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Macroeconomic and bank-specific determinants of non-performing loans: the case of baltic states

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Abstract
This study examines selected macroeconomic and bank-specific determinants of non-performing loans (NPLR) for a panel of 21commercial banks from the Baltics States (Estonia, Latvia and Lithuania), using annual data for the period 2005–2016. To avoid the risk of providing unconsistent and biased results by using only one estimation technique, in our study we implemented three alternative estimation models (fixed- effects model, difference Generalized Method of Moments and system Generalized Method of Moments). Empirical results provide evidence that the most important macroeconomic factors influencing NPLR are growth of GDP, public debt, inflation and unemployment. As for the bank-specific determinants, we found that equity to total assets ratio, return on assets, return on equity and growth of gross loans have an impact on the amount of NPLR.

Keywords Non-performing loans · Macroeconomic determinants · Bank-specific determinants · Baltic states · System generalized method of moments

JEL Classification F61 · F62 · G01 · G21

1 Introduction

Information on the banks' loan quality is an important issue that has aroused the interest of the public as a user of banking services, the public as a potential investor in the banks' equity, the banks' management, the financial markets, the banking supervisors and regulators in terms of controlling the stability of the financial system and of the academic circles. This interest has intensified significantly in the last two decades. Namely, deregulation, technological change and the globalization of

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goods and financial markets, the financial crisis of the 1990s the global economic crisis of 2008–2009 and the European debt crisis of 2011–2012 have all had an impact on banks' loan quality.

One of the most common indicators used to identify the banks' loan quality is the ratio of non-performing loans (NPLR). An increase in this ratio may signal a deterioration in banking sector results (Mörttinen et al. 2005). Experience shows that a rapid build-up of NPLR has a crucial role in banking crises (Demirguc-Kunt and Detragiache 1998; Gonzalez-Hermosillo 1999).

This experience was confirmed during the last few years, that is, since the onset of the global financial crisis in 2007–2008, when the levels of NPLR have significantly increased across countries. However, although after 2007–2008 almost all countries in the world were faced with rapid growth of NPLR, the growth varied significantly among the different groups of countries, and among countries in the same group. For example, according to the data from the World Bank Database in 2007 the amount of NPLR as a share of total loans in high income OECD countries was 2.5%, increasing to 3.7% in 2010, whereas in Central and Southeastern Europe and Baltic it was 2.1% in 2006, and has reached almost 15% in 2014. In countries such as Macedonia, Poland, and Lithuania the NPLR in 2005 were 1.9%, 8.7% and 11.2%, respectively, while in 2014 were 8.2%, 10.8%, and 4.8%, respectively, in 2014.

The large disparity across countries raises questions about what causes this variation and thus what are the determinants for NPLR. There is a rapidly growing number of empirical studies which analyze factors that influence the NPLR (De Nicoló et al. 2003; Quagliarello 2007; Hoggart et al. 2005; Fofack 2005; Baboucek and Jancar 2005; Espinoza and Prasad 2010; Vogiazas and Nikolaidu 2011; Kleein 2013). All these authors have proposed a variety of different macroeconomic and institutional factors as possible determinants of NPLR.

Considering the ratio of non-performing loans to total loans as a measure for NPLR, the aim of this study is to evaluate the impact of selected macroeconomic and bank-specific determinants on NPLR in the Baltic States. We focused on the Baltic countries (Estonia, Latvia, and Lithuania), for the period 2005–2016, because these countries, more than the other countries in Europe, have been affected by the subprime mortgage crisis. For example, in the 2009, in Estonia the NPLR were 5.9%, while in Latvia in the same year the percentage of NPLR was 14.3. The greatest rise of the NPL ratio was recorded in Lithuania, from 6 in 2008 to almost 24% in 2009. Also, according to the (Tang et al. 2000; Koivu 2002) these countries are relatively homogenous and have adopted a broadly common macroeconomic model; they have similar institutions and economies, and their banking sectors share important commonalities.

According to the authors, six studies examine the determinants of NPLR in the Baltic countries (Festic and Repina 2009; Kavkler and Festic 2010; Fainstein and Noitkov 2011; Kleein 2013; Donatah et al. 2014; Kjosevski and Petkovski 2017). Almost all of them have certain similar characteristics. Namely, in these studies some of the authors were using only macroeconomic variables (Fainstein and Noitkov 2011; Donatah et al. 2014) or have analyzed each country individually, not in a panel model (Festic and Repina 2009; Kavkler and Festic 2010; Fainstein and

Noitkov 2011; Donatah et al. 2014). The majority of studies, except the articles of (Kleein 2013; Kjosevski and Petkovski 2017), which have analyzed determinants of NPLR in Baltic States, have used aggregate data for the whole banking system of each country and not disaggregated data (examination of individual data for each bank).

According to the best knowledege of the authors, this is the first study which is entirely focused on the issue of macroeconomic and bank specific determinants of NPLR in the Baltic states As we previously mentioned, the study of (Kleein 2013) analyzes the Baltic States in a panel data set, but within the countries of the Central, Eastern and Southeastern Europe (CESEE), and not as a single region. On the other hand, the article of (Kjosevski and Petkovski 2017) examine the macroeconomic and bank specific determinants of NPLR for a panel of 27 banks from Baltics, but they also investigate the feedback between NPLR and its macroeconomic determinants. They use unbalanced panel for the banks in the Baltic States, but apply only one estimation technique (difference Generalized Method of Moments). To avoid the risk of providing unconsistent and biased results by using only one estimation technique, in our study we implemented three alternative estimation models (fixed-effects model, difference Generalized Method of Moments and system Generalized Method of Moments). We also analyzed longer period, from 2005 to 2016 and included public debt as an additional macroeconomic determinant.

