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ANALYSIS OF THE SYSTEMIC CREDIT RISK COMPONENT IN THE BANKING SECTOR OF THE REPUBLIC OF SERBIA

Analiza sistemske komponente kreditnog rizika u bankarskom sektoru Republike Srbije

Abstract

The subject of this research paper is quantification of the degree of systemic risk exposure of the Serbian banking sector's loan portfolio in the period from 2008Q4 to 2019Q3, including by main commercial segments (corporate and retail). The Basel Committee on Banking Supervision, under its regulatory framework, makes a distinction between corporate and retail loans regarding the exposure to systemic risk. Based on the above, the following hypotheses are set: a) There is a significant difference in systemic risk exposure between corporate and retail loans in the Serbian banking sector and b) Forecasting the exposure to systemic risk of the entire Serbian banking sector can be performed on the basis of corporate loans due to the specificity of the economic system of the Republic of Serbia. The results of the research corroborated the truthfulness of both hypotheses, which has a multifold significance for commercial banks' management, macroeconomic and macroprudential policy makers. First, banking and accounting regulations require stress-testing of probability of default on the change in macroeconomic aggregates and its impact on the bank's capital. Second, a bank's sensitivity to changes in macroeconomic aggregates predominantly depends on the loan portfolio structure by commercial segments. Third, the conclusion of the academic elite that the development of the capital market would lead to an increase in the macroeconomic stability of the Republic of Serbia and reduce the procyclicality of credit risk was confirmed. We used the autoregressive distributed lags model (ARDL model) because there is a difference in order of integration in the observed time series (I(0) and I(1)), and because this method provides good results for relatively small sample data sizes.

Keywords: *commercial banks, systemic risk, credit risk procyclicality, macroeconomic aggregates, financial system.*

Sažetak

Predmet ovog istraživanja je ispitivanje i kvantifikovanje stepena izloženosti sistemskom riziku kreditnog portfelja bankarskog sektora Republike Srbije u periodu od 2008Q4 do 2019Q3, ali i po osnovnim komercijalnim segmentima (privreda i stanovništvo). Bazelski komitet za superviziju banaka, u sklopu regulatornog okvira za utvrđivanje potrebnog nivoa kapitala, pravi razliku u izloženosti sistemskom riziku između kredita odobrenih privredi i kredita odobrenih stanovništvu. Na osnovu navedenog, postavljaju se sledeće hipoteze: a) Postoji značajna razlika u izloženosti sistemskom riziku između kredita odobrenih privredi i kredita odobrenih stanovništvu u bankarskom sektoru Republike Srbije i b) Predikcija izloženosti sistemskom riziku celog bankarskog sektora Republike Srbije može se vršiti na osnovu kredita odobrenih privredi zbog sprecifičnosti ekonomskog i bankarskog sistema Republike Srbije. Rezultati istraživanja su potvrdili istinitost tvrdnje obe hipoteze, što ima višestruki značaj za kreatore makroekonomske politike, nosioce makroprudencijalne politike i nosioce upravljačke funkcije poslovnih banaka. Prvo, bankarska i računovodstvena regulativa zahtevaju izradu stres-testova verovatnoće neizmirenja obaveza dužnika na promenu makroekonomskih agregata i njen uticaj na kapital banke, uvažavajući procikličnost finansijskog sistema. Drugo, osetljivost banke na promene u makroekonomskim agregatima dominantno zavisi od strukture kreditnog portfolia po komercijalnim segmentima. Treće, potvrđen je zaključak akademske elite da bi razvoj tržišta kapitala doveo do povećanja finansijske i makroekonomske stabilnosti Republike Srbije i smanjio procikličnost kreditnog rizika. Korišćen je model autoregresionih distributivnih docnji, tzv. ARDL model (engl. autoregressive distributed lags model), jer postoji razlika u integrisanosti posmatranih vremenskih serija (I(0) i I(1)) i jer ovaj metod daje dobre rezultate na relativno malim uzorcima.

Ključne reči: *poslovne banke, sistemski rizik, procikličnost kreditnog rizika, makroekonomski agregati, finansijski sistem.*

Introduction

Lending to the private sector (corporate and retail) is the main channel of financial intermediation which is the basis of economic growth of developing countries, but also a source of systemic risk [3, p. 2]. The lower the level of development of the financial system, the higher the share and importance of lending activity in the balance sheets of commercial banks, as it is almost the only way to provide external sources of financing for business entities. In such an enviroment, the stability of the financial system of an economy is directly related to the level of credit risk which commercial banks are exposed to based on their lending activity.

A decline in high-quality demand for loans and the increase in nonperforming loans (NPLs) that burden banks' financial statements (income statement and balance sheet) lead to stricter requirements for approving new loans. All this has a feedback effect in the form of further reduction in loan demand, resulting in a decrease in investment, consumption, economic growth and disposable income [28, p. 92]. The mentioned relationships indicate that there is an interaction between these variables and that it is very easy to enter a vicious circle. The analyses made by international financial institutions suggest that the NPLs ratio higher than 10% reduces lending activity by 4% (excluding secondary effects) [24, p. 1]. The lending activity is a prerequisite for economic growth and has a significant impact on economic growth rate.

Boumparis's research paper confirms that systemic factors have an impact on the creation of NPLs, but NPLs, in turn, affect the level of systemic risk. Using impulse response function, it has been confirmed that a one standard deviation shock to NPLs has an impact on the long-term sovereign rating in the next six years (an increase in NPLs leads to deterioration of long-term sovereign rating [7, p. 12]). Conversely, a one standard deviation shock to the sovereign rating has a statistically significant impact on NPLs over a 9-year period, while the strongest impact is reached after 3 years (the increase in NPLs leads to deterioration of the rating [7, p. 13]).

Anastasiou et al. [1, p. 14] have demonstrated that there is a statistically significant difference in sensitivity to deterioration of macroeconomic factors between the peripheral parts of Europe and the core countries of the European Union. The obtained result can be explained by different levels of economic development, but also by differences in the development and efficiency of a country's legal system. Koju et al. [16, p. 50] have shown that industrial development and exports are one of the most important factors in reducing credit risk in highly developed countries. The research by Nkusu [20, p. 18] has confirmed that the decline in economic activity, employment and asset prices contributes to the rise in NPLs in highly developed economies, but also that there is a strong feedback effect from NPLs to economic and lending activity, housing prices and the value of NPLs in the coming years [20, p. 19].

