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POSTOJE LI  
MAKROEKONOMSKI  
PREDIKTORI ZA  
POINT-IN-TIME PD?  
REZULTATI NA OSNOVU  
BAZE PODATAKA STOPA  
NEIZMIRENJA UDRIŽENJA  
BANAKA SRBIJE

Prevod  
obezbedio  
autor

## Rezime

Interni modeli koje banke koriste za ocenu kreditne sposobnosti svojih dužnika po pravilu daju ocene verovatnoće neizmirenja koje obuhvataju čitav poslovni ciklus. Za potrebe primene MSFI 9 neophodne su, međutim, ocene verovatnoće neizmirenja za konkretan vremenski trenutak, kao i uključivanja različitih makroekonomskih scenarija. Ovakve ocene zasnovane su prevashodno na uračunavanju efekata poslovnog ciklusa, te stoga podrazumevaju postojanje dokazive veze između makroekonomskih pokazatelja i ostvarenih stopa neizmirenja. U ovom radu analiziramo da li ovakva veza postoji na podacima banaka koje posluju u Srbiji. Koristimo nekoliko različitih pristupa za utvrđivanje ove veze - linearnu regresiju, autoregresioni proces, model sa korekcijom greške, pristup statičkih i dinamičkih panela, kao i dva Bayes-ova pristupa. Na čitavom uzorku model sa korekcijom greške pokazuje najbolje performanse i daje faktore prihvatljive ekonomske intuicije. Podaci po tipu proizvoda daju nešto manje pouzdane rezultate, što je delimično uslovljeno dominantnim uticajem segmenta malih i srednjih preduzeća u ukupnim stopama neizmirenja. Kao najrobustniji prediktori stopa neizmirenja izdvajaju se docnje u promenama ovih stopa, referentna stopa Narodne banke Srbije i stopa rasta bruto domaćeg proizvoda.

**Ključne reči:** kreditni rizik, verovatnoća neizmirenja, makroekonomski faktori

**JEL:** G21, C22, M41

# ARE THERE MACROECONOMIC PREDICTORS OF POINT-IN-TIME PD? RESULTS BASED ON DEFAULT RATE DATA OF THE ASSOCIATION OF SERBIAN BANKS

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## Summary

Internal models that banks use to assess the creditworthiness of their borrowers, as a rule, give estimates of the probability of default that cover the entire business cycle. For the purposes of applying IFRS 9, however, estimates of the probability of default for a specific moment, as well as the inclusion of different macroeconomic scenarios are required. Such estimates are based primarily on the calculation of the effects of the business cycle, and therefore involve the existence of a provable link between macroeconomic indicators and realized default rates. In this paper we analyze whether this relationship exists using the data of banks operating in Serbia. We use several different approaches to determine this link: linear regression, autoregressive process, error correction model, static and dynamic panel-data models, as well as two Bayesian approaches. On the whole sample, the error correction model shows the best performance and gives the factors of acceptable economic intuition. When data are divided by the type of product, we obtain somewhat less reliable results, which is partly due to the dominant influence of the SME segment in the total default rates. As the most robust predictors of default rates we identify the lagged differences in these rates, the reference rate of the National Bank of Serbia and the growth rate of gross domestic product.

**Keywords:** credit risk, probability of default, macroeconomic factors

**JEL:** G21, C22, M41

## Uvod

Kreditiranje predstavlja srž poslovanja komercijalnih banaka. Kako bi što efikasnije upravljale svojim plasmanima, banke širom sveta razvijaju sopstvene metode ocene kreditne sposobnosti svojih dužnika. Ovi interni modeli banaka razlikuju se kako po specifičnostima njihovih kreditnih portfolija i poslovnih segmenata koji pokrivaju, tako i prema nivou sofistikacije pri upotrebi statistički zasnovanih metoda. Interni modeli se zbog statističke pouzdanosti obično razvijaju na većim uzorcima koji uključuju sve istorijske podatke o izmirenjima obaveza. Stoga oni po pravilu daju ocene verovatnoće neizmirenja (engl. *Probability of Default*, skraćeno PD) koje obuhvataju čitav poslovni ciklus (engl. *Through-the-Cycle*, skraćeno TtC), odnosno vrednosti PD koje su „usrednjene po vremenu“ tokom čitave istorije koju banka koristi za razvoj modela.

Počev od 1. januara 2018. u primeni je Međunarodni standard finansijskog izveštavanja (MSFI) 9, koji precizira kako finansijske institucije treba da klasifikuju i mere finansijske instrumente u svojim portfolijima, kao i kako da ocenjuju njihovo obezvređenje koristeći koncept očekivanog kreditnog gubitka. Jedna od suštinskih razlika ovog standarda u odnosu na, recimo, Bazel 2 i 3 standarde koji se koriste za ocenu adekvatnosti kapitala, jeste ta što su za potrebe primene MSFI 9 neophodne ocene verovatnoće neizmirenja za konkretan vremenski trenutak (engl. *Point-in-Time*, skraćeno PiT). Ovo je neophodno zato što se u očekivanom kreditnom gubitku u MSFI 9 koriste projekcije tokova gotovine koje mogu obuhvatati više vremenskih trenutaka, pa čak (za instrumente Nivoa 2) i više godina ili dekada, što zahteva da se ispravno predvide buduće (uslovne) verovatnoće neizmirenja i uključe efekti različitih makroekonomskih scenarija. Ocene PiT PD zasnovane su prevashodno na uračunavanju efekata poslovnog ciklusa i sposobnosti projektovanja budućih makroekonomskih scenarija koji „gledaju unapred“ (engl. *forward-looking*), te stoga podrazumevaju postojanje dokazive veze između makroekonomskih pokazatelja i ostvarenih stopa neizmirenja. Osnovna pitanja na koja treba obratiti pažnju prilikom

ispitivanja ove veze su kvalitet podataka na osnovu kojih se ona proverava, izbor metodologije za ispitivanje postojanja veze, kao i njena ekonomska interpretacija i mogućnost formiranja smislenih scenarija.

Postojanje kvantifikabilnog i merljivog odnosa između makroekonomskih pokazatelja i ostvarenih stopa neizmirenja je pitanje koje je već deceniju unazad, od Globalne finansijske krize do danas, predmet interesovanja istraživača. Simons & Rolwes (2008) su razvili model veze između makroekonomskih faktora i stope neizmirenja za holandske firme, i pokazali moguće primene modela u stres testovima. Bruche & González-Aguado (2010) su predložili ekonometrijski model u kome istovremene varijacije u stopama neizmirenja i stopama naplate zavise od kreditnog ciklusa. Altman *et al.* (2004) i Altman *et al.* (2005) su među prvima proučavali odnos stopa neizmirenja i stopa naplate. Bellotti & Crook (2009) su razvili model kreditnog skoringa koji koristi makroekonomске promenljive i zasnovan je na analizi preživljavanja (engl. *survival analysis*). Ali & Daly (2010) su empirijski proučavali makroekonomске determinante kreditnog rizika koristeći panel podatke iz više zemalja. Figlewski *et al.* (2012) su modelirali efekte makroekonomskih faktora na stope neizmirenja i kreditne migracije u sektoru velikih preduzeća.

U nešto široj slici, bitno je načelno posmatrati egzogene determinante kreditnog rizika. Duffie *et al.* (2009) nalaze da je verovatnoća ekstremnih gubitaka u slučaju neizmirenja za velika preduzeća u SAD znatno veća u odnosu na onu koja se dobija pretpostavkom da korelacije zavise samo od opservabilnih faktora rizika, te da je neophodno uključiti i latentne faktore. Fons (1991), pored mnogih drugih autora, opisuje tehnikе predviđanja neizmirenja i drugih kreditnih događaja.