Among the main advantages of panel data, compared to other types of data, is that the approach allows testing and adjustment of the assumptions that are implicit in cross-sectional analysis (Maddala 2001). The short time series, poor availability and quality of the data have been the common reasons to refrain from the analysis of Baltic countries. We have addressed these concerns by selecting a more recent time and relatively longer time period, analyzing mainly the crisis and post- crisis times, but also covering the last three years of the pre-crisis boom (2005–2007). We also employ a thorough data preparation process by eliminating inconsistencies, consolidating the existing information and filling in the data gaps for banks with more significant market share by using the banks' public reports. On the basis of the studies of (Bock and Demyanetes 2012; Louzis et al. 2010), we have applied a dynamic panel data approach to explain the determinants of the NPL in Baltic States. In order to provide consistent and unbiased results, we implemented the three alternative estimation techniques fixed effects model, difference Generalized Method of Moments and system GMM.

The results of this study have several policy implications in terms of policy and regulation,The conducted empirical analysis allows regulators to aproximatelly forecast non-performing loans dynamics several years in the future, both in the individual banks operating in the Baltic states and at macro level. This might facilitate communication between regulatory bodies and banks resulting in some mitigating actions.

The structure of the article is as follows. After the Introduction, Sect. 2 gives an overview of the literature on empirical findings relevant to the determinants for NPLR. Methodology is presented in Sect. 3. Sources of the data used, are presented in Sect. 4, while in Sect. 5 we explains the empirical analysis and results. Section 6 concludes the article and gives policy recommendations.

2 Literature review

In this section we present a brief sublimate of literature, dealing with the empirical findings relevant to the determinants for NPLR. Moreover, given the huge number of published studies on this topic (Quagliarello 2007; Boudrig et al. 2009; Dash and Kabra 2010; Espinoza and Prasad 2010; Louzis et al. 2010; Nkusu 2011; Castro 2012; Kleein 2013), are some of the most relevant studies, we focus on empirical literature that examines the determinants of NPLR only in the Baltic States.

Empirical results of the above-mentioned studies differ, because of the differences in databases, time periods, and the different specifics of each of the countries. However, there are some common elements that allow categorizing the determinants of banks' NPLR are usually measured by the ratio of NPLR to total loans. The internal determinants usually include: bank-specific variables, such as size of the bank, equity to total assets ratio (ETA), return on assets (ROA) or return on equity (ROE) and growth of gross loans (GGL). The macroeconomic determinants include the GDP growth, unemployment, exchange rate interest rate and inflation.

In their study**,** Festic and Repina (2009) using panel regression for the period from 1998Q1 to 2008Q3 examine the impact of macroeconomic and bank-specific determinants for NPLR in Baltic States. Their results show that a slowdown in economic activity accelerates the growth of the NPLR. Also, the results suggest that rapid growth of credit harms loan performance, most likely due to soft-loan constraints and macroeconomic overheating.

Kavkler and Festic (2010) applied ordinary least squares method for the period 1997–2007. They analysed effects of 12 financial and macroeconomic variables as predictors for NPLR in the Baltic States. Their results indicated that a sharp slowdown in economic activity (GDP, net exports, investment and savings growth) would likely deteriorate the loan portfolio quality in the Baltic States.

Fainstein and Noitkov (2011) applying a separate vector-error-correction model (VECM) for each of these three Baltic countries, used quarterly data for the periods from 1997 Q3/ 2002Q1 /2004Q1 to 2009Q4 (depending on the country). Their results showed that real GDP growth was the most significant determinant of NPLR' growth in all three countries and that real estate market growth played an important role in two of these countries (Latvia and Lithuania).

The research of (Kleein 2013) examines factors that affected NPLR in CESEE (Bosnia and Herzegovina, Bulgaria, Hungary, Croatia, Czech Republic, Estonia, Latvia and Lithuania) for the period 1998–2011. He used three alternative estimation techniques: fixed effect model, difference GMM and system GMM. The results show that NPLR respond to macroeconomic conditions, such as GDP growth, unemployment and inflation.

Using macroeconomic indicators such as GDP, inflation, unemployment and lending interest rates for the period 2000–2013, (Donatah et al. 2014) estimated the evolution of bad loans ratio in the Baltic States and Romania. Their results show that NPLR' had a significant negative correlation with GDP growth in all

four countries. The inflation rate exhibited a negative correlation with the NPLR in all countries except Lithuania. The lending interest rate was positively correlated with the NPLR in all countries except Romania, whereas the unemployment positively correlated with the NPLR in each of the four countries.

2.1 Macroeconomic determinants

At the core of all the previously mentioned studies, the variables related to gross domestic product (GDP) are the main macroeconomic determinants of NPLR. In this context, several variations of this determinant, such as the annual growth rate of real GDP, the production gap, the growth of income per capita, and so on are well known in the literature. However, the real GDP growth rate is by far the most common macroeconomic determinant used as an example in the studies of: (Gasha and Morales 2004; Jimenez and Saurina 2005; Quagliarello 2007; Marcucci and Qualiarello 2008, 2009; Castro 2012; Nkusu 2011; Kleein 2013; Beck et al. 2013). Hence, we also include the annual growth rate of real GDP in our analysis. Thus, we want to examine the effect of the cycle in which the economy is, on the credit risk. According to (Nkusu 2011), the growing economy associated with the growth of the general level of income and reduced financial stress, and hence GDP growth, should be negatively correlated with NPLR.

