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Comunicaciones Presentadas - Actas del Encuentro

Obra digital - ISBN: 978-84-16286-26-3

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32B

THE FINANCIAL PERFORMANCE AND CREDIT RISK OF MOLDOVAN AND PORTUGUESE COMPANIES USING DATA ENVELOPMENT ANALYSIS

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ÁREA TEMÁTICA: Valoración y Finanzas

Keywords*: Credit risk, data envelopment analysis, financial performance*

[1] R & D institution funded by the Foundation for Science and Technology, Ministry of Education and Science of Portugal.

Abstract:

The objective of this paper is to identify determinants of a company's financial performance and assessing its credit risk by analyzing the differences in technical efficiency among a sample of companies from the Republic of Moldova and Portugal. Data envelopment analysis (DEA) is a mathematical programming model applied to a set of observations for each company corresponding to achieve output level for given input levels. DEA provides a comprehensive analysis of relative efficiency for multiple input – multiple output situations by evaluating each company and measuring its performance relative to an envelopment surface composed of other companies. Companies that lie on the envelopment surface are deemed efficient and companies that do not lie on the surface are termed inefficient and the analysis provides a measure of their relative efficiency.

Keywords*: Credit risk, data envelopment analysis, financial performance*

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INTRODUCTION

In the last decade of the 20th century, nearly all major international banks invested heavily in human and technological resources in order to reorganize their methods of assessing and managing credit risk. This revolutionary process was by no means limited to a mere technical innovation associated with risk management methods, but affected one of the most traditional, established areas of banking, namely credit (Cristoffersen, 2012). As Bruni, Beraldi, and Iazzolino, (2014) say „*credit risk is a hot topic not only for banks, lenders and investors, providing credit to sustain small and medium enterprises, vulnerable to shocks caused by wrong lending decisions, but also for all types of manufacturing firms. Besides the fact that firms act directly as lenders when they grant credit extension to some customers, credit risk evaluation can help to predict and prevent possible defaults within the supply chain*" (p.766).

It is important to give a short explanation of what is meant by "credit risk": *the possibility that an unexpected change in counterparty's creditworthiness may generate a corresponding unexpected change in the market value of the associated credit exposure* (Crouhy, Galai, & Mark, 2000; Giesecke, 2002). There is a vast literature on credit risk assessment and methodologies to measure credit risk (Altman & Saunders, 1997; Calin & Popovici, 2014; Khemakhem & Boujelbènea, 2015). The most popular ones have been the Multifactorial discriminant analysis, whose promoter had been Altman (Altman & Saunders, 1997) but other methodologies that have been proposed are artificial neural networks (Khemakhem & Boujelbènea, 2015) or even Data Envelopment Analysis (DEA) (Bruni et al., 2014; Paradi, Asmild, & Simak, 2004; Tsolas, 2015).

This paper aims to propose a method connecting the credit risk and the technical efficiency provided by the DEA methodology and comparing the results with the official credit risk ratings that have been calculated using the methodology of National Bank of Moldova. The same method is applied to a set of data which includes 530 companies from Portugal. The companies are from a wide range of industries and of different scales in terms of total revenues and total assets. Some obvious outliers have been removed from the initial set of data; however the diversity and wide variation of the data has been preserved (Toma, Dobre, Dona, & Cofas, 2015).

This paper is structured as follows. After this short introduction the data and methodology is presented in the section Material and Method. Then, the results are presented and discussed in the third section and finally the conclusions

MATERIAL AND METHOD

DEA methodology evaluates companies' financial performance using the methods of mathematical programming. Within a given set of companies, we know the obtained output level (sales revenues) for each company and the used input level (financial data from the balance sheet and income statement). On the basis of the given data it can be defined the space of company's performance if only certain hypothesis concerning these facts were accepted (Sironi & Resti, 2007). To measure the performance one should report the sales revenues of each company to the set the frontier of possible values. In order to determine the performance frontier for a given number of companies K and for which we have the primary data concerning the number of inputs M and the number of outputs N, one can define the space of performance possibilities as given by equation 1:

$$\{(x^k, y^k) \in IR^{M+N} (k = 1...K)\} \quad (1)$$

The distance function that evaluates the output oriented efficiency of every company can be calculated as follows (equation 2):

$$DF_O(x, y) = \max\{\theta \mid \theta y \in P(x)\} \quad (2)$$

where P(x) is the space of performance possibilities (Coelli, 1996).