Given the comprehensiveness of their effects, credit risk factors can be divided into two main groups: systemic and specific (idiosyncratic) [28, p. 91]. Irrespective of the factors, there are two macroeconomic scenarios that can trigger the formation of NPLs [6, p. 7]. The first is a slow, but continuous deterioration in asset quality due to an extended period of weak growth (the example of Portugal and Italy). The second scenario is the occurrence of a sudden economic shock to asset quality in the context of a highly indebted financial sector that experienced a rapid growth. In this case, banks are vulnerable to sudden turns in market conditions, particularly if they have mismatched financing structures or the collateral value is significantly overestimated (the case of Ireland and Spain). The vulnerability of the financial system to shocks in macroeconomic aggregates can also be caused by structural weaknesses such as the excess of banks, financial innovation (securitisation of mortgage loans) and the lack of the banks' operational capacity to write off NPLs [6, p. 8].

Due to its importance, the analysis of credit risk determinants has been in the focus of professional literature for years. Knowledge of the factors that affect the level of NLPs is crucial for managers in a risk function in banks, national and international regulators and supervisors responsible for the stability of the banking sector [25, p. 3].

Literature review

The examination of the causality between the credit risk levels in the Serbian banking sector, on the one hand, and the basic macroeconomic aggregates, on the other hand, has been the subject of a number of scientific research papers. Interest in these issues has escalated particularly since 2014, when the share of NPLs in total gross loans reached its historical maximum of 23% vs. 11.2% in 2008. In August 2015, the Government of the Republic of Serbia adopted a strategy for resolution of nonperforming loans. Achieving macroeconomic stability is a necessary albeit not a sufficient condition for the permanent resolution of accumulated NPLs from the previous period. A systemic approach applied simultaneously and in a coordinated manner by commercial banks, the government and the central bank is needed [28, p. 92].

The most significant research studies by domestic authors will be listed in a chronological order. Božović, Živković and Urošević [8, p. 32] analyse the effect of spillover of the exchange rate risk into default risk, using the Merton model to show that in an import-dependent country there is a significant impact of exchange rate devaluation on the borrowers' ability to timely service their obligations. Otašević [22, p. 28] analyses the influence of macroeconomic factors on credit risk in the banking sector in the period from 2008Q3 to 2012Q2 on a sample of 33 commercial banks. Econometric analysis indicates that the statistically most significant factors behind the rising credit risk are the fall in economic activity and depreciation of the dinar. In Jović's doctoral dissertation, [14, p. 196], GDP and the nominal exchange rate of the euro were found to have statistically significant impact on the movement of NPLs in the economy. A forecast error variance decomposition analysis showed that 67.5% of the variability of NPLs can be explained by changes in GDP, the nominal exchange rate of the dinar against the euro and the unemployment rate.

Tabaković [28, pp. 91-105] provides a detailed analysis of the causes of NPLs in the Serbian banking sector, as well as an overview of all the measures that have led to a successful long-term solution to this problem. In her paper [27, pp. 83-102], Tabaković presents a thorough analysis of all monetary policy measures taken in the period following 2012 with a view to achieving price and financial stability, which was a prerequisite for a successful recovery of investment and economic activity. The conclusion is that an efficient monetary policy supported by other macroeconomic policy measures (primarily fiscal consolidation measures) is one of the conditions for reaching financial stability and economic growth.

In Božović's paper [9, p. 12], credit risk is for the first time approximated by the default rate at the level of the Serbian banking sector. Based on the conducted research, the author came to the conclusion that statistically significant predictors of change in the default rate are its fourth lag (negative sign), NBS key rate (positive sign) and GDP growth rate (negative sign).

In addition to the research papers by domestic authors focusing on the analysis of credit risk determinants in the Serbian banking sector, the authors in the surrounding countries have also dealt with this issue. Under the influence of the global economic crisis, the level of NPLs recorded the highest average annual growth rate in 2009 in all countries of Central, Eastern and Southeast Europe [26, p. 50].

Kjosevski, Petkovski and Naumovska [15, p. 1185] have analysed specific and macroeconomic determinants of NPLs in the Republic of North Macedonia using ARDL methods. The results of this research indicate that the profitability of banks, growth of corporate and retail loans as well as GDP growth have an adverse impact on NPLs, while the increased banking sector solvency and unemployment rates have a positive impact on NPLs expansion in both models. Aver [2, p. 317] has studied credit risk factors in the banking sector of Slovenia. The model explains 86.3% of the credit risk variability of the Slovenian banking sector. The growth of real interest rates on consumer loans granted to households, the growth of stock exchange index of the Slovenian capital market, the reduction of the number of employees in Slovenia, the increasing interest rates on government bonds and on mortgage loans have the most significant impact on credit risk growth. Using the ARDL method, Benazić and Radin [5, p. 75] have confirmed a statistically significant long-run equilibrium relationship between real GDP growth, price growth, unemployment, interest rates and

the depreciation of Croatian kuna against the euro and NPLs in the Croatian banking sector. Tanasković and Jandrić [26, p. 58] have analysed the macroeconomic and institutional determinants of NPLs in the period from 2006 through 2013, on a sample of 12 countries in Southeast Europe. It has been found that the movement of GDP adversely impacts the movement of NPLs, while the share of foreign currency-indexed loans in total loans and the depreciation of the local currency have a positive impact on NPLs. Szarowska, in her study [25, p. 33], analyzed macroeconomic determinants of NPLs in the period from 1999 through 2015 in the countries of Central and Eastern Europe. The author used panel regression analysis with fixed effects, finding unemployment rate to have the strongest effect on the level of NPLs (an increase in the unemployment rate by 1pp leads to an increase in NPLs ratio by 0.54pp). Economic growth, nominal exchange rate, inflation and interest rate on loans also have a statistically significant impact.

Bykova and Pindyuk [10, p. 6] have analysed the determinants of NPLs in Central and Southeast Europe using a panel model with fixed effects. The dependent variable was segmented so as to allow for a separate observation of the change in NPLs in four segments: corporate loans, mortgage loans, consumer loans and cash loans to households. The model showed a statistically significant impact of real GDP growth on all segments of NPLs, but the relationship is the strongest in the corporate sector, which corresponds to both the economic intuition and economic theory. Within the retail sector, mortgage loans have the highest degree of procyclicality, which also corresponds to the economic logic. Using a dynamic panel and a sample of 75 countries, Beck et al. [4, p. 525] have found that good predictors of NPLs are real GDP rate, stock price, exchange rate and lending interest rate. Ozili [23, p. 27] has analysed the impact of the degree of development of the banking and financial sector on the total level of NPLs. Data at the level of 96 countries and 6 regional units have been analysed. Indicators of the banking sector development level are the presence of foreign banks (the degree of liberalisation of the banking sector) and private credit by banks to GDP ratio as an indicator of the degree of financial intermediation. It has been determined that NPLs are positively correlated with the high share of the banking sector in the total external financing and with the liberalisation of the banking sector, i.e., with significant presence of foreign banks. Boumparis et al. [9, p. 12] have analysed the mutual impact of sovereign ratings and NPLs in the panel vector autoregressive model (PVAR model). The application of the impulse response function has shown that there is an interaction between NPLs and the long-term sovereign rating.

