# THE EFFECTS OF MACROECONOMIC CONDITIONS ON LOAN PORTFOLIO CREDIT RISK AND BANKING SYSTEM INTEREST INCOME

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***Abstract.*** *This article presents on analysis of macroeconomic conditions in the EU countries in relation loan portfolio to credit risk and banking system interest income. The changing economic environment of banks influences their risks and activity results, so it is important to find the macroeconomic indicators that can determine the changes in debtors' credit risk and banks' financial condition. The banking system performs very important functions in a country's financial system, so for its stability it is important to be able to predict the financial results of the banking system in relation to changes in the economic environment. The new Basel III Agreement seeks to improve the financial sector's resistance to the possible negative scenarios in the economy and motivates to develop the credit risk assessment models considering their dependence on business cycles. For this reason, the statistical dependence between the set of macroeconomic factors and the loan portfolio credit risk together with interest income were estimated in this research. A statistical classification and regression tree model was developed, which allows to predict the possible changes in the interest income of a country's banks with the 82.7% accuracy.*

***Key words:*** *credit risk, interest income, loan portfolio, macroeconomics*

## Introduction

The bank credits are connected with risk and a possible loss, so banks use various credit rating models to assess the of loan applicants' credit risk. If the calculated probability of default is above the determined threshold, no credit will be provided. According to Dzidzevičiūtė (2010), the models may be applied not only in the decision-making process, but also in the pricing process, adding a higher risk premium to riskier credits, calculating specific provisions and capital adequacy, forming a bank's strategy, allocating capital, managing past payments, identifying the clients that could be potential clients for other products, analysing risk-adjusted profitability of a bank, etc. The estimated credit risk level of a debtor can change in future for various reasons including the macroeconomic factors. These changes can cause a loss of banks; so, it is necessary to understand the relation between the macroeconomic factors and the loan portfolio credit risk. Also,

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it is useful to have the instruments that allow to predict the financial results of banks according to the changes in the economy.

The purpose of this study was to find a relation between the macroeconomic conditions and the loan portfolio credit risk, as wellas to develop a statistical model allowing to predict the interest income changes of the banking system in a country. The multidimensional statistical analysis of the EU counties was performed for this purpose, because the interrelations of macroeconomic indicators are often complex, and one of the approaches to the analysis of macroeconomic processes is associated with the development of econometric models. According to Stavytskyy and Martynovych (2012), the advantage of such models is the possibility of a comprehensive analysis of the economic interrelations. The expediency and efficiency of economic and mathematical tools for predicting various indicators have been confirmed by the international practice.

The results of this research may servw for improving the credit risk management in banks, allow to understand the pecularities of economic cycles in relation to credit risk, foresee the possibility of deep financial crises in banking systems and their influence on the economic growth, as wellas to lower the risk of significant failures in loan portfolios.

## 1. The influence of macroeconomic conditions on loan porffolio credit risk

Differently from other industries, the banking sector's activity is based on credits, which mainly influence the financial results of a bank. Banks collect funds and, using labour and physical capital, transform them into loans and other earning assets. While managing the loan portfolios, banks encounter the problem of non-performing loans (NPL), which are an important factor impacting the banking efficiency. Non-performing loans arise due to the inability to meet the financial obligations of the debtors. The banks assess the credit risk of every loan applicant and make decisions as to their financing. Credits are granted to the clients that are at an acceptable credit risk level. However, in future the credit risk level of a debtor can change because of idiosyncratic and systematic risks. Records of past and current ratings document firms' movements among the rating categories and serve as indicators of risk dynamics. For example, if a firm is downgraded from AA to BB, the lender can judge that its default risk has increased significantly (Chen et al., 2012). According to Koopman and Lucas (2005), making a distinction between idiosyncratic and systematic risks, the idiosyncratic risk factors are inherent to individual characteristics of clients. The systematic risk is most important at the loan portfolio level, and the systematic credit risk factors are usually thought to correlate with macroeconomic conditions. The loan portfolios are generally exposed to a counterparty credit risk and asset value risk, which is conditional in the occurrence of credit default events. Credit default and asset value risk are highly interdependent. During economic downturns the asset values decrease and credit default events increase; this amplifies

the realized loss rates (Rosch, Scheule, 2010). One of the indicators of credit risk is the country-level ratio of NPLs to total loans (Delis et al., 2011). If a bank can establish a link between the macroeconomic environment and systematic credit risk factors, this knowledge may help in assessing and managing the portfolio credit risk over time and may prove useful in dynamic credit risk management circumstances in which default scenarios can occur over a variety of economic conditions (Koopman, Lucas, 2005).

Most significant changes in the macroeconomic conditions of a country are observed in business cycles. Choy (2011), for expositional convenience analyzing the business cycles, splits the macroeconomic variables into three categories: national income components, labour market variables, monetary and financial indicators of a country. Also, the domestic business cycles are influenced by foreign economic cycles with regard to their persistence, comovement and volatility properties (Choy, 2011). Some researchers (Yeyati, et al., 2010; Diaz, Olivero, 2011; Fainstein, Novikov, 2011; etc.) have infound relations between the macroeconomic factors and non-performing loans in the banking system. The amount of past non-performing loans interact with the macroeconomic changes and indicate that banks with more non-performing loans are more affected by the macro shocks. The results suggest that non-performing loans increase across banks as macroeconomic risks rise. However, the interaction terms and the macroeconomic factors are highly correlated, so it is difficult to disentangle the independent effects of each macroeconomic variable. Generally, banks with a higher exposure to macroeconomic risk are expected to experience larger non-performing loans (Yeyati et al., 2010).

