their study, Demirgüç-Kunt and Huizinga (1999) analysed bank data from 80 countries and found that larger bank asset to gross domestic product (GDP) ratio and lower market concentration ratio lead to lower margins and profits. Also, foreign banks have higher margins and profits compared to domestic banks in developing countries, while the opposite holds in developed countries. Meanwhile, Claeys and Van der Vennet (2004) investigated determinant of bank interest margin in Central and Eastern Europe counties. They found that concentration, operational efficiency, capital adequacy and risk behaviour are important determinants.

Other studies investigated dynamics of the net interest margin. Aliaga-Diaz and Olivero (2005) studied data from the United States banking sector and found counter-cyclicality of the net interest margin, i.e. margin is higher during recessions and tend to be lower during economic booms.

Another part of literature used gap analysis to identify interest rate risk. This analysis measure the duration (repricing) mismatch between assets and liabilities on the bank balance sheet. An example of such framework is presented by Drehmann *et al*. (2010). They argued that by modelling the whole portfolio of a bank and by taking account of the re-pricing characteristics of all exposures, it is possible to assess the impact of credit and interest rate risk not only on the bank's economic value, but also on its future earnings and credit risk jointly. Although their framework allows including liquidity or credit premium shock, but it is applied only on hypothetical bank.

There are also few papers that tries to identify banks' exposure to interest rate risk by analysing the relationship between bank profitability and interest rate. Maes (2004) investigated Belgian banks and found that there is no significant impact of interest rate changes. Related literature estimates stock market prices as an indicator of profitability. Fraser *et al*. (2002) investigated bank stocks' sensitivity to changes in interest rates and the factors affecting this sensitivity. They found that banks with high dependence on demand deposits, high loan volumes, little equity capital and little non-interest income are more sensitive. Another example is the study by Alessandri and Nelson (2012), who used panel data from UK banks. They found evidence that in the long run, both level and slope of the yield curve contribute positively to profitability. Meanwhile, in the short run, increases in market rates compress interest margins.

The purpose of the present paper is to find and assess the dynamics of bank income statement items, i.e. net interest income, net fee and commission income and operating expenses, and not the interest margins separately. There are only few examples that are closely related to this topic. Albertazzi and Gambacorta (2009) analysed the link between business cycles fluctuations and banking sector profitability and how this link is affected by institutional and structural characteristics. They had panel data from 10 countries and used dynamic panel data estimation. The results showed that GDP has a positive effect

on net interest income and non-interest income. Their analysis also identifies differences in the resilience to macroeconomic and financial factors shocks of the respective banking systems and relates them to the characteristics of their financial structure. A related work of Andersen *et al*. (2008) studied the effect of macroeconomic variables on the operating income in the Norwegian banking sector. They used error correction framework, which allows identifying both short term and long term relationships. They found that net interest income and fee income have a long term co-integration relationship with real GDP and the real interest rate.

There are also few examples of bank profitability models incorporated into stress testing framework. Andersen and Berge (2008) used models of net interest income and fee income estimated by Andersen *et al*. (2008) while stress testing Norwegian banking sector. Geršl *et al*. (2012) used simple ordinary least squares regression to estimate adjusted operating profit. They found that annual change in adjusted operating profit is positively affected by GDP growth and change in the slope of yield curve. Another example is the paper from Miami *et al.* (2012), who used autoregressive distributed lag model for the Italian banking sector stress testing and found a positive co-integration relationship between net interest income and the nominal GDP. Similarly, a positive co-integration restriction between other revenues and the nominal GDP was imposed. Meanwhile, operating expenses increase with increase in wages.