Data

In this paper, we used data on the main macroeconomic indicators which are available on the website of the National Bank of Serbia (secondary source of data). The sample covers the period of 11 years (2008Q4-2018Q3), and time series consist of quarterly data. The Decision on Classification of Bank Balance Sheet Assets and Off-Balance Sheet Items [21, p. 1] gives a precise definition of nonperforming loans. For the purpose of this research, credit risk (dependent variable) is approximated by the level of total NPLs, in millions of dinars. In the literature, nonperforming loans, their level [14, p. 111], their share in total gross loans [15, p. 1189, 25, p. 26], the logarithmic transformation of their share in total gross loans [26, p. 55] or the first difference of their share in the total gross loans [10, p. 23] are usually used as an indicator of the credit risk level which the banking sector is exposed to. In accordance with the results obtained in previous research, the following macroeconomic variables were used as explanatory variables: seasonally adjusted GDP in millions of dinars, nominal dinar exchange rate against the euro (exchange rate at the end of the period), key interest rate of the National Bank of Serbia, the risk premium of the Republic of Serbia measured by EMBI index (emerging market bond index prepared by JP Morgan) and year-on-year inflation rate. Table 1 below displays the descriptive statistics of all observed variables.

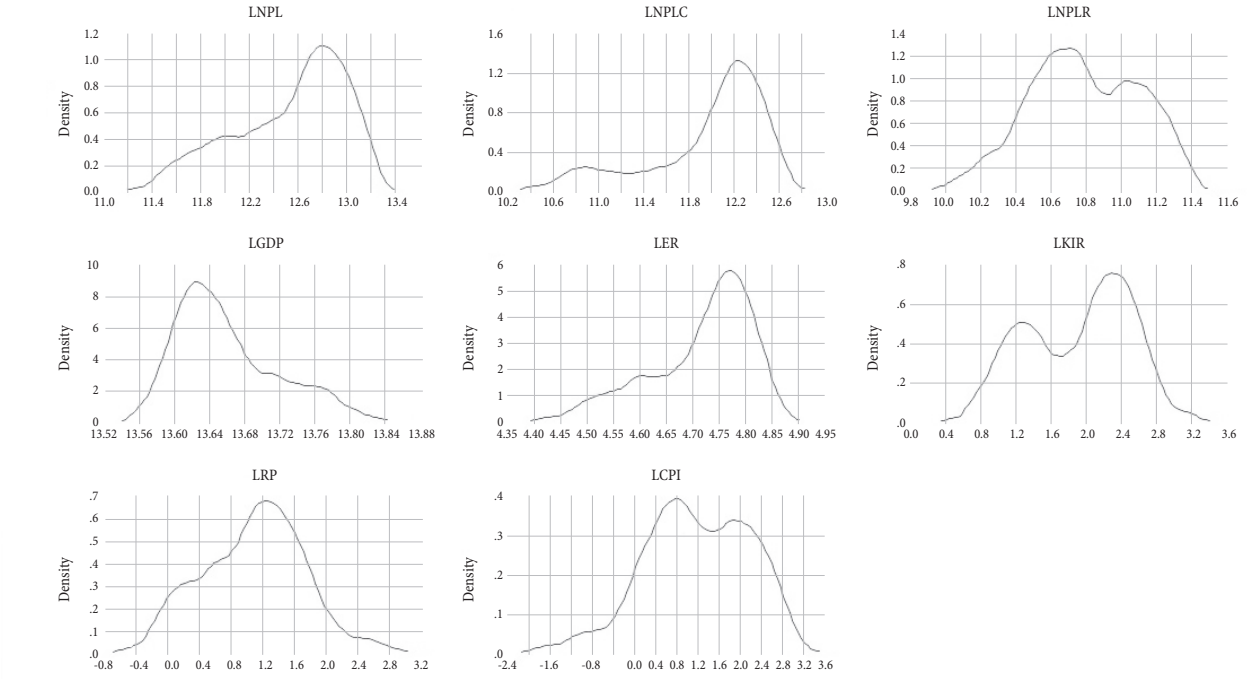
A logarithmic transformation (Box-Cox transformation) [19, p. 25] of time series of all observed variables was performed. This further means that the initial estimated regression at the level of time series represents the estimation of constant elasticity [19, p. 26]. For variables

Figure 1: Descriptive statistics

	LNPL	LNPLC	LNPLR	LGDP	LER	LKIR	LRP	LCPI
Mean	12.54757	12.00512	10.79495	13.66034	4.721188	1.925950	1.103747	1.215391
Median	12.71124	12.19998	10.76557	13.64113	4.751889	2.151695	1.143492	1.163151
Maxlmum	12.99102	12.48518	11.22696	13.79576	4.820023	2.876386	2.504746	2.646175
Minimum	11.62953	10.68329	10.19809	13.59131	4.484143	0.916291	-0.105361	-1.203973
Std. Dev.	0.423569	0.488384	0.289264	0.054358	0.089433	0.557767	0.599281	0.926077
Skewness	-0.791199	-1.365710	-0.075408	0.897320	-1.062579	-0.300393	-0.060855	-0.357738
Kurtosis	2.301543	3.736615	2.041905	2.812787	3.035413	1.681819	2.555350	2.554907
Jarque-Bera	5.485010	14.67264	1.724600	5.968939	8.282182	3.847334	0.389633	1.301689
Probability	0.064409	0.000651	0.422190	0.050566	0.015905	0.146070	0.822986	0.521605
Sum	552.0931	528.2252	474.9778	601.0550	207.7323	84.74179	48.56486	53.47721
Sum Sq. Dev.	7.714661	10.25633	3.597978	0.127056	0.343927	13.37746	15.44290	36.87761
Observations	44	44	44	44	44	44	44	44

Source: Author's calculations.

Figure 2: Empirical distribution of observed time series



Source: Author's calculations.

in which another transformation was performed using the first difference operator in order to achieve time series stationarity, the transformed data represent a continuous growth rate [19, p. 27]. These two conclusions are relevant to the interpretation of the results obtained here.