To reflect the price stability in the model, we follow (Kavkler and Festic 2010; Donatah et al. 2014) and we include the inflation as the general consumer prices rate, but its impact on NPLR is not clear. On the one hand, higher inflation can make debt servicing easier by reducing the real value of outstanding loans, but on the other hand, it can also weaken borrowers' ability to service debt by reducing their real income. Gunsel, 2008; Rinaldi and Sanchis-Arellano 2006) find a positive correlation between the inflation rate and NPLR in North Cyprus and Euro Zone countries. Also in the articles of (Kavkler and Festic, 2010) and (Donatah et al. 2014) in the case of Baltic States the results indicates that inflation was significant and a positive determinant of NPLR in the Baltic States. In the opposite direction, (Sofoklis and Nikolaidu 2011) in the case of Tunisian and Romanian banking sectors, found a negative correlation between inflation and credit risk. The study of (Aver 2008; Bofondi and Ropele 2011) in the case of Slovenian and Italian banking systems, did not find any influence of inflation on credit risk. Therefore, the relationship between inflation and NPLR may be ambiguous.

Regarding unemployment, it is rational to suppose that an increase in the unemployment should influence negatively the cash flow streams of households and increase the debt burden. With regard to firms, increases in unemployment may signal a decrease in production as a consequence of a drop in effective demand. This may lead to a decrease in revenues and a fragile debt condition. Several empirical studies have investigated the relation between unemployment and NPLR and they have found it to be positive (Bofondi and Ropele 2011; Godlewski 2004; Makri et al. 2014). Therefore, we expect that an increase in the unemployment will lead to an increase in the NPLR.

The export growth rate may provide additional information regarding the impact of economic conditions. A decline in exports should lead to a decline of firms' revenues, and in consequence firms face a lower capability in loan repayment. This contributes to a relatively higher NPL percentage to total loan (Clichici and Colesnicova 2014).

When the global economic crisis started in 2008, it has significantly affected government finances and then it has extended its negative impact to the banks. Taking this point into consideration, we will follow (Makri et al. 2014) and we will also include public debt as a determinant of NPLR. We anticipate a positive association between NPLR and public debt.

2.2 Bank-specific determinants

The share of equity in total assets is an important determinant of NPLR. According to the "moral hazard" hypothesis, discussed by (Keeton and Morris 1987) banks with relatively low capital respond to moral hazard incentives by increasing the riskiness of their loan portfolio, which in turn results in higher non-performing loans on average in the future. In this case, the connection with NPLR is negative (Berger and DeYoung 1997; Salas and Saurina 2002; Kleein 2013). On the other hand, according to (Quagliarello 2007), as the risk appetite of the bank is higher, the greater is the share of capital to existing shareholders invested in the bank, in order to convince other shareholders to invest and support the bank. And hence the connection can be positive. Positive connection was discovered in the studies of (Rajan and Dahl 2003; Boudrig et al. 2009; Espinoza and Prasad 2010). According to empirical research and theory, with these determinants we expected an ambiguous correlation with NPLR.

A number of authors consider influence of banks' past performance measured by profitability (ROA–ROE) on future problem loans ratio. It is expected banks which are more profitable to have lower level of NPLR (Swamy 2012) and hence the connection is negative. According to (Boudrig et al. 2009), inefficient banks with lower profitability are tempted to resort to less reliable and risky placements to increase profitability and/or to meet the demands of regulatory authorities. The negative correlation between bank performance (profitability) and credit risk is confirmed by (Godlewski 2004). In this area again we will return to (Berger and DeYoung 1997), who explain the second hypothesis of "bad management" by return on assets. Namely, poor performance of the company can be linked with characteristics of managers that result in decreased profitability (expressed by the low return on assets or equity). This further motivates managers to lend to riskier borrowers, which in the end leads to growth of NPLR. Apart from these factors, we will follow (Makri, et al. 2014) and we will also examine the two profitability ratios (ROA–ROE). Banks' profitability is linked to the risk-taking behaviour of banks. As highly profitable banks have fewer incentives to engage in high-risk activities, ROA and ROE are expected to display a negative sign.

The credit policy of the bank plays an essential role in determining the subsequent levels of NPLR. To maximize the short run benefits, managers seek to rapidly

expand credit activities and may hence take inadequate credit exposures (Castro 2012; Beck et al. 2013; Kleein 2013). Several studies indicate the presence of positive correlation between credit growth and NPLR such as the study of (Dash and Kabra 2010). However, here are studies such as (Salas and Saurina 2002; Quagliarello 2007; Boudrig et al. 2009; Dash and Kabra 2010; Swamy 2012) which found a negative correlation between these two determinants, which may be the result of some specificity, regulation and background in different banking systems that make banks more conservative and cautious in the spread of credit supply (Quagliarello 2007). Therefore the effect of individual credit growth can be in both directions.

3 Methodology

In order to analyse the determinants that affected the NPLR in the Baltic States we adapted panel data analysis, using NPLR in logarithmic differences. In this study, we will follow (Salas and Saurina 2002; Espinoza and Prasad 2010) and our dependent variable NPLR will be the logit transformation, because this transformation ensures that the dependent variable spans the interval $(-\infty;+\infty)$ (as opposed to between 0 and 1) and is distributed symmetrically.

Hsiao (2003) list several benefits of using panel data (1). The use of panel data enables us to control for individual heterogeneity. (2). Panels provides more informative data, more variability, less collinearity among the variables, greater degree of freedom, and more efficiency. (3). With panel data, one is better able to study the dynamics of adjustment. (4). Panel data are more suitable for identifying and measuring effects that are simply not detectable in pure cross-sections or pure time-series data. (5). Panel data models allow us to construct and test more complicated behavioural models than pure cross-section or time data models.