U ovom radu analiziramo da li postoji veza između makroekonomskih pokazatelja i ostvarenih stopa neizmirenja koristeći podatke banaka koje posluju u Srbiji. Konkretno, korišćena je baza podataka o stopama neizmirenja Udruženja banaka Srbije (UBS), u kombinaciji sa javno dostupnim podacima koji su služili za konstrukciju makroekonomskih faktora. Kako bismo ustanovili robustnost

## Introduction

Lending represents the core business of commercial banks. In order to manage their placements as efficiently as possible, banks around the world are developing their own methods of assessing the creditworthiness of their borrowers. These internal models of banks differ according to the specificity of their credit portfolios and business segments that they cover, as well as to the level of sophistication in the use of statistical-based methods. Due to statistical reliability, internal models are usually developed on larger samples that include all historical data on loan repayments. Therefore, they generally give estimates of Probability of Default (PD) that involve the entire business cycle. These so-called Through-the-Cycle (TtC) PDs represent the "time-centered" values of the PD during the entire history that the bank uses to develop the model.

Starting from January 1, 2018, the International Financial Reporting Standard (IFRS) 9 applies. The Standard specifies how financial institutions should classify and measure financial instruments in their portfolios, and how to assess their impairment using the concept of expected credit loss. One of the essential differences of this standard in relation to, for example, Basel II and III standards used to assess capital adequacy, is that IFRS 9 requires the estimation of the probability of default for a specific time point. Point-in-Time (PiT) estimation of PD is necessary because the expected credit loss in IFRS 9 uses cash flow projections that can span a range of maturities, or even (for Stage 2 instruments) several years or decades. This requires that the *future* (conditional) probabilities of default be correctly predicted and that the effects of different macroeconomic scenarios are incorporated. PiT PD estimates are primarily based on calculating the effects of the business cycle and the ability to design forward-looking macroeconomic scenarios, and therefore imply the existence of a provable link between macroeconomic indicators and realized default rates. The basic issues to be addressed in the examination of this link are the quality of the data on which it is tested, the choice of the methodology for examining the

existence of a statistical association, as well as its economic interpretation and the possibility of forming meaningful scenarios.

The existence of a quantifiable and measurable relationship between macroeconomic indicators and realized default rates is a question that has been a subject of interest for researchers over the past decade, since the Global Financial Crisis. Simons & Rolwes (2008) developed a model of the relationship between macroeconomic factors and default rates for Dutch firms, and demonstrated a possible application of the model in stress tests. Bruche & González-Aguado (2010) proposed an econometric model in which simultaneous variations in default and recovery rates depend on the credit cycle. Altman *et al.* (2004) and Altman *et al.* (2005) were among the first to study the relationship between default rates and recovery rates. Bellotti & Crook (2009) developed a credit scoring model that applies macroeconomic variables and is based on survival analysis. Ali & Daly (2010) have empirically studied macroeconomic determinants of credit risk using panel data from several countries. Figlewski *et al.* (2012) modeled the effects of macroeconomic factors on default rates and credit migrations in the corporate sector.

In a slightly broader picture, it is important to take into account the exogenous credit risk determinants. Duffie *et al.* (2009) found that the likelihood of extreme losses in the event of default for large companies in the USA is significantly higher than the one obtained by assuming that the correlations depend only on observable risk factors. Hence, it is necessary to include other, latent factors. Fons (1991), in addition to many other authors, describes the techniques for forecasting defaults and other credit events.

In this paper, we analyze whether there is a link between macroeconomic indicators and realized default rates using the data gathered from banks operating in Serbia. In particular, a database on default rates of the Association of Serbian Banks (ASB) was used, combined with publicly available data that were used to construct macroeconomic factors. In order to determine the robustness of the tested relationships, several econometric techniques

ispitivanih veza, korišćeno je nekoliko ekonometrijskih tehnika: linearna regresija, autoregresioni proces, model sa korekcijom greške, pristup statičkih i dinamičkih panela, kao i dva Bayes-ova pristupa. U prvom delu rada detaljno su opisani korišćeni podaci i prikazane su njihove deskriptivne statistike. U drugom delu izložen je metodološki pristup. Treći deo rada sumira osnovne rezultate. Zaključna razmatranja data su u poslednjem, četvrtom delu rada.

## Podaci

U radu su korišćene dve grupe podataka: (1) podaci o stopama neizmirenja i (2) makroekonomski podaci. Za stope neizmirenja (engl. *Default Rate*, skraćeno DR) korišćeni su agregirani anonimizovani podaci Udruženja banaka Srbije o broju plasmana i iznosima u statusu neizmirenja. Granulacija ovih podataka išla je do nivoa tipa kredita i do podele na tri

neizmirenja prema ukupnim iznosima svih datih kredita. Ovakva definicija delimično otklanja problem pristrasnosti uzorka koji bi se ispoljio kod alternativne definicije zasnovane na broju plasmana. Naime, u takvim situacijama u uzorku bi postojao relativno veliki broj plasmana koji su u statusu neizmirenja, ali ne predstavljaju velike novčane iznose potraživanja, te samim tim čine relativno manji iznos ukupne bankarske aktive. Detaljniju diskusiju o upotrebi različitih definicija stope neizmirenja daje Fridson (1991).

Makroekonomski podaci koji su korišćeni u radu su takođe kvartalni i pokrivaju isti period kao i stope neizmirenja (od četvrtog kvartala 2012. do četvrtog kvartala 2018). Obuhvataju: stopu rasta bruto domaćeg proizvoda (BDP), računatu po principu godina-na-godinu; stopu nezaposlenosti; stopu inflacije, merenu indeksom potrošačkih cena; monetarni agregat M3, tj. novac u najširem smislu; kurs evra prema dinaru; referentnu stopu Narodne banke Srbije (NBS).

Tabela 1: Deskriptivne statistike

	Srednja vr.	St. dev.	Min	Max	ADF
DR (%)	4,07	2,07	1,21	7,67	-0,36
Rast BDP (%)	2,04	2,12	-4,02	4,90	-2,14
Inflacija (%)	3,15	3,16	0,33	12,18	-3,80*
Nezaposlenost (%)	17,63	3,90	11,80	25,00	-1,40
M3 ( $10^{12}$ RSD)	1,99	0,27	1,62	2,61	1,57
Kurs EUR	118,94	3,51	111,72	123,89	-1,61
Ref. stopa (%)	6,24	3,05	3,00	11,75	-1,48

Dužina serija: 2012 Q4 - 2018 Q4

Izvori: UBS, RZS, NBS

\* označava značajnost na nivou poverenja od 99%

grupe uporedivih banaka (prema ukupnim stopama neizmirenja). Anonimizacija se odnosi na činjenicu da zbog poverljivosti informacija autor nije raspolagao podacima do nivoa pojedinačnih banaka, niti delova njihovih portfolija. Podaci imaju kvartalnu frekvenciju i pokrivaju period od četvrtog kvartala 2012. do četvrtog kvartala 2018. (uključujući obe granice navedenog intervala).

Stope neizmirenja u ovom radu računate su kao količnik ukupnih iznosa u statusu

Podaci su javno dostupni u bazama podataka Republičkog zavoda za statistiku (RZS) i NBS.

Deskriptivne statistike za sve podatke prikazane su u Tabeli 1. Za svaku promenljivu (zavisnu i nezavisne) tabela sadrži srednje vrednosti, standardne devijacije, minimume, maksimume i vrednosti proširene Dickey-Fuller (ADF) test statistike. Na osnovu vrednosti ADF uočavamo da je jedina vremenska serija kod koje možemo odbaciti hipotezu postojanja nestacionarnosti jediničnog korena

were used: linear regression, autoregressive process, error correction model, static and dynamic panel-data models, and two Bayesian approaches. The first part of the paper describes in detail the data used and their descriptive statistics are presented. In the second part, methodological approach is presented. The third part summarizes the basic results. The final considerations are given in the last, fourth part of the paper.

## Data

We used two groups of data in this paper: (1) data on default rates and (2) macroeconomic data. The aggregated anonymous data from the Association of Serbian Banks on the number of placements and amounts in the status of default were used to calculate default rates (DR). These data were available on the loan-type level and were, in addition, divided into three groups of comparable banks (according to their total default rates). Anonymization refers to the fact

partially removes the problem of sample bias that would appear in an alternative definition based on the number of placements. Namely, in such situations, there would be a relatively large number of placements in the sample that are in the status of default, although they may not represent large amounts of receivables, and therefore make up a relatively small amount of total banking assets. A more detailed discussion of the use of different definitions of the default rate is given by Fridson (1991).