Model specification

Three basic models in the form of a linear regression model have been developed in order to individually analyse the exposure to systemic risk at the level of the entire banking sector in Serbia, and then separately by individual segments, i.e., at the corporate and retail levels. All three models are illustrated in the text below. All details and EViews programme extracts are shown in Appendix 3. The research results section contains a comparative overview of all three models in terms of: **a.** level of significance at which the existence of cointegration was adopted (F-statistic), **b.** explanatory power of ARDL model with error correction (corrected coefficient of

determination) **c.** adjustment parameter values and **d.** statistically significant long-run regressors (regression coefficient value, standard error and p value). As with the Engle-Granger two-step procedure, the ARDL method can also be used to identify a single cointegration relationship, while using the Johansen method it is possible to identify multiple cointegration vectors.

Model 1

$$LNPL_t = \beta_0 + \beta_1 (LGDP)_t + \beta_2 (LER)_t + \beta_3 (LKIR)_t + \beta_4 (LRP)_t + \beta_5 (LCPI)_t + \varepsilon_t \quad (1.1)$$

Model 2

$$LNPLC_t = \beta_0 + \beta_1 (LGDP)_t + \beta_2 (LER)_t + \beta_3 (LKIR)_t + \beta_4 (LRP)_t + \beta_5 (LCPI)_t + \varepsilon_t \quad (1.2)$$

Model 3

$$LNPLR_t = \beta_0 + \beta_1 (LGDP)_t + \beta_2 (LER)_t + \beta_3 (LKIR)_t + \beta_4 (LRP)_t + \beta_5 (LCPI)_t + \varepsilon_t \quad (1.3)$$

where the variables have the following meaning: LNPL – logarithmic values of the level of NPLs across the entire banking sector, LNPLC – logarithmic values of the level of NPLs in the corporate sector, LNPLR – logarithmic values of the level of NPLs in the retail sector, LGDP – logarithmic values of seasonally adjusted GDP, LER – logarithmic values of the nominal exchange rate of the dinar against the euro, LKIR –logarithmic values of the key interest rate of the National Bank of Serbia, LRP – logarithmic values of the risk premium of the Republic of Serbia, and LCPI – logarithmic values of the year-on-year inflation rate.

Unit root test

In this paper, the subject of the analysis are time series, hence, before deciding which methodology to apply, it is necessary to determine how many times it is necessary to apply differentiation in order to eliminate the presence of one or more unit roots. By applying the ordinary least squares method in a regression model of time series with a unit root, we obtain parameter estimates with undesirable statistical properties. The classical linear regression model does not represent a completely adequate framework for the analysis of the interdependence of time series with a unit root [19, p. 159]. By looking at the observed time series chart, we can see a change in movement in the observed period (2008Q4-2019Q3) in all of them, which can be characterized as a permanent change in the movement of time series (existence of permanent structural break). The Chow test for determining a structural break was also applied in order to verify the conclusions made on the basis of the graphical representation of the series (details are shown in Appendix 2). This phenomenon can be explained by the fact that the period observed here was long enough to cover the moment of the initial effect of the global financial crisis on the Serbian economy, its delayed effects, given that economic time series are characterized by delays in responding to the initial impulse, as well as the recovery period of the Serbian economy and the financial system.

Unfavourable macroeconomic environment (decline in economic activity, depreciation of the dinar exceeding 22% in the period from 2009-2012 and the unemployment growth of around 10 percentage points) is the main trigger for a sharp hike in NPLs [28, p. 94]. In 2015, a strategy for solving NPLs issue was adotped, bringing down the levels of nonperforming loans as a result of the systemic approach applied to their resolution. Nonperforming loans granted to the retail sector follow the trend of NPLs in the corporate segment and at the level of the entire banking sector; however, their upward movement is much slower,

Table 1: Comparative overview of the share of NPLs in total loans at the level of the entire banking sector, in the corporate sector and in the retail sector

	2008Q4	2015Q3	2019Q3
NPLs to total gross loans ratio in the banking sector	11.30%	22.80%	4.70%
Corporate NPLs to gross loans ratio in the corporate segment	14.60%	24.10%	3.70%
Retail NPLs to gross loans ratio in the retail segment	7.30%	11.10%	4.10%
Corporate NPLs to total NPLs ratio	71.00%	56.00%	39.00%
Retail NPLs to total NPLs ratio	21.00%	17.00%	35.00%

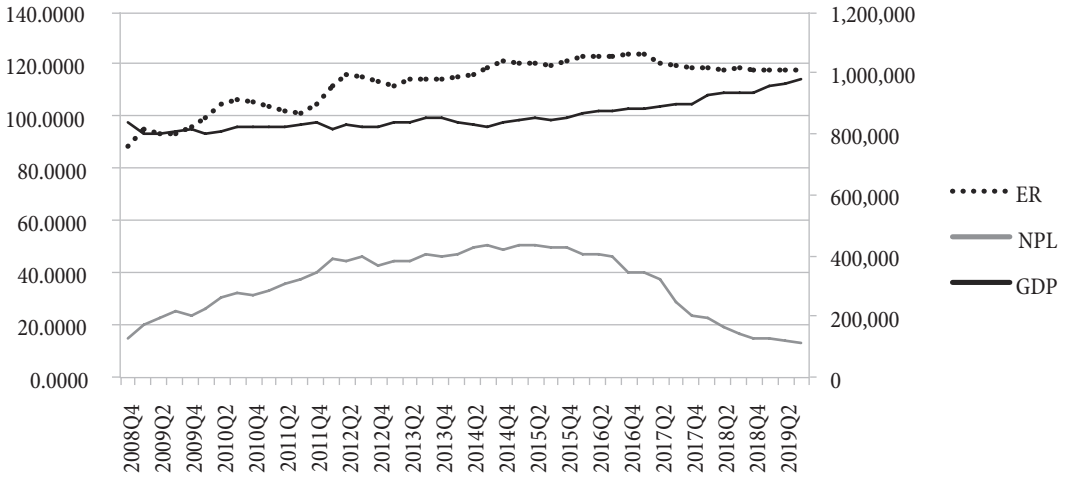
Source: Author's calculations.

resulting in their maximum share in total NPLs during the crisis at 17%. This very data, coupled with the fact that the share of retail NPLs in total NPLs at the level of the entire banking sector increased during 2019 (35%) corroborates the initial hypothesis that there is a difference in systemic risk exposure between the loans granted to the corporate sector and loans granted to the retail sector, i.e., that the degree of procyclicality of retail loans is lower in respect to the corporate loans.

When it comes to GDP series, in the observed period the value of GDP recorded its minimum in the second quarter of 2014 (negative rate of 4.02%), which is partly due to the floods that caused a one-time fall in industrial producton and mining. Negative GDP growth rates were recorded both in 2009, as a consequence of the first impact of the global financial crisis on the Serbian economy, and in 2012, as a consequence of the drought that caused a decline in agricultural production and grain exports. After reaching its minimum in 2014, it is noticeable that the economy has entered a new business and investment cycle, which reflected positively on the lending activity which, in turn, contributed to the growth of investment activity and GDP [28, p. 92].

