MJERENJE RIZIKA KREDITNOG PORTFOLIJA

MEASUREMENT OF LOAN PORTFOLIO RISK

Doc. dr Slobodan Subotić*

*Univerzitet u Istočnom Sarajevu, Saobraćajni fakultet Doboj

University of East Sarajevo, Faculty of Transport and Traffic Engineering Doboj

REZIME

Razlozi lošeg poslovanja neke banke mogu biti mnogobrojni. Ključni razlog ozbiljnih problema nalazi se u loše postavljenim kreditnim standardima pri ocjeni kreditne sposobnosti budućih dužnika, lošem upravljanju kreditnim portfolijom, kao i drugim okolnostima koje dovode do pogoršanja kreditnog rejtinga komitenta. Dakle, ključni razlog lošeg poslovanja banke jeste loše upravljanje kreditnim rizikom. Cilj upravljanja kreditnim rizikom jeste maksimiziranje rizikom korigovane stope prinosa na kapital, a da pri tome izloženost kreditnom riziku ostane u prihvatljivim granicama. Sredinom 90-ih godina prošlog vijeka komercijalne i investicione banke počinju primjenjivati VaR metodologiju za mjerenje kreditnog rizika. U radu su u kratkim crtama objašnjeni VaR koncept i VaR modeli koji se primjenjuju pri mjerenju (kvantifikovanju) rizika kreditnog portfolija. Posebna pažnja je posvećena CreditMetrics modelu, ukazano je na njegove osnovne karakteristike, te na konkretnom primjeru prezentiran i objašnjen način vrednovanja kreditnog portfolija primjenom ovog modela.

Ključne riječi: rizik kreditnog portfolija, *VaR* koncept, *CaR* koncept, *CreditMetrics* model, tranziciona matrica.

SUMMARY

The reasons for a bank's performance may be various. The key reason of serious problems lies in poorly set credit standards related to the assessment of future debtors' credit rating, poor loan portfolio management, as well as other circumstances leading to the deterioration of the customer's credit rating. Therefore, the key reason for poor performance of a bank is its poor risk management. The goal of credit risk management is to maximize risk-adjusted return on capital, while simultaneously maintaining the exposure to credit risk within acceptable limits. In the mid 90s of the 20th century, commercial and investment banks began to implement VaR methodology in order to measure credit risk. This paper briefly explains the VaR concept and VaR models applied in the measurement (quantification) of loan portfolio risk. Special attention was paid to CreditMetrics model, indicating its main features, while presenting and explaining the evaluation of a loan portfolio by applying this model on a specific example.

Keywords: Loan portfolio risk, *VaR* concept, *CaR* concept, *CreditMetrics* model, Transition matrix.

UVOD

Upravljanje bankarskim rizicima ima za cilj optimiziranje odnosa rizika i prinosa. U fokusu bankarskih rizika jeste upravljanje kreditnim i tržišnim rizicima. Ovi rizici presudno utiču na solventnost bankarskih institucija, po-

INTRODUCTION

Management of bank risks aims to optimize risk and income. The focus of the bank risk is to manage credit risks and market risks. These risks have a crucial impact on the solvency of banking institutions, particularly

sebno u uslovima pojačane konkurencije kako na novčanom tržištu tako i na tržištu kapitala. "Kreditni rizik nastaje u uslovima kada potraživanja ne mogu biti relizovana na dan njihovog dospijeća, po punoj knjigovodstvenoj vrijednosti. Kreditni rizik pokazuje trajnu ili trenutnu nelikvidnost dužnika i njegovu nesposobnost da u dogovorenom roku izmiri obaveze. Kreditni rizik kao oblik rizika uslovljen je, u prvom redu, neizvjesnim okolnostima vezanim za poslovanje klijenta banke. Kreditni rizik predstavlja osnovni bankarski rizik i odnosi se na kreditne transakcije ili investicije u obveznice koje neće biti isplaćene o roku njihovog dospijeća" (Vunjak, 2006). U širem smislu, kreditni rizik se odnosi i na rizik pada kreditnog rejtinga dužnika, što sa sobom nosi pad tržišne vrijednosti potraživanja i, po tom osnovu, gubitak za kreditora. Za veliki broj banaka krediti su najveći i najznačajni vid plasmana sredstava a, samim tim, i veliki izvor rizičnog poslovanja.

Upravljanje kreditnim rizikom zahtijeva nezavisnu i neprekidnu provjeru procedura i politike, te identifikaciju, mjerenje, praćenje i kontrolu rizika. Mjerenje kreditnog rizika je izračunavanje visine gubitka koji nastaje djelovanjem neizvjesnih i nepovoljnih budućih događaja. Praćenje kreditnog rizika obuhvata aktivnosti kojima se nadzire kretanje visine rizika, dok se kontrolom provjerava usaglašavanje poslovne prakse sa usvojenom politikom, strategijom i definisanim limitima za preuzimanje rizika. Mjerenjem kreditnog rizika, kao jednom od funkcija upravljanja, određuje se kvalitet svake pojedinačne transakcije, kao i cjelokupnog kreditnog portfolija banke, te vjerovatnoća i iznos gubitaka koji mogu nastati zbog neizvršenja obaveza dužnika.

Najveća opasnost po banke leži u gubicima koji nastaju u slučaju difolta (eng. default), odnosno neizvršenja kreditnih obaveza dužnika. Maksimalni iznos gubitka za banku, determinišu tri faktora: (1) *visina izloženosti*, (2) *vrijednost standardne devijacije*, (3) *izabrani nivo tolerancije*. Mjerenje kreditnog rizika može biti kvalitativno i kvantitativno. Kvantitativno sagledavanje kredit-

in terms of increased competition, both in the money market and the capital market. "Credit risk appears when the claims cannot be collected in their full value, on their due date. Credit risk demonstrates the ongoing or current insolvency of the debtor and its inability to repay its liabilities within the agreed time. In the first place, credit risk was established as one of the risk forms, by uncertain circumstances with regards to the bank's client and its business. Credit risk is the basic banking risk, and it is related to credit transactions or investments into bonds that will not be paid on their due date" (Vunjak , 2006). In a broader sense, credit risk refers to the risk of debtor's credit rating decrease, which entails lower market value of claims, thus resulting in loss to the creditor. For many banks, loans are the largest and most important form of placement of funds, and therefore represent a vast source of risk assets.

Credit risk management requires constant and independent verification of procedures and policies, as well as identification, measurement, monitoring and control of risks. Credit risk measurement represents calculating the amount of loss caused by adverse and uncertain future events. Credit risk monitoring includes activities used for monitoring movement of risk level, whereas the control is used to check the alignment of business practice with the adopted policy, strategy and defined limits for risk taking. Credit risk measurement, as one of the management functions, determines not only the quality of each individual transaction, but of the entire loan portfolio of a bank, as well as the probability and the amount of loss that may arise due to failure of the debtor to perform its duties.

