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THE ATTEMPT TO CREATE AN INTERNAL CREDIT RISK RATING OF PRODUCTION COMPANIES WITH THE USE OF OPERATIONAL RESEARCH METHOD

Ewa Chodakowska, Katarzyna Wardzińska
Faculty of Management, Bialystok University of Technology
e-mail: e.chodakowska@pb.edu.pl, k.wardzinska@pb.edu.pl

Abstract: In the article the ratings developed by Moody's Corporation, Standard & Poor's Ratings Services and financial data of Polish windows manufactures were analyzed. Ratings published by international agencies were compared with an independently developed rating. Authors made an attempt to verify the hypothesis whether the internal rating created by means of operational research method, significantly differs from the ratings prepared by international rating agencies. In the article mathematical possibilities of potential changes in credit rating were presented.

Keywords: rating, credit risk, operational research, DEA

CREDIT RISK RATINGS

Introduction

Credit risk is most simply defined as the potential for the loss due to borrower's failure to meet its contractual obligation to repay a debt in accordance with the agreed terms [Credit Risk Management, The GARP Risk Series]. A popular tool for credit risk assessment are ratings prepared by international ratings agencies. According to the most famous rating agencies: Moody's Corporation and Standard &Poor's Ratings Services the main purpose of ratings is to provide investors with a simple system of gradation by which future relative creditworthiness of securities may be gauged [Ratings Definitions] or to provide a simple, efficient way to communicate creditworthiness and credit quality [About Credit Ratings]. It is worth noting that efficient use of the credit risk ratings by the company can also help in its development, gaining new customers and increasing market share.

Moody's Corporation and Standard & Poor's Ratings Services practically created a duopoly in the global market for credit rating agencies with all its consequences for the prices and quality of service. Moody's defines credit risk as the risk that entity may not meet its contractual, financial obligations as they come due and any estimated financial loss in the event of default [Moody's Rating Symbols & Definitions June 2013]. S&P definition is very similar: S&P credit ratings express the agency's opinion about the ability and willingness of an issuer, such as a corporation or state or city government, to meet its financial obligations entirely and on time [Credit Ratings Definitions & FAQs]. In other words Moody's and S&P's credit ratings are opinions of the credit quality of individual obligations or of an issuer's general creditworthiness. But none of the agencies gives any warranty, expressed or implied, as to the accuracy, timelines, completeness, merchantability or fitness of any rating or other opinions or information given or made by them in any form or manner whatsoever [Moody's Rating Symbols & Definitions June 2013]. Moody's and S&P ratings of credit risk are expressed as symbols grades that range from 'Aaa' to 'C' (Moody's) or from 'AAA' to 'D' (S&P). The general meaning of credit rating symbols is summarized in table 1.

Table 1. Moody's and S&P credit ratings symbols

Moody's rating	S&P rating	Opinions of the credit quality of obligations or of an issuer's general creditworthiness
Aaa,	AAA	Highest quality and lowest credit risk.
Aa1, Aa2, Aa3	AA+, AA, AA-	High quality and very low credit risk.
A1, A2, A3	A+, A, A-	Low credit risk
Baa1, Baa2, Baa3	BBB+, BBB, BBB-	Moderate credit risk
Ba1,Ba2,Ba3	BB+,BB,BB-	Substantial credit risk
B1, B2, B3	B+, B, B-	Speculative, high credit risk
Caa/C	CCC/C	Lowest creditworthiness, very high credit risk
D	D	

Source: based on [Moody's Rating Symbols] and [Guide to Credit Rating Essentials]

Authors made an attempt to verify the hypothesis whether the rating created with the use of one of the operational research methods: Data Envelopment Analysis (DEA), differs significantly from ratings prepared by credit rating agencies (CRA). Authors are aware that Moody's and S&P ratings belong to Through-The-Cycle credit indicators. Traditional DEA utilize available and pertinent information as of a given date so that provides a Point-In-Time credit risk measure. The assessment of changes in credit risk allows for instance the combination of DEA method and Malmquist index [Chodakowska 2013]. Nevertheless, limited by the availability of data, in the article, ratings published by international agencies for Polish windows manufactures were compared with an independently developed rating. Evaluation of similarities between classifications was done using Rand Index

and correlation matrix. At the end, mathematical possibilities of potential changes in credit rating were presented.