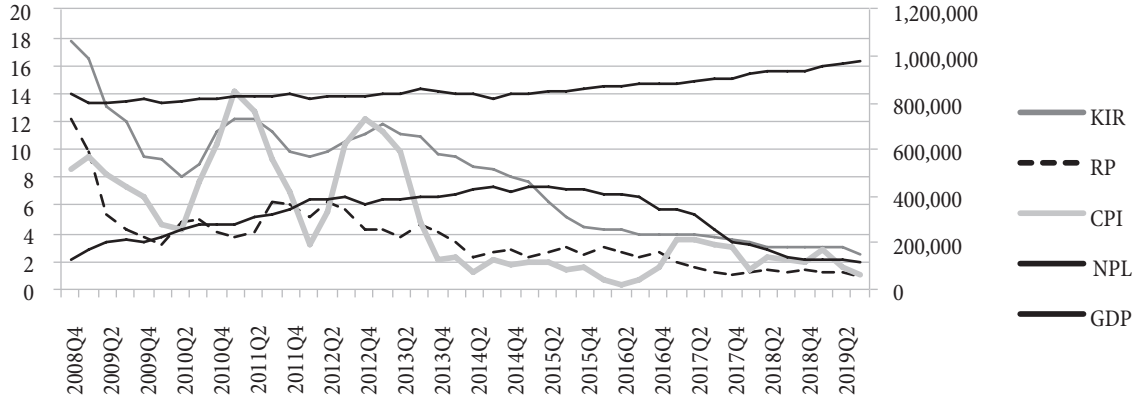
The series showing the movement of the nominal exchange rate has a permanent structural break in the second quarter of 2014. Since then, the nominal exchange rate growth has slowed significantly as a result of a stable monetary policy (falling inflation rate), growing economic activity, reduction in the balance of payments deficit and fiscal consolidation measures (reduction of the public budget deficit and reduction of foreign currency-indexed public debt). In the observed period,

Figure 3: Movement of the nominal exchange rate of the dinar against the euro (left-hand scale), NPLs and GDP in millions of dinars (right-hand scale) in the period from 2014Q4 to 2019Q3



Source: Author's calculations based on NBS data.

Figure 4: Key interest rate, Serbia's risk premium and year-on-year inflation rate (left-hand scale) and GDP and NPLs in millions of dinars (right-hand scale) in the period from 2008Q4 to 2019Q3



Source: Author's calculations based on NBS data.

the exchange rate was the subject of intervention by the monetary authorities aimed at preventing significant fluctuations in the exchange rate, ensuring the stability of the monetary and financial system, but also ensuring price stability [19, p. 33].

The structural break in the trend and the intercept of the time series of the key interest rate occurred in the first quarter of 2015 when there was a significant decline in the value of the key interest rate as a result of a longer period which did not see a sharp increase in year-on-year inflation rate [28, p. 96]. The growth of economic activity, keeping inflation within the target range and the beginning of fiscal consolidation measures significantly reduced inflation expectations and enabled monetary policy makers to reduce the key interest rate and encourage the growth of lending activity.

The series of Serbia's risk premium does not have a monotonous decline in the observed period, but it does have a negative trend which is in line with the improvement of the macroeconomic position of Serbia. The level of risk perception of investors towards investing in Serbia occurs with a certain time lag in respect of the improvement of the macroeconomic environment. A permanent structural break in the year-on-year inflation rate series occurred in the second quarter of 2013, because the same fell from 12.9% in October 2012 to 2.2% a year later [28, p. 96]. The year-on-year inflation rate was close to its maximum level in the fourth quarter of 2012 (12.2%) as a result of the increase in regulated prices, rising VAT rates that caused an increase in prices of a large number of products and services, and as a result of drought and high agricultural products' prices. After that period, it fell sharply to only 2.2% in the fourth quarter of 2013. Due to all the above, there were clear indications that all time series had a permanent structural break. In the case of a permanent structural break in trend stationary time series, the DF unit root test is biased towards accepting the hypothesis of the existence of a unit root [21, p. 224]. The literature defines a group of unit root tests that include a priori information about the existence of a permanent structural break. A modified version of the ADF test for series with structural break was applied here. With this version of the test, it is not necessary to know the moment of structural break a priori. A form of the test which assumes the occurrence of a structural break both in the intercept and in the trend of the time series was applied. In this case, the **null hypothesis** reads: the time series is a random walk with constant increment. The **alternative hypothesis** is defined as follows: the time series is stationary around a trend with a permanent change in its intercept and slope starting at TL+1. To test the existence of a unit root at the series level, two unit root tests were applied: the ADF test and a modified ADF test for series with structural break. In series in which both tests unambiguously adopted the null hypothesis of the existence of a unit root at the series level, testing of the first difference continued with the ADF test, because this test allows for drawing correct inferences when there is a single structural break (if there is a permanent structural break at the series level, by applying the first difference operator the same is transformed into a single structural break). Critical values for both unit root tests were determined at a significance level of 5%, and this significance level will be used for statistical inference within the research presented here.

Table 2: Unit root tests results

	Modified ADF test		Augmented Dickey Fuller Test-ADF			
	At the level		At the level		First difference	
Determinants	t-Statistic	critical value 5%	t-Statistic	critical value 5%	t-Statistic	critical value 5%
LNPL	-4.26	-5.17	-1.85	-2.93	-2.16	-1.94
LNPLC	-4.81	-5.17	-1.34	-3.51	-4.81	-2.93
LNPLR	-5.76	-5.17	-0.64	-3.51	-3.77	-2.93
LGDP	-6.75	-5.17	-2.26	-3.51	-7.75	-2.93
LER	-4.14	-5.17	-1.40	-3.51	-4.47	-2.93
LKIR	-6.07	-5.17	-1.57	-3.51	-4.09	-2.93
LRP			-2.96	-3.51	-5.70	-2.93
LCPI	-4.43	-4.44	-3.11	-3.51	-5.08	-2.93

Source: Author's calculations.

Using the abovementioned tests (the results are shown in Table 3 below), it was determined that the time series of GDP, NPLR (nonperforming loans in the retail sector) and KIR (key interest rate) were stationary (I (0)) around a trend with a permanent change in its intercept and slope starting at TL+1. All other time series are integrated of order one (I (1)). This is why, for these time series, the modified ADF test for series with structural break and ADF test give different results at the time series level. This phenomenon has already been explained in the text above.