3. Methodology and data

In this study, it is wanted to have estimated income statement items linked to the macroeconomic variables and characteristics of individual bank. Therefore, similarly to Albertazzi and Gambacorta (2009), the econometric analysis is done using dynamic panel data estimation. The following model shows how net interest income, net fee and commission income and operating expenses react to changes in macroeconomic environment and individual structure:

$$Y_{i,t} = \alpha + \eta_i + \beta Y_{i,t-1} + \sum_{j=1}^{k} \gamma_j M_{j,t} + \sum_{s=1}^{l} \delta_s B_{s,i,t} + \varepsilon_{i,t}$$

where:

$Y_{i,t}$ – the corresponding income statement item, i.e. net interest income, net fee and commission income or operating expenses;

α – constant;

η_i – unobserved bank individual fixed effect;

$M_{j,t}$ – macroeconomic variables;

$B_{s,i,t}$ – bank specific varianbles;

$\varepsilon_{i,t}$ – error term.

Usually, economic relationships are dynamic and panel data estimation allows understanding better the dynamics of economic variables. Since lagged dependent

variable is included in the equation, the regressor $Y_{i,t-2}$ is correlated with the error term. It follows that a simple ordinary least squares estimator (OLS) is biased and inconsistent. Therefore, a generalized method of moments (GMM) procedure is used, proposed by Arellano and Bond (1991). The GMM estimator is consistent for dynamic panel data. Discussion and various estimation methods for dynamic panel data are presented by Baltagi (2005). Furthermore, Wooldrige (2002) gives detailed surveys of the literature and overview of the GMM estimator.

Many specifications can be viewed as specific cases of the GMM framework, one of which is a two stage least squares estimator (2SLS). In this case, estimates of the coefficients vector, $\hat{\beta}$, is represented as follow:

$$\hat{\beta} = \left(M'_{ZX} M^{-1}_{ZZ} M_{ZX} \right)^{-1} \left(M'_{ZX} M^{-1}_{ZZ} M_{ZY} \right)$$

Meanwhile, coefficient covariance matrix is computed by:

$$V\left(\hat{\beta}\right) = \hat{\sigma}^2 \left(M'_{ZX} M^{-1}_{ZZ} M_{ZX} \right)^{-1}$$

Here, we have matrix M_{ZX} which can be written in a general form:

$$M_{ZX} = \frac{1}{N} \sum_{i=1}^{N} Z'_i X_i$$

Matrix represents instruments used in the estimation. In the present case, we have $Y_{i,t-2}$ and exogenous variables as instruments for estimation of equation.

Data

In the present study, quarterly Lithuanian banks income statement and Lithuanian macroeconomic variables data are used. Data covers the period from 2008 q1 to 2013 q1. Thus, it includes the period of financial crises and port-crises.

Net interest income (*NII*) is defined as the difference between interest income and interest expenses. It is the most significant bank income item. Interest income mostly includes loan payments of bank clients, and interest expenses are related to payments to depositors.

Net fee and commission income (*NFCI*) is the difference between fee and commission income and fee and commission expenses. This income statement component includes revenues generated from fees charged on variety of bank services.

Operating expenses (*OPEX*) include salaries and payments to employees as well as other operating expenses.

Bank specific variables include provisioning ratio (*prov*), total assets of a bank (*A*) and loan portfolio (*LP*) data.

Macroeconomic data set is also used, which consist of the level of Lithuanian seasonally adjusted real GDP (*RGDP*), the level of seasonally adjusted real investment

into gross fixed capital (*Rinvest*), short term interest rate (*i*), i.e. 3-month VILIBOR interest rate, seasonally adjusted compensation per employee (*cpe*).

4. **Estimation results of modelling profitability of banks**

Net interest income

As interest income from loan portfolio is the main component, net interest income and loan portfolio ratio is used in the present estimation. This allows us to compare different bank interest revenues depending on their loan portfolio. The results of the estimation of net interest income are presented in Table 1.

The relationship between net interest income and macroeconomic variables is presented by the effect of real investment. Increasing investment into gross fixed capital increases lending demand, thus, it positively affects the profitability of traditional financial intermediation activity.

Real GDP growth was also examined, and a positive effect was found on net interest income. However, correlation between real investment and net interest income was stronger than correlation between real GDP and net interest income. Real investment is more connected with bank loan portfolio, as investment is usually financed by bank loans. Therefore, investment variable was left in the equation.