According to (Rinaldi and Sanchis-Arellano 2006; Louzis and Metaxas 2012) empirical evidence suggests that the NPL ratio may follow a unit root process hinting at a possible cointegrating relation with macroeconomic variables. To avoid the problem which may arise because of existence of non stationary variables, one might have to identify the order of integration of variables. Cambell and Perron (1991) suggest that standard unit root tests can have low power against stationary alternatives for important cases. In this research, we will focus on two types of panel unit root test, such as (Breitung 2000) which assumes that there is a common unit root process so that $i\ p$ is identical across cross-sections, and the Fisher test using ADF and PP-test (Maddala 2001) that combines the p-values from individual unit root tests. In all these tests, the null hypothesis is non-stationarity.

In the literature which investigates the determinants of NPLR in the Baltic States, the authors usually applied ordinary least squares methods or a fixed effects model (Festic and Repina 2009; Kavkler and Festic 2010; Tanaskovic and Jandric 2015). Also, the difference Generalized Method of Moments was applied by (Kjosevski and Petkovski 2017). In order to provide consistent and unbiased results, we implemented three alternative estimation techniques. The first one is a fixed- effects model, which allows controlling for unobserved heterogeneity across banks. Although this approach is rather simple and intuitive, it may give rise to "dynamic panel bias", which results

from the possible endogeneity of the lagged variable and the fixed effects in the error term. To provide consistent and unbiased results, we implemented the difference Generalized Method of Moments (difference GMM) estimation, which is based on first differences and was introduced by (Arellano and Bond, 1991). Arellano and Bond proposed one and two-step estimators. In this article, we use the one-step GMM estimator since Monte Carlo studies have found that this estimator outperforms the two-step estimator both in terms of producing a smaller bias and a smaller standard deviation (Judson and Owen 1999). Thus, following (Louzis and Metaxas 2012) we instrumented macroeconomic variables by themselves, whereas the bank-specific determinants were instrumented with current and lagged values of the regressors. In order to avoid the problem of too many instruments in comparison to the number of groups (Roodman, 2009), the number of instruments are kept lower than the number of banks. In the standard (un-collapsed) form, each instrumenting variable creates one instrument for each time period and the lag available to that period, whereas in the collapsed form not a whole matrix of instruments, but a single column vector of instruments is created. Although collapsing can reduce statistical efficiency in large samples, it can be very helpful as a tool to avoid the bias in finite samples, which are usually characterized by instrument proliferation. In other words, we control the number of instruments by limiting our analysis to 1 lag. This helps to avoid bias due to too many instruments in a relatively small sample. The validity of chosen instruments for parameters estimation can be tested using the Hansen test. Accepting the null hypothesis means that the chosen instruments are valid. One drawback of this approach, however, is that in samples with a limited time dimension (small T) and high persistence, the estimation has low precision (Blundell and Bond 1998). Namely, according to (Blundell and Bond 1998) if the lagged dependent variables are persistent during the time or tend to be random walk, lagged levels of these variables will be weak instruments in the first difference equation of regression. Therefore, we also estimate a "system GMM" developed by (Arellano and Bover 1995) and (Blundell and Bond 1998), which addresses this concern. Under this approach, the lagged bank level variables were modeled as pre-determined (thus instrumented GMM-style in the same way as the lagged dependent variable) whereas the macro variables were treated as strictly exogenous (instrumented by themselves as "IV style" instrument, (Roodman 2009).

Following (Salas and Saurina 2002; Merkl and Stolz 2009; Louzis and Metaxas 2012; Kleein 2013; Abid et al. 2013), we assume that the share of NPLR in the loan portfolio is closely related to its values in the previous periods, because NPLR cannot be immediately written off and may remain on banks' balance sheets up to several years. In other words, NPL ratio shows a tendency to persist over time. To test the persistence of NPLR, we use the previous year's NPLR rate (NPLt-1) as an independent variable and we expect a positive correlation. The inclusion of lagged terms of the dependent variable on the right hand side of the equation violates the exogeneity assumption for regressors. These dynamic relations are given by the following equation:

$$y_{it} = \alpha_i y_{i,t-1} + \alpha_i B_{i,t} + \alpha_i M_{i,t} + DUM2008 + DUM2009 + \varepsilon_{it} \quad (1)$$

where y_{it} denotes the aggregate NPLR to total gross loans, B denotes the bank-specific variables and M denotes the macroeconomic factors, DUM2008 and DUM2009 are dummies variable. Note that i corresponds to the examined bank of the sample and t to the year, whereas ε denotes the error term.

To test the validity of chosen instruments we will use the Hansen test. Accepting the null hypothesis means that the chosen instruments are valid. Furthemore, we will test serial correlations in the differenced residuals (first-order [AR1]) and second-order [AR2] serial correlations). According to (Arellano and Bond 1991) the first-order autocorrelation in the differenced residuals does not imply that the estimates are inconsistent. However, the second-order autocorrelation would imply that the estimates are inconsistent.

To obtain deeper insight into the relevance of explanatory variables, we estimate Eq. (1) in three different versions; we begin by examining only macro determinants as regressors (model 1), then only bank-specific determinants (model 2), and finally both bank-specific and macro determinants (model 3).

In order to measure the dynamic links between selected determinants and NPLR in this study we also employ the Granger causality test (Nair- Reichert and Weinhold 2001).

The Granger causality model followed is:

$$NPLR_{i,t} = \alpha + \sum_{k}^{k} \gamma_i^{(k)} NPLR_{i,t-k} + \sum_{k}^{k} \beta_i^{(k)} INDVAR_{i,t-k} + \varepsilon_{i,t} \tag{2}$$

where *NPLR* represent the non-performing loans, *INDVAR* represent indipendent variables, *i*ranges from 1 up to N cross units, t represents time periods (1,2, T), α denotes the intercept, k represents the number of lags and ε represents the error term including not only the disturbance term but also the cross-unit specific effects.

