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The Comparative Analysis of Credit Risk Determinants In the Banking Sector of the Baltic States

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Abstract: A vector error correction model is applied to empirically investigate and compare the influence of macroeconomic and real estate market variables on the level of non-performing loans in the three Baltic States. A secondary goal is to analyze the effect of constant loan portfolio growth on the level of non-performing loans in the related countries. The research indicates that the most significant reason for the growth of non-performing loans was caused by the changes in the real GDP in all the three Baltic States. The increasing influence of rapid loan portfolio growth proves the assumption that banks underestimated the changes in the macroeconomic variables during the analyzed periods, especially in Latvia. Rapid growth of the real estate market played an important role in Latvia and Lithuania, but it was not as crucial as it has been previously assumed in Estonia.

JEL Classifications: E44, C32, C52, G21

Keywords: Non-performing loans, Banking system, Credit risk determinants, Vector error correction model

1. Introduction

After the restoration of the independence in the beginning of 90ies the Baltic States have suffered from several financial crises during the last two decades. The last financial crisis, started in 2007, has shown that commercial banks' management in the three Baltic States concentrated mainly on the increasing of market shares and providing constantly growing profit to their shareholders.

The efficiency of credit risk analysis, performed by a banking system can be presented by two parameters: profitability and the level of non-performing loans. The idea of dependence of the banking system credit risk on the level of profitability was proposed by Minsky (1992, p.6) in his "financial instability hypothesis", according to which … "banking is taken seriously as a profit-seeking activity". Debt or indebtedness is taken as the second main parameter in this hypothesis.

Finding an appropriate credit risk model has become increasingly important for stability of any banking system. Based on the development of credit risk determinants in the past, the forecasts of changes of credit risks general level or some parts of it creates the acceptance of appropriate/appropriately measured credit risk.

The constant analysis of credit risk determinants is a basis for the mentioned policies and for further decision-making processes. Against this background and in order to provide stable economic development, it is important to analyze what type of credit risk determinants played the most crucial role in the growth of non-performing loans in the Baltic States.

The analogous researches, covering the comparative analysis of credit risk determinants of all three Baltic States, have not been performed yet. There have been several published research works concentrated on the influence of credit risk determinants of a single country, for example, Fainštein and Novikov (2011), Kattai (2010).

The main idea of the research is to investigate empirically and compare the evolution and the influence of credit risk determinants of banking systems of the three Baltic States, i.e. the influence of macroeconomic and banking sector variables on the level of non-performing loans in each Baltic State, in order to define the similarities and differences.

To perform the analysis and achieve the defined goals, the respective innovative model of credit risk determinants of the Baltic States' banking sector is developed and tested.

The remainder of the paper is organized as follows. Section 2 presents the literature review of the subject. Section 3 presents the comparative market analysis of banking systems of the Baltic States. Section 4 provides the development of the analytical framework and presents the causality of the variables and model specification. Section 5 defines the methodological approach. Sections 6 to 8 concentrate on the econometric analysis of each banking system of the Baltic States. Finally, section 9 provides some concluding remarks.

2. Literature Review

Credit risk is one among many factors with a substantial influence on the stability of a banking system. It is important to measure and control the determinants of the credit risk, especially at the aggregated level. Generally, macroeconomic, banking sector and also microeconomic level variables are the most important for analysis of credit risk.

Carling, Jacobson, Linde and Roszbach (2007), Bonfim (2009), IMF (2000), Jimenez and Saurina (2006) report that, macroeconomic variables should be included into credit risk analysis since they have considerable influence on the changes of credit risk at the aggregated level.

Negative changes of macroeconomic variables are usually treated as external negative shocks. External negative shock can be interpreted as the negative difference between the real and expected value of macroeconomic parameters. Negative shock can be spurred by the change of any macroeconomic parameter.

Fisher (1933) introduced the impact of the general level of indebtedness on the economy. Fisher (1933) and Pesola (2001) indicated that the rise of the instability of a banking system becomes apparent when the level of indebtedness of an economic unit grows constantly. The influence of the external negative shocks starts to play a more crucial role. The internal dynamics of the economy are important, but the growth of instability appears exactly with the changes of external negative shock.

Pesola (2005) proposes the existence of "definite reasons" can cause the rapid growth of the indebtedness level, which together with the influence of external negative shock can become a reason for instability in the banking sector.

Various countries have different levels of aggregated indebtedness, and there is no correct answer when the level of aggregated indebtedness becomes crucial for a banking system. Minsky (1992) stated the following reasons: internal dynamics of the economy and the system of state interventions provide for its existence within definite limits. In other words, the financial markets are constantly unstable and external shocks, as the reason for the system becoming unstable, should always be taken into consideration.

Based on the idea of external negative shock, Pesola (2005) gives the description of credit risk development at the aggregated level. Rapidly growing indebtedness becomes the reason for the possible increase of instability of the banking system. When the conditions of deterioration of

macroeconomic indicators exist, there is an essential decrease in solvency of the banks' customers. These changes cause the growth of non-performing loans. Furthermore, if the economic conditions remain unchanged or have a further negative tendency, the level of loan losses can lead to the bankruptcy of some banks. Fisher (1933) presented a similar end of cycle.

There is a considerable amount of research papers that explain reasons of the rapid growth of credit risk in the banking sector, which has its origins in the internal functioning factors of the banking system, for example: Davis (1995), Drees and Pazarbasioglu (1998), Gourinchas, Valdes and Landerretche (1999), Keeton (1999).

Bonfim (2009), Caruana (2002), Ferguson (2004), Jimenez and Saurina (2006), Pesola (2001) conclude that the result of wrong decisions of financing will become apparent only during the period of recession of the economy and this definitely will cause the growth of non-performing loans and loan losses.

Keeton (1999) and Gourinchas, Valdes and Landerretche (1999) confirmed that the faster the growth of the general level of indebtedness is the more substantial loan losses will be. As a result, the adequacy and sufficiency of credit risk analysis does not proceed in time for rapidly changing market conditions during the stable period of a growing economy. This brings financing to such types of projects that if the detailed analyses had been properly conducted, the borrower would never have received the requested financing.

Pesola (2001, 2005, and 2007) proposes that the main reason for the increase of aggregated credit risk is the growing aggregated indebtedness. Together with the deterioration of macroeconomic factors it is impossible for borrowers to repay their existing financial obligation. Subsequently, it leads to the negative chain reaction throughout the whole economy. This means that the level of credit risk financed by banking systems becomes critical when cash flows of realized projects become insufficient for covering payments needed for fulfillment of the loan contracts' obligations and giving rise to the fall in assets' prices, with its purchase financed by banks.

Marcucci and Quagliariello (2008, 2009) report that the more risky a bank's loan portfolio is the more cyclical it responds to the changes of the business cycle. For example, the influence of the business cycle on the loan portfolio with the lower quality of assets during times of recession is more than three times higher than on a bank with more quality assets in the portfolio. Also its influence during times of recession is more than four times higher than during a period of economic growth.

Borio, Furfin and Lowe (2001), Davis and Zhu (2004), and Goodhart, Hofmann, and Segoviano (2005) state that, the rapid growth of indebtedness follows the rapid growth of the price level of the real estate market. It makes possible the acquisition of new financing more widely available. Prices of banks' financed real estate projects grow constantly and this growth virtually reduces the risk level of financed or soon to be financed projects. In this case any borrower can receive additional financing due to the growth in the value of the collateral, which can be at any moment easily sold by the bank in case of possible problems with the customer's insolvency. As a result, additional financing should not be supported by improved cash flow generated by new investments.

Blaschke, Jones, Majonni and Peria (2001), Bonfim (2009), Jimenez and Saurina (2006), Pesola (2001, 2005, 2007), Shanazarian and Asberg-Sommar (2008) and other authors concentrated mainly on the analysis of the influence of macroeconomic variables on the credit risk growth. Thereby, a research of the combine influence of macroeconomic variables, banking sector variables and microeconomic level variables, together with the rapid growth of aggregated indebtedness on the level of non-performing loans, can be treated as insufficient, especially in the case of a small country with an open economy.

Based on the results of earlier researches and employing the vector error correction model, presented in econometric analysis, the hypothesis to test will be: macroeconomic variables have been important regarding predicting the level of non-performing loans, the rapid growth of indebtedness has

been crucial to the growth of non-performing loans, the rapid growth of real estate markets has been an extremely important variable in forecasting the level of non-performing loans.

Before beginning testing the listed hypothesis, the market analysis will be presented and based on it the analytical framework developed and the initial model described.

3. Market Comparative Analysis

The Baltic States are small countries with open economies that depend substantially on export transactions and foreign investments. The banking sectors of the Baltic States hold the dominant position of the financial system of the countries, which are substantially integrated into the European financial markets. Estonia has joined the Euro area in the beginning of 2011.

Seven commercial banks and 9 foreign bank branches operated in Estonia by the end of 2009, 21 commercial banks and 8 foreign bank branches in Latvia and 9 commercial banks and 7 branches of foreign banks in Lithuania.

In spite of the different number of banking institutions, the banking sector of every Baltic State witnessed similar situations. Swedish banks (Swedbank and SEB Ühisbank) have made considerable investments into capturing an intense market share through their subsidiary banks. Their market share of loans granted in Estonia combined up to 66% and received deposits – up to 74.70% by the end of 2009. In Latvia their market share of loans granted decreased to 39.70% and received deposits – to 27.10% by the end of 2009. The analogous data for Lithuanian market is 49.30% and 53.60% respectfully. If market shares of branches of foreign banks (Nordea, DNB Nord and Danske Bank) are added the total market share of banking institutions with foreign owners constitute the substantial majority in banking sectors in the Baltic States.

Until the end of 2008 the Latvian banking sector differed from banking sectors of other Baltic States due to the presence of Parex Bank; the bank based on the local investor's capital. Its market share by assets combined up to 13.8%, by deposits – 19.2% and by loans – 11.4%. At the end of 2008 this bank was overtaken by the Latvian government due to the banks huge liquidity problems. Currently this bank is in the sale process to a foreign investor.