The studies show that the country-specific credit risk factors have become more important for the emerging market economies in the recent period of globalization, whereas they have become less important for industrial economies. The high interdependence of production output, consumption, and investment in the developing countries is tied with the intermediate levels of financial integration. Such economies are unable to achievean improved risk sharing during the globalization period and must rely on domestic financial resources rather than on high amounts of foreign capital to boost investments. Countries with high levels of financial integration (mostly industrial countries) are able to use international financial markets for a more efficient risk sharing and delink the production output and consumption in a country (Kose et al., 2012). On the other hand, the trade openness (measured by exports plus imports to GDP) is associated with economic performance measures and systematic risk. The economies that depend more on trade are more vulnerable to global trade shocks. A drop in aggregate demand, resulting from the global financial crisis, leads to a dramatic decline in the global trade, and naturally the small open economies that depend on trade are most affected (Claessens et al., 2010).

Fainstein and Novikov (2011) affirm that one of the main reasons for an increase of aggregated credit risk in banks of a country is the growing aggregated indebtedness.

Together with the deterioration of macroeconomic factors, it is impossible for borrowers to repay their financial obligations. This leads to the negative chain reaction throughout the whole economy, i.e. the level of the credit risk financed by banking systems becomes critical when the cash flows of realized projects become insufficient for covering payments needed to fulfil the loan contracts' obligations and giving rise to the fall in assets' prices, with its purchase financed by banks (Fainstein, Novikov, 2011). Diaz and Olivero (2011) have ascertained that in recessions the credit risk increases more for risky and illiquid assets, such as loans, than for more liquid assets such as government securities. This results in banks' shifting their asset portfolios towards more liquid assets during bad times. After changes of the margins in the credit market, the credit becomes more expensive in economic downturns. As a result, firms may delay investment and production and recessions may be exacerbated. In addition, Claessens et al., (2010) maintain that house price appreciation, bank credit growth prior to the crisis, and the size of the current account deficit are significant predictors for the possible recessions: the greater the house price appreciation and credit growth and the larger the current account deficit, the longer, more severe, and more adverse the aggregate economic slowdown.

There are some other researches linking the loan portfolio credit risk with macroeconomic factors and showing that the default risk tends to increase during economic downturns. Fei et al. (2012) document that unemployment and real GDP growth are strongly correlated with default risk. Also, the other macroeconomic covariates involved into the internal credit rating system of a bank, such as the S&P500 index, have a good explanatory power. Claessens et al., (2010) have found a few variables to be statistically significant, consistent with the general spread of the financial crisis. The ratio of private credit to the GDP is positively related to an increase in the Financial stress index (FSI), suggesting that the financial stress is greater in economies with a greater financial indebtedness. Koopman and Lucas (2005) have also retraced an empirical evidence of a relation between credit risk and macroeconomy. For their data sample, there appeared to be a strong co-cyclicality between GDP and defaults.

When identifying the business cycles in an economy, it is important to understand their evidences. Creal et al., (2010) have developed a flexible business cycle indicator whuch accounts for a potential time variation in macroeconomic variables. The estimated parameters imply that inflation lags industrial production by just over a quarter, and unemployment lags it by one month. Industrial production, in its turn, lags real GDP by three to four months. The variables of productivity, real consumption of nondurables plus services, and manufacturing lead the cycle most. The real GDP, retail sales, and investment appear to be roughly coincident. Almunia et al. (2010) habe estimated that the growth of government expenditure has a positive impact on the GDP growth as well as on defaults. They habe also found a negative impact of interest rate changes on GDP growth, implying that an expansive monetary policy may have a positive impact on the

economy. The debt-to-GDP ratio itself acts negatively, implying that a higher debt slows down the growth. Hagen and Ho (2007) have found that the slowdown of the real GDP, lower real interest rates, an extremely high inflation, large fiscal deficits, and over-valued exchange rates tend to precede the banking crises.

Most of banking crisis theories are based on changes in economic fundamentals as a natural consequence of business cycles, with credit growing procyclically. Credit grows rapidly when the economy is booming, as investors turn more optimistic about the future and lending standards deteriorate. When the economic growth slows down, this causes a collapse in crediting. The macroeconomic origins of banking crises lie in unsustainable macro policies and global financial conditions. The overly expansionary monetary and fiscal policies have spurred lending booms, excessive debt accumulation, and overinvestment in real assets, causing deterioration in the quality of bank assets. The banking crises are typically preceded by credit booms and asset price bubbles (Laeven, 2011).

The banking crises may compel banks to restrict credit even to solvent firms and subsequently force firms to limit their economic activity or bankrupt. In this way, some sectors of the economy that are more dependent on external funding are forced to reduce their output. Second, bank failures decrease aggregate credit supply, and this in turn forces companies and households to limit their investment and consumption. The lower investment and consumption immediately decrease output growth. In the long run, lower investments reduce capital growth and productivity. Larger costs incurred by companies and households may also be caused by banks increasing interest rates on loans, for example, due to high expected losses from bad loans (Serwa, 2012).