The greatest danger to the banks lies in the losses incurring in the event of default, or failure of the debtor to repay its liabilities. The maximum amount of loss to the bank is determined by the following three factors: (1) *level of loss exposure*, (2) *value of standard deviation*, (3) *selected tolerance level*. Credit risk measurement can be performed both in qualitative and quantitative terms.

nih rizika ima sve veću primjenu, a sastoji se u izračunavanju prosječnog iznosa gubitka i stope disperzije gubitka oko srednje vrijednosti. Osnovno statističko mjerilo disperzije oko srednje vrijednosti jeste standardna devijacija[1] kao mjerilo volatilnosti[2].

VaR MODELI KREDITNOG PORTFOLIJA

Pod pojmom kreditnog portfolija banke treba podrazumijevati grupu kredita ili sve kredite u aktivi banke koje je menadžment banke klasifikovao (struktuirao). Primjera radi, krediti mogu biti: komercijalni, investicioni, hipotekarni, agrarni, stambeni, potrošački, exportno-importni i sl. Kreditni portfolio banke se može posmatrati i sa šireg aspekta (kompleksni portfolio), pri čemu on obuhvata ne samo kredite već i ostale izvore sredstava u pasivi bilansa stanja banke. Na ovaj način se uspostavlja ravnoteža između kredita (plasmana) i izvora sredstava banke. *Ključni ciljevi kreditnog portfolija* odnose se na: (1) obim portfolija, (2) strukturu portfolija, (3) kreditne usluge, (4) naplatu kredita, (5) cijenu kredita, (6) ostvareni profit (dobit) (Vunjak, 2008).

Sredinom 80-ih godina prošlog vijeka razvijaju se modeli zasnovani na konceptu raspodjele vjerovatnoće gubitka, odnosno promjene vrijednosti portfolija. Iako su prvenstveno razvijeni za potrebe mjerenja tržišnog rizika, ovi modeli su se počeli sredinom 90-ih godina koristiti za mjerenje kreditnog rizika. Razvijen je *VaR* (eng. Value at Risk) koncept kao opšta mjera ekonomoskog gubitka koji može odgovarati riziku pojedinačnih pozicija i ukupnom riziku portfolija. Ovaj koncept, kao takav, i danas dominira u oblasti mjerenja svih vrsta rizika velikih svjetskih banaka. Mjerenje rizika primjenom VaR metodologije koriste najčešće komercijalne i investicione banke

Quantitative measurement of credit risk has been increasingly used and consists of calculating the average amount of loss and the rate of loss dispersion around the mean. The basic statistical measure of dispersion around the mean is the standard deviation[1] used as a measure of volatility[2].

VaR MODEL OF CREDIT PORTFOLIO

The term bank loan portfolio includes a group of loans or all the loans in bank assets that the bank's management has classified (structured). For example, the type of loans may vary: commercial, investment, mortgage, agricultural, residential, consumer, export-import, etc. Bank's loan portfolio can be viewed from a broader point of view (complex portfolio), in which case it includes not only loans, but also other sources of funding in the liabilities of a bank's balance sheet. That way, a balance between loans (investments) and sources of bank funds is established. *The key objectives of the loan portfolio* are as follows: (1) scope of the portfolio, (2) structure of the portfolio, (3) credit services, (4) loan payment, (5) loan cost, (6) earned profit (gain) (Vunjak, 2008).

Models based on the concept of probability distribution of the loss or the change of the portfolio value appeared in the mid-80s of the 20th century. Although primarily developed for measuring market risk, these models began to be used for credit risk measurement in the mid 90's. *VaR* (Value at Risk) concept was developed as a general measure of economic loss that may correspond to the risk of individual positions and overall portfolio risk. This concept, as such, continues to dominate the field of all-risk measurement of large global banks. Measuring risk using *VaR* methodology is most used by commercial and invest-

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1 Srednja vrijednsot neke stohastičke varijable *(x)* se izračunava po formuli: $E(x)=(\Sigma x_i)/n$, pri čemu je *E(x)* očekivana (srednja) vrijednost stohastičke varijable. Varijansa (σ^2) za seriju vrijednosti *(x)* dobija se po formuli: $\sigma^2=[\Sigma x_i-E(x)]^2/n$, dok je standardna devijacija jednaka kvadratnom korijenu varijanse: $\sigma=\sqrt{\sigma^2}$.
2 Volatilnost se može definisati kao kolebljivost cijena kredita i hartija od vrijednosti.

1 Mean value between a stochastic variable *(x)* is calculated by the formula: $E(x)=(\Sigma x_i)/n$, where E(x) is the expected (mean) value of the stochastic variable. Variance (σ^2) for a series of values (x) is obtained by the formula: $\sigma^2=[\Sigma x_i-E(x)]^2/n$, while the standard deviation equals the square root of the variance: $\sigma=\sqrt{\sigma^2}$.
2 Volatility can be defined as: the volatility (hesitance) of the loans cost and securities.

kako zbog konceptualne jednostavnosti tako i činjenice da *VaR* sintetiše u jednoj vrijednosti moguće gubitke koji se mogu dogoditi sa definisanom vjerovatnoćom. *VaR* se može definisati kao "*maksimalni očekivani gubitak, tokom datog vremenskog perioda posmatranja, pod normalnim tržišnim uslovima, uz definisani nivo pouzdanosti*" (Vujnović, 2007).

Vrijednost pod rizikom (VaR) bismo mogli definisati i kao maksimalni mogući gubitak pri datom nivou tolerancije.[3] Ovako izračunata vrijednost VaR-a podrazumijeva da bi, u slučaju nivoa tolerancije od 2%, izračunata vrijednost pod rizikom važila u 98% slučajeva, dok bi u 2% slučajeva, po računu vjerovatnoće, ta vrijednost bila probijena. Banka bi u principu trebalo da sama odluči da li želi da upravlja rizicima na bazi određenog praga tolerancije, čija vrijednost može varirati. Međutim, nivo tolerancije je regulisan od strane regulatornih vlasti u skladu sa prudencionom kontrolom i supervizijom internacionalizacije poslovanja finansijskih institucija.[4]

Smisao kvantitativnog određenja *VaR (eng.Value at Risk)* jeste da se obezbijedi adekvatan kvantitativni nivo trajnog kapitala banke, odnosno kapitala pod rizikom *CaR (eng. Capital at Rsik)*. Kako se CaR tretira kao krajnja zaštita banke od nesolventnosti, suština upravljanja bankarskim rizicima svodi se na izračunavanje visine *VaR*-a da bi se na toj osnovi odredila adekvatna visina *CaR*-a. Banka ipak može biti dovedena u stanje nesolventnosti ukoliko se dogodi katastrofalni ili stresni gubitak koji *CaR* ne može pokriti, jer je došlo do probijanja nivoa tolerancije. S obzirom na to da kapital pod rizikom (*CaR*) obuhvata sve tipove rizika banke, treba ga kvantifikovati i posmatrati na nivou banke kao cjeline, odnosno na portfolio nivou.

