So every market structure between H and B as well as between A and H gravitates to H. It is obvious that H is stable equilibrium. So it is an attractor.

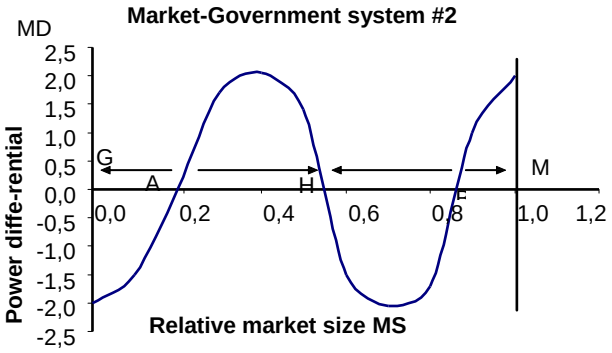


Fig. 2. **Evolutionary path #2**

What about the interval between B and M? Every structure within this interval due to economic entities positive feedback nature precipitates to M, the absolute market dominance.

Yet, the moves from A to H and from B to H need more explanation. Why is it that market domination power in A-H interval decreases? Why is there a decrease in government domination power within H-B interval? In case of precipitous positive feedback does not accelerating dynamics work?

Well, positive economic entities feedback nature remains intact, of course, yet it may be confronted by regulation.

This is why the system comes to the stable equilibrium point H.

It is interesting that Fig. 2 reveals two regulation types. Within A-H interval it is in favor of the market (the antitrust laws in the USA) and within interval H-B it is against market expansion or market failure (Glass-Steagall Act in the USA).

The notion of regulation, though, should be enlarged. To put it in a nutshell, each and every economic entity – households, companies, governments, should exercise some kind of regulation and self-regulation given the challenges of supposedly unsustainable (positive feedback loops at work!) life modes on our planet.

Regulation is a process characterized with a negative feedback loop. In a negative feedback loop the feedback signal works against the change in the system, leading to stable equilibrium, i. e. homeostasis. The notion of homeostasis is no stranger to biology. What is strange is that it has no place in economic theory, despite all signs of being absolutely adequate to the reality. Paradoxically, it may take evolutionary game theory to make it relevant to Economics.

Down to the economic interpretation of Fig. 2, given some factual evidence of existing stable equilibriums, attractors, it is inevitable that there are always unstable ones, repellers. There are two of them in our case.

Hence, repellers may represent crisis points. Point A may describe a transition to the market economy. Point B may well be adequate to the US situation before the recent crisis. The repeal of Glass-Steagall Act in the USA, among other things, intensified instability of the markets. Tipping the economy into reasonable regulation could have pushed it in the homeostasis direction. As with human body, it might have been temporary; the direction would still have been correct. Yet the economy was tipped by sub-prime mortgage mechanism in the direction of unfettered markets where market failures were more pronounced.

References: 1. Jacques Attali. A Brief History of the Future. Arcade Publishing. New York, 2009. 2. Donald. G. Saari. The Power of Mathematical Thinking: From Newton's Laws to Elections and the Economy, The Teaching Company, 2010.

Information about the author

Andrey Zanegin – PhD, Economics.

Інформація про автора

Занегін Андрій Георгійович – докт. екон. наук, професор.

Информация об авторе

Занегин Андрей Георгиевич – докт. экон. наук, профессор.

Рецензент
докт. екон. наук,
професор Лепейко Т. І.

Стаття надійшла до ред.
07.06.2012 р.

METHODICAL APPROACH TO ESTIMATION OF CORPORATE BONDS ISSUER DEFAULT RISK

UDC 336.763.3

O. Slutska

The article is devoted to the development of methodical approach to corporate bonds issuers default risk estimation. Fuzzy logic rules have been laid down generated to determine default risk level, focusing on four financial indicator values and of market

interest rate level. In addition, probabilities of company transition to another risk level and bonds issuer default after a certain time period have been calculated.

Key words: corporate bonds, issue, default risk, fuzzy logic, the classification tree, Markov chain.