## 2. Instruments of improving the banking system stability

While banks are influenced by competition, irrespective of the macroeconomic conditions they often try to increase their market share and profit by imposing price policies, such as raising deposit rates, lowering loan rates or, even worse, providing loans to those with high risks, which will increase the probability of default (Chiu et al., 2010). As a consequence, a high fraction of debtors in the credit portfolio can be unable to meet their financial obligations. A sharp decline in the quality of bank loans or an increase in non-performing loans cause a loss of liquidity in the banking sector (Hagen, Ho, 2007).

The main responsibility for financial stability and crisis management in the EU lies with national authorities and national deposit insurance schemes. However, the particular EU bodies and procedures exist that provide some degree of harmonization between national rules and authorities. The exchange of information in crisis situations is based on the Memorandum of Understanding (MoU) of March 2003 on high-level principles of cooperation between the banking supervisors and central banks of the EU in crisis management situations. Cooperation among treasuries, and between treasuries and

central banks, takes place at the level of ministers and central bank governors through the ECOFIN Council. The decisions of the ECOFIN in all matters, including crisis management, are prepared by the Economic and Financial Committee (EFC), which comprises deputy finance ministers, deputy central bank governors and EU authorities (Ferry, Sapir, 2010).

The Basel II Capital Accord encourages banks to base their capital requirement for credit risk on internal or external rating systems. With Basel II, the Bank of International Settlements aims to strengthen the risk management systems of international financial institutions. The international operating banks use the internal-rating-based approach to determine capital requirements for their loan portfolios. Thus, assigned ratings, corresponding default probabilities and the probabilities of rating changes are determinants of a bank's credit risk management (Truck, 2008). It is important that banking regulation is structured to solve the market failures in the financial system. The regulations are designed to minimize the pernicious effects of contagion. Capital regulation appears to have an important role to play in this respect (Allen, Carletti, 2010).

The financial crisis of 2007–2009 gave rise to concerted international efforts under the G20 process to arrive at strengthened capital requirements for banks. The international efforts resulted in a new capital regime known as Basel III, which was agreed upon by the 27 member countries of the Basel Committee for Banking Supervision (Adrian, Shin, 2011). The Basel III seeks to improve the financial sector's resilience to stress scenarios, which calls for a reassessment of banks' credit risk models and, particularly, of their dependence on business cycles (Fei et al., 2012). The Basel III provides for a "macroprudential overlay" to better deal with the systemic risk, with a significant increase in the required level of capital, an increase in the quality of banks' capital, and a stricter definition of the core capital. Another objective of the Basel III is to reduce systemic risk by reducing procyclicality, i.e. the financial system's tendency to amplify the ups and downs of the real economy. Banks will be required to hold a capital conservation buffer of 2.5% to withstand the future periods of stress. This countercyclical buffer would be built up during periods of a rapid aggregate credit growth. The capital held in the buffer could then be released in the downturn of the cycle, reducing the risk that the available credit would be constrained by regulatory capital requirements, and reducing the possibility of an adverse cycle of losses and tightening credits (Sarra, 2012).

## 3. Modeling the dependence among macroeconomic indicators, doubtful and non-performing loans, and bank interest income in the EU

The hypothesis raised in this research is that the negative macroeconomic changes in a country can increase the proportion of doubtful and non-performing loans in banks. First, companies in a weak condition generate non-performing loans during recessions. Bad loans lead to increased capital provisions and losses of banks. Increased provisions,

in turn, limit the lending activity of banks. In addition, banks with many "bad loans" may introduce more restrictive lending policies that will make credit unavailable to some customers. Second, balance sheet problems of companies and the declining earnings and consumption of households may reduce their demand for bank loans during recessions (Serwa, 2012). So, the provision of loans in the economic downturns decline. Therebre banks usually tighten the credit policy and the credit portfolio becomes lesser. The decreasing demand of money for loans reduces the interest rates. Also, the increasing risk of clients raises the interest rates for the debtors. The interest rate can increase significantly to compensate a possible loss in case of default, if a firm has a weak credit rating (Czarnitzki, Kraft, 2007). If, as expected, a higher credit risk is associated with periods of a declining economic activity, risk is a very important candidate to explain the countercyclical behaviour of margins. The reason is that an increase in the share of bad loans can imply a fall in the banks' income and motivate to increase the margins (Diaz, Olivero, 2011). All these fastors can significantly influence the interest income of banks and their profit (Fig. 1).