ment banks, mainly owing to the conceptual simplicity, and the fact that *VaR* synthesizes potential losses that can occur with a defined probability in a single value. *VaR* can be defined as: "*the maximum expected loss over a given period of observation, under normal market conditions, with a defined level of reliability*". (Vujnović, 2007)

Value at risk (VaR) can be defined as the maximum possible loss at a certain tolerance level.[3] Such calculated value of VaR implies that in case of a 2% tolerance level, the calculated value at risk would be valid in 98% of the cases, while in 2% of the cases, on the basis of probability calculation, that value would be exceeded. The bank should, in principle, decide for itself whether it wishes to manage risks based on a certain threshold of tolerance, which may vary. However, the level of tolerance is regulated by the regulatory authorities in accordance with the prudential control and supervision of internationalization of financial institutions business.[4]

The purpose of quantitative determination of *VaR (Value at Risk)* is to provide adequate quantitative level of a bank's permanent capital, or *Capital at Risk (CaR)*. As the *CaR* is treated as the ultimate protection of a bank from insolvency, the essence of bank risk management is reduced onto calculating the amount of *VaR*, which is later to be used for determining the appropriate *CaR* level. The bank may still become insolvent, in the case of a catastrophic or a stressful loss, which *CaR* cannot cover since the tolerance level has been breached. Given that Capital at Risk (*CaR*) includes all types of bank risk, it should be quantified and considered at the level of a bank as a whole, or on a portfolio

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3 Pod nivoom tolerancije se podrazumijeva vjerovatnoća da gubici probijaju matematički projektovanu granicu.

4 Bazelski komitet je 1988. propisao *Bazel I* sporazumom da je visina adekvatnog nivoa kapitala 8% za riziko ponderisanu aktivu. Kasnijim revidiranjem ovog sporazuma 2004. godine plasiran je Novi sporazum, odnosno *Bazel II* sporazum, kojim je propisano da visina obaveznog kapitala bude u skladu sa rizikom dužnika na mikro nivou.Tako su dužnici svrstani u odgovarajuće kategorije rizika po rejting skali (rejting klase) na bazi pondera rizika.Visina kreditnog rizika se dobije množenjem kreditne izloženosti (nominalni iznos zajma) sa ponderima rizika.

3 Tolerance level implies the probability that the losses exceed the projected mathematical limit.

4 In 1988, Basel Committee defined *Basel I* Agreement stating that the adequate level of equity is 8% for risk-weighted assets. Subsequent revision of th Agreement in 2004, resulted in the launch of a new, *Basel II* Agreement, which stipulates that the amount of regulatory capital shall be in line with the debtor risk at a micro level. That way, the debtors have been classified in the appropriate risk categories on the basis of a rating scale (rating class), based on the risk weight. Credit risk level is obtained by multiplying the credit exposure (nominal amount of the loan) with the risk weights.

Da bi banka mogla nesmetano funkcinisati, neophodno je međusobno uskladiti vrijednosti *VaR*-a i *CaR*-a. Odnosno, ukoliko dođe do povećanja rizika (*VaR*), neophodno je i povećanje kapitala pod rizikom (*CaR*) i obrnuto.

Modeli kreditnog rizika koriste pretpostavke i finansijske teorije u cilju procjene parametara gubitaka na osnovu male količine posmatranih podataka. Pristupi koji se koriste kao baza svih praktičnih modela kreditnog rizika su: model kovarijanse, model zasnovan na aktuarskom pristupu i modeli zasnovani na simulaciji. Osnovna razlika između ovih modela je pristup karakterizaciji korelacija. Svaki od ovih modela je integrisan u softverski paket kreiran u različitim kompanijama (Vujnović, 2007). Iako se po pristupu razlikuju, *VaR* modeli imaju određeni broj istih prednosti i ograničenja. Svaki pristup uzima u obzir širok spektar faktora rizika (kamatne stope, devizni kursevi, terminske cijene i dr.). Nedostatak svakog od pristupa je u tome što pretpostavlja da će istorijski odnosi između faktora rizika biti ponovljeni u budućnosti. Zajedničko za sve modele kreditnog rizika jeste da koriste pretpostavke i finansijske teorije u cilju procjene parametara gubitaka na osnovu male količine raspoloživih podataka. *VaR* modeli kreditnog portfolija primjenjivi u praksi su: (1) *Model kovarijansi*, (2) *CreditMetrics model*, (3) *McKinsey model*, (4) *CreditRisk metodologija*.

Model kovarijansi, poznat i kao "*Markovitz*" model, je model kod koga su korelacije definisane kao korelacije neizvršenja obaveza. S obzirom na to da se primjenjuje pri izračunavanju visine kreditnog rizika, potrebno je izračunati i rezultate srednje vrijednosti. Koristi se za sve vrste kreditne izloženosti i formuliše se u četiri koraka: (1) definisanje očekivanog gubitka (EL) i neočekivanog gubitka (UL) portfolija, (2) procjena korelacije neizvršenja obaveza, (3) procjena sveobuhvatne distribucije vjerovatnoća portfolija na osnovu definisanih vrijednosti (EL) i (UL), (4) alokacija kapitala cjelokupnog portfolija na individualne kredite koristeći koncept doprinosa neočekivanih gubitaka (UL).

basis. In order for the bank to operate safely it is necessary to mutually adjust the value of both *VaR* and *CaR*. That is, if there is an increase in risk (*VaR*), it is necessary to increase capital at risk (*CaR*) and vice versa.

Credit risk models utilize assumptions and financial theories in order to estimate the parameters of losses based on a minor amount of observed data. The approaches used as the base for all practical models of credit risk are as follows: covariance model, actuarial approach based model and simulation-based model. The main difference between these models is the approach to the characterization of correlations. Each of these models has been integrated into a software package created in different companies (Vujnović, 2007). Although different in their approach, *VaR* models share a certain number of advantages and limitations. Each approach takes into account a wide range of risk factors (interest rates, foreign exchange rates, forward prices, etc.). The lack of each of the approaches is that they assume that the historical relationship between the risk factors shall be repeated in the future. Typical to all models of credit risk is to use assumptions and financial theories in order to estimate the loss parameters based on a limited amount of data available. *VaR* Credit portfolio models applicable in practice are as follows: (1) *Covariance model*, (2) *CreditMetrics model*, (3) *McKinsey model*, (4) *CreditRisk methodology*.

Covariance model, also known as "*Markowitz*" model, is a model in which the correlations are defined as default correlations. Since it is applied in the calculation of the amount of credit risk, the results of the mean value should be calculated as well. It is used for all types of credit exposure and is formulated with four steps: (1) Defining the expected loss (EL) and unexpected loss (UL) of portfolio, (2) Evaluation of the default correlation, (3) Evaluation of a comprehensive probability distribution of portfolio based on defined values (EL) and (UL), (4) Allocation of the overall portfolio capital onto individual loans using the concept of unexpected losses (UL) contribution.