МЕТОДИЧНИЙ ПІДХІД ДО ОЦІНЮВАННЯ РИЗИКУ ДЕФОЛТУ ЕМІТЕНТІВ КОРПОРАТИВНИХ ОБЛІГАЦІЙ

УДК 336.763.3

Слуцька О. В.

Стаття присвячена розробці методичного підходу до оцінювання ризику дефолту емітентів корпоративних облігацій. Сформовано нечіткі логічні правила, які надають змогу визначати рівень ризику дефолту, орієнтуючись на значення чотирьох фінансових показників та рівень ринкових відсоткових ставок. Крім того, розраховано ймовірності переходу компанії до іншого рівня ризику, а також ймовірність дефолту емітента облігацій через певний проміжок часу.

Ключові слова: корпоративні облігації, емісія, ризик дефолту, нечітка логіка, дерева класифікації, марківські ланцюги.

МЕТОДИЧЕСКИЙ ПОДХОД К ОЦЕНКЕ РИСКА ДЕФОЛТА ЭМИТЕНТОВ КОРПОРАТИВНЫХ ОБЛИГАЦИЙ

УДК 336.763.3

Слуцкая О. В.

Статья посвящена разработке методического подхода к оценке риска дефолта эмитентов корпоративных облигаций. Сформированы нечеткие логические правила, которые дают возможность определять уровень риска дефолта, ориентируясь на значения четырех финансовых показателей и уровень рыночных процентных ставок. Кроме того, рассчитаны вероятности перехода компании на другой уровню риска, а также вероятность дефолта эмитента облигаций через определенный промежуток времени.

Ключевые слова: корпоративные облигации, эмиссия, риск дефолта, нечеткая логика, дерева классификации, марковские цепи.

Due to the crisis in the Ukrainian economy in 2008 – 2010, there was a significant deterioration in corporate bonds issuers' creditworthiness. This resulted in lower liquidity and significantly reduced amounts of primary and secondary market debt securities. One of the main reasons for this status was lack of attention, and sometimes ignorance, of risk management procedures by a number of borrowers and investors. Given this Ukrainian corporate bonds market restoration requires appropriate issuer's default risk assessment methods development. That will enable to assess properly corporate borrower reliability.

Research in bond issuers' default probability estimation has been conducted by worldwide renowned scholars: E. Altman, F. Black, D. Duffy, R. Jerome, R. Merton, A. Peresetsky, R. Singleton, S. Turnbull, F. Fabozzi, W. Hickman, M. Scholes etc. Since the Ukrainian bond market is characterized by slightly different dimensions, existing models cannot be correctly applied to assess local issuers default risk, because they are based on data received from overseas financial markets. Problem of debt securities issuers reliability evaluation has also been studied by Ukrainian scientists: I. Britchenko, G. Velykoivanenko, V. Vitlinskii, L. Dolinskii, A. Kaminskii, B. Kyshakevych etc. However, the problem of corporate bonds issuer's default risk requires more detailed research and further development.

Risk assessment science-based methods development for corporate bonds and in particular issuer default risk as one of the most dangerous ones will heighten the interest of potential investors in these financial instruments. The tasks to be solved are based on the real defaults history in the domestic bond market in the past, with account taken of Ukrainian debt securities issuers peculiar features.

Bond issuers' default risk assessment must include decision-making mechanism that will predict the possibility of borrower's default in the future. Relating to previous research finding [1], the most appropriate approach in terms of Ukrainian economy conditions implies the use of bond issuers financial

statements. Higher quality results will be reached with account taken of macroeconomic indicators in the model, which determine default risk systematic component.

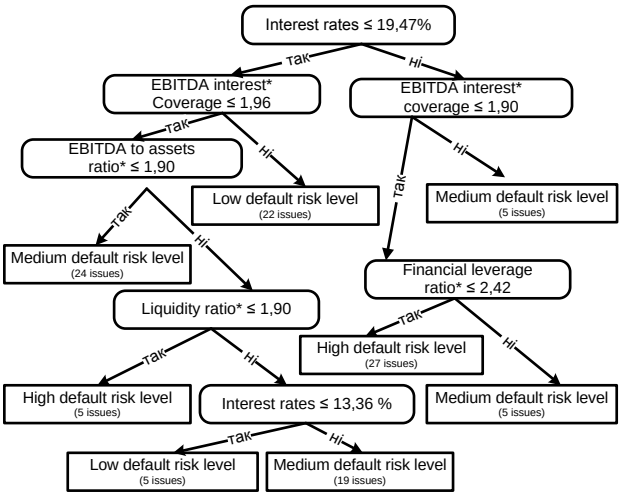
The correlation ratio has been calculated in order to analyse the relation between the observed number of defaults and macroeconomic indicators as well as determine the key exogenous indicators to forecast borrowers' default [2]. The result has revealed the most significant correlation to be observed between the quantity of defaults and bank interest rates.