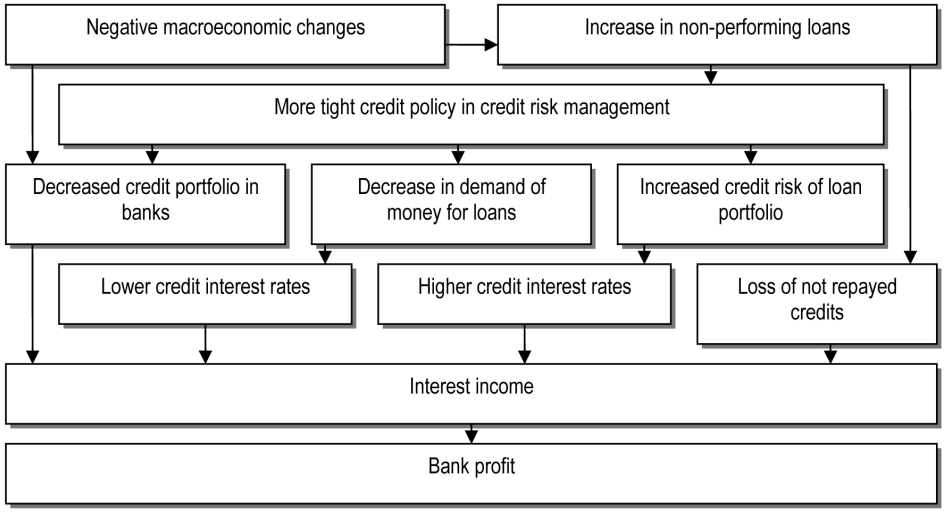



FIG. 1. **Hypothetical scheme of macroeconomic changes influencing bank's activity results**

The estimation of the influence of macroeconomic changes on loan portfolio credit risk and bank activity results was based on a statistical analysis of the 27 EU countries: Belgium (BE), Bulgaria (BG), Czech Republic (CZ), Denmark (DK), Germany (DE), Estonia (EE), Ireland (IE), Greece (GR), Spain (ES), France (FR), Italy (IT), Cyprus (CY), Latvia (LV), Lithuania (LT), Luxembourg (LU), Hungary (HU), Malta (MT), the Netherlands (NL), Austria (AT), Poland (PL), Portugal (PT), Romania (RO), Slovenia (SI), Slovakia (SK), Finland (FI), Sweden (SE), and the United Kingdom (UK).

The research seeks to answer the question whether the macroeconomic factors, non-performing loans and banks' interest income are statisticaly related.

The average proportion of doubtful and non-performing loans in the EU banks (years 2000–2011) was 3.25%. Figure 2 indicates that this proportion in 2009–2011 was above the average, so it is important to understand the macroeconomic changes that can influence this negative tendency to increase the amount of non-performing loans in banks. The statistical data of year 2008 in the further analysis will be considered as the basic level, and the main changes of the finance sector and macroeconomic rates in 2009 and 2010 will be analyzed.

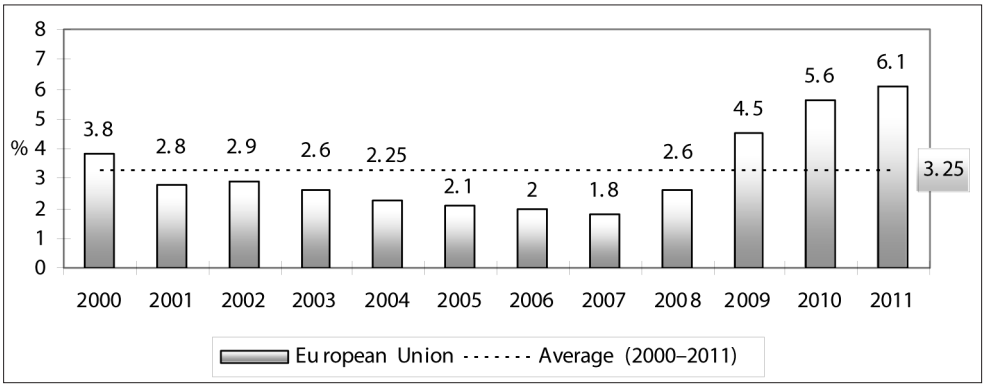



FIG. 2. **The average proportion of doubtful and non-performing loans in the EU countries**

Fourteen macroeconomic factors of the EU countries were estimated: gross domestic product (GDP) at market prices (EUR / 1 inhabitant) – GDP1I; GDP growth (annual, %) – GDPG; compensation of employees (EUR / 1 inhabitant) – CE; employment (employees / 1 inhabitant) – EMP; long-term unemployment rate (%) – LTU; exports of goods and services (EUR / 1 inhabitant) – EXP; imports of goods and services (EUR / 1 inhabitant) – IMP; inflation rate (%) – INF; gross fixed capital formation (investments) (EUR / 1 inhabitant) – INV; business investment (% of GDP) – BINV; general government gross debt (EUR / 1 inhabitant) – GD; final consumption expenditure of general government (EUR / 1 inhabitant) – CEG; final consumption expenditure of households and non-profit institutions serving households (EUR / 1 inhabitant) – CEH; research and development expenditure, by sectors of performance (% of GDP) – RD.