Presented market shares have direct connections to the number of banking institutions operated in the country. The greater the number of actively operating banking institutions is in the country the harder the competition between them should follow. This strongly supported the overheating of the economies and loan markets of the Baltic States.

Stability of the banking system and economic growth are complementary processes. Stability of the banking system contributes to the stability of the economy and provides economic growth. Pesola (2001) indicates that a stable macroeconomic environment results in the stability of a banking system. Banks frequently assist the credit risk growth when incorrect and insufficient analysis of credit risk is applied.

Until the year 2008 all Baltic States were constantly referred to as Baltic tigers due to the high growth rate of their economies. Annual average growth rate of real GDP of Latvia combined up to 8.76% calculated on the data for the period 2000 - 2007, for Lithuania – 7.49% and for Estonia – 8.35%. It was a 3.5 – 3.6 times higher result than the European Union member's average growth. Later on, in 2009 the real GDP of Estonia declined 14.1%, compared with 27 other European countries' average decline of 4.2%. Only Latvia and Lithuania faced a more considerable real GDP decline, 18.0% and 14.8% respectively.

All three Baltic States have also been constantly suffering from the continuous reduction of the population that started in the year 1990. During the period 1997 – 2009 the population decrease in Estonia combined up to 7.43%, in Latvia – 9.57% and in Lithuania - 8.05%. The greatest downfall in

population was witnessed by the Latvian economy. The following statistics assumes quiet a substantial amount of taxes not received by all Baltic States during years before the crises and after it.

The real GDP per capita presents additional information regarding the Baltic States economies' development. The calculated increase of the real GDP per capita for the period 1998-2009 for Estonia was 1.63 times, for Latvia – 1.61 and for Lithuania 2.22 times. At the same time the biggest real GDP per capita measured in EUR was achieved by the Estonian economy (6 573 EUR). The respective numbers for Latvian economy is 4 287 EUR and Lithuanian economy – 5 969 EUR respectfully.

The insufficient analysis of credit risk by all banks in the Baltic States and strong dependence of current consumption on short-term foreign investments caused more substantial recession of the economies than in other European countries and a substantial decrease of the real estate market (see figure 1).

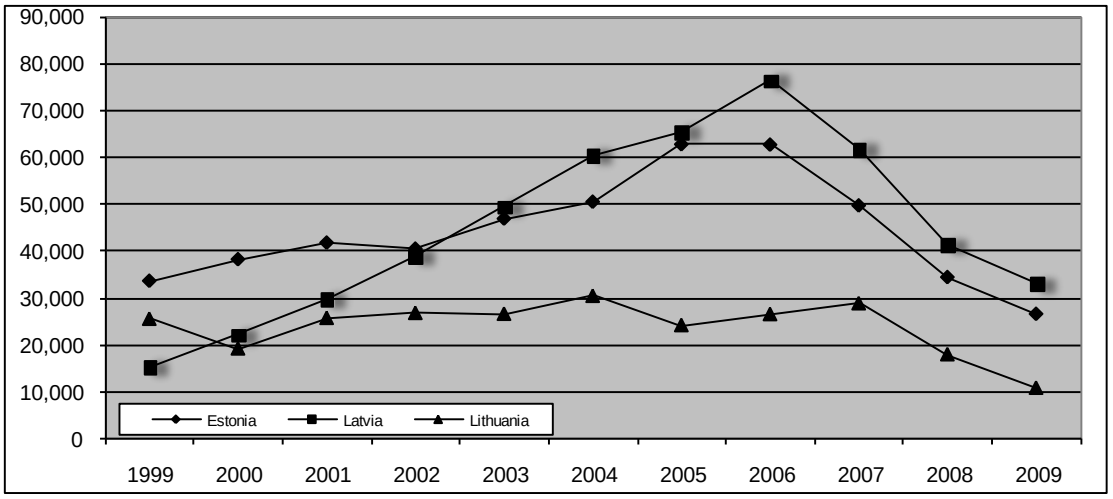

Figure 1 The quantity of deals concluded on real estate market

Source: Data obtained through the internet from Statistics Estonia (http://www.stat.ee/), the Land register of Latvia (http://www.zemesgramata.lv) and the Land register of Lithuania (http://www.registrucentras.lt/ntr/stat/)

Since 1990 the banking systems of the three Baltic States have faced several financial crises. During last financial crises the rapid growth of real GDP was substantially supported by rapid loan portfolio growth in every Baltic State. During the period 1997 to 2009 the Latvian banking sector experienced the most considerable growth in their loan portfolios, i.e. +2975%. This growth was 2.84 times higher than the growth of the loan portfolio granted by the Estonian banking system (i.e. 1049.27% respectfully) and 2.12 times higher than the growth of the loan portfolio granted by the Lithuanian banking system (i.e. 1402.34% respectfully). As a result, the significant growth of non-performing loans and instability followed.

Therefore the general level of indebtedness in the Baltic States, measured as aggregated loan portfolio divided by the real GDP, has grown rapidly and substantially during the period 1998 - 2009: for the Estonian economy 6.53 times, for the Latvian economy 13.31 times and for the Lithuanian economy 7.49 times. The general level of indebtedness for the mentioned period for Estonian economy changed from 27.19% up to 177.53%, for the Latvian economy from 17.02% up to 226.45%, for the Lithuanian economy from 12.54% up to 93.93%.

The Latvian banking system witnessed a substantial growth of its aggregated loan portfolio. Without having the perspective base for loan repayments, for example growth of population together with GDP per capita, the Latvian economy has resulted in a more substantial decrease compared with other Baltic States. If the Latvian economy had grown by 101.28% by the year 2007, then due to the fall in the next two years the growth had decreased up to 58.28% by the end of 2009. The changes of

the same ratio for Estonian and Lithuanian economy are: 89.31% / 56.83% and 76.08% / 54.19% for the same periods respectfully.

The growth of real GDP was partially supported by investments into real estate markets of all three Baltic States. The best way to present the volume of a real estate market is the use of concluded contracts measured in national currencies. However these statistics are only available for the Estonian market. Instead of this the quantity of deal concluded during the period were used as the base statistics. For the Lithuanian market the quarterly data of number of dwelling transactions were used.

The volume of the real estate market for Estonia, measured in the quantity of concluded deals, decreased by 21% by the end of 2007, by 31% - by the end of 2008 and by 23% - by the end of 2009. The analogous results for Latvian real estate market were 19%, 33% and 20%. The Lithuanian real estate market decreased in 2008 and 2009 by 38% and 40% respectively.

The data of Figure 1 confirms that the greatest growth and fall were faced by the Latvian real estate market. The Estonian real estate market also faced a substantial fall of the real estate market.

The insufficient and timely inadequate analysis of credit risk of financed projects can be treated as the initial reason for the rapid development of the financial crises started in the Baltic States in years 2007 – 2008. This caused the substantial growth of the level of problem loans, as Figure 2 presented.

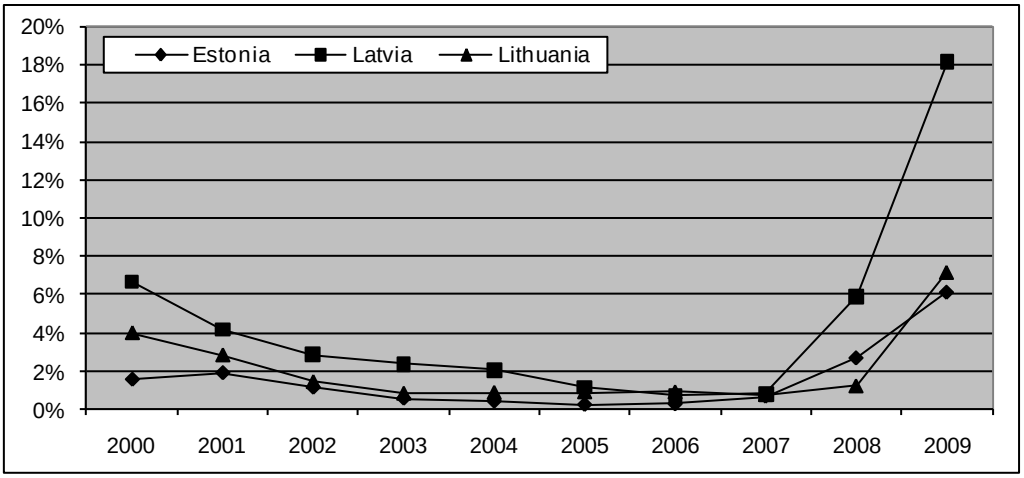

Figure 2 The level of non-performing loans in Baltic States as a percentage of aggregated loan portfolios

Note: results calculated by authors; *Source:* Initial data obtained through the internet from Bank of Estonia (http://www.eestipank.info), the Financial and Capital Market Commission of Latvia (http://www.fktk.lv) and the Bank of Lithuania (http://www.lb.lt)

To calculate the level of non-performing loans for the Estonian banking system the volume of overdue loans over 60 days was used, for the Latvian banking system - close-watch loans plus non-performing loans, for the Lithuanian banking system – impairment loans. The use of identical data of problem loans for the three Baltic States was not possible due to different statistical methodological approaches. In spite of this the lines presented in Figure 2 describe precisely the tendency dominated in the banking sectors of the Baltic States. As Figure 2 shows the level of non-performing loans started to grow in 2008 and achieved its peek point in 2009.

Based on the data presented above, we can conclude that the Latvian economy has experienced the greatest problems in the economy and in the banking system compared with the two other Baltic States. The constant decrease in population and real GDP per capita should have meant a more balanced and conservative growth of the total economy. The statistics present an opposite view of the development of the Latvian economy. As it has been mentioned, Latvia has had the highest growth rate of real GDP. As it has been shown it was achieved with borrowed resources.

4. Analytical Framework

4.1 Development of the framework

Generally, there can be identified two types of credit risk analysis models depending on the required inputs: (i) models, which are presented as a simple function, and (ii) models, which are presented as a composite function.