The macroeconomic data used in this paper are also quarterly and cover the same period as the default rates (from the fourth quarter of 2012 to the fourth quarter of 2018). They include: the growth rate of gross domestic product (GDP), calculated on a year-to-year basis; the unemployment rate; the inflation rate measured by the consumer price index; monetary aggregate M3, i.e. the broad money; the exchange rate of the euro (EUR) against the Serbian dinar (RSD); the benchmark rate of the National Bank of Serbia (NBS). The data

Table 1: Descriptive statistics

	Mean	St. Dev.	Min	Max	ADF
DR (%)	4.07	2.07	1.21	7.67	-0.36
GDP growth (%)	2.04	2.12	-4.02	4.90	-2.14
Inflation (%)	3.15	3.16	0.33	12.18	-3.80*
Unemployment (%)	17.63	3.90	11.80	25.00	-1.40
M3 ( $10^{12}$ RSD)	1.99	0.27	1.62	2.61	1.57
EUR/RSD exchange rate	118.94	3.51	111.72	123.89	-1.61
Benchmark rate (%)	6.24	3.05	3.00	11.75	-1.48

Length of the series: 2012 Q4 - 2018 Q4

Sources: ASB, RSO, NBS

\*significant at 99% confidence level.

that due to the confidentiality of information, the author did not have the data down to the level of individual banks, nor parts of their portfolios. The data have a quarterly frequency and cover the period from the fourth quarter of 2012 to the fourth quarter of 2018 (including the both boundaries of the specified interval).

The default rates in this paper were calculated as the ratio of total amounts in the default status to the total outstanding amounts of all the loans in the sample. This definition

are publicly available in the databases of the Republic Statistical Office (RSO) and the NBS.

Descriptive statistics for all data are shown in Table 1. For each variable (dependent and independent), the table contains their mean values, standard deviations, minima, maxima, and values of the Augmented Dickey-Fuller (ADF) test statistics. Based on the values of the ADF, we note that the only time series in which we can reject the null-hypothesis of the existence of a unit-root non-stationarity is the

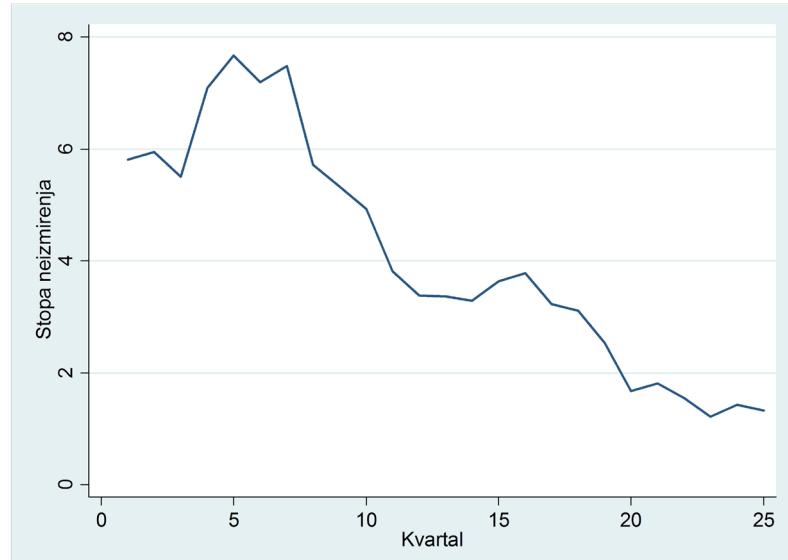
stopa inflacije. Sve ostale serije su, dakle, nestacionarne i ovu činjenicu moramo uzeti u obzir prilikom konstrukcije ekonometrijskih modela.

Ilustracija 1 prikazuje evoluciju agregatne stope neizmirenja (za sve banke i tipove proizvoda). Uočljiv je trend pada, sa maksimalne vrednosti od 7,67% u prvom kvartalu 2014. godine na minimalnu vrednost od 1,21% u drugom kvartalu 2018. godine. Istovremeno, uprkos relativno kratkoj seriji, donekle su uočljivi obrasci cikličnog ponašanja u stopama neizmirenja, pošto pad nije monoton.

Pregled stope neizmirenja po tipu proizvoda i grupama uporedivih banaka dat je u Tabeli 2. U prvoj koloni Tabele 2 pobrojani su tipovi proizvoda prema kategorizaciji iz baze UBS (kreditne kartice, gotovinski i potrošački krediti, krediti preduzetnicima, krediti velikim pravnim licima, krediti telima lokalne samouprave, stambeni krediti,

prekoračenja po tekućem računu, krediti poljoprivrednim gazdinstvima, mikro krediti, krediti malim i srednjim pravnim licima). Od

Ilustracija 1: Evolucija stope neizmirenja



Izvor: UBS

druge do četvrte kolone prikazane su stope neizmirenja po grupama uporedivih banaka, koje su grupisane prema stopi neizmirenja za sve tipove proizvoda zajedno (poslednji red u tabeli). Poslednja kolona u Tabeli 2 sadrži stope neizmirenja računate za sve banke u uzorku, po tipovima proizvoda.

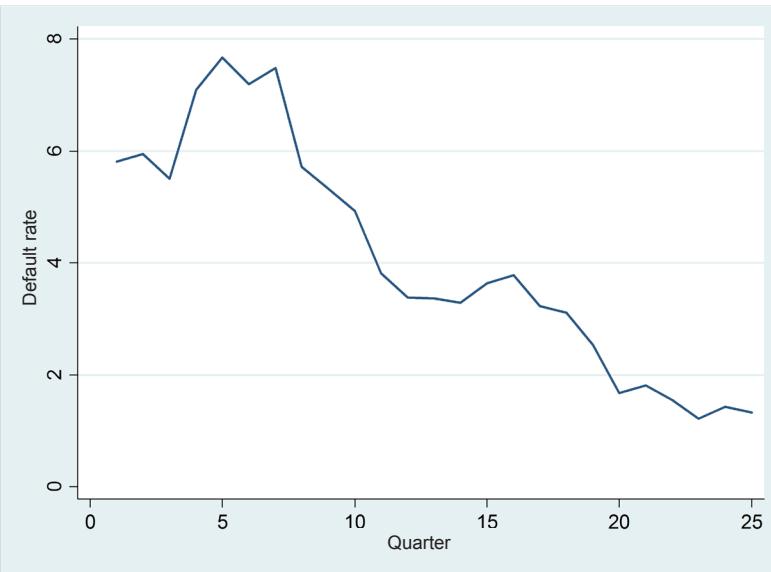
Tabela 2: Stope neizmirenja po tipu proizvoda i grupama uporedivih banaka

Tip	Grupa 1	Grupa 2	Grupa 3	Ukupno
Kreditne kartice	2,54	2,53	4,14	2,54
Gotovinski i potrošački krediti	3,03	2,72	2,26	2,93
Preduzetnici	4,01	2,90	2,38	3,39
Velika pravna lica	4,87	3,29	7,11	4,70
Lokalna samouprava	0,18	2,40	0,00	0,31
Stambeni krediti	1,42	3,13	1,23	1,89
Prekoračenja po tekućem računu	1,93	3,41	2,44	2,18
Poljoprivredna gazdinstva	3,11	1,75	1,48	2,13
Mikro krediti	8,00	8,85	9,97	8,46
Mala i srednja pravna lica	5,39	6,51	10,97	5,95
Ukupno	3,94	4,21	6,46	4,07

Izvor: UBS, RZS, NBS

inflation rate. All other series are therefore non-stationary and this fact must be taken into account when constructing econometric models.

Figure 1: Evolution of default rates



Source: ASB

Figure 1 shows the evolution of the aggregate default rate (for all banks and types of products). A downward trend is evident, from a maximum of 7.67% in the first quarter of 2014 to a minimum of 1.21% in the second quarter of 2018. At the same time, in spite of the relatively short series,

there are somewhat noticeable patterns of cyclical behavior in the default rates of failure, since the decline is not monotonous.