CreditMetrics model je prvi put publikovan aprila 1997. godine kao model na osnovu kojeg se može mjeriti kreditni rizik širokog niza finansijskih instrumenata i njihovih portfolija, polazeći pri tome od portfolio teorije i *VaR* metodologije. Ovaj model je publikovala banka *J.P. Morgan*, a u saradnji sa *Bank of America, BZW, Deutsche Morgan Grenfell, Swiss bank Corporation, Union bank of Switzerland i KMW Corporation.* Iako se zasniva na modelu koji je *J.P. Morgan* razvio za mjerenje, upravljanje i kontrolu tržišnog rizika, *CreditMetrics* model se znatno razlikuje od ovog modela. Naime, ovaj model predstavlja dobru metodologiju za mjerenje rizika neizvršenja obaveza. Za razliku od tržišnih rizika, koji na osnovu podataka o dnevnim cijenama omogućavaju neposrednu kalkulaciju *VaR*-a, ova metodologija konstruiše hipotetičku tržišnu vrijednost i volatilnost vrijednosti na osnovu promjene kreditnog rejtinga koji se ne mogu direktno posmatrati. Treba istaći, da su modeli za kvantitativno mjerenje tržišnih vrijednosti bankarskih kredita nastali znatno kasnije od modela za mjerenje vrijednosti tržišnih finansijskih instrumenata (npr. obveznica). Razlog ovome je što bankarski krediti ne predstavljaju tržišne instrumente, osim u izuzetnim slučajevima. Ovaj problem je rješen na način da su bankarski krediti graduirani na skali kreditnih rejtinga od strane poznatih rejting agencija. U pitanju su rejtinzi kompanija, uključujući promjene kreditnih rejtinga bilo po osnovu emitovanih obveznica, ili kredita koje su kompanije dobile od banaka.

McKinsey model je komplementaran sa *CreditMetrics* metodologijom, a osnovni koncept je tranziciona matrica za pojedinu zemlju. Ovaj model je multifaktorski, a koristi se za simulaciju zajedničke uslovne distribucije neizvršenja obaveza i vjerovatnoće migracije za različite rejting klase kako u različitim privrednim granama tako i za svaku zemlju. Pri tome se uzima u obzir vrijednost makroekonomskih faktora. S obzirom na to da je ekonomija pod velikim uticajem makroekonomskih faktora, *McKinsey* model je sredstvo za povezivanje svih makroekonomskih faktora sa neizvršenjem obaveza i promjenjivim vjerovatnoćama.

CreditMetrics model was first published in April in 1997, as a model which can be used for measurement of the credit risk of a wide range of financial instruments and their portfolios, thereby starting with portfolio theory and *VaR* methodology. This model was published by the *J.P. Morgan bank*, in collaboration with *Bank of America, BZW, Deutsche Morgan Grenfell, Swiss Bank Corporation, Union Bank of Switzerland and KMW Corporation*. Although based on a model which *J.P. Morgan* developed to measure, manage and control the market risk, *CreditMetrics* model differs significantly from such model. In fact, this model represents a good methodology for measuring the risk of default. Contrary to market risks, which allow direct calculation of *VaR* on the basis of the data on daily prices, this methodology constructs a hypothetical market value and volatility of value based on changes in credit ratings that cannot be directly observed. It should be noted that the models for quantitative measurement of the bank loans' market value incurred much later than the models for measuring the market value of financial instruments (e.g. bonds). The main reason is that bank loans are not market-based instruments, apart from exceptional cases. Such problem was solved by grading bank loans on a credit rating scale by well-known rating agencies, with regards to ratings of companies, including credit ratings changes, either on the basis of issued bonds or loans that companies received from banks.

McKinsey model is complementary to the *CreditMetrics* methodology, with the basic concept being the transition matrix for a country. This model is multifactorial and is used to simulate joint conditional distribution of default and migration probability for different rating classes, both in a variety of industries and for each country. At the same time, the value of macroeconomic factors is taken into account. Given that the economy is heavily influenced by macroeconomic factors, *McKinsey* model is an instrument to connect all the macroeconomic factors with default and variable probabilities. During operation-

Prilikom operacionalizacije, ovaj model koristi makroekonomske pokazatelje kao što su: stopa nezaposlenosti, stopa rasta bruto domaćeg proizvoda, nivo dugoročnih kamatnih stopa, devizni kursevi, visina kamatnih stopa na štednju i sl. Ukoliko se raspolaže navedenim podacima, ovaj model se može, bez izuzetka, primijeniti na svaku zemlju, sektor ili klasu dužnika, koji reaguju različito kroz poslovne cikluse.

CreditRisk metodologija operiše samo sa rizikom neizvršenja obaveza, dok zanemaruje rizik promjene kreditnog rejtinga. Model polazi od pretpostavke da je vjerovatnoća neizvršenja obaveza (PD) u posmatranom periodu ista kao u svakom drugom periodu, te da je (PD) po jednom dužniku mala, a broj neizvršenja obaveza u jednom periodu nije u bilo kakvoj vezi sa brojem neizvršenja obaveza u drugom periodu. Takođe, ne pravi pretpostavke oko razloga neizvršenja obaveza.

INDIKATOR VJEROVATNOĆE PROMJENE KREDITNOG REJTINGA (TRANZICIONA MATRICA)

VaR koncept je u svojoj prvobitnoj namjeni služio za mjerenje tržišnog rizika, dok se sredinom 90-ih godina prošlog vijeka počeo primjenjivati pri mjerenju kreditnog rizika. Osnovna razlika VaR koncepta za mjerenje kreditnog rizika u odnosu na mjerenje tržišnog rizika jeste u izboru egzogenih varijabli koje utiču na vrijednost portfolija. Kod tržišnih rizika kao egzogene varijable uzimaju se: (1) tržišne cijene akcija, (2) tržišne cijene roba, (3) kamatne stope i (4) devizni kursevi. Dok se pri mjerenju kreditnog rizika, kao egzogene varijable, pojavljuju: (1) kreditni rejting dužnika[5], (2) tranziciona matrica kreditnog rejtinga i (3) korelacija kretanja kreditnog rejtinga dužnika. Interni (kreditni) rejting je zapravo ocjena kreditne sposobnosti dužnika izražena putem određene rejting skale. Promjene vri-

alization, this model uses macro-economic indicators such as: unemployment rate, gross domestic product growth rate, level of long-term interest rates, foreign exchange rates, level of interest rates on savings accounts, etc. If such data is available, the model can be applied without exception to any country, sector or class of debtors, who respond differently throughout business cycles.

CreditRisk methodology operates only with the risk of default, while neglecting the credit rating change risk. The Model assumes that the Probability of Default (PD) in a certain period is the same as in any other period, and that (PD) by a debtor is low, with the number of defaults in one period not being in any way related to the number of defaults in the other period. Likewise, it does not make assumptions about the causes of default.