Data

The analysis covered 35 largest Polish companies in terms of revenue in 2010 estimated by the Centre of Sectoral Analysis in the industry: Manufacture of builders' ware of plastic (22.2.3 by Statistical Classification of Economic Activities in the European Community). Financial data for analysis was collected from ISI Emerging Markets Database. Available reports included employment, simplified profit and loss account, simplified balance sheet, simplified cash flow statement and selected financial ratios, e.g. in terms of financial leverage — total debt ratio, in the area of short-term liquidity — the share of cash in current assets, in the area of long-term liquidity — the share of equity and non-current liabilities in fixed assets and in the area of profitability — return on gross assets (ROA). The analyzed companies were classified by Moody's and S&P from Baa1/BBB+ to D (table 3).

Data Envelopment Analysis

Data Envelopment Analysis (DEA) is more and more popular and widely used method for determining the effectiveness of both commercial and non-profit organizations. Determining the effectiveness of the units using DEA method is to find the optimal technology by solving the adequate linear programming task [Cooper at al. 2007]. The optimal technology of the unit minimizes its inputs to a level not higher than the authentic and allows to get results not worse than the authentic (or maximizes the results to a level not lower than the authentic inputs, not higher than authentic) [Guzik 2009]. Comparing the optimal technology and empirical efficiency ratio is obtained. The resulting ratio has a value in the range of <0,1> [Guzik 2009].

From a variety of DEA analytical capabilities in the article authors used: determining the effectiveness of the units, rankings of the units' effectiveness and determining structure of inputs and outputs that guarantee 100% effectiveness.

ANALYSIS

Variables selections

In this article Authors made an attempt to compare the rating created with the use of operational research method and ratings prepared by CRA. For this purpose nine variables were selected: one informing about the size of the company — employment (X1), and eight financial indicators: debt ratio (X2), cash and cash equivalents in current assets (X3), equity and long-term liabilities in fixed assets (X4), sales revenue (X5), fixed assets (X6), current assets (X7), short-term liabilities

(X8), ROA (X9). Variables X10 and X11 denote Moody's and S&P rating. Correlation matrix for all the variables shown in table 2.

Table 2. Correlation matrix

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
X1	1.000	-0.196	0.188	-0.218	**0.833**	**0.663**	**0.656**	**0.526**	0.124	-0.223	-0.194
X2		1.000	**-0.364**	-0.243	-0.215	-0.181	-0.285	0.158	**-0.625**	**0.775**	**0.734**
X3			1.000	0.161	0.123	-0.058	0.285	-0.100	0.324	**-0.640**	**-0.672**
X4				1.000	-0.158	-0.239	-0.184	-0.268	**0.413**	**-0.374**	-0.266
X5					1.000	**0.798**	**0.801**	**0.783**	0.183	-0.229	-0.213
X6						1.000	**0.787**	**0.831**	-0.043	-0.112	-0.094
X7							1.000	**0.759**	0.143	**-0.343**	**-0.340**
X8								1.000	-0.140	0.092	0.086
X9									1.000	**-0.786**	**-0.764**
X10										1.000	**0.974**

Source: own calculations using STATISTICA 10;
bold — correlations are significant $p < 0.05$,
cells filled with grey — correlations between variable selected and Mood's and S&P rating

On the basis of correlation matrix Moody's and S&P ratings depend mainly on debt ratio (X2), cash and cash equivalents in current assets (X3) and ROA (X9). These variables as outputs and employment (X1) as the input indicator of the size of the company were chosen for further analysis with DEA BCC-O model for variable returns to scale [Cooper at al. 2007; Guzik 2009].