Subsequently the factor analysis and the "gravity centre" method of were used to select basic financial indices for corporate bonds issuer's default risk estimation [3]. Financial leverage ratio, liquidity ratio, EBITDA interest coverage and EBITDA to assets ratio have been determined as the most significant financial indicators in determining a company's financial position. In order to determine the issuer's financial position classification criteria the three-level scale scores for previously selected parameters assessment have been elaborated [4]. The assessment is due to be conducted basing on the fuzzy logic tools.

The database of bond issuers, classified as reliable and unreliable ones in terms of their debt obligations, has been formed in order to identify certain relations between selected financial and macroeconomic indicators and the fact of a borrower's default in the past. Selected bond issuers' financial ratios that were outstanding within 2007 – 2011 have been transferred into fuzzy scale to form the initial database for further research. Each credit redemption event, which characterizes the issuer's reliability, or the last default (coupon payments violation and principal debt repayment, or moratorium on obligations repayment), which characterizes the borrower's unreliability have been considered as the research object. As a result, the sample of 112 objects, comprising of 69 event commitments and 43 defaults has been received.

A combination of StatSoft Statistica® Data Mining classification tree methods have been used to solve the bond issuers distribution problem in terms of default risk with regard to the selected ratios. Firstly, the Boosted Trees method was used. The basic principle of this method is to build a sequence of very simple binary trees [5]. As a result, 86 % of actually unreliable issuers, i.e. those who defaulted, have been classified correctly. As for reliable borrowers, the percentage of correctly classified ones was somewhat lower and amounted to almost 58 %.

Thus, the use of the boosted trees for company classification has resulted in failure to distribute bond issuers into two classes according to default risk. An intermediate class of issuers has been established taking into account a certain degree of belonging to reliable or unreliable issuers' classes. Bond issuers have been divided into three classes according to risk, namely low, medium and high classes, on the basis of borrowers' default probability represented using the boosted trees classification method. Furthermore, the CART method has been used to determine the classification rules for issuers' default risk. As a result, the classification tree structure represented in Fig. 1, has been obtained.



* – financial ratios were translated into fuzzy scale

Fig. 1. **Bond issuers classification at default risk**

The comparison of the actual credit events and projected default risk levels identified by the classification tree (Fig. 1) enabled to detect minor differences. Thus, only three issuers that were classified at low forecast default risk levels actually violated its debt obligation terms. However, it ought to be noted that the violations were recorded within technical default, because the obligations on the bonds were still being fulfilled, which confirmed the appropriate issuers financial condition level. Late payments in these cases were due to other reasons rather than borrower's financial inability, which is difficult to predict.

A more detailed analysis of eight issuers, who eventually fulfilled their obligations on the bonds, but had a high estimated risk level, led to the following summaries. Four issuers are subsidiaries of foreign or domestic financial groups. As a result, it is important for the mentioned debt issuers to maintain high reputation and positive credit history. Therefore, most likely, even with poor borrowing enterprises' financial state, parent companies did not permit to default on other group members bonds. As for other issuers with high default risk, which had still fulfilled their obligations, it ought to be noted that they made a breach in other payment periods on those or other series of bonds, and some of them were eventually declared bankrupt. All the above confirms high predicted borrower's default risk and possibility of their debt failure.