Applied methodology

In accordance with obtained unit root test results, it is clear that the observed time series are not integrated of the same order (I(0)) and I(1)), thus it is not possible to apply the Engle-Granger two-step procedure (Engle & Granger, 1987) and Johansen method of cointegration (Johansen & Juselius, 1990) for determining long-run correlations in the movement of NPLs and other explanatory variables. The application of the mentioned methods requires that all observed time series be integrated of order one (I(1)). The autoregressive distributed lags method (ARDL method) represents an appropriate methodological framework for cointegration when the observed time series do not have the same order of integration (Pesaran and Pesraran (1997)). Its application requires that none of the observed time series be integrated of order I(2) (Ouattara (2004)). In this research, the mentioned requirements have been met. Moreover, this methodological framework gives better results on smaller samples, from 30 to 80 observations (Pattichis, 1999; Mah, 2000) compared to other methods for determining cointegration. The model with error correction can be obtained by linear transformation of the ARDL model, which can be represented by the following formula:

$$\Delta y_t = \beta_0 + \sum_{j=0}^{p} \beta_i \Delta y_{t-i} + \sum_{j=0}^{p} \beta_j \Delta x_{t-j} + \lambda_1 y_{t-1} + \lambda_2 x_{t-1} + \varepsilon_t$$

where y is a dependent variable, x are independent, i.e., explanatory variables, β are the coefficients of short-run dynamics, λ are coefficients of long-run dynamics and ε_t is a random error. The first part of the model describes short-run dynamics, while the second part of the model shows the long-run correlation between the dependent variable and explanatory variables in the model. Before applying the ARDL model, the key question is how many lags should be included in the model. The decision on the optimal number of lags is made on the basis of information criteria and provided the conditions for a good model specification have been met (residuals have normal distribution, there is no autocorrelation between residuals, and residuals have constant variance, i.e., there is no heteroscedasticity).

Research results

The selection of the optimal number of lags in all three models was performed by applying the Akaike information criterion. In choosing the optimal number of lags, we started with two lags due to the large number of independent variables. All three models have satisfied the basic criteria for a good model specification: the residuals have a normal distribution, the residuals have a constant variance, and there is no autocorrelation between them. Specification tests for all three models are shown in Table 4 below.

The next step is to test the existence of cointegration, i.e., the long-run equilibrium relationship between variables

Table 3: Model specification tests and information criterion value

Model specification test and information criteria	Model 1	Model 2	Model 3
Number of time lags	ARDL (1,0,0,0,0,0)	ARDL (1,0,0,0,1,0)	ARDL (1,0,0,1,1,2)
Akaike information criteria	-2.93	-2.45	-3.23
Diagnostic tests	Model 1	Model 2	Model 3
	p value		
JB (Jarque-Bera) test	0.55	0.06	0.80
Breusch-Godfrey Serial Correlation LM test	0.1	0.33	0.10
Heteroskedasticity test: Breusch-Pagan-Godfrey	0.06	0.36	0.20

Source: Author's calculations.

in the model. Statistical inference is performed by applying a bounds test, where the null hypothesis is based on the claim that there is no long-run relationship between the observed variables. If the F-statistic is higher than the upper bound value, which is given for the variables that are stationary at the first difference (I (1)), then the claim of the null hypothesis is rejected and an alternative hypothesis is adopted, which in the context of this test implies the existence of statistically significant long-run equilibrium relationship between the observed variables. The upper bound value is given for all four significance levels: 10%, 5%, 2.5% and 1%. For all models, the value of F-test and the bound values are shown in Table 5 below.

Based on the value of F-statistic that was higher than the upper bounds test value in all three models, the null hypothesis was rejected and the alternative hypothesis of the existence of statistically significant long-run equilibrium relationship between the observed variables was adopted. The alternative hypothesis in all models was adopted at a significance level of 1%.

In the models in which the movement of NPLs was assessed at the level of the entire banking sector and in the corporate sector, there is a statistically significant long-term impact of GDP (denoted as LGDP). The impact of GDP on the movement of NPLs in the retail segment is not statistically significant, which is in line with the conclusions already made on the basis of the given time series chart. Based on the obtained results, we can conclude that the procyclicality of NPLs in the corporate segment is higher than at the level of the entire banking sector (the value of the regression coefficient with GDP is higher in the corporate segment compared to the entire banking sector), and that procyclicality of NPLs in the retail sector is not statistically significant, at least when it comes to the impact of GDP thereon.

In the long run, the growth of GDP by 1% leads to a decline in NPLs at the level of the entire banking sector and in the corporate segment by 4.94% and 6.78% respectively, other things being equal. The relationship between the observed variables is negative (with a negative sign), which is in line with the results of previous research and with economic theory. The growth of the business activity increases the creditworthiness of borrowers and reduces the amount of NPLs, i.e., credit risk level.

The impact of the nominal exchange rate on NPLs is statistically significant in all three models. In the long run, a decrease in the nominal exchange rate by 1 % (appreciation of 1%) leads to a fall in NPLs by 2.97% at the level of the entire banking sector, by 2.37% in the corporate segment and by 2.66% in the retail segment, other things being equal. The relationship between the observed variables is positive. The growth of the nominal exchange rate increases the foreign currency-indexed loan instalment and leads to a reduced creditworthiness of borrowers. In economies like ours, this effect is particularly pronounced because there is a high share of foreign currency loans in the total loan portfolio. The main reasons for the high degree of euroisation of the Serbian economy in the observed period are: low level of confidence in domestic currency, lower interest rates on euro-denominated loans, lack of

Table 4: Bounds test results

	Model 1		Model 2		Model 3	
F-statistic	18.12		13.62		8.58	
k	5		5		5	
Critical values Bounds test	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
10%	2.26	3.35	2.26	3.35	2.26	3.35
5%	2.62	3.79	2.62	3.79	2.62	3.79
2.5%	2.96	4.18	2.96	4.18	2.96	4.18
1%	3.41	4.68	3.41	4.68	3.41	4.68

Source: Author's calculations.