In order to fulfill the postulates of the DEA methodology i.e. unity of preference of all outputs and positive sign of the all the variables a differential transformation was applied for the variables X2 and X9:

for X2:

$$x_{i2} = a - bx_{i2}, \quad (1)$$

where:

$$a = \max_i \{x_{i2}\},$$

$$b = 0.9999,$$

for X9:

$$x_{i9} = a - bx_{i9} \quad (2)$$

where:

$$a = \min_i \{x_{i9}\},$$

$$b = 0.9999.$$

The authors are aware that every transformation of variables, except for scaling, affects the estimated using DEA efficiency, however, authors decided to apply transformations than exclude variable or units

Ratings

Analyzed polish manufactures of builders' ware of plastic have the rating from range Baa1/BBB to D by Moody's and S&P. Agencies are very similar in credit risk assessment. Differences between classes in their ratings are usually by one position up/down, maximum by two. CRA are fully completed in opinions about companies with lowest creditworthiness (Table 4). The correlation coefficient between these

ratings is 0.974. Generally, CRA estimate credit risk rather guardedly: substantial credit risk concerns 15 (16) enterprises. Only 5 (4) companies are judged higher.

Efficiency estimated using selected variables and DEA vary in the range from 18.8% to 100% (table 3). 11 out of the 35 enterprises are classified as 100% effective. This is due to the specificity of the linear programming problem solved in DEA, in which weights of the inputs are optimized to maximize the efficiency of each unit. Fully effective enterprises have the lowest credit risk in analyzed group, but not necessary in the whole sector. Nevertheless, the results of the DEA and the ratings issued by Moody's and S&P are similar. The correlation coefficient is 0.877 (Moody's) or 0.844 (S&P).

Because of the large number of classes they have been grouped for comparison. CRA' ratings for four categories according to the rating symbols' definitions as: moderate credit risk (1), substantial credit risk (2), speculative, high credit risk (3) and lowest creditworthiness, very high credit risk (4).

Similar, enterprises with the credit risk estimated using DEA were grouped. In this article for classification was used arithmetic mean $\bar{z}$ and standard deviation σ. 100% effective enterprises belong to first class of credit rating The other three groups include the companies with the values of effectiveness from the following ranges: second class $100\% > z_i \geq \bar{z}$, third class: $\bar{z} > z_i \geq \bar{z} - \sigma$, the fourth class: $\bar{z} - \sigma > z_i$. Categorized results are shown in table 4.

Table 3. Moody's, S&P and DEA credit ratings

Code	Decision Making Unit (DMU)	Moody's rating	S&P rating	DEA score	DEA rating
P1	Anwisa G Wiśniewscy sp.j.	Ba2	BB-	94.47	5
P2	Budvar Centrum SA	Ba1	BB	91.79	6
P3	Classen Pol SA	Caa/C	CCC/C	58.69	18
P4	Defor SA	D	D	38.17	23
P5	Drutex SA	Baa1	BBB+	100	1
P6	Eljako Al sp. z o.o.	Ba3	BB-	86.58	8
P7	Eurocolor sp. z o.o.	B3	B-	64.2	15
P8	Excellent Profile Grzybczyk Rogoda Szczepocki Ziębicki sp.j.	Ba1	BB	100	1
P9	Fakro Gp sp. z o.o.	Ba1	BB	100	1
P10	Firma Produkcyjno Handlowo Usługowa Wiśniowski	Ba3	BB-	100	1
P11	Hormann Legnica sp. z o.o.	Ba2	BB	88.02	7
P12	Invado sp. z o.o.	B3	B-	67.15	13
P13	Ispol sp. z o.o.	D	D	49.33	20
P14	Komandor SA	Ba1	BB	100	1
P15	Krispol sp. z o.o.	Ba2	BB-	79.3	11
P16	Markisol International Ltd sp. z o.o.	Ba2	BB-	100	1
P17	Mercor SA	Ba2	BB	66.55	14
P18	Nb Polska sp. z o.o.	B1	B	85.5	9