PROBABILITY INDICATOR OF CREDIT RATING CHANGE (TRANSITION MATRIX)

VaR concept initially served its intended purpose of measuring the market risk, while in the mid-90s of the 20th century it began to be applied in credit risk measurement. The main difference between the use of VaR concept for credit risk measurement in relation to the measurement of market risk is the selection of exogenous variables that affect the portfolio value. With the market risk, the following items are used as exogenous variables: (1) market price of shares, (2) market price of commodities, (3) interest rates and (4) foreign currency exchange rates. On the other hand, the following items occur as exogenous variables in the process of measuring credit risk: (1) credit rating of the debtor[5], (2) credit rating transition matrix, and (3) the correlation of debtor's credit rating movement. Internal (credit) rating is actually a credit score of the debtor expressed through a specific rating scale. Value

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5 Kreditni rejting se definiše kao ocjena kreditne sposobnosti komitenta izražena određenom ordinalnom skalom. Rejtinzi se obično obilježavaju slovnim oznakama koje određuju rang kvaliteta neke firme ili hartije od vrijednosti.

5 Credit rating is defined as client's credit standing score expressed using a specific ordinal scale. Ratings are often marked by letters determining the ranking quality of a company or securities.

jednosti kreditnog portfolija banke se dešavaju kao posljedica promjene internog rejtinga dužnika koji se nalaze u portfoliju.

Treba istaći da se rejtinzi svake kompanije mijenjaju tokom vremena i, samim tim, utiču na vrijednost portfolija banke. Pri mjerenju kreditnog rizika primjenom *VaR* metodologije, najbitnija je izrada *tranzicione matrice* kao najefikasnijeg načina za prikazivanje vjerovatnoće promjene kreditnog rejtinga. Tranziciona matrica ukazuje na vjerovatnoću promjene rejtinga u određenom vremenskom periodu, koji se najčešće odnosi na jednu godinu dana. Jednogodišnji period se uzima zato što se svi finansijski i drugi izvještaji o poslovanju kompanija objavljuju jednom godišnje.

change of a bank's loan portfolio occurs as a result of changes in the internal rating of the debtors within the portfolio.

It should be noted that the ratings of each company vary over time, therefore affecting the value of the bank's portfolio. In the process of Credit risk measurement using *VaR* methodology the most important aspect is the preparation of *transition matrix* as the most effective method to demonstrate the change probability in credit ratings. The transition matrix indicates the probability of a rating change within a certain period, which is usually one year. One year period is used mainly because all the financial and other reports of the companies are published annually.

Tabela 1
Tranziciona matrica
(Standard&Poor's, 1996)

Table 1
Credit rating change Matrix
(Standard&Poor's, 1996)

Inicijalni rejting Initial rating	Rejting na kraju godine (%) Year-end rating (%)							
	AAA	AA	A	BBB	BB	B	C	D
AAA	90,81	8,33	0,68	0,06	0,12	0,00	0,00	0,00
AA	0,70	90,65	7,79	0,54	0,06	0,14	0,02	0,00
A	0,09	2,27	90,05	5,52	0,74	0,26	0,01	0,06
BBB	0,02	0,33	5,95	86,93	5,30	1,17	0,12	0,18
BB	0,03	0,14	0,67	7,73	80,53	8,84	1,00	1,06
B	0,00	0,11	0,24	0,43	6,48	83,46	4,07	5,20
C	0,22	0,00	0,22	1,30	2,38	11,24	64,86	19,79

Tabela 1 prikazuje izgled jedne tranzicione matrice. Zbir svih vjerovatnoća u tranzicionoj matrici mora biti 100 u svakom od redova, dok svaki red polazi od inicijalnog rejtinga. Ukoliko se želi provjeriti vjerovatnoća kompanije koja danas rangira AA, a na kraju godine BBB, iz tranzicione matrice se vidi da je njena vrijednost 0,54. Takođe se može primijetiti da su najveće vjerovatnoće po dijagonali tranzicione matrice, što ukazuje na činjenicu da većina kompanija ne mijenja rejting u toku godine. Pojedine vjerovatnoće u tranzicionoj matrici su jednake nuli (B, C, D), a što navodi na zaključak da je vjerovatnoća ravna nuli da neka kompanija iz ranga AAA bankrotira.

Table 1 demonstrates the appearance of a transition matrix. The sum of all probabilities within a transitional matrix must be 100 in each row, with each row starting with the initial rating. If the purpose is to check the credit rating change probability of a company that is currently ranked as AA, while having the rating of BBB at the end of the year, the transition matrix shows that its value is 0.54. It may also be noted that the highest probability levels are set on the transition matrix diagonal, which indicates that most companies do not change their rating within a year. Some of the probabilities within the transitional matrix are equal to zero (B, C, D), which suggests that the probability of AAA ranked company going bankrupt equals zero.

Tranzicione matrice se izrađuju na osnovu istorijskih podataka o kretanju rejtinga svih dužnika koji čine portfolio. Pomoću tranzicionih matrica i metoda istorijske tabulacije[6] promjena kreditnog rejtinga svih dužnika iz kreditnog portfolija, tokom određenog broja godina, moguće je utvrditi vjerovatnoću promjene kreditnog rejtinga svakog dužnika. Gotove tranzicione matrice se mogu preuzeti od više eksternih rejting agencija. Pojedine banke i same izrađuju tranzicione matrice na osnovu sopstvenih vremenskih serija promjena kreditnog rejtinga svojih komitenata.

Prilikom izrade tranzicione matrice treba voditi računa o četiri osnovna pravila vezana za vjerovatnoće promjene kreditnog rejtinga: (1) bolji kreditni rejtinzi nikad ne smiju imati veću vjerovatnoću difolta od lošijih; (2) vjerovatnoća promjene rejtinga je manja što je rejting kategorija više udaljena; (3) vjerovatnoća promjene rejtinga u određenu rejting kategoriju treba da bude veća za rejting kategorije koje su bliže datoj rejting kategoriji; (4) vjerovatnoća difolta je veća što je duži vremenski period posmatranja

Da bi se shvatila suština navedenog, ova pravila je potrebno pojasniti. Prvo, što je veći kreditni rejting nekog dužnika, to je manja vjerovatnoća njegovog bankrota. Tako je manja vjerovatnoća da neki dužnik iz kategorije AA bankrotira, od vjerovatnoće za dužnika iz kategorije BBB. Drugo, manja je vjerovatnoća da se promijeni rejting za dvije ili tri katagorije, nego za jednu (BB u A, nego BBB). Treće, veća je vjerovatnoća da neka kompanija pređe u određenu rejting kategoriju ukoliko je njen rejting bliži toj kategoriji. Odnosno, veća je vjerovatnoća da neko iz kategorije BB pređe u A, nego iz kategorije C. Četvrto, postoji veća vjerovatnoća da kompanija bankrotira u dužem vremenskom periodu, nego u kraćem vremenskom periodu. To znači da kumulativne vjerovatnoće difolta moraju biti veće od vjerovatnoće difolta za godinu dana.