To test the Granger non-causality for *INDVAR–NPL*, the null hypothesis is $H0$: $\beta i = 0$, *for all* $i = 1, \ldots, N$. The alternative hypothesis states that there is a causality relationship from *NPLR* to *INDVAR* for at least one cross unit of the panel: $H0$: $\beta i = 0$, *for all* $i = 1, \ldots, N.$, $\beta i \neq 0$ *for* $i = N\,\mathrm{N}_1 + 1, \mathrm{N}_1 + 2, \ldots, \mathrm{N}$; $0 \leq \frac{N_1}{N} \leq 1$

$$INDVAR_{i,t} = \alpha + \sum_{k}^{k} \gamma_i^{(k)} INDVAR_{i,t-k} + \sum_{k}^{k} \beta_i^{(k)} NPLR_{i,t-k} + \varepsilon_{i,t} \tag{3}$$

To test the Granger non-causality for *NPLR*to *INDVAR*, the null hypothesis is $H0$: $\beta i = 0$, *for all* $i = 1, ..., N$. The alternative hypothesis states that there is a causality relationship from *INDVAR*to *NPLR*for at least one cross unit of the panel: $H0$: $\beta i = 0$, *for all* $i = 1, ..., N.$, $\beta i \neq 0$ *for* $i = \mathrm{N}_1 + 1, \mathrm{N}_1 + 2, ..., \mathrm{N}$; $0 \leq \frac{N_1}{N} \leq 1$.

For our research we used an unbalanced panel with 21 commercial banks in the Baltic States (Estonia, Latvia and Lithuania). Data are based on annual frequency for 2005–2016, and the number of banks was chosen in accordance with the avialability of data. Unbalanced panel data are able to have more observations and their results are less dependent on a particular period Rinaldi and Sanchis-Arellano (2006).

4 Empirical data and analysis

The data for the bank-specific determinants (ROA, ROE, and growth of gross loans) were collected from balance sheets, income statements and notes from the annual reports from the Bankscope database.The data for macroeconomic-determinants (GDP growth unemployment, inflation, consumer prices and public debt (percentage of GDP) were obtained from the World Development Indicators (WDI) database.

Before attempting to identify potential internal and external determinants of NPLR, it is necessary to identify the dependent determinant. In the literature to date there is no internationally harmonized definition that has been applied in all or most countries of the world for a considerable period of time. In this context it is worth mentioning that Bankscope reports the level of "impaired loans", which may be different than the official classification of NPLR. "Impaired loans" is an accounting concept, which reflects cases in which it is probable that the creditor will not be able to collect the full amount that is specified in the loan agreement, whereas "NPL" is a regulatory concept, which primarily reflects loans that are more than 90 days past due Report of the Working Group on NPLR in Central, Eastern and Southeastern Europe (CESEE 2012). Bearing these differences in mind, we will follow (Klein 2013) and treat "impaired loans" as NPLR.

The determinants that we used as control determinants, which may explain the NPLR of banks, are:

- Macroeconomic determinants: public debt-PD; GDP growth—GDPG; inflation – INF; unemployment – UN;Export growth-EXPG.
- Bank-specific determinants: ratio of equity to total assets – ETA; return on assets- ROA; return on equity- ROE; growth of gross loans—GGL;

Table 1 Apart from the actual determinants in the empirical model, we included two dummy variables that marked the global economic crisis. Thereby, DUM 2008 had the value of 1 for the period in 2008 and 0 for all other periods and DUM 2009

Table 1 List of selected variables in the model

Variables	Explanatory of variables	Frequency	Source
LNPLR	Logit transformation of ratio of impaired (NPLs) to total (gross) loans	Annual	Bankscope
GDPG	GDP growth (annual %)	Annual	World Bank
INF	Inflation, consumer prices (annual %)	Annual	World Bank
UN	Unemployment, total (% of total labor force)	Annual	World Bank
PD	Public debt (% of GDP)	Annual	World Bank
EXPG	Exports of goods and services (annual%)	Annual	World Bank
ETA	Ratio of equity to total assets	Annual	Bankscope
ROA	Return on assets	Annual	Bankscope
ROE	Return on equity	Annual	Bankscope
GGL	Growth of gross loans of each individual bank (annual %)	Annual	Bankscope

that had the value of 1 for the 2009 and 0 for all other periods. Because to the consequential deterioration of economic activity, borrowers had more difficulties paying off their debts, therefore increasing the rate of NPLR; hence, we expected a positive and significant sign for the coefficient on these dummies

Table 2 presents descriptive statistics for the determinants involved in the regression model. Key figures, including mean, standard deviation, and minimum and maximum values, are reported. This table gives an overall description about data used in the model and serves as a data screening tool to spot unreasonable figures. According to Table 2, there were observations missing in all bank specific determinants. This is mainly due to unreported figures in annual financial reports from some banks. Also, from Table 2, we can see that NPLs variable have mean value of 15.50, which goes to the maximum of 95.51 and minimum of 0.100. The high maximum value is due to the period when the data is collected, which covers the years of the world economic and financial crisis, with some banks being affected more than others. Furthermore, from Table 2 we can see that all bank specific determinants have negative values. These results also confirm the fact that banks from the Baltic States were affected by the global economic crisis. From the macroeconomics variables, GDPG, INF and EXPG have negative values and significant variations between the minimum and the maximum values.