TABLE 1. **The canonical analysis results**

| Canonical Analysis Summary: Canonical R = 0.91770; $Chi^2(42) = 231.56$; p = 0.0000 | | |
|---|---|---|
| | **Left set** | **Right set** |
| **No. of variables** | 14 | 3 |
| **Variance extracted** | 43.4320% | 100.000% |
| **Total redundancy** | 29.4891% | 75.0142% |

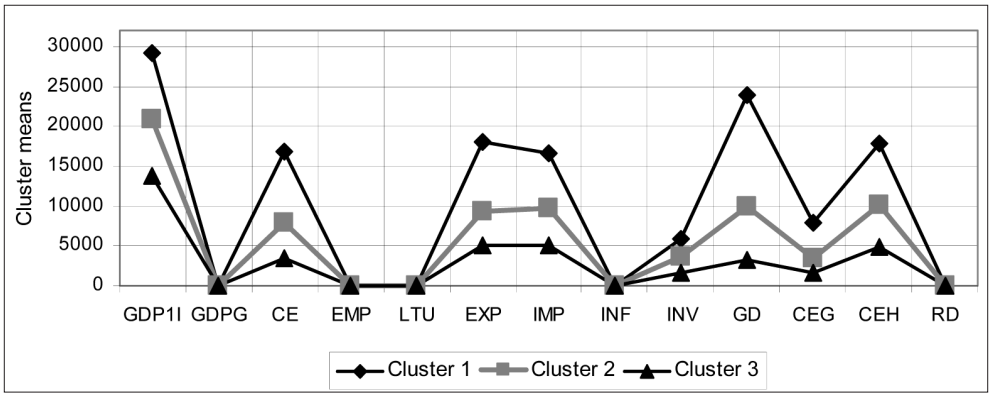



FIG. 3. **Cluster means**

The canonical correlation coefficient in Table 1 (R = 0.91770) has indicated that there is a very strong relation between 14 macroeconomic factors (left set) and the proportion of dobtful and non-performing loans, interest income and net interest income (right set) in the banking system. The canonical analysis was implemented by using statistical information about 27 EU countries for the years 2008–2010.

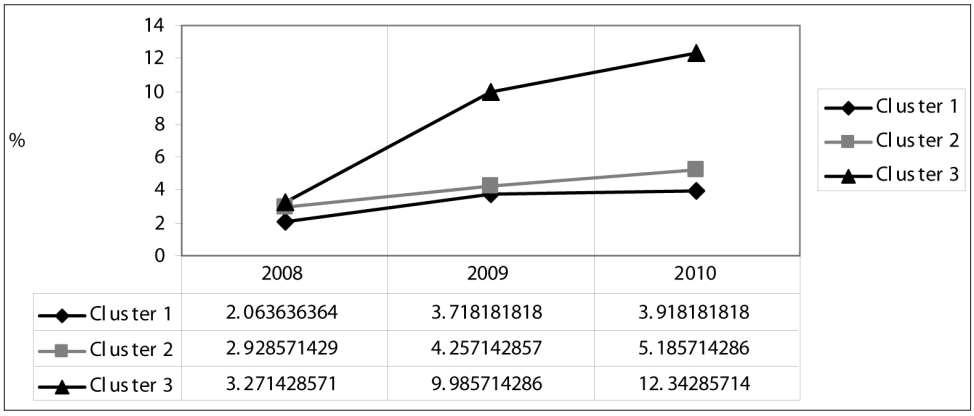
The increase of doubtful and non-performing loans in the EU countries was different, so the cluster analysis (method of *k*-means) was made, and these countries were separated into three clusters (Fig. 3). The main task of cluster analysis was to group the EU members so that the macroeconomic differences inside the clusters would be the least and the differences among clusters would be significant. The cluster analysis included 14 macroeconomic factors of the year 2010.

TABLE 2. **Cluster means and differences**

| Rate | Mean | | | Difference from Cluster 3 (%) | |
|---|---|---|---|---|---|
| | Cluster 1 | Cluster 2 | Cluster 3 | Cluster 1 | Cluster 2 |
| GDP1I | 29 090.91 | 20 785,71 | 13 757.14 | 111.5 | 51.1 |
| GDPG | 2.30 | 1.91 | 1.49 | 0.8 | 0.4 |
| CE | 16 886.24 | 7 934.41 | 3 400.03 | 396.6 | 133.4 |
| EMP | 0.46 | 0.44 | 0.42 | 9.5 | 4.8 |
| LTU | 2.91 | 4.79 | 5.61 | -2.7 | -0.8 |
| EXP | 18 016.46 | 9 340.48 | 5 075.41 | 255.0 | 84.0 |
| IMP | 16 520.35 | 9 679.24 | 4 983.68 | 231.5 | 94.2 |
| INF | 1.54 | 1.71 | 2.74 | -1.2 | -1.0 |
| INV | 5 892.01 | 3 594.76 | 1 554.13 | 279.1 | 131.3 |
| BINV | 15.21 | 16.69 | 15.17 | 0.04 | 1.52 |
| GD | 23 898.84 | 9 971.00 | 3 269.90 | 630.9 | 204.9 |
| CEG | 7 911.45 | 3 538.54 | 1 570.79 | 403.7 | 125.3 |
| CEH | 17 734.47 | 10 184.71 | 4 781.62 | 270.9 | 113.0 |
| RD | 2.44 | 1.20 | 0.85 | 1.6 | 0.4 |

Luxembourg and Greece were not included into the cluster analysis process because of the lack of statistical data. The members of clusters are:

- Cluster 1: BE, DK, DE, IE, FR, IT, NL, AT, FI, SE, UK (40.7% of EU).
- Cluster 2: CZ, ES, CY, MT, PT, SI, SK (25.9% of EU).
- Cluster 3: BG, EE, LV, LT, HU, PL, RO (25.9% of EU).




| | 2008 | 2009 | 2010 |
|---|---|---|---|
| Cluster 1 | 2.063636364 | 3.718181818 | 3.918181818 |
| Cluster 2 | 2.928571429 | 4.257142857 | 5.185714286 |
| Cluster 3 | 3.271428571 | 9.985714286 | 12.34285714 |

FIG. 4. **The average proportion of dobtful and non-performing loans in clusters**

The cluster means of macroeconomic rates (year 2010) and their differences were shown in Table 2. The rates are worst in Cluster 3, and these rates in Clusers 2 and 1 constantly increase, except the business investment which is about 15.17%–16.69% of GDP in all clusters. If we look at the analysis results from the attitude of Cluster 3, the GDP for 1 inhabitant in Cluster 2 is higher by 51.1% and in Cluster 1 by 111.5%. The countries of Cluster 1 show the highest annual GDP growth rate, compensation of employees and employment. The long-term unemployment rate and inflation in Cluster 1 are the least. Also, this cluster has the highest export, import, investment amounts per one inhabitant. So, the members of Cluster 1 can be considered as the developed countries of the EU, and the calculated average values reflect the main macroeconomic differences in other countries. Conversely, the countries in Cluster 3 have the least government debt per one inhabitant. In Clusters 1 and 2, the debt is higer by 630.9% and 204.9% arespertivoly. We can presume that in this case the high governmental debt influences the higher consumption expenditure of the government. The average consumption expenditure of households in Cluster 1 is higher by 270.9% and in Cluster 2 by 113% than in countries of Cluster 3. The research and development expenditure (% of GDP) is also the highest in the developed countries.

Thus, the cluster analysis highlighted and quantitatively evaluated the macroeconomic differences in the grouped EU countries. Also, it was interesting to elucidate differences in the increase of the average proportion of doubtful and non-performing loans in the

EU banks (Fig. 2) of different countries. The research allowed to estimate the reasons for negative changes in the EU statistics in 2009–2011: did the average proportion of doubtful and non-performing loans in the EU banks increase in all countries equally or in a particular group of the EU members?

Figure 4 shows that changes in the percentage of doubtful and non-performing loans in clusters were different. In 2008, the average percentage of doubtful and non-performing loans ranged between 2.06–3.27%, but in the next years the increase of this indicator in the clusters was conspicuous. In countries of Cluster 3 where macroeconomic rates were the worst, the increase of doubtful and non-performing loans was the highest: in 2010 this rate increased 3.8 times, whereas in Clusters 1 and 2 it increased by 1.8% and 2.3%.

TABLE 3. **Data of t-test for independent samples**

| Rate | Cluster 1 – Cluster 2 | | Cluster 1 – Cluster 3 | | Cluster 2 – Cluster 3 | |
|---|---|---|---|---|---|---|
| | *t*-value | *p* | *t*-value | *p* | *t*-value | *p* |
| GDP1I | 7.38100 | 0.000002 | 14.14377 | 0.000000 | 6.03087 | 0.000059 |
| GDPG | 0.51687 | 0.612319 | 1.06688 | 0.301862 | 0.52968 | 0.605996 |
| CE | 6.43637 | 0.000008 | 10.73203 | 0.000000 | 4.70185 | 0.000513 |
| EMP | 0.81613 | 0.426408 | 2.36141 | 0.031223 | 1.45326 | 0.171799 |
| LTU | -1.75727 | 0.097986 | -2.84008 | 0.011821 | -0.59672 | 0.561781 |
| EXP | 2.40941 | 0.028383 | 3.63040 | 0.002250 | 2.81186 | 0.015695 |
| IMP | 2.34581 | 0.032202 | 4.00730 | 0.001016 | 3.57934 | 0.003787 |
| INF | -0.35499 | 0.727237 | -1.44367 | 0.168126 | -1.11743 | 0.285683 |
| INV | 4.50388 | 0.000361 | 9.79060 | 0.000000 | 5.57735 | 0.000120 |
| BINV | -1.05818 | 0.305688 | 0.02566 | 0.979843 | 1.34166 | 0.204543 |
| GD | 5.44699 | 0.000054 | 8.78890 | 0.000000 | 3.55601 | 0.003953 |
| CEG | 5.14096 | 0.000099 | 7.63371 | 0.000001 | 5.23097 | 0.000211 |
| CEH | 7.77548 | 0.000001 | 21.91376 | 0.000000 | 4.79867 | 0.000435 |
| RD | 3.45305 | 0.003272 | 4.79355 | 0.000199 | 1.24608 | 0.236513 |

The analysis has shown the tendency of increasing the doubtful and non-performing loans in countries with low macroeconomic indicators. In these countries, the credit risk of banks' loan portfolio is more sensitive to the negative macroeconomic fluctuations. The reliability of calculated means in clusters depends on the variation of the variables. So, the coefficients of variation were calculated for 42 observations (14 rates in 3 clusters), and the qualitative explanations of variance are the following: the variation is very high in 21 cases, high 10, medium in 6, low in 5 cases. Because of mainly high variations of variables in the clusters, the significance of mean differences was estimated by *t*-tests (Table 3). The *t*-test is a method to evaluate the differences in mean values between two groups. The *p*-level reported with a *t*-test represents the probability of error involved in accepting the research hypothesis about the existence of a difference. The means in clusters are different if $p < 0.05$.