It was also found that the change in short term interest rate affects net interest income. Increasing interest rates increase loans interest and, therefore, it positively affects banks' interest income.

The estimation results are consistent with Albertazzi and Gambacorta (2009) and Andersen *et al*. (2008) studies, who also found a positive effect of GDP and interest rate on net interest income.

Table 1. Estimation results of the net interest income equation

	constant	*(NII/LP)_1*	*Δlog(Rinvest)*	*Δi*	*Dummy_1*	*Dummy_2*	*Dummy_3*
Coefficient	0.0018	0.7593	0.0026	0.0004	0.0035	-0.0025	0.0068
	(0,0294)	*(0.0000)*	*(0.0044)*	*(0.0001)*	*(0.0000)*	*(0.0182)*	*(0.0000)*

Notes: Adj.R^2=0.90

Coefficients' p-values are presented in parentheses

Net fee and commission income

Analysing net fee and commission income, it was found that there is a seasonal pattern in data. Therefore, seasonally adjusted net fee and commission data were used. Also, in order to have a relative ratio, net fee and commission income were divided by bank total assets in previous quarter data. The results of the estimation of net fee and commission income are presented in Table 2.

The estimated equation shows that GDP growth positively affects fee and commission income. Increasing GDP reflects increasing economic activity, which then leads to a higher demand on various financial transactions and services. Banks charge their customers for a variety of financial services and in that way a higher economic activity increases bank fee and commission income.

The estimation results also show that increase in a bank provisioning ratio decreases their net fee and commission income. This can be interpreted as the following: increasing provisioning ratio shows that more clients face difficulties and use less service from bank.

Table 2. Estimation results of the net fee and commission income equation

	constant	*$(NFCI\_sa/A\_1)\_{-1}$*	$\Delta\log(RGDP_{-1})$	*Δprov*	*Dummy_4*
Coefficient	0.00025	0.90266	0.00067	-0.00002	0.00048
	(0.0167)	*(0.0000)*	*(0.0291)*	*(0.0434)*	*(0.0000)*

Notes: Adj.R^2=0.98

Coefficients' p-values are presented in parentheses

Operating expenses

Banks usually have a target for operating expenses and income ratio. Therefore, operating expenses are modelled as a ratio of net fee and commission income. The results of the estimation of net fee and commission income are presented in Table 3.

The estimation results show that the ratio depends positively on its lagged value and increase in compensation per employee and depends negatively to GDP growth.

Expenses are related to employees in the most significant part of operating expenses. Thus, as expected, there is a positive relationship between operating expenses and salaries, which are approximated by compensation per employee variable.

A negative coefficient of GDP growth indicates cost stickiness, i.e. when GDP falls, income falls by more than expenses, so the ratio of operating expenses over net fee and commission income increases.

Table 3. Estimation results of the operating expenses equation

	constant	*$(OPEX/NFCI)_{-1}$*	*Δlog(cpe)*	*Δlog(RGDP)*	*Dummy_5*
Coefficient	1.2470	0.4740	1.9914	-2.6693	1.4330
	(0.0057)	*(0.0096)*	*(0.0415)*	*(0.0112)*	*(0.0027)*

Notes: Adj.R^2=0.98

Coefficients' p-values are presented in parentheses

Income statement items forecast

The estimated equations of net interest income, net fee and commission income and operating expenses were used to evaluate development of bank profitability after

macroeconomic shock. The results of forecasted income statement items are presented in Table 4.

Two scenarios were analysed, i.e. baseline economic development scenario and stress scenario after macroeconomic shock. In the baseline scenario, increase in GDP (as well and investment) and small increase in interest rate are involved. Under the stress scenario, GDP declines and interest rate increases more than in the baseline scenario.

In a short term, a bigger increase in interest rate has a strong positive effect on net interest income, but later, decline of investment and slower interest rate change put more pressure on interest rate income.

As expected, decline of GDP has a stronger negative impact on net fee and commission income than on operating expenses, e.g., under stress scenario, the forecasted net fee and commission income increase by 0.5% compared to 2012 fact (-11.5% change from the baseline), meanwhile, operating expenses increase by 6.9% compared to 2012 (-9.1% change from the baseline).