Transition matrices are made on the basis of historical data on the rating movement of all the debtors forming a portfolio. Using the transition matrices and the method of historical tabulation[6] of credit ratings changes of debtors in the loan portfolio over a certain period of years, it is possible to determine the probability of credit rating change of each debtor. Completed transition matrices can be obtained from several external rating agencies. Some banks prepare the transition matrices themselves, based on their own time series of its customers' credit rating changes.

In the process of making the transition matrix, four basic rules regarding the probability of changes in credit ratings should be taken into account: (1) A superior credit rating should never have a higher default probability than the inferior one; (2) The further the rating category is, the lower is the probability of a rating change; (3) Probability of a rating change into a particular rating category should be higher for rating categories closer to the given rating category; (4) The probability of default is higher the longer the period of observation is.

In order to understand the essence of the above, these rules need clarification. Firstly, the higher the credit rating of a debtor, the lower the probability of its bankruptcy is. Thus, the probability that a debtor from the AA category goes bankrupt is lower than the probability that a debtor from the BBB category goes bankrupt. Secondly, the possibility of a rating change for two or even three categories is lower than for just one (more likely for BB to directly go into BBB than into A). Thirdly, the probability that a company moves to a particular rating category is higher if its rating is closer to that category. That is, it is more likely that a company from the BB category moves to A category, than a company from the C category. Finally, there is a greater probability that a company goes bankrupt in the long run, than in the short period of time. That implies that the cumulative probability of default must be higher than the annual probability of default.

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6 Metod istorijske tabulacije pretpostavlja da je za sve dužnike kreditni rejting određen pravilno i korektno. Odnosno, da su svi dužnici obilježeni istim slovima za rejting istog kvaliteta.

6 Historical tabulation method assumes that the credit rating for all of the debtors has been determined properly and fairly. That is, that all the debtors have been marked with the same letter for the same quality rating.

Tabela 2   Table 2
Matrica promjene kreditnog rejtinga   *Credit rating change Matrix*
(Stojanovski, 2006)   *(Stojanovski, 2006)*

Inicijalni rejting Initial rating	Rejting na kraju godine (%) Year-end rating (%)								
	AAA	AA	A	BBB	BB	B	C	D	Ukupno Total
AAA	1800	170	15	12	3	0	0	0	2.000
AA	35	4.500	390	30	20	15	10	0	5.000
A	140	340	13.640	740	80	30	25	5	15.000
BBB	5	75	1.500	21.750	1.300	275	85	10	25.000
BB	3	12	70	775	8.120	882	125	13	10.000
B	1	5	10	20	185	2.140	124	15	2.500
C	1	0	2	16	22	77	357	25	500
Total	1.985	5.102	15.627	23.343	9.730	3.419	726	68	60.000

Ukoliko bismo htjeli izraditi tranzicionu matricu primjenom metoda istorijske tabulacije, potrebno je najmanje pet godina pratiti kretanje kreditnog rejtinga (npr. hiljadu kompanija) koje čine portfolio. Tako bi se dobila baza podataka od 60 hiljada kompanija-mjeseci (1000x5x12), koja predstavlja *matricu promjene kreditnog rejtinga* prikazanu u tabeli 2. Dobijena matrica promjene kreditnog rejtinga se prevodi u tranzicionu matricu tako što se računaju vjerovatnoće promjene. Primjera radi, da kompanija iz kategorije A na kraju godine završi u kategoriji BBB, vjerovatnoća promjene kreditnog rejtinga se izračunava kao količnik 740/15000=0,0493 ili 4,93%. Vjerovatnoća da kompanija iz BBB ostane u BBB se izračunava kao količnik 21750/25000=0,87, ili 87%. Na ovaj način se formira tranziciona matrica za vjerovatnoće promjene kreditnog rejtinga koja je slična tranzicionoj matrici prikazanoj u tabeli 1.

In order to prepare a transition matrix using methods of historical tabulations, at least five years period is required to track the movement of credit rating (e.g. of a thousand companies) comprising the portfolio. Thus, a database of 60 thousands companies-months would be generated (1000x5x12), which represents a Credit rating change matrix shown in Table 2. The resulting Credit rating change matrix is converted into transition matrix by calculating the probability of change. For example, for a company from the category A to move into the category BBB, the probability of the credit rating change is calculated as the quotient of 740/15000=0.0493 or 4.93%. The probability that a company from BBB remains in BBB is calculated as the ratio of 21750/25000=0.87 or 87%. That way, a transition matrix for the possibility of credit rating change is formed, which is similar to the transition matrix shown in Table 1.

VREDNOVANJE KREDITNOG PORTFOLIJA

EVALUATION OF CREDIT PORTFOLIO

Moguće promjene kvaliteta kredita u portfoliju kredita banke moguće je ilustrovati primjenom *CreditMetrics* modela. *CreditMetrics* model procjenjuje individualne i portfolio vrijednosti pod rizikom (*VaR*), a da pri tome najprije određuje profil izloženosti riziku svake od pozicija u kreditnom portfoliju. Nakon toga

Possible credit quality changes in the loan portfolio of banks can be illustrated using the *CreditMetrics* model. *CreditMetrics* model assesses individual and portfolio values at risk (*VaR*), while first determining the risk exposure profile of each of the positions in the portfolio, followed by the calculation of vol-

se izračunava volatilnost svake pozicije nastale povećanjem ili smanjenjem kreditnog rejtinga kompanija, odnosno neotplaćenih kredita. Svaka promjena rejtinga se konvertuje u promjenu tržišne vrijednosti kredita kompanija, dok se agregiranjem volatilnosti individualnih kredita dobija volatilnost portfolija.

Suština *CreditMetrics* modela je u tome da daje kvantitativni okvir za sagledavanje promjene kreditnih rejtinga i neplaćanje kreditnih obaveza, odnosno difolta (default). Nasuprot tradicionalnim modelima (kao što je npr. *Z-score model*), koji izračunavaju samo vjerovatnoću izvršenja i neizvršenja kreditnih obaveza dužnika, *CreditMetrics* model kao ulazni podatak uzima bilo koju procjenu vjerovatnoće neizvršenja obaveza (*Probability of Default-PD*)[7], te procjenjuje rizik portfolija usljed promjene u vrijednosti duga, koje su izazvane promjenama u kreditnom kvalitetu dužnika. Važno je naglasiti da ovaj model procjenjuje rizike u okviru cjelokupnog portfolija, pri čemu uzima u obzir korelaciju među dužnicima.