Code	Decision Making Unit (DMU)	Moody's rating	S&P rating	DEA score	DEA rating
P19	Okna Rąbień sp. z o.o.	D	D	43.16	22
P20	Oknoplast sp. z o.o.	Baa3	BBB-	100	1
P21	Opal Ryszard Szulc Wacław Olejniczak sp.j.	B3	B-	63.32	17
P22	Petecki sp. z o.o.	B3	B-	56.47	19
P23	Podlaska Fabryka Okien I Drzwi Witraż sp. z o.o.	B3	B+	63.86	16
P24	Pol Skone sp. z o.o.	Ba2	BB-	82.79	10
P25	Porta Kmi Poland SA	Ba1	BB	96.87	4
P26	Portos Renata Tomasz Szukalscy sp.j.	Baa2	BBB	100	1
P27	Pozbud T R SA	Baa2	BBB+	100	1
P28	Przedsiębiorstwo Produkcyjno Usługowo Handlowe Filplast Głogówek sp. z o.o.	B1	B+	97.4	3
P29	Roto Frank Okna Dachowe sp. z o.o.	Baa3	BB	100	1
P30	Seeger Dach sp. z o.o.	B2	B	100	1
P31	Sokółka Okna i Drzwi SA	D	D	23.55	24
P32	Sonarol sp.j. Najda	Ba3	BB-	78.04	12
P33	Stolbud Włoszczowa SA	D	D	18.82	25
P34	Stollar Systemy Okienne sp. z o.o.	D	D	47.86	21
P35	Velux Polska sp. z o.o.	Ba1	BB+	98.96	2

Source: ISI Emerging Markets Database and own calculations

Table 4.Moody's, S&P and DEA credit ratings

Moody's rating	S&P rating	DEA Class	Enterprises		
			Moody's classification	S&P classification	DEA classification
Baa1	BBB+	1	P5	P5, P27	P5, P8, P9, P10, P14, P16 ,P20, P26, P27, P29, P30
Baa2	BBB		P26, P27	P26	
Baa3	BBB-		P20, P29	P20	
Ba1	BB+	2	P2, P8, P9, P14, P25, P35	P35	P1, P2, P6, P11, P15, P18, P24, P25, P28, P35
Ba2	BB		P1, P11, P15, P16, P17, P24	P2, P8, P9, P11, P14, P17, P25, P29	
Ba3	BB-		P6, P10, P32	P1,P6, P10, P15, P16, P24, P32	
B1	B+	3	P18, P28	P23, P28	P3, P7, P12, P17, P21, P22, P23, P32
B2	B		P30	P18, P30	
B3	B-		P7, P12, P21, P22, P23	P7, P12, P21, P22,	
Caa/C	CCC/C	4	P3	P3	P4, P13, P19, P31, P33, P34,
D	D		P4, P13, P19, P31, P33, P34	P4, P13, P19, P31, P33, P34	

Source: ISI Emerging Markets Database and own calculations

In Table 5 were shown correlation coefficients between origin CRA' ratings, DEA rating, and grouped on the basis of DEA ratings (DEA class).

Table 5. Correlation

	DEA score	DEA ranking	Moody's rating	S&P rating	Moody's class	S&P class	DEA class
DEA score	**1.000**	**-0.980**	**-0.868**	**-0.835**	**-0.835**	**-0.834**	**-0.939**
DEA ranking		**1.000**	**0.877**	**0.844**	**0.838**	**0.832**	**0.964**
Moody's rating			**1.000**	**0.974**	**0.968**	**0.964**	**0.865**
S&P rating				**1.000**	**0.957**	**0.970**	**0.828**
Moody'sclass					**1.000**	**0.985**	**0.839**
S&P class						**1.000**	**0.830**

Source: own calculations using STATISTICA 10
bold — correlations are significant $p < 0.05$

For a formal comparison of ratings Rand index (R) and Adjusted Rand index (AR) were used (table 6). Rand index takes values from the range <0, 1>. The higher values indicate greater similarity with classification results.