The overview of default rates by type of product and bank peer groups is given in Table 2. The first column of Table 2 lists the types of products according to the categorization from the ASB database (credit cards, cash and consumer loans, loans to entrepreneurs, loans to large corporate entities, loans to local governments and municipalities, mortgage loans, current account overdrafts, loans to agricultural holdings, micro loans, and loans to small and medium-sized enterprises). From the second to the fourth column, the default rates

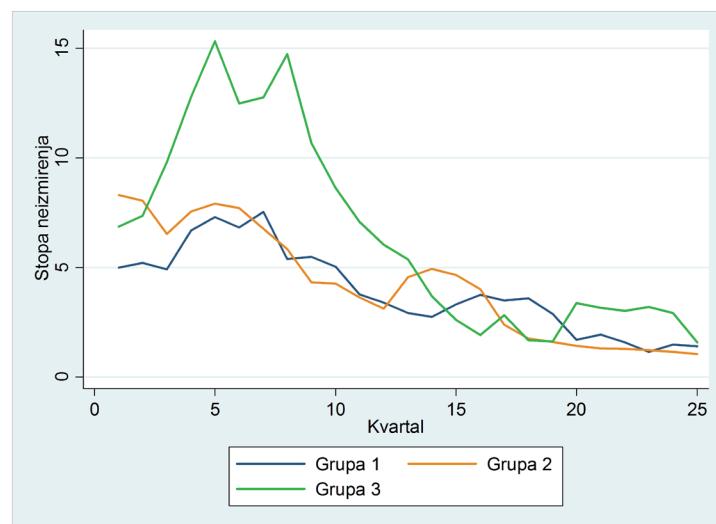
by bank peer groups are presented. They are grouped according to the default rate for all types of products combined (shown in the last line of the table). The last column in Table 2 contains default rates calculated for all banks in the sample, by product type.

Table 2: Default rates by product type and bank peer groups

Product type	Group 1	Group 2	Group 3	Total
Credit cards	2.54	2.53	4.14	2.54
Cash and consumer loans	3.03	2.72	2.26	2.93
Loans to entrepreneurs	4.01	2.90	2.38	3.39
Loans to large corporate entities	4.87	3.29	7.11	4.70
Loans to local governments	0.18	2.40	0.00	0.31
Mortgage loans	1.42	3.13	1.23	1.89
Overdrafts	1.93	3.41	2.44	2.18
Agricultural loans	3.11	1.75	1.48	2.13
Micro loans	8.00	8.85	9.97	8.46
Loans to SMEs	5.39	6.51	10.97	5.95
Total	3.94	4.21	6.46	4.07

Sources: ASB, RSO, NBS

Ilustracija 2: Evolucija stope neizmirenja po grupama uporedivih banaka



Izvor: UBS

Ilustracija 2 prikazuje evoluciju stope neizmirenja po grupama uporedivih banaka. Upadljivo se izdvaja treća grupa, u kojoj su banke sa najvišim prosečnim stopama neizmirenja. U ovoj grupi uočavamo porast u stopama neizmirenja, praćen padom, koji se vidi i na Ilustraciji 1 za sve banke zajedno. Prve dve grupe banaka imaju nešto manje izražen porast, tj. ispoljavaju monotoniji trend pada. Pažljivijom analizom Tabele 2 možemo bolje razumeti odakle potiče ovaj efekat - stope neizmirenja najizraženije su u segmentima pravnih lica i kod mikro kredita. Upravo su ovi segmenti dominirali ukupnim neizmirenjima tokom posmatranog perioda.

## Metodološki pristup

Vezu između ostvarenih stope neizmirenja i makroekonomskih pokazatelja možemo proveravati na više načina. „Naivni“ pristup, koji bi podrazumevao proveravanje korelacija stope neizmirenja i pojedinačnih makro pokazatelja, sporan je sa ekonometrijske strane zato što zanemaruje (trend-)nestacionarnost zavisne promenljive i nezavisnih faktora. Stoga ćemo analizu bazirati na regresijama stacionarnih promenljivih.

Kao što se vidi u Tabeli 1, sve promenljive osim stope inflacije su nestacionarne. ADF test nad prvim diferencama stope neizmirenja i makroekonomskih faktora pokazuje da se za ovako formirane promenljive hipoteza

nestacionarnosti može odbaciti na svim relevantnim nivoima značajnosti. Stoga je prvi logičan korak sprovođenje obične linearne regresije stacionarnih promenljivih:

$$\Delta DR_t = \beta_0 + \sum_{k=1}^K \beta_k \Delta X_{k,t} + \varepsilon_t$$

gde su  $X_{k,t}$  različiti makroekonomski pokazatelji. Kako je stopa neizmirenja ograničena na vrednosti između 0 i 1, alternativa koja uzima u obzir ovu cenzuru promenljive  $DR_t$  jeste upotreba logističke transformacije oblika:

$$y_t = \ln\left(\frac{DR_t}{1 - DR_t}\right).$$

Koristeći ovu transformaciju, moguće je zameniti prethodni model linearnom regresijom oblika:

$$\Delta y_t = \beta_0 + \sum_{k=1}^K \beta_k \Delta X_{k,t} + \varepsilon_t.$$

Ciklični efekti se mogu ispoljiti i kroz autoregresione članove. Stoga ćemo u metode uključiti i običan autoregresioni proces, AR( $M$ ):

$$\Delta DR_t = \alpha_0 + \sum_{j=1}^M \alpha_j \Delta DR_{t-j} + \varepsilon_t$$

Takođe, u običnu linearnu regresiju možemo dodati i docnje makro pokazatelja, i dobiti model oblika

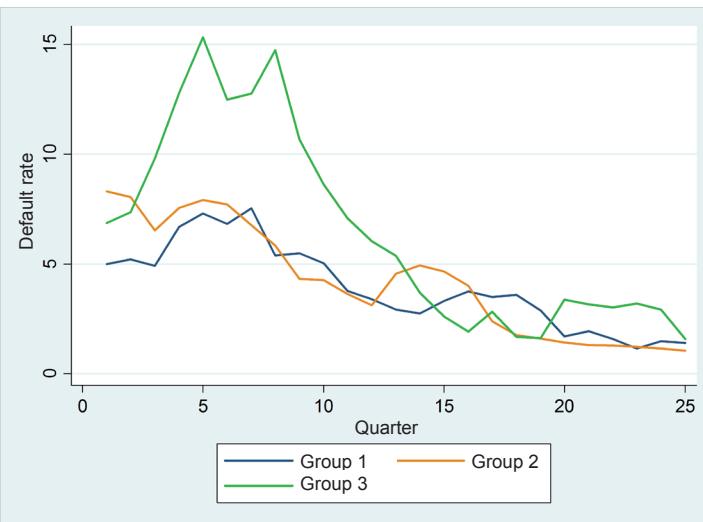
$$\Delta DR_t = \beta_0 + \sum_{j=0}^L \sum_{k=1}^K \beta_k \Delta X_{k,t-j} + \varepsilon_t$$

Kombinovanjem autoregresionog modela i modela sa docnjama makroekonomskih (ili u opštem slučaju, egzogenih) faktora dobijamo najpotpuniji model, AR( $M$ )-X( $L$ ):

$$\Delta DR_t = \sum_{j=1}^M \alpha_j \Delta DR_{t-j} + \sum_{j=0}^L \sum_{k=1}^K \beta_k \Delta X_{k,t-j} + \gamma u_{t-1} + \varepsilon_t$$

Kao alternativu običnim regresijama u jednom koraku, možemo primeniti i model sa korekcijom ravnotežne greške (engl. *Error Correction Model*, skraćeno ECM). U ovom modelu, dugoročna ravnotežna zavisnost opisana je jednačinom u nivoima stope

Figure 2: Evolution of default rates by bank peer groups



Source: ASB

Figure 2 shows the evolution of default rates by groups of comparable banks. A third group, where the banks with the highest average default rates are, is particularly striking. In this group, we notice an increase in default rates, followed by a decrease. The same decrease can be seen in Figure 1 for all banks together. The first two groups of banks have a slightly more gradual decrease, i.e. they exhibit a monotonous downward trend. A careful analysis of Table 2 helps us understand where this effect comes from – default rates are most evident in the segments of legal entities and in micro loans. It was these segments that dominated the aggregate defaults during the observed period.