Subsequently, certain future default risk evaluation rules, represented as fuzzy linguistic variables shown in Tab. 1, have been formed on the basis of generalized bond issuers' distribution with regard to classification trees with fuzzy financial performance scales. Note that each rule weight reflects its degree of importance and adequacy. In order to determine optimal weight values for each of the proposed rules neural-fuzzy networks method with back propagation algorithm [6], which is implemented in the Matlab® ANFIS editor has been applied. Following up the procedure described, of model parameters optimization has been performed. Initial weight values for each rule have remained unchanged and equal to 1.

Table 1

Rules for determining corporate bonds issuers' default risk level

№	The indices level					Weight	The level of bonds issuer's default risk
	Financial leverage ratio	Liquidity ratio	EBITDA coverage of interest	EBITDA to assets ratio	Interest rates in the market	w	
1	×	×	-L	×	-H	1	L
2	×	-L	L	-L	L	1	L
3	×	×	-L	×	H	1	M
4	H	×	L	×	H	1	M
5	×	×	L	L	-H	1	M
6	×	-L	L	-L	M	1	M
7	-H	×	L	×	H	1	H
8	×	L	L	-L	-H	1	H

Note: L(-L) – low (not low) level; M(-M) – medium (not medium) level; H(-H) – high (not high) level

The borrower's default risk has been determined, using the operations with fuzzy sets based on the proposed fuzzy scales of four financial indicators, the interest rates level in the economy and prescribed rules. It ought to be mentioned that, as a result of calculation, the ambiguous issuer identity at one of default risk three levels has been obtained, providing more valid risk assessment, given the impact of numerous external and internal factors for each individual borrower.

Although at previous stages bonds issuers' classification problem was solved in terms of default risk, the next step is to solve the problem of borrower's risk class forecasting. To achieve this, the bond issuer's dynamic default risk level has been analysed using Markov chains method. Markov chain is a sequence of dependent trials, in which conditional events occurrence probability in each trial depends solely on the outcome of the previous trial [7].

In order to elaborate a transition probability matrix for each of the abovementioned 112 issues, specified issuers' default risk level has been assessed for the first-, second-, third and fourth-quarter period prior to a credit event (execution or defaults on bond issue). A number of causes for risk level conversions in any quarter in comparison with the previous quarter have been calculated. For the last quarter prior to credit events the transition to one of two states – default or debt payment – have been traced.

Markov chain of bonds issuers's default risk levels has been schematically represented in Fig. 2.

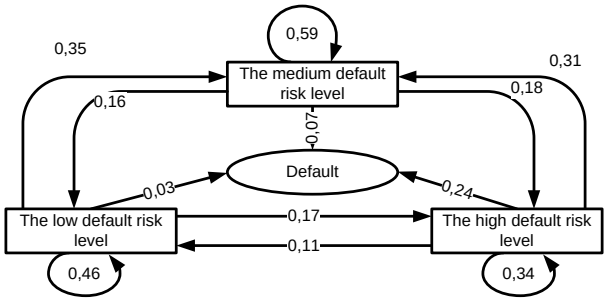


Fig. 2. **The probabilities of changing the bonds issuers' default risk level**

In Fig. 2 each risk level is defined by the probability of company's bond obligation default of to be averted in the next quarter. Thus, if the issuer is characterized by low risk in the current quarter, within the next period it will remain in this class with the probability of 46 %. It will shift to the middle level with the probability of 35 %, transfer to the high grade accounts for the probability of 17 %. The remaining 3 % characterises the default probability on bonds.

Thus, the use of Markov chains has enabled to predict the bonds issuer's default risk over time, relating to the current risk level and probability values transfer within risk classification in the next quarter. Bonds issuers' default probability after a certain period of time has been defined. The results have been presented in Tab. 2.

Table 2

Bonds issuers' default risk probability

The current bonds issuer's risk class	The issuer's default probability			
	within 1 quarter	within 2 quarters	within 3 quarters	within 4 quarters
Low level	3 %	9 %	14 %	18 %
Medium level	7 %	14 %	20 %	24 %
High level	24 %	33 %	39 %	43 %

Thus, in case the issuer is currently at the low risk level the issuer default probability within a quarter will total 3 %, and within 4 quarters – 18 % (see Table 2). The borrower's default possibility, being in the middle or high risk class in the current quarter also increases gradually along with broadening forecast horizon. These results are quite logical, because a longer time period always implies higher risk, due to the influence of various factors, both internal and external, which are difficult to predict.