There is no statistical by significant difference (highlighted in grey) in the mean values of GDP growth, inflation and business investment in all clusters. Also, between clusters 1 and 2 and 2 and 3 there is no difference in the mean values of employment and the long-term unemployment rate. In clusters 2 and 3, the mean values of research and development expenditure do not differ significantly. According to the other macroeconomic indicators, a significant difference was noted in these three groups of the EU countries.

The statistical data of loans and receivables was available for 22 EU countries. In 2009, their loan portfolio in banks decreased by 4.47% and in 2010 decreased by 1.53% (Fig. 5).

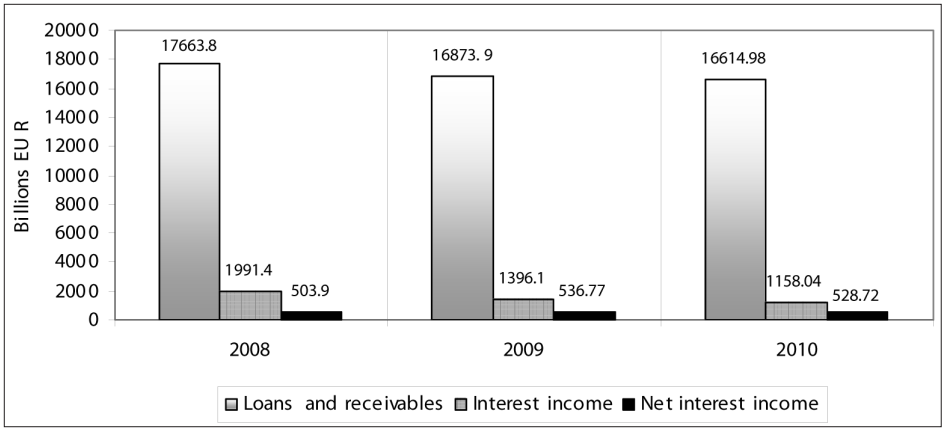



FIG. 5. **Loans and receivables (including finance leases) in banks of 22 EU countries**

When the proportion of doubtful and non-performing loans increased, the interest income of the EU banks decreased considerably: in 2009 by 29.89% and in 2010 by 17.05% (Fig. 5). However, difference in the net interest income (as the deduction of interest income and interest expenses) was not so significant. The net interest income in the EU banks in 2009, on the contrary, increased by 6.52% and in 2010 decreased only by 1.5%. It can be concluded that banks absorbed the decrease in interest income by reducing the interest rates for deposits when the demand of loans decreased. According to the European Central Bank, the interest expenses in the EU banks decreased by 45.46% in 2009 (from 1 284,3 to 700,5 billion EUR) and by 18.93% in 2010 (to 567,9 billion EUR).

In 2009, a very high decrease (by more than 25%) of interest income was observed in 14 EU countries (Fig. 6). In the banking systems of seven countries, the interest income decreased from 25% to 10%. In 2010, such changes of the banking systems' interest income were noted in 5 and 11 countries, respectively. To estimate the main macroeconomic changes that cause significant differences in interest income, a

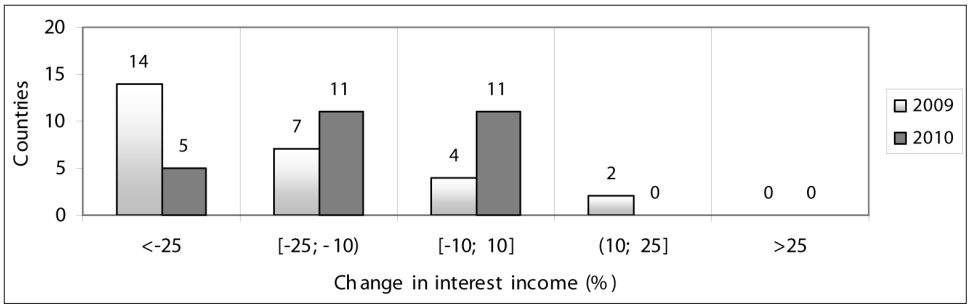



FIG. 6. **Changes of interest income in banking systems of the EU countries**

classification and regression tree (CART) model was developed (Fig. 7). The dependent variable *M* in this model is the change in interest income; it was coded {-2; -1; 0; 1; 2} according to the values on axis *x* of Fig. 6. The independent variables in the CART model are the catenary indexes of the macroeconomic indicators that reflect their changes. When creating the CART model, three macroeconomic variables (GDP growth, inflation; business investments) were not included into the analysis because the *t*-test had shown that their mean values in the countries did not differ significantly. The *ID* in the developed tree graph is the node number, *N* is the size of a node, and *M* is the dependent variable. The macroeconomic conditions and the classification thresholds are