## Methodology

We can test the existence of a relationship between the realized default rates and macroeconomic indicators in several ways. A “naïve” approach, which would involve calculating the correlation between default rates and the individual macro indicators, is controversial from the econometric point of view because it neglects the (trend-)non-stationarity of the dependent variable and independent factors. Therefore, we will base our analysis on the regression of stationary variables.

As we can see from Table 1, with the exception of the inflation rate all variables are non-stationary. The ADF test over the first

differences in default rates and macroeconomic factors shows that the null-hypothesis of non-stationarity can be rejected at all relevant levels of significance. Therefore, the first logical step is to implement an ordinary linear regression of stationary variables:

$$\Delta DR_t = \beta_0 + \sum_{k=1}^K \beta_k \Delta X_{k,t} + \varepsilon_t$$

where  $X_{k,t}$  are different macroeconomic factors. Since default rates are bounded between 0 and 1, an alternative that takes into account this censoring of the variable  $DR_t$  is to apply a logistic transformation

of the form:

$$y_t = \ln\left(\frac{DR_t}{1 - DR_t}\right).$$

Using this transformation, it is possible to substitute the previous model with a linear regression of the form:

$$\Delta y_t = \beta_0 + \sum_{k=1}^K \beta_k \Delta X_{k,t} + \varepsilon_t.$$

Cyclical effects can be captured through autoregressive terms as well. Hence, we will also include an ordinary autoregressive process, AR( $M$ ):

$$\Delta DR_t = \alpha_0 + \sum_{j=1}^M \alpha_j \Delta DR_{t-j} + \varepsilon_t$$

Similarly, we can include lags of macroeconomic factors in an ordinary linear regression, and obtain a model of the form:

$$\Delta DR_t = \beta_0 + \sum_{j=0}^L \sum_{k=1}^K \beta_k \Delta X_{k,t-j} + \varepsilon_t$$

By combining an autoregressive model and a model with lags in macroeconomic (or, more generally, exogenous) factors, we obtain the most complete model, AR( $M$ )-X( $L$ ):

$$\Delta DR_t = \sum_{j=1}^M \alpha_j \Delta DR_{t-j} + \sum_{j=0}^L \sum_{k=1}^K \beta_k \Delta X_{k,t-j} + \gamma u_{t-1} + \varepsilon_t$$

As an alternative to ordinary one-step regressions, we can apply an error correction model (ECM). In this model, a long-term

neizmirenja i makroekonomskih faktora:

$$DR_t = b_0 + \sum_{k=1}^K b_k X_{k,t} + u_t,$$

dok kratkoročna zavisnost sledi jednačinu:

$$\Delta DR_t = \sum_{j=1}^M \alpha_j \Delta DR_{t-j} + \sum_{j=0}^L \sum_{k=1}^K \beta_k \Delta X_{k,t-j} + \gamma u_{t-1} + \varepsilon_t$$

gde bi statistički značajan koeficijent  $\gamma$  uz prvu docnju reziduala iz dugoročne ravnotežne regresije implicirao postojanje dugoročne (kointegrirajuće) veze stopa neizmirenja i makro pokazatelja. Označićemo opšti model sa ECM( $M, L$ ).

Pored navedenih klasičnih pristupa, primenićemo i Bayesovo usrednjavanje po modelima (engl. *Bayesian Model Averaging*, skraćeno BMA). Ovaj metod, opisan recimo u radu Magnus *et al.* (2010), koristi usrednjavanje rezultata ocene klasičnih regresionih modela. Kao rezultat daje uprosečenu (u Bayesovom smislu) ocenu beta koeficijenata u regresiji i odgovarajuće *a posteriori* verovatoće uključivanja u model. U sličnoj familiji metoda nalazi se i stepenasti (*stepwise*) metod, koji je zasnovan na postepenom uključivanju ili isključivanju objašnjavajućih promenljivih u model na osnovu  $p$ -vrednosti dobijene u regresijama. Potrebno je definisati prag za uključivanje (ukoliko se krene od minimalnog modela) ili isključivanje (ukoliko se krene od maksimalnog modela).

U uzorku koji sadrži podelu po tipu proizvoda moguće je primeniti i pristup (dinamičkih) panela. Opšti izraz za regresionu jednačinu u ovom pristupu je:

$$\Delta DR_{i,t} = \alpha_{i,0} + \sum_{j=1}^M \alpha_{i,j} \Delta DR_{i,t-j} + \sum_{k=1}^K \beta_k \Delta X_{k,t} + \sum_{l=1}^{L-1} \gamma_{i,l} D_{i,l} + \varepsilon_{i,t}$$

gde su  $X_{k,t}$  različiti makroekonomski pokazatelji a  $D_{i,l}$  veštačke promenljive (*dummies*) za svaki tip proizvoda  $i$  u trenutku  $t$ . Koristićemo nekoliko metoda ocene: agregirani (engl. *pooled*) panel, regresiju sa fiksnim efektima, regresiju sa slučajnim efektima, kao i autoregresivni model raspoređenih docnji (engl. *Autoregressive Distributed Lags*, skraćeno ARDL) u dinamičkom panelu.

## Rezultati

U ovom delu sumiraćemo najznačajnije rezultate u radu. Obična linearna regresija stacionarnih promenljivih i linearna regresija sa logističkom transformacijom nemaju značajnih faktora. Zbog relativno male dužine vremenskih serija, autoregresioni proces je ocenjen zaključno sa četvrtim redom, AR(4), što odgovara pretpostavci da je dovoljno uzeti poslednja četiri kvartala podataka o stopi neizmirenja kako bi se autoregresionim mehanizmom objasnile buduće stope neizmirenja. Ovaj proces daje statistički značajan koeficijent samo uz četvrti red docnje,  $\Delta DR_{t-4}$ . Koeficijent je negativan, što bi značilo da bi, recimo, porast u stopi neizmirenja koji se dogodio pre četiri kvartala najverovatnije doveo do pada stope neizmirenja danas. Za linearu regresiju sa docnjama makro pokazatelja takođe su korišćena poslednja četiri kvartala, tj. koristi se najviše četiri reda docnje egzogenih promenljivih. U takvom modelu, X(4), jedini statistički značajan faktor je prva docnja stopa inflacije, koja ima pozitivan znak regresionog koeficijenta. Ovo možemo interpretirati na jednostavan način - porast u stopi inflacije odslikava se na porast u stopi neizmirenja jedan kvartal kasnije. Međutim, stopa inflacije prestaje da bude značajan faktor ako se koristi definicija  $DR_t$  po broju plasmana u statusu neizmirenja. Ovo je čini nedovoljno robustnim prediktorom budućih neizmirenja, bar u modelu X(4). Kombinovani model, AR(4)-X(4), daje kvalitativno isti rezultat kao AR(4): statistički značajan koeficijent dobija se samo uz četvrti red docnje,  $\Delta DR_{t-4}$ .

Za prethodno navedene modele zbog preglednostinećemodavatičsplicitnevrednosti ocenjenih koeficijenata niti odgovarajuće test statistike, već ćemo se usredsrediti na ostale modele kod kojih se dobija veća objašnjavajuća moć faktora. Jedan takav model je ECM(4,1), kod koga se kao statistički značajni faktori na nivou poverenja od 95 procenata pojavljuju prva, treća i četvrta docnja stope neizmirenja,  $\Delta DR_{t-1}$ ,  $\Delta DR_{t-3}$  i  $\Delta DR_{t-4}$ , zatim prva docnja stope rasta BDP, agregat M3 i njegova prva docnja, referentna stopa NBS i njena prva docnja, kao i stopa inflacije. Stopa nezaposlenosti je značajna samo na nivou poverenja od 90 procenata. Ovi rezultati sumirani su u Tabeli 3. Koeficijenti uz

equilibrium relationship is described by an equation that uses levels of default rates and macroeconomic factors:

$$DR_t = b_0 + \sum_{k=1}^K b_k X_{k,t} + u_t,$$

while the short-term dependence satisfies the equation:

$$\Delta DR_t = \sum_{j=1}^M \alpha_j \Delta DR_{t-j} + \sum_{j=0}^L \sum_{k=1}^K \beta_k \Delta X_{k,t-j} + \gamma u_{t-1} + \varepsilon_t$$

where a statistically significant coefficient  $\gamma$  associated with the first lag of the residual from the long-term equilibrium regression would imply the existence of a long-term (cointegrating) relationship of default rates and macroeconomic factors. We will denote the general model by ECM( $M, L$ ).