Thus, the results of the study have formed grounds for a common methodological approach to corporate bonds issuers default risk evaluation. The sequence of main steps within this approach and implementation methods have been presented schematically in Fig. 3.

Thus, correlation between the values of bond issuers selected financial indicators (a reflection of the borrower internal condition) and the market interest rates level (a reflection of the environment) on the one hand, and fulfilment of obligations or default on bonds, on the other, have been ascertained.

The research findings have enabled to classify bonds issuers into three default risk levels on the basis of the generated and optimized fuzzy rules of attribution to a particular risk level. Probability values of transfer to other level in the forthcoming quarter have been determined and the issuer's default probability after a certain period of time has been estimated on the basis of current risk class.

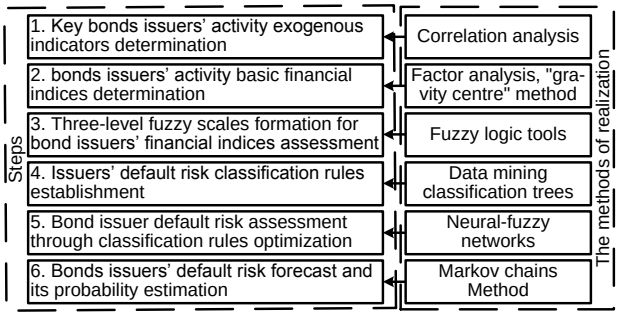


Fig. 3. **The sequence of steps for methodical approach to bonds issuers' default risk assessment**

Conclusions. The issuer classification highly depends on two major indices: EBITDA interest coverage and market interest rates. It has been proved shown that fuzzy logic assessment tools provide higher model adequacy, so they are recommended for practical application within the analysis of bond issuers and other enterprises. Established risk classes have appeared to be quite stable within time, periods which enables to use statistic methods in default probability forecast.

The methodical approach to corporate bonds issuers's default risk estimation has been elaborated, with account taken of the borrower's features, financial performance dynamics, the impact of macroeconomic factors and the overall market environment. In addition, it renders possible to determine default risk with some degree of affiliation. This enables to take into account the effects of other factors on the borrower, excluded from the model.

Further research of issuers' default risk impact is needed in the fund market influence field in Ukraine. Liquidity and other bond market risks estimates ought to be made as well.

Література: 1. Слуцька О. В. Аналіз методичних підходів до оцінки імовірності дефолту емітентів облігацій / О. В. Слуцька, І. І. Нескородєва // Вісник економіки транспорту і промисловості. – 2010. – № 31. – С. 124–130. 2. Слуцька О. В. Визначення факторів зовнішнього середовища при прогнозуванні дефолту емітентів облігацій / О. В. Слуцька // Збірник тез доповідей V Міжнародної науково-практичної конференції ["Теорія і практика економічного аналізу: сучасний стан, актуальні проблеми та перспективи розвитку"], (м. Тернопіль, 29 вересня – 1 жовтня 2011 року). – Тернопіль : ТНЕУ, 2011. – С. 314–316. 3. Слуцька О. В. Актуалізація інформаційної бази оцінки ризику дефолту емітентів корпоративних облігацій / О. В. Слуцька // Збірник матеріалів VI Міжнародної науково-практичної конференції ["Реформування економіки України: стан та перспективи"], (м. Київ, 24 – 25 листопада 2011 року). – К. : МІБО КНЕУ, 2011. – С. 217–220. 4. Слуцька О. В. Особливості оцінки фінансового стану емітентів корпоративних облігацій / О. В. Слуцька // Матеріали Міжнародної науково-практичної інтернет-конференції ["Стратегічні напрями розвитку національної економіки у посткризовий період"], (м. Львів, 2 – 3 квітня 2012 року). 5. Mease D. Boosted Classification Trees and Class Probability/Quantile Estimation / David Mease, Abraham J. Wyner, Andreas Buja // Journal of Machine Learning Research. – 2007. – № 8. – P. 409–439. 6. Матвійчук А. Моделювання фінансової стійкості підприємств із застосуванням теорій нечіткої логіки, нейронних мереж і дискримінантного аналізу / А. Матвійчук // Вісник НАН України. – 2010. – № 9. – С. 24–46. 7. Айвазян С. А. Теория вероятности и прикладная статистика / С. А. Айвазян, В. С. Мхитарян. – М. : ЮНИТИ-ДАНА, 2001. – 656 с.