Exogenous variables used in the first type of models are presented as percentage change of different parameters treated as credit risk determinants. Blaschke, Jones, Majonni and Peria (2001) researched the sensitivity of unexpected loan losses to negative external shocks. They used exogenous variables such as: nominal interest rate, inflation rate, percentage changes of real GDP and percentage change in terms of trade. Shanazarian and Asberg-Sommar (2008) analyzed distance to default or the ratio of value of company equity to the standard deviation of assets' market value, where a company equity value is based on future cash flows. They used as exogenous variables the 3-month state bonds' interest rate, the interstate index of industrial production and the interstate index of consumption prices.

These models prove the proposition that loan portfolio quality depends on the economy cycle.

The second type of models use composite exogenous variables; where one parameter is multiplied by a ratio of two other variables, for example: Pesola (2001, 2005).

It should be noted that endogenous variables in both types of models are presented as a ratio of two different parameters and can be interpreted as default rate, probability of default, default frequency measure, expected default frequency etc.., for example: Bonfim (2009), Gasha and Morales (2004), Jim ́enez and Saurina (2006), Marcucci and Quagliariello (2008, 2009), Meyer and Yeager (2001), Pesola (2001, 2007).

Due to a strong bias of the mentioned models to one type of variables, and in order to better understand links between credit risk and macroeconomics, banking sector and microeconomic level variables, the new model is constructed. This model will be based on a simple function connection between variables and the causality of them will be discussed in the next sub-paragraph.

Generally, the vector error correction model can be applied if there is an absence of a well-developed macroeconomic model, or if this model is not compatible to generate negative macroeconomic shocks.

4.2 Causality of variables and model specification

The variable mainly used as a dependent variable is the quotient of non-performing loans to the aggregated loan portfolio, for example: Bonfim (2009), Gasha and Morales (2004), Jim ́enez and Saurina (2006), Meyer and Yeager (2001), Pesola (2001, 2007). Instead of non-performing loans, the changes in non-performing loans or loan losses can be used, for example: Marcucci and Quagliariello (2008, 2009). The following interpretation allows tracking changes of the variables, but the usage of changes of non-performing loans will shorten the time series. The variable loan losses is difficult to use due to its identification problem. With respect to the mentioned problems of other variables, the ratio of non-performing loans to the aggregated loan portfolio was applied. The following ratio has been used by Gasha and Morales (2004), Jimenez and Saurina (2006), Meyer and Yeager (2001), Pesola (2001, 2007).

Generally, GDP related variables are used as a basis of macroeconomic variables. There are different variations of variables: real GDP growth, output gap, GDP growth rate, per capita income growth etc. Marcucci and Quagliariello (2008, 2009), Bonfim (2009), Meyer and Yeager (2001), Carling, Jacobson, Linde ´and Roszbach (2006), Gasha and Morales (2004), Jim ́enez and Saurina (2006) used growth rate of real GDP as a basis of macroeconomic variables. Regarding this, the real GDP growth was chosen as the first independent variables.

The second macroeconomic variable, used in the research, is the unemployment rate. Bonfim (2009) and Meyer and Yeager (2001) included labor market data into their researches.

As a banking sector variable, we used in the current research the growth of an aggregated loan portfolio. Marcucci and Quagliariello (2008, 2009) used the analogues variable. As it has been shown before, rapid growth of indebtedness causes further growth of non-performing loans during a recession of the economy.

Figure 1 shows that the real estate market faced rapid growth of prices in the years 2004 – 2006 and tremendous decline during the period 2007 - 2009. In connection to this the growth rate of the real estate market was chosen as the fourth independent variable.

Following a variables' analysis the respective model is to be specified. The estimations are based on the aggregated quarterly data. Table 1 presents time range and the initial number of observations for the three Baltic States.

Table 1 Time range of research for the three Baltic States

	Estonia	**Latvia**	**Lithuania**
Time range	July 1997 - 4Q 2009	1Q 2002 - 4Q 2009	1Q 2004 - 4Q 2009
Initial number of observations	51	32	24

The general theoretical relationship between variables for estimation of non-performing loans is as follows:

$$RNPL_t = \beta_0 + \beta_1 GALP_t + \beta_2 GGDP_t + \beta_3 RRE_t + \beta_4 UN_t + \varepsilon_t \qquad (1)$$

Where $RNPL_t$ is the ratio of non-performing loans to the aggregated loan portfolio of banks.
$GALP_t$ is the growth of a banks' aggregated loan portfolio.
$GGDP_t$ is the growth rate of real GDP.
RRE_t is the growth rate of the real estate market in Estonia.
UN_t is the unemployment rate.

Based on the chosen variables and specified model, the hypothesis proposed in the literature review will be tested in the econometric analysis paragraph separately for the three Baltic States. No additional normalization to the variables of the three Baltic States has been applied. The calculations, presented in the econometric analysis paragraph, are performed using E-Views software.

5. Methodological Approach

In general, if time series are non-stationary the estimates calculated using Ordinary Least Squares procedure (OLS) and research conclusions based on non-stationary time series will be inaccurate. This will easily cause the results' wrong interpretation and incorrect forecasts.

Since the theory proposes that if some time series are non-stationary in levels, the combination of such differenced time series may have one or several co-integrating connections and therefore be *I(1)* co-integrated, the Vector Error Correction Model (VECM) is employed.

To investigate whether time series are non-stationary the Augmented Dickey-Fuller test (1979, 1981) should be carried out.

Granger (1983) proposes that the Error Correction Model can present a system of time series of co-integrated variables. The postulate of VECM states that disequilibrium in one period is to be corrected in the next period, i.e. the long-term equilibrium is presented as the following (Granger and Engle, 1987):

$$\beta_t x_t = 0 \qquad (2)$$

where x_t is a vector of some variable x, and β_t is a co-integrating vector. Equilibrium error e_t shows the deviation from long-run equilibrium, and in most time periods x_t will not be in equilibrium or $e_t = \beta_t x_t$.

The VEC model developed by Johansen (1991) can be presented as:

$$\Delta X_t = \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \prod X_{t-k} + \Phi D_t + \mu + \varepsilon_t \qquad (3)$$

Here Γ denotes an $(n \times n)$ matrix of coefficients and contains the short-term relationships information among variables. Π is an $(n \times n)$ coefficient matrix, which can be decomposed as $\Pi = \alpha\beta'$, where α and β compose $(n \times r)$ matrix with full rank r. Variables $\beta_{(1)}, \ldots, \beta_{(r)}$ of matrix are linearly independent co-integrating vectors. Variables α of the matrix are the adjustments coefficients by stationary linear combinations. D_t are seasonal dummies.

The main principle of the Johansen procedure lies in the estimation of the rank of the matrix and its characteristic roots performing co-integration test. After that, the two important parameters to be estimated in VECM model are β and α coefficients.

Prior to running the co-integration test, the optimal VEC autoregressive lag length should be determined. This can be done using information criteria, such as AIC (Akaike Information Criteria) and BIC (Bayesian Information Criteria) (Winker, 2000) or a residual autocorrelation test (Jacobson, 1993). Liew (2004) showed that AIC and FPE (Final Prediction Error) provide better results with small samples.

The co-integration test used in the article was developed by Johansen (1991).

When the VEC model is constructed the results of the model are interpreted by the impulse response functions. The generalized impulses suggested by Pesaran and Shin (1998) are used, since this function does not depend on the VAR order.

In order to confirm whether the model presents valid results, various tests for misspecification should be conducted. We have chosen the LM test for autocorrelation in the residuals, White's heteroskedasticity test and Jarque-Bera test.

6. Econometric Analysis of the Estonian Banking System

6.1 Variables' description

The estimations are based on the aggregated quarterly data for the period from July 1997 up to December 2009, which is the longest time range of time series for three Baltic States. The following time range covers at least two financial crises undergone by the Estonian banking system. The use of a longer time period was not possible due to the absence of the respective statistics of non-performing loans for the Estonian banking sector.

Banks and branches of foreign banks operating in Estonia represent the Estonian banking sector. According to the legislation, only banks have to present obligatory reports to the financial supervision authority. Therefore the banking sector's data used in the article includes data of Estonian banks only. Data of branches of foreign banks is not presented in the official banking statistics.

The detailed description of variables used for estimation of non-performing loans of the Estonian banking system is as follows:

$RNPL_t$ is the ratio of non-performing loans to the aggregated loan portfolio of banks. Initial data for calculation was obtained from the Bank of Estonia. Lis, Pages, and Saurina (2000) point out that according to standard practice a loan is treated as non-performing if some part of this loan or interest is overdue past 90 days. For Estonia the following statistics covers non-performing loans with the period overdue past 60 days only.

$GALP_t$ is the growth of a banks' aggregated loan. The initial data for calculations was obtained from the Bank of Estonia. Since the third quarter of 1999 to the fourth quarter of 2008 the loan portfolio of Estonian banks has been constantly growing.

$GGDP_t$ is the growth rate of real GDP. The initial data for calculation was obtained from Estonian statistics. Data has been seasonally adjusted. The growth of real GDP continued up to the end of 2007.

RRE_t is the growth rate of the real estate market in Estonia. The initial data for calculations was obtained from Estonian statistics. The growth rate calculation is based on the level of concluded deals within the quarter measured in Estonian Kroons. The period from 2003 up to 2007 can be treated as a period of real estate boom (Pesola, 2001, p. 13). During the time period from the first quarter of 2003 to fourth quarter of 2006, the growth of concluded real estate deals on a quarter bases was up 418.45%. Since the second quarter of 1997 to the second quarter of 2003, the analogous number was 115.01%. The ratio of concluded real estate deals to real GDP was 55% by the fourth quarter of 2006, with an average ratio of 20.44% for the period from the second quarter of 1997 to fourth quarter of 2009. The following ratio (concluded real estate deals to real GDP) decreased substantially by the end of 2009 and reached the level of 2002, i.e. 14.66%.

UN_t is the unemployment rate.