Table 6. Rand Index and Adjusted Rand Index

	S&P classification		DEA classification	
Moody's classification	R=0.968	AR=0.922	R=0.739	AR=0.333
S&P classification			R=0.721	AR=0.290

Source: own calculations

High compatibility of ratings allows to induce that changes in levels in variables in DEA model should also change Moody's and S&P ratings. However it is worth notice that there is a large disparity between AR and R measures.

Potential changes

Potential improvements were identified through the analysis. Mathematical possibility to change the position of inefficient enterprises in the DEA ranking was presented. The optimum value, determined by the peer object was calculated. As a result, possibilities of rise enterprises efficiency by enhancing outputs and reducing inputs were showed. To show the possibility of changes in the ranking DEA for objects outside the first-class rating (inefficient) the target technology was calculated (technology that guarantees 100 percent efficiency). Optimal technology can be written as [Guzik 2009]:

$$T_i^* = \sum_{j=1}^{J} \lambda_{oj} T_j \tag{3}$$

where λ_{oj} means non-negative optimal weight for $j = 1,..,J$ object. T_j means j-th object technology. Weights are calculated with assumption that the i-th object to obtain optimal results uses not more than the real inputs.

Table 7. Optimal weight for inefficiency objects

DMU	Score	λ_{oj}										
		P5	P8	P9	P10	P14	P16	P20	P26	P27	P29	P30
P1	94.47	0	0	0	0	0.87	0	0	0.13	0	0	0
P2	91.79	0	0	0	0	0.845	0	0	0.155	0	0	0
P3	58.69	0	0	0	0	0.615	0	0	0.385	0	0	0
P4	38.17	0	0	0	0	1	0	0	0	0	0	0
P6	86.58	0	0.26	0	0.95	0	0	0	0	0	0.645	0
P7	64.2	0	0	0.273	0	0.269	0	0	0.458	0	0	0
P11	88.02	0	0	0	0	0.849	0	0	0.151	0	0	0
P12	67.15	0	0	0	0	0.294	0	0	0.76	0	0	0
P13	49.33	0	0.488	0.344	0	0	0	0	0.139	0	0.29	0
P15	79.3	0	0	0.71	0	0.169	0	0	0.341	0	0.419	0
P17	66.55	0.163	0	0	0	0	0.138	0	0.7	0	0	0
P18	85.5	0	0	0	0	0.542	0	0	0.458	0	0	0
P19	43.16	0	0	0	0	1	0	0	0	0	0	0
P21	63.32	0	0.27	0	0	0	0.14	0	0.32	0	0.558	0
P22	56.47	0.71	0	0	0	0	0.89	0	0.839	0	0	0
P23	63.86	0	0	0.75	0	0.25	0	0	0	0	0	0
P24	82.79	0	0	0	0	0.354	0	0	0.646	0	0	0
P25	96.87	0	0	0	0	0.588	0	0	0.412	0	0	0
P28	97.4	0	0	0.217	0.75	0	0	0	0	0	0	0.33
P31	23.55	0	0	0	0	0	0	0.238	0	0.762	0	0
P32	78.04	0	0	0.39	0	0.29	0	0	0.663	0	0	0
P33	18.82	0.169	0	0	0	0	0.831	0	0	0	0	0
P34	47.86	0	0.969	0	0	0	0.31	0	0	0	0	0
P35	98.96	0	0.59	0	0	0	0.34	0	0.14	0	0.361	0
Numbers of references		3	5	6	2	12	6	1	16	1	5	1

Source: own calculations using Banxia Frontier Analyst

In the table 7 optimal weights for inefficient objects were presented. Peers for them are: P5, P8, P9, P10, P14, P16, P20, P26, P27, P29 and P30 (units with the 100% efficiency score). The enterprise P26 was peers most frequently (16 times). This object was classified by the analyzed ratings in 1 class (table 4).