The forecasts indicate that banks' profitability reacts to changes in macroeconomic situation.

Table 4. Forecasted income statement items. Change from fact in 2012 for baseline and stress scenarios. Stress scenario change from baseline scenario.

Banking system	Change from 2012				Change from baseline scenario	
	2013_B	2013_S	2014_B	2014_S	2013_S	2014_S
Net interest income	1.5%	14.4%	12.3%	7.7%	13.2%	-5.3%
Net fee and commission income	8.7%	6.9%	10.8%	0.5%	-2.0%	-11.5%
Operating expenses	12.4%	14.1%	14.7%	6.9%	2.0%	-9.1%
Operating profit	-9.0%	8.5%	7.7%	2.8%	16.0%	-5.3%

5. Conclusions

This study estimates the relationship between bank income statement items and Lithuanian macroeconomic variables. It was found that net interest income is positively affected by increase in investment and increase in short term interest rate. Thus, net interest income is pro-cyclical to economic environment. These results are consistent with the results of other studies.

Net fee and commission income also has a cyclical behaviour, i.e. increase in economic activity increases banks' revenue from services, as clients use them more than in periods of a slower GDP growth.

The estimation showed that operating expenses have cost stickiness, i.e. are more stable than net fee and commission income.

This study investigates only a short period of data. A further revision of equations and relationships between income statement items and macroeconomic variables could be done as longer data set will be available. Another research could be done by analysing aggregate banking sector data and trying to find and assess long term and short term relationships between banking sector profitability and real economy.

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BANKŲ PELNINGUMO MODELIAVIMAS, TAIKANT DINAMINĮ SEKINIŲ DUOMENŲ VERTINIMO METODĄ

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Santrauka

Tikslas – *surasti ir įvertinti ryšį tarp bankų sektoriaus pelningumo ir realios ekonomikos duomenų, naudojant sekinius duomenis, bei parodyti, kokias analizės galimybes suteikia dinaminiai sekinių duomenų vertinimo metodai.*

Metodika *– sekinių duomenų imtį sudaro duomenys, gauti kelis laiko momentus stebint tuos pačius individus. Sekiniai duomenys ir jų vertinimo metodai yra dažnai taikomi atliekant ekonominius tyrimus, kadangi jie suteikia daugiau informacijos nei vien tik vienalaikiai duomenys arba laikinės sekos.*

Išvados *– analizuodami ryšį tarp bankų pelno (nuostolio) ataskaitos eilučių (grynųjų palūkanų pajamų, grynųjų paslaugų ir komisinių pajamų ir operacinių išlaidų) bei makroekonominių kintamųjų taikėme dinaminių sekinių duomenų vertinimo metodus. Modelių vertinimas rodo, kad į analizę įtraukti makroekonominiai kintamieji yra reikšmingi, ir kad yra sąveika tarp bankų pelningumo ir realios ekonomikos. Mes nustatėme, kad grynosios palūkanų pajamos priklauso nuo realių investicijų ir trumpo laikotarpio palūkanų normų, grynosios paslaugų ir komisinių pajamos reaguoja į realiojo bendrojo vidaus produkto pokyčius, o operacinės išlaidos yra susijusios su realiuoju BVP ir kompensacija vienam dirbančiajam.*

Praktinis pritaikymas *– įvertinti modeliai yra naudojami, siekiant apskaičiuoti pelno (nuostolio) ataskaitos eilučių pokyčius, kurie galimai įvyktų atsitikus išoriniam prognozuojamam makroekonominiam poveikiui. Apskaičiuotos reikšmės parodo, kad bankų pelningumas reaguoja į makroekonominės situacijos pokyčius.*

Raktiniai žodžiai**:** *sekinių duomenų metodai, makroekonominis poveikis, bankų pelningumas, finansų sektoriaus ir realios ekonomikos sąveika.*

Straipsnio tipas**:** *atvejo analizė.*