Na sljedećem primjeru je ilustrovana primjena CreditMetrics modela u izračunavanju vrijednosti kreditnog portfolija.

 atility of each position resulting from an increase or decrease in the credit rating of companies, or unpaid loans. Each rating change is converted into the market value change of the companies' loans, while aggregation of the individual loans' volatility results in portfolio volatility.

The essence of the CreditMetrics model is that it provides a quantitative framework for understanding the credit rating changes and loan liabilities or default. In contrast to traditional models, such as *Z-score model* that calculates only a probability of enforcement and non-enforcement of loan liabilities of the debtor, *CreditMetrics* model uses any assessment of the *Probability of Default (PD)*[7], and estimates the portfolio risk due to changes in the debt value, caused by the changes in the debtor's credit quality. It is important to emphasize that this model predicts the risks within the entire portfolio, simultaneously taking into account the correlation among the debtors.

The following example illustrates the application of CreditMetrics model in calculating the loan portfolio value.

Tabela 3
Moguće promjene kvaliteta kredita u portfoliju (Marcia, M. C., Antony, S., 1999)

Table 3
Possible changes in credit quality within a portfolio (Marcia, M. C., Antony, S., 1999)

Budući kreditni rejting Future credit rating	Vjerovatnoće promjene kreditnog rejtinga (%) Probability of credit rating change (%)	Buduća vrijednost zajma (u 000 $) Future loan value (in 000 $)
AAA	0,02	4.375
AA	0,33	4.368
A	5,95	4.364
BBB	86,93	4.300
BB	5,30	4.081
B	1,17	3.924
CCC	0,12	3.346
Default	0,18	2.125

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7 Banke koje, prema *Bazel II* sporazumu koriste osnovni ili napredni *IRB* pristup pri određivanju kreditne sposobnosti dužnika, primjenjuju *IRB* metodologiju koja obuhvata četiri bazične komponente rizika: (1) vjerovatnoću neizvršenja dužničkih obaveza PD (Probability of Default), (2) veličinu mogućeg gubitka LGD (Loss Given Default), (3) visinu izloženosti u momentu neizvršenja obaveza EAD (Exposure At Default), (4) ročnost M (Maturity).

7 Banks which, according to *Basel II*, use basic or advanced *IRB* approach in determining creditworthiness, utilise the *IRB* methodology which includes four basic components of risk: (1) Probability of Default of debt liabilities (PD), (2) Amount of a potential loss (Loss Given Default - LGD), (3) Amount of exposure at the time of default (Exposure at Default - EAD), (4) Maturity (M).

Pretpostavka je da kreditni portfolio ima kreditni rejting BBB i tržišnu vrijednost od 4,300.000,00$. U tabeli 3 je vidljivo da će portfolio zadržati postojeći kreditni rejting BBB, sa vjerovatnoćom 86,93%, čime bi njegova tržišna vrijednost ostala nepromijenjena. Ukoliko se uzme u obzir da ponderisana buduća vrijednost ovog portfolija, poslije godinu dana, ima srednju vrijednost od 4,281.911,00 $[8], dok vrijednost standardne devijacije (σ) iznosi 116.698,00$[9]. Tada, apsolutna vrijednost standardne devijacije iznosi +116.698,00$ u odnosu na srednju vrijednost portfolija od 4,281.911,00 $. S obzirom na to da pri normalnoj distribuciji rizika postoji vjerovatnoća od 1% (nivo tolerancije) da će portfolio vrijednost pasti za 2,33σ[10], mogući gubitak banke bi u tom slučaju iznosio 271.906,00$ (2,33x116.698$). Time bi vrijednost portfolija pala na 4,010.005,00 $ (4,281.911$ - 271.906$). To znači, da uz nivo tolerancije od 1%, izračunata vrijednost pod rizikom važi u 99% slučajeva, dok u 1% slučajeva može biti probijena. Ukoliko bi se desilo da kreditni rejting portfolija padne sa BBB na B, uz moguću vjerovatnoću od svega 1,17% (vrijednost iz tabele br. 3.), banka bi tada imala gubitak od 357.911,00$, dok bi vrijednost portfolija iznosila 3,924.000,00$ (4,281.911$ - 357.911$) (Millon, Saunders, 1999).

Ukoliko kreditni rejting neke kompanije, koja je dobila bankarski zajam, bude snižen, onda bi ta kompanija trebalo da plati povećanu kamatnu stopu (tzv. spred) zbog toga što je ušla u klasu povećanog rizika. Međutim, kako je kompanija već dobila bankarski zajam po fiksnoj kamatnoj stopi, onda bi tekući prinos (*yield*) trebalo da se reflektuje u višoj diskontnoj stopi koja se primjenjuje na novčane tokove dok zajam ne bude vraćen. Kada se na nominalne novčane tokove zajma primijeni viša diskontna stopa, dobija se smanjena tržišna vrijednost zajma u sadašnjem momentu. I

The initial assumption is that the credit portfolio has a credit rating of BBB and a market value of $4,300.000,00. The table no.3 clearly specifies that the portfolio is likely to retain the existing credit rating BBB, with the probability of 86.93%, which would leave its market value unchanged. If we take into account that the weighted future value of the portfolio, after one year, has a mean value of $4.281.911,00[8] while the standard deviation (σ) is $116,698.00[9]. Then, the absolute value of standard deviation is $116,698.00 compared to the portfolio mean value of $4,281.911,00. Given that with the normal distribution of risk, there is a 1% probability (tolerance level) that the portfolio value will drop by 2.33 σ[10], potential bank loss in that case would amount to $271,906.00 (2.33x$116,698). This would reduce the portfolio value to $4,010.005,00 ($4,281.911 - $271,906). It means that with the tolerance level of 1%, the calculated value at risk is applicable in 99% of cases, while in 1% of the cases it can be exceeded. If the portfolio credit rating would drop from BBB to B, of which the probability is only 1.17% (the value from the Table 3.), The bank would suffer a loss of $357,911.00, while the value of the portfolio would amount to $3,924.000,00 ($4,281.911 - $357,911) (Millon, Saunders, 1999).

If the credit rating of a company, which received a bank loan, is reduced, then the company should pay an increased interest rate (the spread) because it has entered a higher risk category. However, since the company has already obtained a bank loan at a fixed interest rate, then the current yield should be reflected in a higher discount rate applied to the cash flows until the loan is repaid. Applying a higher discount rate onto nominal cash flows of the loan, results in a reduced market value of the loan at the present time. Likewise, if a company is awarded

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8 Vrijednost dobijena po formuli: $E(x)=\Sigma p_i x_i$, gdje su (*p*) vrijednosti, a (*x*) vjerovatnoće.
9 Vrijednost dobijena po formuli: $\sigma=\sqrt{\sigma^2}$, gdje je standardna devijacija jednaka kvadratnom korijenu varijanse. Navedene vrijednosti su dobijene složenim računskim operacijama koje su ovdje izostavljene.
10 Standardna vrijednost za 1. percentil normalne raspodjele je 2,33

8 The value obtained using the following formula: $E(x)=\Sigma p_i x_i$ where (*p*) is the value, and (*x*) is the probability.
9 The value obtained by the formula: $\sigma=\sqrt{\sigma^2}$, with standard deviation equal to the square root of the variance. Values specified are obtained by complex calculations not specified in the paper.
10 The default value of 1 percentile of the normal distribution is 2.33.

obrnuto, ako kompanija dobije poboljšan kreditni rejting, tržišna vrijednost njenog zajma se u ovom trenutku povećava (Ćirović, 2006).