Before going to VECM, all variables are tested for presence of unit root in time series.

6.2 Unit root and Co-integration tests

Performing the ADF test the null hypothesis of presence of unit root in time series is tested. Table 2 presents the results of unit root tests for 5 variables.

Table 2 Augmented Dickey-Fuller test results

	Intercept	**Trend and Intercept**
GALP	-2.01007	-1.15262
∇GALP	-3.37729**	-8.20360**
GGDP	-0.84797	-1.24183
∇GGDP	-16.6934***	-16.6155***
RNPL	-1.21053	1.23296
∇RNPL	-3.01655**	-3.40097*
RRE	-3.36591**	-3.59013**
∇RRE	-3.36591**	-26.6728***
UN	-1.14325	0.09904
∇UN	-5.19197***	-5.31096***

Notes: (1) ∇ means 1st difference; (2) *, ** and *** imply rejection of the unit root at the 10%, 5%, 1% level.

The results of the test indicate that the time series of all variables, except RRE, are non-stationary in levels. The first-differenced time series found all to be stationary. The null hypothesis of presence of unit root is rejected for most variables at the 5% significance level, except for RNPL, for which the null hypothesis is rejected at the 10% significance level. When trend and intercept in time series are applied all the null hypothesis of unit root is rejected for all variables at least at the 5% significance level. Results of Table 2 indicate that the time series are *I(1)* co-integrated.

Since the variables are co-integrated of the same order, an optimal autoregressive lag has to be found and the co-integration test to be performed. Based on the AIC and Lagrange Multiplier (LM) test the optimal autoregressive lag was found to be 3.

Based on the optimal autoregressive lag length, the co-integration procedure was estimated with the purpose to choose the optimal model and the number of co-integrating vectors. The model with no deterministic trend (restricted constant) with two co-integrating vectors was chosen. A gradually better L_{trace} result was shown by the model with a linear deterministic trend, but based on this choice the

constructed VECM had worse results. According to the ADF test (see table 2) the model with no trend is preferable, since results for all variables are significant at 5%.

Table 3 Johansen' test for co-integrating vectors

Hypothesized No. of CE(s)	Eigen value	Trace Statistic	0.05 Critical Value	Prob.
None *	0.763233	136.0197	76.97277	0.0000
At most 1 *	0.495686	69.74849	54.07904	0.0011
At most 2 *	0.316503	38.25889	35.19275	0.0226
At most 3 *	0.23171	20.7544	20.26184	0.0428
At most 4	0.171049	8.629352	9.164546	0.0631

Hypothesized No. of CE(s)	Eigen value	Max-Eigen Statistic	0.05 Critical Value	Prob.
None *	0.763233	66.27116	34.80587	0.0000
At most 1 *	0.495686	31.48960	28.58808	0.0207
At most 2	0.316503	17.50449	22.29962	0.2045
At most 3	0.231710	12.12505	15.89210	0.1788
At most 4	0.171049	8.629352	9.164546	0.0631

Notes: * denotes rejection of the hypothesis at the 5% level.

Regarding Table 3, the trace statistics (L_{trace}) and the max-eigen statistics (L_{max}) have a different number of co-integrating vectors (4 and 2 respectively). In case the statistics have a different number of co-integrating vectors, it is recommended to choose the respective number of co-integrating vectors based on the economic interpretation of co-integrating relations. Following that reasoning the model with two co-integrating vectors was chosen.

6.3 VEC model specification

After the co-integrating rank and optimal lag structure are determined, the VEC model for Estonia is specified as follows:

$$\Delta x_t = c_0 + \Gamma_1 \Delta x_{t-1} + \Gamma_2 \Delta x_{t-2} + \Gamma_3 \Delta x_{t-3} + \alpha\beta' x_{t-1} + \varepsilon_t \qquad (4)$$

where x_t = [$RNPL_t$, RRE_t, $GALP_t$, $GGDP_t$, UN_t], $\varepsilon_t \sim N(0,\Omega)$.

Table 4 below summarizes the estimates for the beta parameters in the long-run relationships in the estimated model. Almost all coefficients are significant at the 5% level and have the expected sign.

Table 4 β coefficients of co-integrating vectors

	RNPL	RRE	GALP	GGDP	UN	C
Coint.1	1	0	0.49238**	0.53416*	0.16935**	-1.09746**
			[5.01073]	[1.90900]	[2.31205]	[-4.09812]
Coint.2	0	1	-2.75392**	-23.1307**	-4.29456**	25.7952**
			[-2.68296]	[-7.91373]	[-5.61297]	[9.22143]

Note: t-statistics are in square brackets; * and ** present statistical significance of variable at the 10%, 5% level.

Real GDP changes have the greater influence regarding long-run relationships. The other variables; such as, loan portfolio growth, changes of real estate market and unemployment have their respective influence in the long run.

Adjustment coefficients of co-integrating vectors returning the variables to the long run equilibrium after-shocks are presented in table 5.

The adjustments coefficients of real GDP growth, loan portfolio growth and unemployment are statistically significant.

Table 5 α adjustments coefficients

	RNPL	GALP	GGDP	RRE	UN
Coint.1	-0.17500*	-0.34765	2.23777	-4.65912	-0.00456**
	[1.9297]	[0.9534]	[0.0192]	[0.4180]	[-3.1259]
Coint.2	0.01383**	-0.07980**	0.10319**	-0.59742	0.03847**
	[-2.3517]	[1.8858]	[-2.5093]	[1.4796]	[-2.2235]

Note: t-statistics are in square brackets; * and ** presents statistical significance at the 10% and 5% level.

6.4 Specification tests for estimated model validity

Table 6 presents the summarized results of three specification tests for normal distribution in the residuals, which have been performed to confirm the validity of the estimated VEC model.

Table 6 LM-test, White's heteroskedasticity test and Jarque-Bera test results

Test	**LM test**				**White's heteroskedasticity**	**Jarque-Bera**
Explanation	**No autocorrelation**				**No heteroskedasticity**	**Normality test**
Nr. of lags	Lag 1	Lag 2	Lag 3	Lag 4		
P-value	0.6412	0.5612	0.5758	0.1327	0.3204	0.5384

The results of the three conducted tests confirm that the VEC model is correctly specified.

6.5 Impulse response functions

The diagrams in Figure 3 indicate the impulse responses of an endogenous variable of the estimated model with 3 lags and two co-integrating vectors. The length of the forecast is 16 periods ahead (16 quarters, 4 years).

The results show that RNPL decrease with the growth of real GDP. If a seventh period is achieved the growth of real GDP by 1% causes the decrease of problem loans by 0.613%. The further growth of real GDP can cause the growth in the level of problem loans. This fact is quite realistic since the achievement of real GDP of the so called critical level can result in an increase of problem loans. The showed results prove the first hypothesis that real GDP is an important variable for predicting the level of non-performing loans.

The influence of rapid loan portfolio growth is quite similar to the real GDP influence. The real GDP and loan portfolio growth until the seventh period will cause the fall in the level of non-performing loans. The following relationship between real GDP, loan portfolio and non-performing loans is natural. Nevertheless, the influence of real GDP growth vanishes at the 7-th period, but influence of loan portfolio growth continues until the 8-th or 9-th period. Since this represents some time shift to the changes between variables or exactly proves the direct influence of external negative shock, which is seen as the initial point for deterioration of economic conditions. The further growth of real GDP and loan portfolio causes the opposite changes in the level of non-performing loans, i.e. they start growing. The following change in the variable movement direction is interpreted as the deterioration of the barrier's credit risk analysis policies and the substantial decrease in the quality of loans granted. As a result, more speculative deals will be financed.

The following facts prove the second hypothesis that rapid growth of indebtedness has crucial consequences to the growth of non-performing loans. The influence of rapid loan portfolio growth comes with some time shift after negative effects have been caused by the respective changes in real GDP. The stronger influence of rapid loan portfolio growth also proves the proposition that banks' credit risk analysis policies had been insufficient in the previous periods. If banks had run stricter credit risk policies the impulse responses of NPL to GALP would be smoother and could mean less realized non-performing loans.

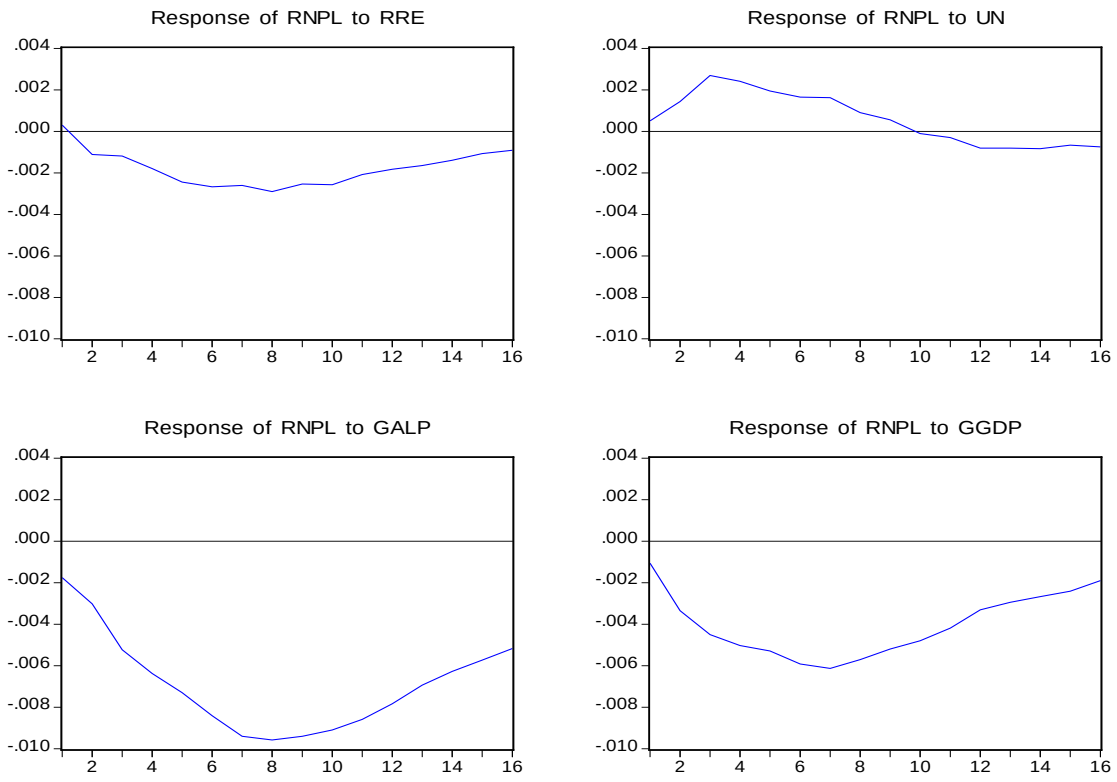

Figure 3 Response of RNPL to GGDP, GALP, RRE and UN

Changes of the real estate market (RRE) caused analogues influence as GGDP and GALP did. Comparing to GGDP and GALP, the influence of RRE turned out to be two-three times weaker by the 7-th period depending on the comparing variable. The third hypothesis of considering the changes of the real estate market as an extremely important variable has been partially proved. Namely, it has been proved that rapid growth of the real estate market prices did play some partial, important role regarding the growth of NPL. The influence of RRE has not been as crucial as it has been previously assumed. The influence of RRE has also appeared with a time shift; as it has also been showed with GALP.