In addition to the above conventional approaches, we will also apply Bayesian Model Averaging (BMA). This method, described for example in Magnus *et al.* (2010) applies averaging of estimation results of the classical regression models. The result is the averaged (in a Bayesian sense) estimate of the beta coefficients in regression and the corresponding *a posteriori* probability of inclusion into the model. In a similar family of methods, there is a stepwise method, which is based on the gradual inclusion or exclusion of explanatory variables in the model based on the  $p$ -values obtained in the regression. It is necessary to define an inclusion threshold (if it starts from the minimum model) or an exclusion threshold (if it starts from the maximum model).

In the sample split by the type of product we can apply the approach of (dynamic) panel-data models. The general expression for a regression equation in this approach is:

$$\Delta DR_{i,t} = \alpha_{i,0} + \sum_{j=1}^M \alpha_{i,j} \Delta DR_{i,t-j} + \sum_{k=1}^K \beta_k \Delta X_{k,t} + \sum_{l=1}^{L-1} \gamma_{i,l} D_{i,l} + \varepsilon_{i,t}$$

where  $X_{k,t}$  are different macroeconomic indicators and  $D_{i,l}$  are dummies associated with every type of product  $i$  and every moment  $t$ . We will use several estimation methods: pooled panel, fixed-effect regression, random-effect regression, and autoregressive Distributed Lags (ARDL) in the dynamic panel.

## Results

In this section we summarize the most important results obtained in this research. Simple linear regression with stationary variables and linear regression with a logistic transformation have no significant factors. Due to the relatively short length of the time series, we ran the autoregression process up to the fourth lag, AR (4). This corresponds to the assumption that it is sufficient to take the last four quarters of the data on default rate in order to explain the future default rates by the autoregressive mechanism. The AR(4) process gives a statistically significant coefficient only for the fourth lag,  $\Delta DR_{t-4}$ . The coefficient is negative, which implies that, for example, an increase in the default rate that occurred four quarters ago would most likely lead to a fall in the default rate today. For linear regression with macro indicators, the last four quarters were used, i.e. up to four lags of exogenous variables. In such a model, X(4), the only statistically significant factor is the first lag of the inflation rate, which has a positive sign of the regression coefficient. This can be interpreted in a simple way – an increase in the inflation rate leads to an increase in default rate one quarter later. However, the inflation rate ceases to be a significant factor if the definition of  $DR_t$  based on the number of placements in the default status is used. This makes it an insufficiently robust predictor of future failures, at least in the X(4) model. The combined model, AR(4)-X(4), gives qualitatively the same result as AR(4): statistically significant coefficient is obtained only at the fourth lag,  $\Delta DR_{t-4}$ .

For the above mentioned models, we will not give explicit values of the estimated coefficients or the corresponding test statistics for the sake of tractability. Instead, we will focus on other models where a greater explanatory power of the factors is obtained. One such model is the ECM (4,1), where the first, third and fourth lag of the default rate,  $\Delta DR_{t-1}$ ,  $\Delta DR_{t-3}$  and  $\Delta DR_{t-4}$ , appear as statistically significant factors at the confidence level of 95 percent, along with the first lag of GDP growth rate, M3 aggregate and its first lag, the NBS reference rate and its first lag, as well as the inflation rate. Unemployment rate is significant only at the 90-percent

Tabela 3: Rezultati za ECM(4,1)

$\Delta DR_t$	Koeficijent	St. greška	p-vrednost
$\Delta DR_{t-1}$	0,4618	0,0386	0,000
$\Delta DR_{t-2}$	0,0554	0,0341	0,104
$\Delta DR_{t-3}$	0,3990	0,0285	0,000
$\Delta DR_{t-4}$	-0,1248	0,0535	0,020
Stopa rasta BDP <sub>t</sub>	0,0519	0,0308	0,093
Stopa rasta BDP <sub>t-1</sub>	-0,1210	0,0322	0,000
Stopa nezaposlenosti	0,0199	0,0108	0,065
M3 <sub>t</sub>	-1,2146	0,5157	0,019
M3 <sub>t-1</sub>	1,9567	0,6647	0,003
Kurs EUR	0,0133	0,0134	0,325
Referentna stopa,	0,2889	0,0637	0,000
Referentna stopa <sub>t-1</sub>	-0,2060	0,0642	0,001
Stopa inflacije	0,1265	0,0359	0,000
$u_{t-1}$	-1,1688	0,1180	0,000

Izvor: Sopstveni proračuni autora

statistički značajne makroekonomskе faktore imaju ekonomski intuitivan znak. Konkretno, prva docnja stope rasta BDP ima negativan znak, što ukazuje da se pad privredne aktivnosti reflektuje na porast u statusima neizmirenja jedan kvartal kasnije. Slično, porast stope nezaposlenosti dovodi do porasta u stopi neizmirenja, što vidimo iz pozitivnog predznaka ovog faktora koji nam ukazuje na pad otplatne sposobnosti dužnika. Uvećanje monetarnog agregata M3 povećava raspoloživost izvora finansiranja, što sa druge strane dovodi (barem inicijalno) do alociranja tih sredstava na nove plasmane, potencijalno na efikasniji način nego što je to bio slučaj sa prethodnim. Stoga vidimo kombinovani efekat naizmeničnog uvećanja pa umanjenja stope neizmirenja. Konačno, referentna stopa NBS ima pozitivan predznak, što se može interpretirati kao direkstan efekat uvećanja prosečnih kamatnih stopa, tj. troškova servisiranja kredita. Negativan predznak docnje referentne

stope bi mogao biti interpretiran cikličnošću. Stopa inflacije ima pozitivan predznak, što ukazuje da inflacija utiče nepovoljno na otplatnu sposobnost dužnika. Konačno, možemo uočiti da je znak uz koeficijent  $\gamma$  uz prvu docnju reziduala iz dugoročne ravnotežne regresije statistički značajan i negativan, što nam ukazuje da dugoročna ravnotežna zavisnost postoji. Kao značajni kointegrišući faktori dobijaju se stopa rasta BDP, stopa inflacije i M3 agregat. Koeficijent determinacije u ovom modelu je veoma visok i iznosi 0,987, što ukazuje da značajni makroekonomski faktori, u kombinaciji sa docnjama u stopi neizmirenja, mogu objasniti skoro 99 procenata varijacija u  $DR_t$ . Hikvadrat test statistika je visoko značajna.

U pristupu Bayesovog usrednjavanja po modelima (BMA) primenili smo usrednjavanje klasičnih ocena beta koeficijenata za 1024 modela koji kombinuju faktore zaključno sa četvrtim redom docnje. U Tabeli 4 sumirani su faktori čija je *a posteriori* verovatnoća uključivanja u model veća od 0,5. Uočavamo

Tabela 4: Rezultati za BMA

	Koeficijent	St. greška	PIP
Konstanta	-0,0742	0,2153	1,00
$\Delta DR_{t-4}$	-0,7207	0,1058	1,00
Referentna stopa	0,6421	0,1946	0,97
Stopa rasta BDP	-0,1522	0,0888	0,85
$\Delta DR_{t-2}$	-0,2525	0,2218	0,65
Stopa inflacije	-0,1233	0,1163	0,62

Izvor: Sopstveni proračuni autora

da su najrobustniji prediktori promena u stopi neizmirenja njena četvrta docnja (sa negativnim predznakom), referentna stopa NBS (sa pozitivnim predznakom) i stopa rasta BDP (sa negativnim predznakom). Kvalitativno isti rezultati se dobijaju i primenom *stepwise* metoda,

confidence level. These results are summarized in Table 3. Coefficients with statistically significant macroeconomic factors have an economically intuitive sign. In particular, the first lag in the growth rate of GDP has a negative sign, which indicates that the decline in economic activity is reflected in the increase in loan defaults a quarter later. Similarly, an increase in the unemployment rate leads to an increase in default rates. This can be seen from the positive sign of this factor, which points to the decline in the repayment ability of the borrower. Increasing the monetary aggregate M3 increases the availability of funding sources, which on the other hand leads (at least initially) to the allocation of these funds to new placements, potentially in a more efficient way than it was the case prior to the increase. Therefore, we see the combined effect of alternating increase and decrease of default rate. Finally, the NBS reference rate has a positive sign, which can be interpreted as the direct effect of increasing the average interest rates, i.e. loan servicing costs. A negative sign of the lag in the reference rate could be interpreted by cyclical. The inflation rate has a positive sign, which indicates that inflation affects unfavorably the debtor's