CreditMetrics model može se primijeniti, na prezentirani način, za izračunavanje vrijednosti portfolija kredita samo pod uslovom da kompanije koje koriste kredite imaju verifikovane kreditne rejtinge od strane priznatih rejting agencija. Tabela 4 prikazuje uporedni pregled rejting sistema poznatih svjetskih rejting agencija.

Tabela 4
Uporedni pregled rejting sistema
(Bjelica, 2001)

an improved credit rating, the market value of its loan is increased at the current moment (Ćirović, 2006).

CreditMetrics model can be applied to the above presented method for calculating the value of the credit portfolio only under the condition that the companies using the loans have their credit ratings verified by a recognized rating agency. Table 4 shows the comparison of the rating system by renowned international rating agencies.

Table 4
Comparison of rating scale
(Bjelica, 2001)

Moody's	Standard & Poor's	Bank Watch	Kvalitet Quality
Aaa	AAA	A	Najveći Highest grade
Aa	AA	A/B	Visok High grade
A	A	B	Viši srednji Upper medium grade
Baa	BBB	B/C	Srednji Medium grade
Ba	BB	C	Niži srednji Lower medium grade
B	B	C/D	Špekulativni Highly Speculative
Caa	CCC	D	Loš Substantial risks
Ca	CC	D/E	Visoko špek. Extremely speculative
C	C	E	Vrlo loš Very poor
	D		Rizičan In default

Ukoliko dotične kompanije imaju i emitovane obveznice na finansijskom tržištu, tada je moguće uporediti tržišne cijene obveznica sa rejtinzima priznatih agencija. Problem nastaje kod bankarskih zajmova koji nemaju ni tržišne cijene obveznice, ni rejting profesionalnih rejting institucija. Prema odredbama *Bazel II sporazuma*, banke mogu koristiti dva pristupa određivanju kreditne sposobnosti dužnika: standardizovani pristup i pristup internog rej-

If the concerned companies have issued bonds in the financial markets, it is possible to compare the market prices of the bonds with the ratings of recognized agencies. The problem arises with bank loans that have neither a market price of a bond, nor a rating established by professional rating institutions. Under the provisions of Basel II, banks can use two approaches to determine creditworthiness: the standardized approach

tinga (*IRB-Internal Ratings Based Approach*). Ukoliko banka koristi standardizovani pristup, tada na svaku klasu rizika mora primijeniti pondere rizika, koje određuje supervizorska institucija, na bazi procjene kreditnih rizika od strane neke priznate rejting agencije. Međutim, pri primjeni *IRB* pristupa, sofisticirane banke koriste svoje interne metodologije, pod uslovom da su verifikovane od strane odgovarajuće supervizorske institucije.

and Internal Ratings Based Approach (IRB). If a bank uses the standardized approach, the risk weights must be applied to each of the risk classes, as determined by a supervisory institution, based on the credit risk assessment by a recognized rating agency. However, when applying the IRB approach, sophisticated banks utilise their own methodology, provided that they have been certified by the appropriate supervisory institutions.

ZAKLJUČAK

Sredinom 90-ih godina prošlog vijeka razvijen je *VaR (Value at Risk)* koncept koji je danas dominantan u oblasti mjerenja svih vrsta rizika u velikim svjetskim bankama. Finansijske institucije su razvile *VaR* koncept kao opštu mjeru ekonomoskog gubitka, koji može odgovarati riziku pojedinačnih pozicija i ukupnom riziku portfolija. Zajedničko za sve *VaR* modele kreditnog portfolija jeste da koriste pretpostavke i finansijske teorije u cilju procjene parametara gubitaka na osnovu male količine raspoloživih podataka. Najbitnija stvar kod mjerenja kreditnog rizika *VaR* modelima jeste izrada *tranzicione matrice*, kao pokazatelja vjerovatnoće promjene kreditnog rejtinga kompanije u određenom vremenskom periodu. Jedan od *VaR* modela vrednovanja kreditnog portfolija jeste *CreditMetrics model*. *CreditMetrics* model, prvi put publikovan 1997. godine, je model na osnovu kojeg se može mjeriti kreditni rizik širokog niza instrumenata i njihovih portfolija, pri tome polazeći od portfolio teorije i *VaR* metodologije. Nasuprot tradicionalnim modelima, koji izračunavaju samo vjerovatnoću izvršenja i neizvršenja kreditnih obaveza dužnika, *CreditMetrics* model kao ulazni podatak uzima bilo koju procjenu vjerovatnoće neizvršenja obaveza (*PD*), te procjenjuje rizik portfolija usljed promjene u vrijednosti duga, koje su izazvane promjenama u kreditnom kvalitetu dužnika. Takođe, procjenjuje rizike u okviru cjelokupnog portfolija, pri čemu uzima u obzir korelaciju među dužnicima. *CreditMetrics* model može se primijeniti za izračunavanje vrijednosti portfolija kredita

CONCLUSION

In the mid-90s of the 20th century, the *VaR (Value at Risk)* concept was developed. The concept is now dominant in the field of measurement of all types of risk in large global banks. Financial institutions have developed the *VaR* concept as a general measure of an economic loss, which may correspond to individual positions risk and overall portfolio risk. Common to all of the *VaR* credit portfolio models is to use assumptions and financial theories in order to estimate the parameters of losses based on a little amount of data available. The most important aspect in measuring credit risk by *VaR* model is preparing the *transition matrix* as an indicator of the probability of a company's credit rating change over a certain period of time. One of the *VaR* models for evaluating the loan portfolio is *CreditMetrics* model. CreditMetrics model, first published in 1997, is a model on the basis of which a credit risk of a wide range of instruments and their portfolios can be measured, while starting from portfolio theory and VaR methodology. In contrast to the traditional models, which calculate only the probability of enforcement and non-enforcement of loan liabilities of the debtor, *CreditMetrics* model uses any assessment of the *Probability of Default (PD)* as input, and it estimates the risk of the portfolio due to changes in the value of debt, caused by the changes in the debtor's creditworthiness. Likewise, it estimates the risks in the overall portfolio, taking into account the correlation among the debtors. *CreditMetrics* model can be applied to calcu-

samo pod uslovom da kompanije imaju veri-fikovane kreditne rejtinge od strane priznatih rejting agencija ili banaka.

late the value of the loan portfolio only if the companies have had their credit ratings veri-fied by recognized rating agencies or banks.

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