There is an interesting influence of the unemployment rate on the level of problem loans. It is obvious that the determination of the unemployment influence is much more precise if the analysis is performed with mortgage loans only. The current data of non-performing loans consists of combined data of private persons and companies. A decrease in UN by 1% causes RNPL growth of 0.25% by the 3-rd and 4-th period. Further unemployment growth can cause the growth of non-performing loans and simultaneous movements of the variables. Analogous changes in the variables UN and RNPL movements observed in the periods since fourth quarter 2005 to second quarter 2008, as presented by Figure 4 on the next page.

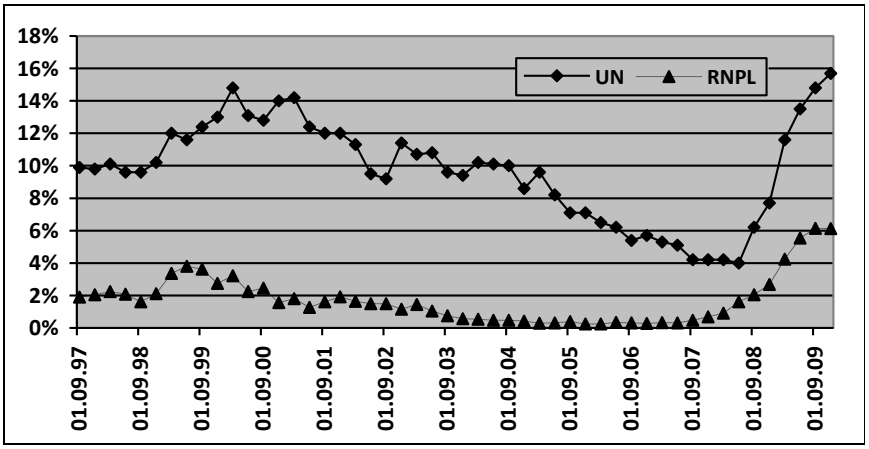

Figure 4 Changes of UN and RNPL during second quarter 1997 to fourth quarter 2009

Note: results calculated by authors.

Source: Initial data obtained through internet from Bank of Estonia (http://www.eestipank.info) and Estonian Statistics (http://www.stat.ee).

During the period since second quarter 1999 to first quarter 2001, the variables moved in the different directions.

7. Econometric Analysis of the Latvian Banking System

7.1 **Variables' description**

The time range of the analysis, based on the aggregated quarterly data, covers the period from March 2002 up to December 2009. The following period consists of 32 observations. The following time range covers just one financial crisis started in 2007. The results of the research are consistent and sufficient to make reliable conclusions. The use of longer time series was not possible due to the absence of quarterly data of unemployment rates for the Latvian economy.

Banks and branches of foreign banks operate in Latvia according to the Credit Institution Law. Responsibility for supervising and collecting respective banking statistics is executed by the Financial and Capital Market Commission. Therefore the banking sector's data used in the article includes data of banks and branches of foreign banks (thereafter, banks). Compared to the data of the Estonian banking sector, data of Latvian banking statistics gives the full picture of the banking sector.

The detailed description of variables used for estimation of non-performing loans of Latvian banking system is as follows.

$RNPL_t$ is the ratio of close watch loans plus non-performing loans to the aggregated loan portfolio of banks. Initial data for calculation was obtained from the Financial and Capital Market Commission. Until the end of 1999 only annual data of close watch loans plus non-performing loans were collected. Since the beginning of 2000 there are available quarter statistics of the variable. The Financial and Capital Market Commission collected the statistics of the variable until the end of 2008. Since the year 2009 there are available only statistics of non-performing loans that are past due over 90 days. This variable was collected since the fourth quarter of 2004 and data was also adjusted in the fourth quarter of 2006. The statistics of non-performing loans past due over 90 days were not used due to the short time period and an adjustment that shifted the data substantially.

In order to make the research more appropriate and to take into account the substantial changes of the market in 2009, the time series of close watch loans plus non-performing loans were extrapolated over 4 periods up to the fourth quarter of 2009. The extrapolation was calculated by multiplying the quarter data of non-performing loans past due over 90 days with the average ratio close watch loans

plus non-performing loans to non-performing loans past due over 90 days for the period of fourth quarter 2006 – fourth quarter 2008.

$GALP_t$ is the growth of a banks' aggregated loan. The initial data for calculations was obtained from the Financial and Capital Market Commission. Since the beginning of the sample to the third quarter of 2008 the aggregated loan portfolio of Latvian banks has been constantly growing.

$GGDP_t$ is the growth rate of real GDP. The initial data for calculation was obtained from Latvian statistics. Data has been seasonally adjusted. The growth of real GDP continued up to the end of 2007.

RRE_t is the growth rate of the real estate market in Latvia. The initial data for calculations was obtained from the Land Register. The growth rate calculation is based on the quantity of concluded deals within the quarter. The period from the first quarter of 2003 up to the third quarter of 2007 can be treated as a period of real estate boom (Pesola, 2001, p. 13). During the time period from first quarter 2003 to fourth quarter 2006, the growth of concluded real estate deals on a quarter basis was up 114%. Since the first quarter 2002 to the fourth quarter of 2002, the analogous number was 45%. If the number of concluded deals within the quarter were used, measured in Lats, there is definitely included the influence of constantly growing real estate prices.

UN_t is the unemployment rate.

Before going to VECM, all variables are tested for presence of unit root in time series.

7.2 Unit root and Co-integration tests

Performing the ADF test the null hypothesis of presence of unit root in time series is tested. Table 7 presents the results of unit root tests for 5 variables.

Table 7 Augmented Dickey-Fuller test results

	Intercept	Trend and Intercept	None
GALP	-0.824496	-2.016232	-0.556911
∇GALP	-6.936370***	-7.825566***	-6.996698***
GGDP	-2.315578	-3.368343*	-0.593914
∇GGDP	-7.937462***	-4.481037***	-8.017798***
RNPL	-2.345088	0.595062	-0.590346
∇RNPL	-2.419857	-3.376735*	-2.501572**
RRE	-8.855302***	-8.652788***	-9.042066***
∇RRE	-8.855302***	-8.652788***	-9.042066***
UN	-1.654730	1.153160	1.108449
∇UN	-3.655796**	-4.285633**	-3.527406***

Notes: (1) ∇means 1st difference; (2) *, ** and *** imply rejection of the unit root at the 10%, 5%, 1% level.

The results of the test indicate that the time series of all variables, except GGDP time series with trend and intercept and RRE, are non-stationary in levels. The first-differenced time series found all to be stationary. The null hypothesis of presence of unit root is rejected for most variables at the 5% significance level, except for RNPL, for which the null hypothesis is rejected at the 10% significance level if trend and intercept is included and at 5% without trend and intercept. Results of table 7 indicate that the time series are *I(1)* co-integrated.

Since the variables are co-integrated of the same order, optimal autoregressive lag has to be found and the co-integration test to be performed. Based on the AIC and Lagrange Multiplier (LM) test the optimal autoregressive lag was found to be 2.

Based on the optimal autoregressive lag length, the co-integration procedure was estimated with the purpose to choose the optimal model and the number of co-integrating vectors. The model with trend and intercept with two co-integrating vectors was chosen.

Table 8 Johansen' test for co-integrating vectors

Hypothesized No. of CE(s)	Eigen value	Trace Statistic	0.05 Critical Value	Prob.
None *	0.821334	119.6018	88.8038	0.0001
At most 1 *	0.677953	71.37912	63.8761	0.0102
At most 2	0.566665	39.65354	42.91525	0.1021
At most 3	0.319356	16.2387	25.87211	0.4735
At most 4	0.177361	5.466659	12.51798	0.5308
Hypothesized No. of CE(s)	**Eigen value**	**Max-Eigen Statistic**	**0.05 Critical Value**	**Prob.**
None *	0.821334	48.22267	38.33101	0.0027
At most 1	0.677953	31.72557	32.11832	0.0558
At most 2	0.566665	23.41484	25.82321	0.1007
At most 3	0.319356	10.77204	19.38704	0.5370
At most 4	0.177361	5.466659	12.51798	0.5308

Notes: * denotes rejection of the hypothesis at the 5% level.

Regarding table 8, the trace statistics (L_{trace}) and the max-eigen statistics (L_{max}) have an analogous number of co-integrating vectors (2 and 1 respectively). In case the statistics have a different number of co-integrating vectors, it is recommended to choose the respective number of co-integrating vectors based on the economic interpretation of co-integrating relations. Based on that principle the model with two co-integrating vectors was chosen.