References: Slutska O. V. Analiz metodychnykh pidkhodiv do otsinky imovirnosti defoltu emitentiv obligatsii [Analysis of Methodical Approaches to the Bond Issuers' Default Probability Estimation] / O. V. Slutska, I. I. Neskorodieva // Visnyk ekonomiky transportu i promyslovosti. – 2010. – No. 31. – Pp. 124–130. 2. Slutska O. V. Vyznachennia faktoriv zovnishnogo seredovyshcha pry prognozuvanni defoltu emitentiv obligatsii [Exogenous Factors Determination in Bond Issuer's Default Forecast] / O. V. Slutska // Zbirnyk tez dopovidei V Mizhnarodnoi naukovo-praktychnoi konferentsii ["Teoriia i praktyka ekonomichnogo analizu: suchasnui stan, aktualni prob-lemy ta perspektyvy rozvytku "], (m. Ternopil, 29 veresnia – 1 zhovtnia 2011 roku). – Ternopil : TNEU, 2011. – Pp. 314–316. 3. Slutska O. V. Aktualizatsiia informatsiinoi bazy otsinky ryzyku defoltu emitentiv korporatyvnykh obligatsii [Updating the Data base Corporate Bonds Issuers' Default Risk] / O. V. Slutska // Zbirnyk materialiv VI Mizhnarodnoi naukovo-praktychnoi konferentsii ["Reformuvannia ekonomiky Ukrainy: stan ta perspektyvy"], (m. Kyiv, 24 – 25 lystopada 2011 roku). – K. : MIBO KNEU, 2011. – Pp. 217–220. 4. Slutska O. V. Osoblyvosti otsinky finansovogo stanu emitentiv korporatyvnykh obligatsii [Estimation features of Corporate Bonds Issuers' Financial Situation] / O. V. Slutska // Materialy Mizhnarodnoi naukovo-praktychnoi internet-konferentsii ["Strategichni napriamy rozvytku natsionalnoi ekonomiky u postkryzovyi period"], (m. Lviv, 2 – 3 kvitnia 2012 roku). 5. Mease D. Boosted Classification Trees and Class Probability/Quantile Estimation / David Mease, Abraham J. Wyner, Andreas Buja // Journal of Machine Learning Research. – 2007. – No. 8. – Pp. 409–439. 6. Matviichuk A. Modeliuvannia finansovoi stiikosti pidpryiemstv iz zastosuvanniam teorii nechitkoi logiky, neironykh merezh I dyskryminantnogo analizu [Enterprises Financial Stability Modeling Using the Theory of Fuzzy Logic, Neural Networks and Discriminant Analysis] / A. Matviichuk // Visnyk NAN Ukrainy. – 2010. – No. 9. – Pp. 24–46. 7. Ayvazyan S. A. Teoriya veroyatnosti i prikladnaya statistika [Probability Theory and Applied Statistics] / S. A. Ayvazyan, V. S. Mkhitaryan. – M. : YUNITI-DANA, 2001. – 656 p.

Information about the author

Olga Slutska – Postgraduate student of Finance Department at Kharkiv National University of Economics (9a, Lenina ave., Kharkiv, 61166; e-mail: olga_slutskaya@mail.ru).

Інформація про автора

Слуцька Ольга Володимирівна – аспірант кафедри фінансів Харківського національного економічного університету (61166, м. Харків, пр. Леніна, 9а, e-mail: olga_slutskaya@mail.ru).

Информация об авторе

Слуцкая Ольга Владимировна – аспирант кафедры финансов Харьковского национального экономического университета (61166, г. Харьков, пр. Ленина, 9а; e-mail: olga_slutskaya@mail.ru).

Рецензент
докт. екон. наук,
професор Лепейко Т. І.

Стаття надійшла до ред.
18.05.2012 р.