Table 5: Long-run correlation coefficients

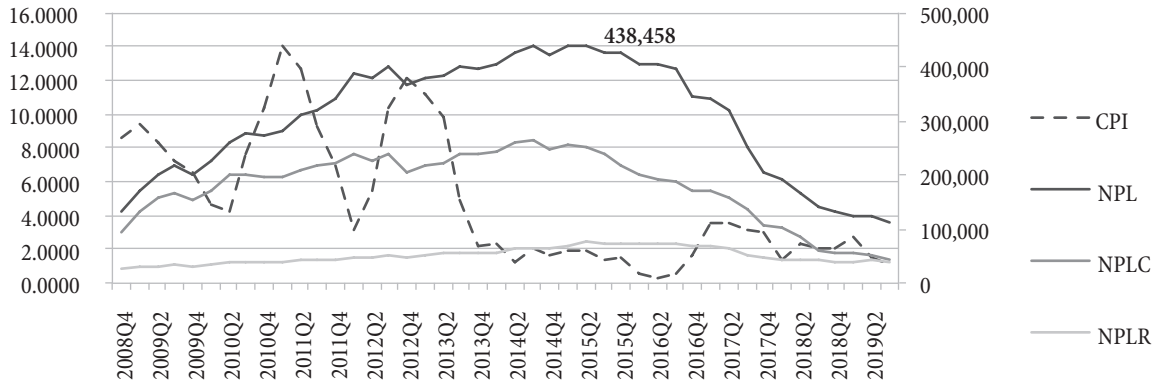
Determinants	LGDP			LER			LKIR			LRP			LCP		
Model	coeficient	standard error	p value	coeficient	standard error	p value	coeficient	standard error	p value	coeficient	standard error	p value	coeficient	standard error	p value
Model 1 LNPL	-4.94	1.97	0.01	2.97	0.94	0.00	0.58	0.26	0.03	0.39	0.19	0.05	-0.22	0.09	0.01
Model 2 LNPLC	-6.78	1.71	0.00	2.37	0.73	0.00	0.81	0.24	0.00	0.11	0.16	0.47	-0.17	0.06	0.01
Model 3 LNPLR	0.14	1,50	0.92	2.66	0.60	0.00	0.58	0.22	0.01	0.07	0.11	0.52	-0.25	0.07	0.00

Source: Author's calculations.

acceptable sources of financing in domestic currency when it comes to medium and long-term financing, the dominant presence of foreign banks and low credibility of the macroeconomic policy makers in the previous periods [13, p. 203]. Based on conducted econometric research Lojanica [18, p. 14] confirmed that the exchange rate is the most important transmission channel in Serbia, whose influence is not limited to the monetary sphere only (price stability), but also contributes to the economic growth. The variance decomposition of the consumer price index established that the effects of the exchange rate after four years accounted for 45% of total price fluctuations [18, p. 28]. The impact of the key interest rate of the National Bank of Serbia on nonperforming loans is statistically significant in all three models. Slope coefficient with the key interest rate which shows long-run correlation in the models can be interpreted as follows: **in the long run, a 1% drop in the key interest rate leads to a 0.58% drop in nonperforming loans at the level of the entire banking sector and in the retail segment, and to a 0.81% drop in the corporate segment, other things being equa**l. The relationship between the observed variables is positive. The growth of the key interest rate increases the costs of borrowing by commercial banks with the National Bank of Serbia and on the interbank market. Increased borrowing costs are incorporated into lending interest rates on corporate and retail loans, which reduces the borrowers' repayment capacity. The transmission of the key interest rate to interest rates on loans depends on many factors, including the loan maturity [4, p. 548]. Due to the low dinarisation rate of our economy, the interest rate channel as one of the classic instruments of monetary policy does not have the impact that it has in developed economies of the world [20, p. 30]. The impact of the risk premium of the Republic of Serbia is not statistically significant in all three models, but in the model used to assess the movement of nonperforming loans at the level of the entire banking sector (model 1), the regression coefficient with the risk premium cannot be completely ignored, because the p value equals 0.05. The slope coefficient with Serbia's risk premium in the model showing long-run correlation can be interpreted as follows: **in the long run, a 1% drop in the risk premium leads to a 0.39% drop in nonperforming loans at the level of the entire banking sector, other things being equa**l. Its decline indicates a decline in risk and an increase in macroeconomic stability, resulting in a fall in nonperforming loans.

The impact of the year-on-year inflation rate in all three models is statistically significant. The slope coefficient with year-on-year inflation rate which shows long-run correlation in the models can be interpreted as follows: **in the long run, a 1% year-on-year inflation rate increase leads to a 0.22% drop in nonperforming loans at the level of the entire banking sector, 0.17% drop in the corporate sector and 0.25% drop in the retail segment, other things being equal**. The relationship between the observed variables is negative, which is not in line with the economic theory. The obtained result is a consequence of the specifics of Serbia's economic system. First, the low level of dinarisation of the Serbian economy (both deposits

Figure 5: Movement of the year-on-year inflation rate, nonperforming loans at the level of the entire banking sector, in corporate and retail sectors in the period (in millions of dinars) from 2008Q4 to 2019Q3



Source: Author's calculations based on NBS data.

and loans) prevents the following expected impact: a rise in inflation should cause rising lending interest rates, which increases the credit risk level. Second, a rise in inflation devalues the real value of the borrowers' obligations and affects the creation of the so-called debtors' gain and credit risk mitigation. Third, the absence of expected price impact on the exchange rate, and subsequently on the credit risk level, resulted in the price increase which led to devaluation of the dinar, and the latter to a decline in creditworthiness of the borrowers, i.e., to the growth of NPLs. This missing influence is owed to the import dependence of the Serbian economy and its high euroisation level, where the exchange rate has a significant impact on prices. Analysis of time series using the VAR model (daily data from 2 January 2009 through 31 October 2019) found that the depreciation of the dinar against the euro of 1% leads to a rise in prices by 0.76%, while the rise in prices in the euro area by 1% leads to an increase in prices in Serbia by 2.09% [17, p. 26]. Fourth and last, both observed variables (NPLs and y-o-y inflation rate) were subject to government intervention in the observed period so that their movement cannot be directly related. The chart shows that the year-on-year inflation rate recorded alternating periods of sharp hike and fall up to the second quarter of 2015, while nonperforming loans recorded only continuous growth.

The analysis continued with a focus on coefficients showing short-run dynamics, including adjustment coefficients for all three models with error correction. A detailed overview is given in Table 7 below.

In all three models, the adjustment coefficient has a negative sign and is statistically significant. Table 8 gives a comparative overview of the parameters of all models, based on which it can be concluded that the models with greatest explanatory power (corrected coefficient of determination) are the ones used to assess the movement of NPLs at the level of the entire banking sector and in the corporate segment. 74% of variations in nonperforming loans at the level of the entire banking sector and 72% of variations in nonperforming loans in the corporate segment can be explained by changes in gross domestic product, nominal exchange rate, key interest rate of the National Bank of Serbia and year-on-year inflation. The model used to assess the movement of nonperforming loans in the retail segment demonstrated the lowest explanatory power amounting to 59%. The model used to assess the movement of NPLs in the corporate segment has the highest adjustment coefficient, which shows that during one quarter 29.4% of NPLs movement in the corporate segment adjust to their long-run equilibrium relationship with gross domestic product, nominal foreign exchange risk, key interest rate and year-on-year inflation rate.