7.3 VEC model specification

After the co-integrating rank and optimal lag structure are determined, the VEC model for Latvia is specified as:

$$\Delta x_t = c_0 + \Gamma_1 \Delta x_{t-1} + \Gamma_2 \Delta x_{t-2} + \alpha\beta' x_{t-1} + \varepsilon_t \qquad (5)$$

where x_t = [$RNPL_t$, RRE_t, $GALP_t$, $GGDP_t$, UN_t], $\varepsilon_t \sim N(\mathbf{0},\Omega)$.

Table 9 summarizes the estimates for the beta parameters in the long-run relationships in the estimated model. Almost all coefficients, except UN, are significant at the 5% level and have the expected sign.

Table 9 β coefficients of co-integrating vectors

	RNPL	GALP	GGDP	RRE	UN	@TREND (2002 Q2)	C
CointEq1	1	0	0.785368**	-0.046075**	0.070459	0.001559**	-0.807132
			[6.63392]	[-2.72545]	[0.36245]	[2.41849]	
CointEq2	0	1	-3.768732**	0.420804**	-1.14548	-0.00341	2.460723
			[-4.61379]	[3.60763]	[-0.85402]	[-0.76652]	

Note: t-statistics are in square brackets; * and ** present statistical significance of variable at the 10%, 5% level.

As in the research of the Estonian case, the real GDP changes have the greater influence regarding long-run relationships. The other variables; such as, changes of real estate market and unemployment have their respective influence in the long run.

Adjustment coefficients of co-integrating vectors returning the variables to the long run equilibrium aftershocks are presented in table 10 below.

Table 10 α adjustments coefficients

	RNPL	GALP	GGDP	RRE	UN
CointEq1	-1.31783**	1.783735	1.856777**	-5.743665	-1.43866**
	[-3.29998]	[1.27835]	[2.80468]	[-0.79109]	[-4.27659]
CointEq2	-0.16951**	0.209286	0.490154**	-3.043193**	-0.11236*
	[-2.38055]	[0.84120]	[4.15235]	[-2.35074]	[-1.87314]

Note: t-statistics are in square brackets; * and ** present statistical significance of variable at the 10%, 5% level.

The adjustments coefficients of real GDP growth, real estate market growth and unemployment are statistically significant.

7.4 Specification tests for estimated model validity

Table 11 presents the summarized results of three specification tests for normal distribution in the residuals, which have been performed to confirm the validity of the estimated VEC model.

Table 11 LM-test, White's heteroskedasticity test and Jarque-Bera test results

Test	LM test			White's heteroskedasticity	Jarque-Bera
Explanation	No autocorrelation			No heteroskedasticity	Normality test
Nr. of lags	Lag 1	Lag 2	Lag 3		
P- value	0.762	0.9381	0.9788	0.3586	0.99

The results of the three tests conducted confirm that the VEC model is correctly specified.

7.5 Impulse response functions

The diagrams in Figure 5 present the impulse response functions constructed on the responses of an endogenous variable of the estimated model with 2 optimal lags and two co-integrating vectors. The data were forecasted ahead for 9 periods (9 quarters, i.e. 2.25 years).

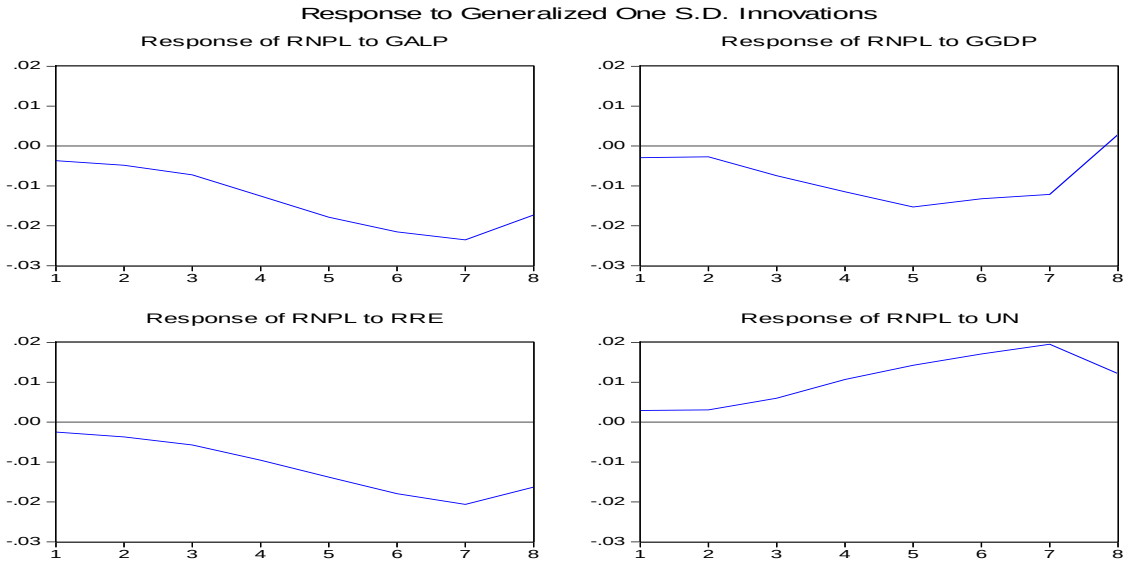

Figure 5 Response of RNPL to GGDP, GALP, RRE, and UN

In spite of the different time range in Estonian and Latvian banking sector analysis, the results received and responses of endogenous variable are similar. The difference between the Latvian and the

Estonian market appears in the terms or speed of the response of RNPL to the impulses of exogenous variables.

The results of the research support that initial impact on the level of non-performing loans comes from the changes in real GDP, as Figure 5 indicates. If the fifth period is achieved the growth of real GRP by 1% causes the decrease of problem loans by 0.0163%. The further growth of real GDP causes the growth in the level of RNPL. This fact is quite realistic since the achievement of real GDP of the so called critical level can result in an increase of problem loans. The results shown prove the first hypothesis that real GDP is an important variable for predicting the level of non-performing loans.

The influence of GALP and RRE has quite an identical trend. The loan portfolio and real estate market growth until the seventh period causes the fall in the level of non-performing loans, as Figure 6 presents. Taking into account the changes of real GDP, the following relationship between these variables are natural. Nevertheless, the influence of real GDP growth vanishes at the 5-th period, but influence of the loan portfolio and real estate market growth continues up to the 7-th period. Since this represents some time shift to the changes between variables or exactly proves the direct influence of external negative shock, which is seen as the initial point for deterioration of economic conditions. The further growth of real GDP, loan portfolio and real estate market causes the opposite changes in the level of non-performing loans, i.e. they start growing. The following change in the variable movement direction is interpreted as the deterioration of barriers' of credit risk analysis and the substantial decrease in the quality of loans granted. As a result, more speculative deals will be financed. The following facts completely prove the second and third hypothesis that rapid growth of indebtedness and real estate market has crucial consequences to the growth of non-performing loans. The influence of rapid loan portfolio and real estate market growth comes with some time shift after negative effects have been caused by the respective changes in real GDP. The stronger influence of rapid loan portfolio and real estate market growth also proves the proposition that banks' credit risk analysis policies had been insufficient in the previous periods. If banks had run stricter credit risk policies the impulse responses of NPL to GALP and NPL to RRE would be smoother and could mean less realized non-performing loans.

There is an interesting influence of the unemployment rate on the level of problem loans. Regarding the interpretation of results of UN, the time range of the research of the Latvian market should be taken into consideration.

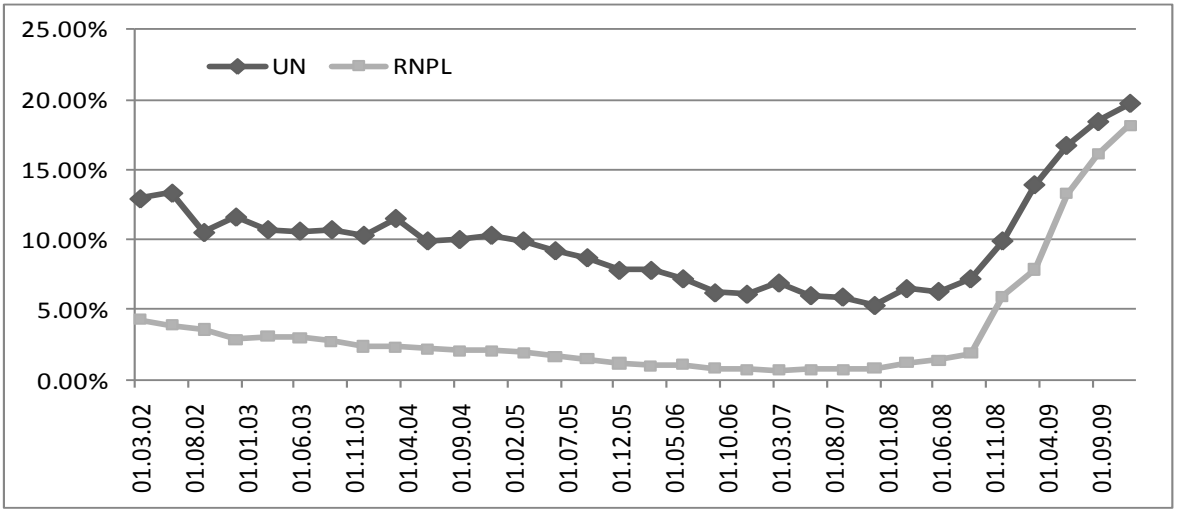

Figure 6 Changes of UN and RNPL during fourth quarter 2002 to fourth quarter 2009

Note: results calculated by authors.

Source: Initial data obtained through internet from Statistics Latvia and the Financial (www.csb.gov.lv/) and Capital market commission of Latvia (http://www.fktk.lv).

The movements of UN and RNPL variables presented in Figure 6 are analogous to the movements of UN and RNPL variables presented in Figure 4. The difference in response of RNPL to the impulses of UN for the Estonian and Latvian market is in the speed of changes of the variables. Therefore impulse response of RNPL to UN for the Estonian and Latvian market has some differences.