Table 3: Results for ECM(4,1)

$\Delta DR_t$	Coefficient	St. error	p-value
$\Delta DR_{t-1}$	0.4618	0.0386	0.000
$\Delta DR_{t-2}$	0.0554	0.0341	0.104
$\Delta DR_{t-3}$	0.3990	0.0285	0.000
$\Delta DR_{t-4}$	-0.1248	0.0535	0.020
Growth rate of $GDP_t$	0.0519	0.0308	0.093
Growth rate of $GDP_{t-1}$	-0.1210	0.0322	0.000
Unemployment rate	0.0199	0.0108	0.065
$M3_t$	-1.2146	0.5157	0.019
$M3_{t-1}$	1.9567	0.6647	0.003
EUR/RSD exchange rate	0.0133	0.0134	0.325
Reference rate <sub>t</sub>	0.2889	0.0637	0.000
Reference rate <sub>t-1</sub>	-0.2060	0.0642	0.001
Inflation rate	0.1265	0.0359	0.000
$u_{t-1}$	-1.1688	0.1180	0.000

Source: Author's own calculations

equilibrium regression, is statistically significant and negative. This indicates that the long-term equilibrium dependence exists. As significant co-integrating factors, we obtain the GDP growth rate, inflation rate and M3 aggregate. The coefficient of determination in this model is very high and amounts to 0.987, indicating that significant macroeconomic factors, combined with the lags of default rate, can account for almost 99 percent of variations in  $DR_t$ . Chi-square test statistics is highly significant.

In the Bayesian Model Averaging (BMA) approach, we applied the averaging of classical beta estimates for 1024 models that combine factors up to their fourth lag. Table 4 summarizes the factors with *a posteriori* inclusion probability greater than 0.5. We notice that the most robust predictors of changes in default rates are its fourth lag (with a negative sign), the NBS reference rate (with a positive sign) and GDP growth rate (with a negative sign). Qualitatively the same results are obtained with the stepwise method, using

Table 4: Results for BMA

	Coefficient	St. error	PIP
Constant	-0.0742	0.2153	1.00
$\Delta DR_{t-4}$	-0.7207	0.1058	1.00
Reference rate	0.6421	0.1946	0.97
GDP growth rate	-0.1522	0.0888	0.85
$\Delta DR_{t-2}$	-0.2525	0.2218	0.65
Inflation rate	-0.1233	0.1163	0.62

Source: Author's own calculations

repayment ability. Finally, we can notice that the sign of the coefficient  $\gamma$ , associated with the first lag of the residual from the long-term

positive sign) and GDP growth rate (with a negative sign). Qualitatively the same results are obtained with the stepwise method, using

Tabela 5: Rezultati za Stepwise metod

	Koeficijent	St. greška	p-vrednost
Konstanta	-0,2836	0,0810	0,003
$\Delta DR_{t-4}$	-0,6869	0,0950	0,000
Referentna stopa	0,5044	0,1573	0,006
Stopa rasta BDP	-0,1046	0,0439	0,031

Izvor: Sopstveni proračuni autora

u pristupu koji je zasnovan na dodavanju faktora čija je *p*-vrednost ispod 0,10 (Tabela 5). Navedena tri faktora objašnjavaju preko 80 procenata varijacija u promenama stope neizmirenja.

Panel regresije, zasnovane na uključivanju dodatne dimenzije koju podrazumeva tip proizvoda, daju manje ubedljive rezultate. Konkretno, agregirani (*pooled*) panel kao značajne faktore daje samo monetarni agregat M3 i veštačku promenljivu asociranu sa kreditima malim i srednjim preduzećima. Koeficijent determinacije je znatno manji nego u regresijama nad ukupnim podacima i iznosi 0,112. Regresija sa fiksним efektima pored M3 kao značajne faktore daje i prvu i četvrту docnju promene stope neizmirenja,  $\Delta DR_{t-1}$  i  $\Delta DR_{t-4}$  (uz  $R^2 = 0,110$ ), dok regresija sa slučajnim efektima uključuje još i veštačku promenljivu asociranu sa kreditima malim i srednjim preduzećima ( $R^2 = 0,227$ ). Autoregresivni model raspoređenih docnji (ARDL) daje slične rezultate, s tim da umesto  $\Delta DR_{t-4}$  figuriše  $\Delta DR_{t-3}$ . Međutim, ovaj model je od malog praktičnog značaja pošto pokazuje da dugoročna zavisnost *ne* postoji. Na osnovu prethodno navedenog, nećemo detaljno prikazivati rezultate za panel regresije

Tabela 7: Rezultati Stepwise sa panelima

	Koeficijent	St. greška	p-vrednost
Konstanta	-0,2414	0,0730	0,001
$\Delta DR_{t-1}$	-0,1376	0,0648	0,035
$\Delta DR_{t-4}$	-0,2413	0,0544	0,000
M3	2,8973	1,2214	0,019
MSP	-0,7545	0,1405	0,000

Izvor: Sopstveni proračuni autora

u klasičnim pristupima.

U Bayesovom pristupu, BMA sa panelima koristi usrednjavanje po 2048 modela. U Tabeli 6 sumirani su faktori čija je *a posteriori* verovatnoća uključivanja u model veća od 0,5. Uočavamo da su najrobustniji prediktori promena u stopi neizmirenja njena četvrta docnja (sa negativnim predznakom), veštačka promenljiva koja odgovara kreditima malim i srednjim preduzećima (sa negativnim predznakom) i M3 (u srednjem, sa statistički neznačajnim predznakom). Slični rezultati

Tabela 6: Rezultati BMA sa panelima

	Koeficijent	St. greška	PIP
Konstanta	-1,1855	0,1072	1,00
$\Delta DR_{t-4}$	-0,2390	0,0558	1,00
MSP	-0,6929	0,1479	1,00
M3	1,6357	1,7521	0,55

Izvor: Sopstveni proračuni autora

se dobijaju i primenom *stepwise* metoda, u pristupu koji je zasnovan na dodavanju faktora čija je *p*-vrednost ispod 0,10 (Tabela 7), s tim da je ovde značajna i prva docnja promene stope neizmirenja. Ovi faktori, međutim, objašnjavaju ispod 20 procenata varijacija u promenama stope neizmirenja.

## Zaključna razmatranja

U ovom radu analizirali smo da li postoji veza između stopa neizmirenja i makroekonomskih faktora koristeći bazu podataka o neizmirenjima Udruženja banaka Srbije. Primljeno je nekoliko različitih pristupa za proveru postojanja ove veze. Za podatke koji odgovaraju čitavom uzorku banaka u Srbiji regresije u jednom koraku ne daju (robustne) veze stopa neizmirenja i makroekonomskih faktora. Model sa korekcijom greške pokazuje najbolje performanse i daje faktore prihvatljive ekonomske intuicije. Docnje u promenama stope neizmirenja, referentna stopa NBS i stopa rasta BDP se čine najrobustnijim prediktorima budućih stopa neizmirenja.

the approach based on progressively adding factors with a *p*-value less than 0.10 (Table 5). The former three factors explain over 80 percent of variations in the first difference of the default rate.