5 Results and discussion

In this section, we begin with analysis of the results of multicollinearity. One of the assumptions of the linear regression model is that there is no multicollinearity among the explanatory determinants. Multicollinearity is a problem when the correlation is above 0.80 (Kennedy 2008). The correlation among the five variables is broadly in line with economic theory: The highest correlation coefficient was between ROA and ROE, which is both logical and expected because net income is a component of both the ROA and the ROE of the banks. Furthemore, NPLR were negatively correlated with GDP growth and inflation, and positively correlated with the change of unemployment, and public debt. The correlation matrix Table 3 shows that, in our sample multicollinearity problems were either not severe or non-existent.

Table 2 Descriptive statistics. *Source:* Author's calculations

	NPL	GDPG	INF	UN	EXPG	PD	ETA	ROA	ROE	GGL
Mean	15.50	2.798	3.615	10.42	6.994	25.51	9.868	0.089	5.067	20.75
Median	10.59	3.251	2.975	9.600	6.978	18.70	10.03	0.904	9.044	5.450
Maximum	95.51	12.23	17.64	19.48	23.50	47.40	26.70	14.36	256.9	423.8
Minimum	0.100	−17.95	−1.094	4.249	−12.88	3.700	−134.4	−44.34	−298.1	−61.21
Std. Dev	17.53	6.632	4.024	4.117	8.537	14.11	12.50	5.054	41.87	51.07
Observations	207	252	242	252	252	252	221	236	236	228

Table 3 Correlation matrix. *Source:* Author's calculations

	NPL	CGD	UN	GDPG	INF	EXPG	ROA	ROE	ETA	GGL
NPL	1									
CGD	0.388	1								
UN	0.361	0.517	1							
GDPG	0.013	0.024	−0.361	1						
INF	−0.333	−0.467	−0.418	0.004	1					
EXPG	0.446	0.091	−0.030	0.645	−0.024	1				
ROA	−0.645	−0.255	−0.301	−0.011	0.194	−0.073	1			
ROE	−0.286	–0.161	−0.361	0.041	0.151	−0.103	0.691	1		
ETA	−0.475	−0.176	−0.016	−0.026	0.017	−0.001	0.587	−0.128	1	
GGL	−0.458	−0.403	−0.562	0.113	0.56	0.014	0.354	0.341	0.030	1

The results of unit root test are presented in Table 4. The unit root analysis, according to ADF and PP Fisher-type tests, indicates that null hypothesis of non-stationarity can be rejected for all our determinants. The results of Breitung test indicates that hypothesis of non-stationarity cannot be rejected for the three determinants (NPLR, INF and ROE). However, bearing in mind that the other two unit tests (ADF and PP Fisher-type) show that these determinants were stationary at their levels, we include NPL, INF and ROE in our models, and we treat them as non-stationary variables at their levels.

Next in the the Table 5 we report the empirical results of fixed effects model, difference GMM and system GMM. Despite their difference, all approaches arrive at essentially similar results as to the sign, and the statistical significance of most variables in the regression specification. This confirms that our results are robust to

Table 4 Panel unit root tests. *Source*: Author's calculations

Test variables	ADF-fisher chi square		PP-fisher chi square		Breitung	
	Level	First difference	Level	First difference	Level	First difference
NPLR	99.3397***		117.431***		0.4612	−1.478***
PD	205.422***		164.631***		6.5870***	
UN	100.287***		98.0210***		3.8414***	
GDPG	86.2740***		28.7410*		5.4369***	
INF	42.7059*		14.5055*		3.0501	4.334***
EXPG	84.31***		360.6***		7.878**	
ROA	68.2197*		101.425***		1.5413***	
ROE	44.9057*		98.5600***		1.3679	3.521***
ETA	62.3250*		67.6904***		2.0207*	
GGL	68.9775**		71.1816***		3.6052*	

***, **, * Denote statistical significance at the 1, 5, 10 percent level respectively

Table 5 Estimation results. *Source:* Author's calculation

	Fixed effects (FE) regressions			Difference GMM			System GMM		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
LNPLR(−1)				0.55*** (0.50)	0.78*** (0.78)	0.57*** (0.43)	0.79*** (0.33)	0.83*** (0.51)	0.83*** (0.05)
Const	2.25*** (0.17)	− 5.47*** (0.68)	−3.13*** (0.43)	10.94*** (8.23)	−6.80 (1.14)	6.57** (0.86)	0.22*** (0.72)	0.55** (0.59)	1.81*** (0.61)
PD		0.02 (0.01)	−0.05* (0.08)		0.11 (0.26)	0.15 (0.06)		0.12 (0.26)	−0.02 (0.01)
UN		0.11** (0.02)	0.08 (0.12)		0.66*** (0.13)	0.45*** (0.19)		0.67 *** (0.18)	0.52*** (0.02)
GDPG		−0.05 (0.01)	−0.11* (0.04)		−0.26* (0.15)	−0.67* (0.14)		−0.23*** (0.43)	−0.58*** (0.15)
INF		0.07** (0.03)	0.05** (0.03)		0.22 (1.37)	0.02 (0.22)		0.72 (0.22)	0.29 (0.22)
EXPG		−0.11*** (0.14)	−0.08*** (0.12)		0.03 (0.08)	0.06 (0.11)		−0.07* (0.23)	−0.04 (0.02)
ROA	−0.09*** (0.03)		−0.03* (0.32)	−0.12*** (0.23)		−0.62 (0.06)	−0.97*** (0.19)		−0.89*** (0.23)
ROE	−0.01 (0.08)		−0.01 (0.04)	−0.03 (0.08)		−0.40 (0.82)	−0.02*** (0.02)		−0.22 (0.05)
ETA	−0.05 (0.18)		−0.05* (1.01)	0.10 (0.19)		−0.19* (0.67)	0.14** (0.05)		0.02** (0.06)
GGL	0.03*** (0.02)		0.13*** (0.02)	−0.15*** (0.02)		0.17*** (0.04)	0.06*** (0.01)		0.05** (0.89)
DUM 2008	0.38* (0.16)	0.11 (0.37)	0.04 (0.30)	0.38*** (0.14)	0.14*** (0.33)	0.18 (0.21)	0.41* (0.14)	0.24 (0.37)	0.44 (0.31)
DUM 2009	1.11*** (0.12)	0.92** (0.42)	0.77*** (0.25)	0.76* (0.45)	0.17** (0.36)	0.40* (0.47)	1.14 *** (0.13)	0.27* (1.04)	0.48** (0.61)