8. Econometric Analysis of the Lithuanian Banking System

8.1 Variables' description

The time range of the analysis of the Lithuanian market is the shortest one, compared with other Baltic States. The research period is based on 24 observations from March 2004 up to December 2009. The following time range covers the last financial crisis. The results of the research are consistent and sufficient to make reliable conclusions regarding the direction of changes of the variables. The use of a longer time series was not possible due to the absence of quarter data of non-performing loans for the Lithuanian economy.

Banks and branches of foreign banks operate in Lithuania according to the Law on Financial Institutions. Responsibility for supervising and collecting respective banking statistics is executed by the Bank of Lithuania. Therefore the banking sector's data used in the article includes data of banks and branches of foreign banks (thereafter, banks).

The detailed description of variables used for estimation of non-performing loans of the Lithuanian banking system is as follows:

$RNPL_t$ is the ratio of impairment losses to the aggregated loan portfolio of banks. Initial data for calculation was obtained from the Bank of Lithuania. The Bank of Lithuania collected two types of variables describing non-performing loans: the ratio of impairment losses to the aggregated loan portfolio and the ratio of non-performing loans to the aggregated loan portfolio. The use of a second variable would be preferable, but the break in the data time series due to change in the non-performing loans definition in the second quarter of 2008 made it impossible to use due to data absence. Until the end of 2005 only annual data of impairment losses were collected. At the start of 2006 there are available quarter statistics of the variable.

Since the initial result of the ADF test proved that the time series of the endogenous variable for the period fourth quarter 2005 to fourth quarter 2009 were non-stationary in level and in first differences, the time ranges were prolonged up to the first quarter 2004. The interpolation of data was based on the annual data for endogenous variable.

$GALP_t$ is the growth of a banks' aggregated loan. The initial data for calculations was obtained from the Bank of Lithuania. Since the first quarter of 2001 to the third quarter of 2008 the aggregated loan portfolio of Lithuanian banks has been constantly growing.

$GGDP_t$ is the growth rate of real GDP. The initial data for calculation was obtained from Lithuanian statistics. Data has been seasonally adjusted. The growth of real GDP continued up to the end of 2008.

RRE_t is the growth rate of the real estate market in Lithuania. The initial data for calculations was obtained from the Bank of Lithuania and Cadastre Registers. The calculation of the growth rate is based on the quarter number of dwelling transactions. Therefore it has a definite influence on the descriptive power of the RRE as a variable of the research.

UN_t is the unemployment rate.

Before going to VECM, all variables are tested for presence of unit root in time series.

8.2 Unit root and Co-integration tests

Performing the ADF test the null hypothesis of presence of unit root in time series is tested. Table 12 presents the results of unit root tests for 5 variables.

Table 12 Augmented Dickey-Fuller test results

	Intercept	Trend and Intercept	None
GALP	-0.824496	-2.016232	-0.556911
∇GALP	-6.936370***	-7.825566***	-6.996698***
GGDP	-2.315578	-3.368343*	-0.593914
∇GGDP	-7.937462***	-4.481037***	-8.017798***
RNPL	-2.345088	0.595062	-0.590346
∇RNPL	-2.419857	-3.376735*	-2.501572**
RRE	-8.855302***	-8.652788***	-9.042066***
∇RRE	-8.855302***	-8.652788***	-9.042066***
UN	-1.654730	1.153160	1.108449
∇UN	-3.655796**	-4.285633**	-3.527406***

Notes: (1)∇ means 1st differences; (2) *, ** and *** imply rejection of the unit root at the 10%, 5% and 1% levels.

The results of the test indicate that the time series of all variables, except GGDP time series with trend and intercept and RRE, are non-stationary in levels. The first-differenced time series found all to be stationary. The null hypothesis of presence of unit root is rejected for most variables at the 5% significance level, except for RNPL, for which the null hypothesis is rejected at the 10% significance level if trend and intercept is included and at 5% without trend and intercept. Results of table 12 indicate that the time series are *I(1)* co-integrated.

Since the variables are co-integrated of the same order, optimal autoregressive lag has to be found and the co-integration test to be performed. Based on the AIC and Lagrange Multiplier (LM) test the optimal autoregressive lag was found to be 1.

Based on the optimal autoregressive lag length, the co-integration procedure was estimated with the purpose to choose the optimal model and the number of co-integrating vectors. The model with trend and intercept with two co-integrating vectors was chosen.

Table 13 Johansen' test for co-integrating vectors

Hypothesized No. of CE(s)	Eigen value	Trace Statistic	0.05 Critical Value	Prob.
None *	0.821334	119.6018	88.8038	0.0001
At most 1 *	0.677953	71.37912	63.8761	0.0102
At most 2	0.566665	39.65354	42.91525	0.1021
At most 3	0.319356	16.2387	25.87211	0.4735
At most 4	0.177361	5.466659	12.51798	0.5308

Hypothesized No. of CE(s)	Eigen value	Max-Eigen Statistic	0.05 Critical Value	Prob.
None *	0.821334	48.22267	38.33101	0.0027
At most 1	0.677953	31.72557	32.11832	0.0558
At most 2	0.566665	23.41484	25.82321	0.1007
At most 3	0.319356	10.77204	19.38704	0.537
At most 4	0.177361	5.466659	12.51798	0.5308

Notes: * denotes rejection of the hypothesis at the 5% level.

Regarding table 13, the trace statistics (L_{trace}) and the max-eigen statistics (L_{max}) have an analogous number of co-integrating vectors (2 and 1 respectively). In case the statistics have a

different number of co-integrating vectors, it is recommended to choose the respective number of co-integrating vectors based on the economic interpretation of co-integrating relations. Based on that principle the model with two co-integrating vectors was chosen.

8.3 VEC model specification

After the co-integrating rank and optimal lag structure are determined, the VEC model for Lithuania is specified as follows:

$$\Delta x_t = c_0 + \Gamma_1 \Delta x_{t-1} + \alpha\beta' x_{t-1} + \varepsilon_t \qquad (6)$$

where x_t = [$RNPL_t$, RRE_t, $GALP_t$, $GGDP_t$, UN_t], $\varepsilon_t \sim N(\mathbf{0},\Omega)$.

Table 14 below summarizes the estimates for the beta parameters in the long-run relationships in the estimated model. Almost all coefficients are significant at the 5% level and have the expected sign.

Table 14 β coefficients of co-integrating vectors

	RNPL	RRE	UN	GALP	GGDP	C
CointEq1	1	0	-0.015473	0.038097**	-0.092433**	0.042329
			[-0.76981]	[2.46065]	[-11.4552]	
CointEq2	0	1	-9.281128**	4.494286	-22.37207**	17.59466
			[-2.45457]	[1.54302]	[-14.7381]	

Note: t-statistics are in square brackets; * and ** present statistical significance at the 10%, 5% level.

Real GDP changes have the greater influence regarding long-run relationships. The other variables; such as, loan portfolio growth, changes of real estate market and unemployment have their respective influence in the long run.

Table 15 α adjustments coefficients

	RNPL	RRE	UN	GALP	GGDP
CointEq1	0.375469**	41.87474	-3.453867**	-9.72321	11.28868
	[2.02315]	[1.29142]	[-2.25271]	[-1.30472]	[1.19698]
CointEq2	-0.001624*	-0.019225	0.014033**	0.044423	0.040878
	[-1.84834]	[-0.12526]	[1.93365]	[1.25930]	[0.91569]

Note: t-statistics are in square brackets; * and ** presents statistical significance at the 10%, 5% level.

Adjustment coefficients of co-integrating vectors returning the variables to the long run equilibrium aftershocks are presented in table 15 above.

The adjustments coefficient of unemployment is statistically significant.

8.4 Specification tests for estimated model validity

Table 16 presents the summarized results of three specification tests for normal distribution in the residuals, which have been performed to confirm the validity of the estimated VEC model.

Table 16 LM-test, White's heteroskedasticity test and Jarque-Bera test results

Test	LM test		White's heteroskedasticity	Jarque-Bera
Explanation	No autocorrelation		No heteroskedasticity	Normality test
Nr. of lags	Lag 1	Lag 2		
P value	0.1801	0.0309	0.4355	1.00

The results of the three tests conducted confirm that the VEC model is correctly specified.

8.5 Impulse response functions

The diagrams in Figure 7 present the impulse response functions constructed on the responses of the dependent variable of the estimated model with 1 optimal lags and two co-integrating vectors. The data were forecasted ahead for 10 periods (10 quarters, i.e. 2.5 years). It should be taken into

consideration that research is based on a short time range and the tendency of development of responses of an endogenous variable is described.

The results of the current research have completely proved all hypotheses. The greatest influences on the level of non-performing loans have the changes of real GDP and RRE, as Figure 7 presented.

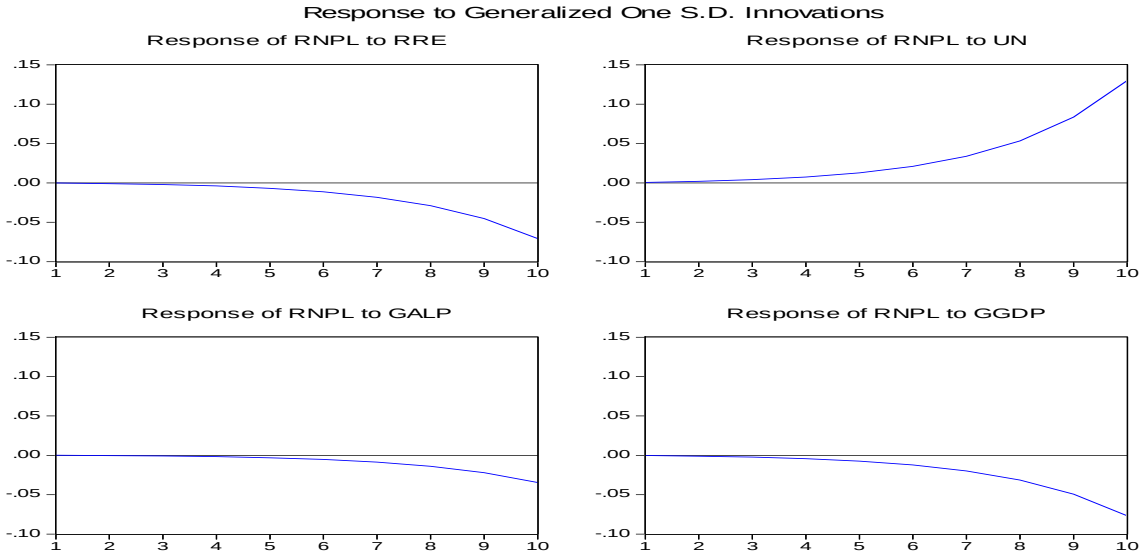

Figure 7 Response of RNPL to GGDP, GALP, RRE and UN

The changes of the real estate market has a definite influence on the level of non-performing loans, but it is weaker then the influence of real GDP and GALP.