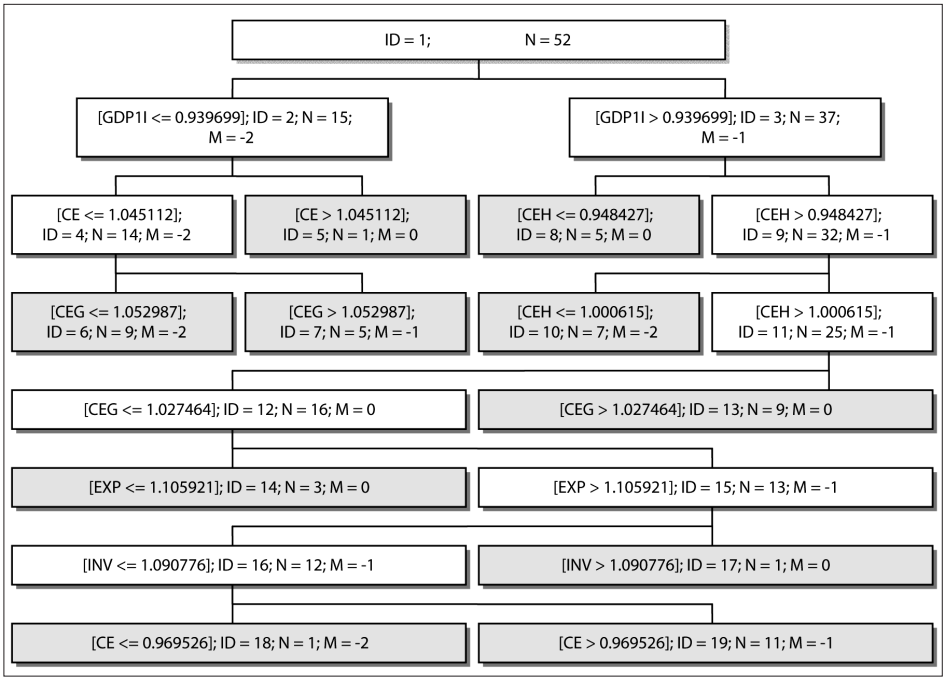



FIG. 7. **The CART model for the prediction of interest income changes**

in brackets. The end nodes are shown highlighted in grey. The economic interpretation of the CART analysis results is as follows.

We can expect a very high decrease (by more than 25%) of interest income in banks of a country if:

- the GDP increase is less than or equal to 6.1%, the employees' compensation increase is less than or equal to 4.5%, and the consumption expenditures of the government increase by 5.3% or less;
- the GDP increase is higher than 6.1%, consumption expenditures of households increase by more than 5.2% and are less than or equal to 0.06%;
- the GDP increase is higher than 6.1%, consumption expenditures of households increase by more than 0.06%, consumption expenditures of the government increase by less than or by 2.7%, exports increase by more than 10.6%, investment increase is less than or equal to 9.1%, and the compensation of employees increase is less than or equal to 3.1%.

We can expect a significant decrease (from 10% to 25%) of interest income in banks of a country if:

- the GDP increase is less than or equal to 6.1%, the compensation of employees' increase is less than or equal to 4.5%, and the consumption expenditures of government increase is higher than 5.3%.
- the GDP increase is higher than 6.1%, consumption expenditures of households increase by more than 0.06%, consumption expenditures of the government increase by less than or by 2.7%, exports increase by more than 10.6%, investment increase is less than or equal to 9.1%, and the compensation of employees' increase is higher than 3.1%.

In other macroeconomic conditions, an insignificant decrease (up to 10%) or increase in interest income is expected. The total accuracy of the developed CART model is 82.7%. The model confirms that general changes in macroeconomic conditions are typical of different countries regarding changes in the banking system performance. The results show that it is possible to internelate the macroeconomic conditions of a country and the banking system interest income. The statistical analysis techniques allow predicting the particular financial results of banks' performance considering the country's macroeconomic data.

## Conclusions

In the period under analysis (2009–2010), a significant increase of doubtful and non-performing loans in the EU banks occurred, so for bankers and economics analysts it became important to understand the macroeconomic conditions that could influence this negative tendency. The scientific literature analysis confirmed the importance of

considering the systemic risk factors on credit risk in banks, because the loan portfolio quality is often strongly related to macroeconomic conditions.

The empirical research quantitatively related the proportion of doubtful and non-performing loans with the macroeconomic indicators. This relation was confirmed by the canonical analysis and cluster analysis results. The increase of doubtful and non-performing loans in the EU statistics was mostly influenced by a group of the EU members, which was compounded by cluster analysis. These seven countries show the worst macroeconomic rates, and the increase of doubtful and non-performing loans in this group was the highest. In other clusters, the increase of the macroeconomic indicators was related to the decreasing proportion of doubtful and non-performing loans in banks.

This negative period for banks is also characterized by a decrease of interest ingome, which is a very important risk factor of possible losses. The stability of banks highly depends on their ability to earn profit, so understanding the macroeconomic changes that can result in a decrease of interest income becomes very important. The proposed classification and regression tree model allowed to define several relations between macroeconomic conditions of a country and the possible changes in the interest income of the banking system. The model can help to foresee the negative direction of interest income changes with 82.7% accuracy.

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