An example of changes in the ratings and classification of the group will be discussed at P1 enterprise. This object received in the Moody's rating Ba2 grade, at S&P — BB and was on the 5th place in DEA ranking with 94.47% efficiency score (table 4). From table 7 and by the actual data, the optimal technology for the enterprise P1 was written as:

$$T_{P1}^{*} = \lambda_{P14}T_{14} + \lambda_{P26}T_{26} = 0{,}87 \begin{vmatrix} x_{2,P14} \\ x_{3,P14} \\ x_{9,P14} \\ x_{1,P14} \end{vmatrix} + 0{,}13 \begin{vmatrix} x_{2,P26} \\ x_{3,P26} \\ x_{9,P26} \\ x_{1,P26} \end{vmatrix} = \begin{vmatrix} 0.986 \\ 0.364 \\ 0.379 \\ 182 \end{vmatrix}$$

The actual values for the object P1 are: $x_2 = 0.5596$, $x_3 = 0.0783$, $x_9 = 0.3582$, $x_1 = 250$. Comparison of actual results with the optimal allows to determine the direction and magnitude of change. The company P1 to reach a value that will change

places in the DEA ranking must: reduce the debt ratio of about 76%, increase cash and cash equivalents in current assets over three times (364%) and ROA about 6% even reduce employment of about 27%. These improvements would enable change the result of the efficiency, and thus change the classification of a group of 2 to 1. The same procedure can be used for other inefficient objects.

The example shows one of the possible changes in the ranking with using math calculations. In particular the target values for the analyzed variables was showed. In fact, the size of such modification (such as increase cash and cash equivalents in current assets over three) is not always possible. However this analysis may indicate direction of changes which leads to a reduction of credit risk. Computing capabilities are obviously larger (e.g., what kind of improvements enterprises can make to change only one level in the classification). This is not the purpose of this article to show all possibilities changes but only show that DEA can be used to determine them.

SUMMARY

Main issues of this article are relatively widely present in literature studies. The U.S. credit rating agencies after the spectacular scandals have been subjected to severe criticism. It is worth recalling the most famous: the Enron scandal revealed in 2001 — the giant U.S. energy company, which until its downfall had the highest credit rating AAA, or a fraud committed by Goldman Sachs, which mortgage securities awarded AAA in 2006 and 2007 were later downgraded to junk status [Faux 2011]. Rating agencies are criticized mainly for lack of transparency, conflicts of interest and ratings shopping, and lack of accountability for the ratings prepared [Deb 2011]. However, the ratings published by U.S. credit rating agencies still have great impact both on individual companies and global economy. Credit rating agencies play a significant opinion-forming role in global securities and banking services. Their ratings are often treated as 100% sure assessment, although agencies have borne no direct liability for errors in their judgments. The main reason is that ratings, although based on complex fundamental analysis and advanced mathematical models can be used mechanically by investors regardless of their education, knowledge or experience. The rating agencies, though undeservedly, still possess impeccable reputation and for many market participants are a sources of objective analysis [Brylak 2011].

This article shows how to create ratings and classified enterprises in groups using mathematical methods without the use of sophisticated analysis and based on the basic data (debt ratio, cash and cash equivalents in current assets, ROA and employment). The DEA ranking was almost 90% compatible with the rankings of the specialized agencies. In addition, the use of the DEA method allows to show the mathematical possibilities changes in the ranking. The results can be used by managers for determine directions of change that will allow the group to move to a lower credit risk. The study had cognitive and application character. It was

shown that the Data Envelopment Analysis can also be used as a tool for the analysis of credit risk.

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