Table 6: Error correction model - comparative overview of all three models

Determinant	Coefficient	Standard error	p value	Determinant	Coefficient	Standard error	p value
Model 1				Model 3			
Constant	12.86	1.15	0.00	Constant	-1.29	0.16	0.00
Adjustment coefficient	-0.19	0.01	0.00	D(LKIR)	-0.007	0.07	0.92
Model 2				D(LRP)	0.07	0.03	0.02
Constant	27.03	2.79	0.00	D(LCPI)	-0.03	0.01	0.01
D(LRP)	0.10	0.04	0.02	D(LCPI (-1))	0.04	0.01	0.01
BREAK	0.07	0.02	0.01	Adjustment coefficient	-0.27	0.03	0.00
Adjustment coefficient	-0.29	0.03	0.00				

Source: Author's calculations.

Table 7: Comparative overview of statistical properties of all three models

Dependent variable	Independent variables	ARDL model	Adjusted coefficient of determination	Adjustment coefficient	Independent variables that are statistically significant
NPL	GDP, ER, KIR, RP i CPI	ARDL (1,0,0,0,0,0)	74%	19%	GDP, ER, KIR i CPI
NPLC	GDP, ER, KIR, RP i CPI	ARDL (1,0,0,0,1,0)	72%	29%	GDP, ER, KIR i CPI
NPLR	GDP, ER, KIR, RP i CPI	ARDL (1,0,0,1,1,2)	59%	27%	ER, KIR i CPI

Source: Author's calculations.

The adjustment coefficient of 29.4% shows that in 3.4 quarters (100%/29.4%) or 10.2 months, the movement of NPLs in the corporate segment adjusts towards the long-run equilibrium relationship path with these variables. 19.8% of NPLs movement at the level of the entire banking sector in one quarter is adjusted to the long-run equilibrium relationship with gross domestic product, nominal exchange rate, key interest rate, RS risk premium and year-on-year inflation. **In 5 quarters (100%/19.8%) or 15 months, the NPLs movement at the level of the entire banking sector achieve full adjustment to the path of the long-run equilibrium relationship with these variables**.

27.5% of the movement of NPLs granted to the retail sector in one quarter adjust to the long-run equilibrium relationship with the nominal exchange rate, key interest rate and year-on-year inflation rate. **In 3.6 quarters (100%/27.5%) or 11 months, the movements of NPLs granted to the retail sector fully adjust to the path of the long-run equilibrium relationship with these variables**.

In the model used to assess the movement of NPLs at the level of the entire banking sector (model no. 1), in the part thereof showing short-run dynamics, except for the adjustment coefficient, there is no statistically significant coefficient ($p<0.05$). The constant is statistically significant and it shows that in the short run there is a level of NPLs that was carried over from the previous periods (persistence of nonperforming loans). In the model used to assess the movement of NPLs in the retail sector (model no. 2), in the part thereof showing short-run dynamics, the regression coefficient with the risk premium is statistically significant and it shows that in the short run, i.e., during the same quarter, a 1pp drop in the risk premium leads to a 0.10pp drop in NPLs in the corporate sector. Both the constant and the artificial variable are statistically significant. The constant shows that in the short run there is a level of NPLs that is determined autonomously, i.e., it represents an inherited level from the previous periods (persistence of nonperforming loans). The artificial variable covers the period from 2016Q2 to 2018Q2 and indicates the period when the government intervention in resolving NPLs granted to the corporate sector was the most intensive. In the model assessing the movement of NPLs in the corporate sector (model no. 3), in the part thereof showing short-run dynamics, the regression coefficient with the risk premium in the same quarter, and year-on-year inflation in the same quarter and with a lag of one quarter, show statistical significance of impact on retail NPLs. Despite the statistical significance, a very low value of the regression coefficients cannot be treated as a significant influence

Concluding remarks

Based on obtained results, the correctness of initial research hypotheses was corroborated: 1) there is a difference in systemic risk exposure between corporate loans and retail loans in the banking sector of the Republic of Serbia and 2) systemic risk exposure of the entire banking system of the Republic of Serbia can be approximated by corporate loans due to the specificity of Serbia's economic and banking system.

The obtained results show that the impact of GDP on NPLs in the retail segment is not statistically significant, while there is statistical significance and a high regression coefficient in the corporate segment and at the level of the entire banking system. Models used to assess the movement of NPLs in the corporate sector and at the level of the entire banking sector have similar statistical properties (the same statistically significant regressors with similar values and almost the same explanatory power of the model). The results of this research are especially significant because they have shown that the sensitivity of banks to changes in macroeconomic aggregates is important not only for management structures in commercial banks but also for macroeconomic and macroprudential policy makers. Finally, based on the conducted research, we can conclude that the financial system of the Republic of Serbia is much more sensitive to changes in the stages of the business cycle due to its underdevelopment (high share of corporate loans in the bank's total loan portfolio). The development of the capital market would enable business entities to have access to other sources of financing, which would have a triple effect on increasing the financial stability of the Republic of Serbia. First, access to different sources of financing would reduce the default rate of business entities

regardless of the stage of the business cycle, because it would facilitate the provision of external sources of financing, and competition would lead to lowering interest rates. In this way, banks would not lose their market share, because they would expand the range of services offered to the corporate and retail sectors (investment banking services) and diversify the structure of their assets, i.e., placements in favour of investments in corporate shares and corporate bonds. An additional argument in support of the abovesaid is the behaviour of commercial banks in the period when the level of NPLs threatened Serbia's financial stability. At that time, banks were reluctant to lend to the corporate sector, and the excess liquidity was directed towards the NBS bills and securities of the Republic of Serbia [12, p. 1]. Second, a lower level of corporate loans in the total loan portfolio of the banks would reduce the exposure to systemic risk, i.e., the level of credit risk procyclicality, thereby enhancing banks' resilience to changes in the stages of the business cycle. In the long run, change in the banks' loan portfolio structure in favour of retail loans would increase the profitability of banks, because retail loans have higher interest rates while requiring lower capital costs. Third, banks' balance sheets would be less sensitive to changes in interest rates as a result of reduced interest rate volatility. In this way, the financial system of the Republic of Serbia would not have found itself in a situation it experienced following 2008. At a time when the financial crisis had taken over the world and when monetary authorities of the world's leading economies were lowering interest rates, Serbia saw rising interest rates due to the inability of domestic banks to use sources of financing from their parent banks [11, p. 491]. During that period, banks in Serbia were faced with constant deleveraging to their parent banks [12, p. 12], hence they were focused exclusively on domestic deposits, which significantly raised the interest rates on deposits, followed by rising interest rates on loans.

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