Table 5 (continued)

	Fixed effects (FE) regressions			Difference GMM			System GMM		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Number of observation	173	198	165	123	139	109	151	172	143
Number of banks	21			21			21		
Hansen test (p-value)				0.478	0.515	0.457	0.539	0.619	0.721
Test for AR(1) errors				0.068	0.005	0.032	0.047	0.018	0.062
Test for AR(2) errors				0.227	0.216	0.679	0.565	0.578	0.684

1. Arellano-Bond test that average autocovariance in residuals of order 1 is 0 (HB0B: No autocorrelation)

2. Arellano-Bond test that average autocovariance in residuals of order 2 is 0 (HB0B: No autocorrelation)

Standard errors are in parenthesis

*,** and *** Show that the null hypothesis can be rejected at 10%, 5% and 1% significance levels respectively

different specifications, although the precision of the estimated coefficients differs across different methods that we have used in our study.

The results presented in Table 5 broadly confirm that both bank-level and macroeconomic factors play a role in affecting the banks' asset quality. The Hansen test shows that the chosen instruments are valid (with a p value of 0.48 for model 1, 0.52 for model 2, and 0.46 for the third model) in the difference GMM and (with p value of 0.54 for model 1, 0.62 for model 2, and 0.72 for the third model) in the system GMM. The estimator ensures efficiency and consistency provided that the residuals do not show serial correlation of order two (even though the equations indicate that negative first order autocorrelation is present, this does not imply that the estimates are inconsistent). Inconsistency would be implied if second-order autocorrelation was present Arellano and Bond (1991), but this case is rejected by the test for AR(2) errors.

The lagged dependent variable is statistically significant and have positive value in all three models, confirming the dynamic character of the models. The values of this determinant are between 0.51 and 0.87, suggesting that a shock to NPLR is likely to have a prolonged effect on the banking system. These results are similar to those found by previous studies (Jimenez and Saurina, 2005) for Spain where lagged NPLR value was 0.55 and (Kjosevski and Petkovski 2017) for Baltic States where values of lagged NPLR were between 0.33 and 0.49.

From the macroeconomic determinants we found evidence that public debt was significant in both models when we used fixed effect model and difference GMM. The positive signs are in line with the literature. This relationship highlights that higher public debt in Baltic States might lead to an important rise of NPLR. Our results are consistent with the findings of Makri et al. (2014) where the results were between 0.11 and 0.12 for 14 countries from Eurozone.

The positive effect of unemployment emphasized in the literature is confirmed by the results of this study. Obviously, when a person loses his source of income he cannot return his loan, or regarding to enterprises, the rise of unemployment could lead to a decline in production due to the fall in effective demand. In both cases that will lead to higher NPLR. Because we used annual data, the significant impact of unemployment NPLR was in the current period. Namely, a rise of unemployment affects households' ability to service their debts, and firms cut their labor costs with a three-month time delay (Louzis et al. 2010). Our results are consistent with the findings of (Nkusu 2011) where the results were between 0.20 and 0.24) for 26 advanced economies and (Makri et al. 2014) between 0.23 and 0.09, for 14 countries from Eurozone.

The results of our article show that growth of gross domestic product has a significant and negative impact on NPLR. They confirm that change in economic activity affects the NPLR. The values were between 0.16 and 1.58 and were significant in all three estimation models. These results are consistent with the results of (Louzis et al. 2010) where values of GDP growth were between 0.25 and 0.46 for Greece, (Nkusu 2011), (0.18–0.04) for 26 advanced economies Kleein (2013). (0.05–0.08) for 16 countries from Central and Eastern Europe, Beck et al. (2013), (1.50–1.52), for 75 countries of the world, Makri, et al. (2014), (0.053–0.071) for 14 countries from Eurozone.

As for inflation, our results show a positive impact of inflation which indicates that higher inflation probably was anticipated by the banks management, which in turn implies that interest rates have been appropriately adjusted. Actually, inflation reduces the capacity of banks' borrowers to repay the loans through the income channel or due to the falling value of income amid rising inflation. The positive results were also found in the studies of (Rinaldi and Sanchis-Arellano 2006) with the value 0.23 for seven countries of the euro area, (Kleein 2013) with the values for inflation between 0.006 and 0.38, for 16 countries from Central and Eastern Europe and Makri et al. (2014) with values of inflation between 0.039 and 0.045 for 14 countries from Eurozone.

Export growth only yields significant coefficients in the fixed effect model thus suggesting that this variable is not a key determinant of commercial bank NPLR within our sample. Therefore, our findings confirm the importance of general macroeconomic conditions as key determinants of non-performing loans within our transition countries Mazreku et al. 2018.