Panel regressions, based on the inclusion of the type of product as an additional dimension, give less convincing results. In particular, the pooled panel only yields the monetary aggregate M3 and a dummy variable associated with loans to small and medium-sized enterprises (SME) as significant factors. The determination coefficient is significantly lower than in the regressions over the total data and is equal to 0.112. Fixed-effects model, in addition to M3, also gives the first and

Table 5: Results for Stepwise method

	Coefficient	St. error	<i>p</i> -value
Constant	-0.2836	0.0810	0.003
$\Delta DR_{t-4}$	-0.6869	0.0950	0.000
Reference rate	0.5044	0.1573	0.006
GDP growth rate	-0.1046	0.0439	0.031

Source: Author's own calculations

Table 6: Results for BMA with panel data

	Coefficient	St. error	PIP
Constant	-1.1855	0.1072	1.00
$\Delta DR_{t-4}$	-0.2390	0.0558	1.00
SME dummy	-0.6929	0.1479	1.00
M3	1.6357	1.7521	0.55

Source: Author's own calculations

fourth lag of the difference in the default rate as significant factors,  $\Delta DR_{t-1}$  and  $\Delta DR_{t-4}$  (with  $R^2 = 0.110$ ). Random-effects model includes the SME dummy as an additional significant variable ( $R^2 = 0.227$ ). The ARDL model provides similar results, with  $\Delta DR_{t-3}$  instead of  $\Delta DR_{t-4}$  as a significant variable. However, this model is of little practical significance as it shows that long-term dependence does not exist. Hence, we will not display detailed results for panel regressions under classical approaches.

Table 7: Results for Stepwise method with panel data

	Coefficient	St. error	<i>p</i> -value
Constant	-0.2414	0.0730	0.001
$\Delta DR_{t-1}$	-0.1376	0.0648	0.035
$\Delta DR_{t-4}$	-0.2413	0.0544	0.000
M3	2.8973	1.2214	0.019
SME dummy	-0.7545	0.1405	0.000

Source: Author's own calculations

In the Bayesian approach, BMA with panel data applies an averaging over 2048 models. Table 6 summarizes factors with *a posteriori* inclusion probability greater than 0.5. We see that the most robust predictors of the first difference of the default rate are its fourth lag (with a negative sign), the SME dummy (with a negative sign) and M3 (with an insignificant sign of the average beta coefficient). Similar results are obtained with the stepwise method, using the approach based on progressively adding factors with a *p*-value less than 0.10 (Table 7). The significant factors, however, explain less than 20 percent of variations in the first difference of the default rate.

## Concluding Remarks

In this paper, we have analyzed whether there is a link between default rates and macroeconomic factors using the database on loan defaults of the Association of Serbian Banks. We applied several approaches to examine the existence of this link. For data that corresponds to a whole sample of banks in Serbia, one-step regressions did not give any (robust) relationships between default rates and macroeconomic factors. The error correction model shows the best performance and gives factors of acceptable economic intuition. Lags of the first differences of default rates, the NBS reference rate and the growth rate of GDP are the most robust predictors of future default rates.

We used panel regressions for data separated by the type of product. Differences in default rates are mostly explained by their own lags and the

Za podatke po tipu proizvoda koristili smo panel regresije. Promene u stopama neizmirenja uglavnom su objašnjene sopstvenim docnjama i monetarnim agregatom M3. Veliki deo pada u stopama neizmirenja zapravo ne potiče od poslovnog ciklusa, već se može objasniti idiosinkratikom segmenta malih i srednjih preduzeća. Niski koeficijenti determinacije, tj. mali procenat objašnjениh varijacija, potiču od objašnjavajućih promenljivih - nedostaju dodatni faktori specifični za segmente koji bi, uz veštačke promenljive, doprineli većoj objašnjavajućoj i/ili prediktivnoj moći modela.

Dobijeni rezultati su možda nedovoljno robustni i konkluzivni. Jedno moguće objašnjenje za to je da su tokom posmatranog perioda bili evidentni ciklusi u makroekonomskim faktorima, ali ne nužno i

ciklusi u stopama neizmirenja. Drugim rečima, stope neizmirenja još nemaju dovoljno istorije da bi napravile „pun krug“, kao što je to slučaj na nekim finansijski razvijenijim tržištima. Asinhronost i razlika u periodima ciklusa predstavljaju veliki izazov za ovakve modele, što važi i načelno, a ne samo za podatke koji se odnose na Srbiju ili region jugoistočne Evrope. Za kreiranje pouzdanog modela veze stopa neizmirenja i makroekonomskih faktora u Srbiji bilo bi poželjno i da postoje podaci nižeg nivoa agregacije koji bi sadržali varijacije po segmentima, kako bi paneli imali više stepeni slobode. Alternativni pravac budućih istraživanja na ovu temu bi mogao da korisiti i panel podatke sakupljene za više uporedivih zemalja, recimo uz formiranje regionalne baze podataka o statusu neizmirenja.

## Literatura / References

- Ali, A. & Daly, K. (2010). Macroeconomic determinants of credit risk: Recent evidence from a cross country study. *International Review of Financial Analysis*, 19(3), 165–171. <https://doi.org/10.1016/j.irfa.2010.03.001>
- Altman, E.I., Brady, B., Resti, A. & Sironi, A. (2005). The Link between Default and Recovery Rates: Theory, Empirical Evidence, and Implications. *Journal of Business*, 78(6), 2203–2228. DOI: 10.1086/497044 <https://www.jstor.org/stable/10.1086/497044>
- Altman, E.I., Resti, A. & Sironi, A. (2004). Default Recovery Rates in Credit Risk Modelling: A Review of the Literature and Empirical Evidence. *Economic Notes*, 33(2), 183–208.
- Bellotti, T. & Crook, J. (2009). Credit scoring with macroeconomic variables using survival analysis. *Journal of the Operational Research Society*, 60(12), 1699–1707. DOI: 10.1057/jors.2008.130
- Bruche, M. & González-Aguado, C. (2010). Recovery rates, default probabilities, and the credit cycle. *Journal of Banking and Finance*, 34(4), 754–764. <http://doi.org/10.1016/j.jbankfin.2009.04.009>

monetary aggregate M3. A large part of the decline in default rates does not actually arise from the business cycle, but can be explained by the idiosyncrasies related to small and medium-sized enterprises. Low determination coefficients, i.e. a small percentage of the explained variations, can be attributed to the explanatory variables – there are no additional factors specific to segments that could, along with the dummy variables, contribute to the greater explanatory and/or predictive power of the model.

The obtained results are perhaps not sufficiently robust and conclusive. One possible explanation for this claim is that in the observed period there were evident cycles in macroeconomic factors, but not necessarily cycles

in default rates. In other words, the default rates still do not have enough history to make a “full circle”, as is the case in some of the financially more developed markets. Asynchrony and difference in cycle periods are a major challenge for such models. This holds in general, and not only for Serbia or the region of South East Europe. In order to create a reliable model for the link between default rates and macroeconomic factors in Serbia, it would be desirable that there are data on a lower level of aggregation that would contain segment variations in order for the panels to have more degrees of freedom. An alternative avenue of future research on this topic could also use panel data for several comparable countries, for example, by creating a regional database on loan defaults.

6. Duffie, D., Eckner, A., Horel, G. & Saita, L. (2009). Frailty Correlated Default. *Journal of Finance*, 64(5), 2089–2123.  
<https://doi.org/10.1111/j.1540-6261.2009.01495.x>
7. Figlewski, S. Frydman, H. & Liang, W. (2012). Modeling the effect of macroeconomic factors on corporate default and credit rating transitions. *International Review of Economics and Finance*, 21(1), 87–105.  
<https://doi.org/10.1016/j.iref.2011.05.004>
8. Fons, J. S. (1991). An Approach to Forecasting Default Rates. Moody's Special Report, August
9. Fridson, M. (1991). Everything You Ever Wanted to Know about Default Rates. Extra Credit, Merrill Lynch High Yield Strategy, July/August: 4-14.
10. Magnus, J. R., Powell, O. & Prüfer, P. (2010). A comparison of two model averaging techniques with an application to growth empirics. *Journal of Econometrics*, 154(2), 139–153.  
<https://EconPapers.repec.org/RePEc:eee:econom:v:154:y:2010:i:2:p:139-153>
11. Simons, D. & Rolwes, F. (2008). Macroeconomic Default Modeling and Stress Testing. Working paper, De Nederlandsche Bank.  
<https://www.semanticscholar.org/paper/Macroeconomic-Default-Modeling-and-Stress-Testing-Simons-Rolwes/5db01c384d451c91f5224c50731ceedb0b29821e>