The influence of UN is analogues to the influences of UN of Estonia and Latvia, as presented in Figure 8.

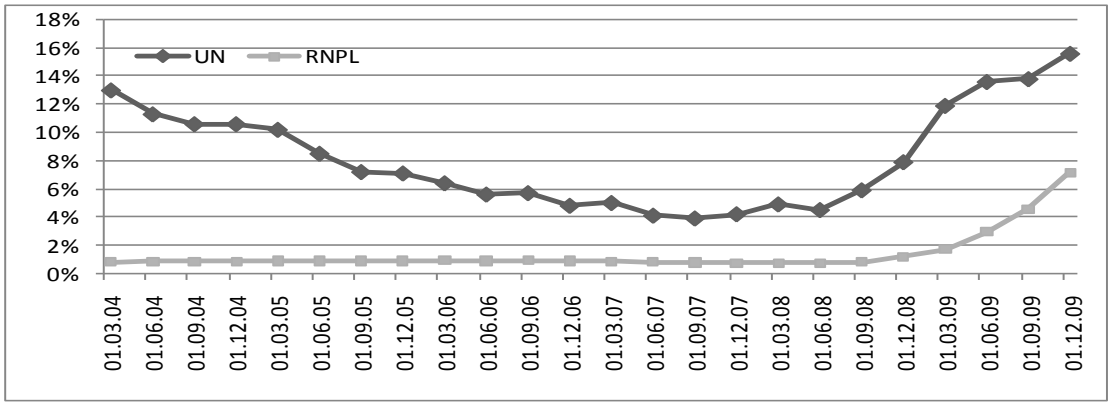

Figure 8 Changes of UN and RNPL during fourth quarter 2002 to fourth quarter 2009

Note: results calculated by authors.

Source: Initial data obtained through internet from Statistics Lithuania (www.stat.gov.lt/en/) and Bank of Lithuania (http://www.lb.lt).

9. Conclusions and Summary

The current paper focuses on the estimation of the role of macroeconomic determinants in the credit risk measurement of the Estonian, Latvian and Lithuanian banking systems.

Due to quarterly data absence for some variables the time range of researches for analyzed countries are different. During the analyzed period, i.e. second quarter of 1997 to fourth quarter 2009, the Estonian banking system faced two financial crises. Data of the Latvian and Lithuanian banking system covers the last financial crisis. Therefore, the effect of different factors on non-performing loans has ultimately an empirical interest.

The literature review concluded the results of earlier researches and three hypotheses have been proposed. For Latvia and Lithuania all three hypothesis were proved completely. For the Estonian banking system two hypothesis were proved completely and one partially.

A vector error correction model (VECM) is applied to identify as long-term relations between variables, as well as short-term fluctuations between them. A market comparative analysis concentrated on the comparison of the development of economies and also the credit risk determinants of banking systems of the Baltic States. An analytical framework presented the initial model specification and variables selection process. The model is based on aggregated data of three macroeconomic variables. Two banking sector variables are also included.

The influence of four variables as real GDP growth, loan portfolio growth, real estate market changes and also the level of unemployment rate were investigated. The choice of the variables was dictated by the significant growth of the real GDP, the real estate market and the growth of the level of indebtedness. The achieved results indicate that all used variables are statistically significant and have their definite influence on the level of the non-performing loans. The bigger the number of actively operating banks is, the greater the competition between market participants is, and the greater are the problems faced during the period of recession of the economy. Strong competition and profit targets encourage market participants to ignore adequate credit analysis and to rely on the possibility of the continuation of the existing growth providing more new loan resources to the market. Compared to other Baltic States, the Latvian banking sector has the biggest number of market participants, totaling up to 29. Also the Swedish banks have the lowest market share in that market. As an ultimate result of strong competition between market participants and neglecting proper credit risk analysis the Latvian economy has faced in 2009 the biggest real GDP decrease by -18%, the highest level of non-performing loans by 18.16% and the highest number of aggregated losses of the banking system by 487 EUR per capita.

The results of the research proved that the macroeconomic variables are important regarding predicting the level of non-performing loans. It has been indicated that the changes of the real GDP have the initial influence on the growth on the level of non-performing loans. This is important since the other variables move with some time shift, following the changes of the real GDP, and additional time is required for them to make the respective adjustments. The longer the variables' adjustment period is the higher the level of non-performing loans will be. Compared to other Baltic States, the Latvian economy had the longest adjustment period of other variables that resulted in the highest level of non-performing loans.

Regarding the growth of the real GDP and its components, their proportion and financing of them should be considered. The greater the growth of real GDP relies on the current consumption and short-term financing without the cover of the respective export volume, the greater the possibility the problem will be faced during the recession. Figure 9 presents the Balance of the current account of the Baltic States for the period 1998 – 2009, and according to it the highest level was faced by the Latvian economy.

The second hypothesis was also proved completely for all Baltic States: the rapid growth of indebtedness has been crucial to the growth of non-performing loans. It has been shown that parallel growth of variables as the real GDP and loan portfolio until a definite period, which was different for every country, will cause the fall in the level of non-performing loans. The following relationship between real GDP, loan portfolio and non-performing loans can be treated as natural. The continued

growth of real GDP and loan portfolio causes the opposite changes in the level of non-performing loans, i.e. they start growing. The substantial influence of constant growth of GALP was especially proven for the Latvian banking system. The following change in the variable movement direction is interpreted as the deterioration of the barriers' of the credit risk analysis policies and the substantial decrease in the quality of loans granted. As a result more speculative deals will be financed. In conclusion, granting such loans will cause the growth of problem loans with some lags.

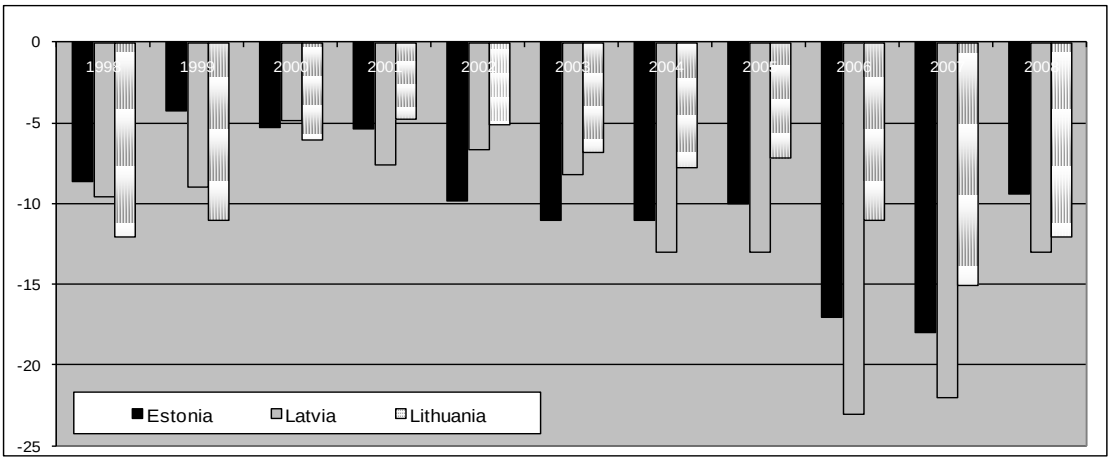

Figure 9 Balance of the current account of the Baltic States for the period 1998 - 2009, as % of GDP

Source: Obtained through internet from Eurostat (http://epp.eurostat.ec.europa.eu).

The results of the research and data of Table 17 prove that the faster growth of the general level of indebtedness is the more substantial the level of non-performing loans will be.

Table 17 Influence of aggregated loan portfolio annual growth, on the level of non-performing loans

	Estonia	**Latvia**	**Lithuania**
Aggregated loan portfolio annual growth, 1997-2009 yy	1049.27%	2975.78%	1402.34%
The level of non-performing loans in 2009 y.	6.13%	18.16%	7.16%

Note: Results calculated by authors.

Source: Initial data obtained through internet from Statistics Estonia (http://www.stat.ee/), Statistics Latvia (http://www.csb.gov.lv/), and Statistics Lithuania (http://www.stat.gov.lt/en/).

The influence of RRE had played an important role regarding the growth of NPL in Latvia and Lithuania, but it has not been as crucial as it has been assumed in Estonia. Since the real estate market had been growing constantly it had been seen as an efficient and profitable investment area. The rapid growth of the real estate market in the Baltic States was substantially supported by loan resources invested by banking sectors. As a result the real estate and credit boom developed simultaneously, supporting each other.

The level of unemployment determines a portion of problem loans. In general this comes from granted mortgage loans. The growth of unemployment has its respective influence on problem loan growth. For a more definite analysis of the relationship between unemployment and non-performing loans future research should be based on mortgage loans only.

The models' performance is evaluated with its three respective tests, and the results of the conducted three tests confirm that the VEC models for the three Baltic States are correctly specified.

For further analysis one should consider the problem loans' analysis of the other Baltic States based on panel data compared with the achieved results. To get more detailed results, the usage of seasonal or financial crises dummies can be implemented.

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