The results from the bank-specific determinants are in line with literature. The empirical results of return on assets (ROA) and return on equity (ROE) show that profitability has a significant negative impact on NPLR.This relationship, is consistent with the empirical results from (Makri et al. 2014) with values between − 0.052 and − 0.038, for 14 countries from Eurozone. The results for ROA were confirmed in the study of (Erdinc and Abazi 2014) with values between − 0.34 and − 0.55, for 20 emerging European countries and (Makri et al. 2014) with values between − 0.62 and − 0.38, for 14 countries from Eurozone. These results demonstrate the validity of the hypothesis of "bad management", reflected in the reduced profitability, which in turn motivates managers to go for an increased risk exposure, therefore creating growth of bad loans.

As we expected, risk behavior of banks ETA, is statistically significant, but only in the two models (fixed and difference GMM) and has a negative sign. This relationship is also confirmed by (Kleein 2013) with results between − 0.04 and − 0.06 for 16 countries from Central and Eastern Europe and (Makri et al., 2014) where the results were between − 0.01 and − 0.13, for 14 countries from Eurozone. This results means that banks who have higher capital ratios are involved in high risk activities.

As for the dummy variables, which are introduced to cover the global economic crisis,we found that both DUM 2008 and DUM 2009 are statistically significant at the 1% level of significance, in all three models. These results confirmed that the rise of the global economic crisis led to a deterioration in the quality of bank loans to enterprises and households. This was not surprising, because the banks in Baltic States were among those that were most affected by the crisis and as a result they had the largest increase of NPLR.

Table 6 reports the results of Granger causality test. According to the results of the Granger causality analysis; the NPLS were influenced by ROA, GGL, ETA, INF, GDPG, UN and CGD in the significance levels of 0.01 and CGD in the significance level of 0.05. On the other hand, the NPLS had also impact on ROA, ROE GGL, ETA GDPG and INF. So, there are bidirectional Granger causalities from NPLs to ROA, GGL, ETA, INF and GDPG. Furthermore, there are no Granger causality relationships between NPLS and EXPG. In other words, any kind of causality relation

Table 6 Granger-causality tests. *Source*: Author's calculations

Null hypothesis	*P* value	Decision
ROA does not granger cause NPLS	0.0004	Null hypothesis rejected
NPLS does not granger cause ROA	0.0461	Null hypothesis rejected
ROE does not granger cause NPLS	0.5511	Null hypothesis cannot be rejected
NPLS does not granger cause ROE	0.0253	Null hypothesis rejected
GGL does not granger cause NPLS	0.0195	Null hypothesis rejected
NPLS does not granger cause GGL	0.0886	Null hypothesis rejected
ETA does not granger cause NPLS	0.0001	Null hypothesis rejected
NPLS does not granger cause ETA	0.0028	Null hypothesis rejected
EXPG does not granger cause NPLS	0.6742	Null hypothesis cannot be rejected
NPLS does not granger cause EXPG	0.1192	Null hypothesis cannot be rejected
INF does not granger cause NPLS	0.0322	Null hypothesis rejected
NPLS does not Granger cause INF	0.0095	Null hypothesis rejected
GDPG does not granger cause NPLS	0.0671	Null hypothesis rejected
NPLS does not granger cause GDPG	0.0277	Null hypothesis rejected
UN does not Granger Cause NPLS	0.0656	Null Hypothesis rejected
NPLS does not Granger Cause UN	0.1337	Null Hypothesis Cannot be rejected
CGD does not Granger Cause NPLS	0.0533	Null Hypothesis rejected
NPLS does not Granger Cause CGD	0.2778	Null Hypothesis Cannot be rejected

was determined neither from NPLS to the EXPG nor from the EXPG–NPLS. The Granger results of the study as a whole, the selected macroeconomic and bank specific variables have impact of NPLS in the banking sector of Baltic States. These results mainly confirm the results from our estimation models (fixed- effects model, difference Generalized Method of Moments and system Generalized Method of Moments).

6 Conclusions

The results of our research provide evidence that from among the macroeconomic determinants in our baseline model, public debt, growth of GDP, inflation and unemployment have the strongest effect on NPLR. Furthermore, we have found that ETA, ROA, ROE and GGL as bank specific determinants have an influence on NPLR. Also, we found that the dummy variables that we introduced to cover the global economic crisis, DUM 2008 and DUM 2009, have the positive impact on the growth of NPLR of Baltic States. This study complements the existent economic literature by analyzing the impact of selected macroeconomic and bank-specific determinants on the NPLR in the Baltic States.According to the best knowledege of the authors, this is the first article which is entirely focused on the issue of macroeconomic and bank specific determinants of NPLR in the Baltic states.

Further research may broaden the scope of the examination. First, it would be maybe interesting for future authors to extend the sample and comparatively analyse

sub-groups of transition countries (South Eastern Europe, Baltic and Balkan States) in order to elucidate the determinants that affect non-performing loans. Second, future studies could provide a breakdown of all non-performing loans to non-performing loans to enterprises and to households. Third, it would be beneficial as a measure of credit risk, to also apply changes in the status of non-performing loans,or bad debt reserves, along with the ratio of non-performing loans over total loans. Lastly,the research may be improved by including other macroeconomic determinants (monetary aggregates, stock prices and exchange rate) or bank-specific factors (size, loans-to-assets ratio, and so on).

The findings of this paper also have some implicatons in terms of regulation and policy. The conducted empirical analysis allows regulators to approximately forecast non-performing loans dynamics several years in the future, both in the individual banks operating in the Baltic states and at macro level. This might facilitate communication between regulatory bodies and banks resulting in some mitigating actions.A better understanding of the individual factors that make some banks more resilient than the others to adverse economic trends can prevent a rise of credit risk and thus reduce negative feedback between the financial sector and the real economy. However, in order to obtain more precise results, further research needs to be done, developing comprehensive stress test scenarios,where reactions of non-performing loans could be monitored by observing fluctuating values of the established determinants.

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