The mathematical model which determines the relative efficiency for the set of K companies with the variable return to scale is given by set of equations 3:

$$\begin{aligned} &\max_{\lambda,\theta} \theta \\ &I_K^T \lambda = 1 \\ &X^T \lambda \le x^0 \\ &Y^T \lambda \ge \theta y^0 \\ &\lambda, \theta \ge 0 \end{aligned} \quad (3)$$

Where, I_K is a vector column with all other K components equal to 1.

The given model identifies the biggest growth that is equiproportional with θ^0 of the output y^0 for which still exists a convex combination of the primary set of data $(X^T\lambda, Y^T\lambda)$, that is at least as efficient as $(x^0, \theta^0 y^0)$. If the multitude of performance possibilities has a non-decreasing return to scale growth, then the condition $I_K^T\lambda = 1$ must be replaced with $I_K^T\lambda \geq 1$. In this case, if θ^0 is a solution of the mathematical model, for $\theta^0 \leq 1$ the company (x^0, y^0) doesn't belong to the multitude of performance space offered by the set of data $\{(x^k, y^k) \in IR^{M+N} (k = 1...K)\}$. If $\theta^0 = 1$, then the company (x^0, y^0) is efficient, and if $\theta^0 \geq 1$, the company (x^0, y^0) is inefficient. In this case the value $\theta^0 y^0$ represents the biggest output that can be obtained by equiproportional growth of the output y^0, which is possible to be obtained with the input x^0. This point represents the output radial projection y^0 on the frontier of the space of performance possibilities P(x).

RESULTS AND DISCUSION

Economic data processing has been done with the programme "DEAP 2.1" (Coelli, 1996). The set of data used to estimate company's financial performance includes outputs and input factors as follows:

As outputs:

Y1 – sales revenues, thousand lei,

A inputs

X1 – total long term assets, thousand lei

X2 – inventories, current assets, thousand lei

X3 – other short term assets, thousand lei

X4 – owners' equity, thousand lei.

X5 – total short term liabilities, thousand lei

X6 – total long term liabilities, thousand lei

The Table 1, below presents the calculated values for the financial performance using DEA analysis and also the credit risk rating attributed using National Bank of Moldova regulations to a set of Moldavian companies. The credit risk assessment was performed by the specialists of a Moldovan commercial bank. Their methodology includes financial statement analysis of the companies, but also the credit history, payment behaviour and some subjective information. It is worth mentioning that a rating of value "2" implies almost no risk (under 2% default risk) and a rating of "5" implies a bigger amount of credit risk (about 5%-10% default risk).

Table 1. Financial performance and credit risk

Number of company	Performance using constant returns to scale	Performance using variable returns to scale	Scale	Type	Credit rating
1	0,057	0,422	0,134	drs	2
2	0,039	0,111	0,347	drs	5
3	0,237	0,383	0,619	drs	2
4	0,001	0,005	0,173	drs	5
5	0,007	0,028	0,246	drs	2
6	0,024	0,036	0,672	irs	5
7	0,044	0,045	0,966	drs	2
8	0,020	0,058	0,343	drs	2
9	0,065	0,418	0,156	drs	2
10	0,414	0,650	0,637	drs	2
11	0,044	0,100	0,444	drs	2
12	0,007	0,012	0,537	drs	5
13	0,040	0,441	0,091	drs	2
14	0,178	0,209	0,852	drs	2
15	0,002	0,013	0,181	drs	2
16	0,002	0,004	0,535	drs	5
17	0,285	0,566	0,505	drs	2
18	0,006	0,015	0,407	drs	2
19	0,437	0,649	0,673	drs	2
20	0,160	0,253	0,631	drs	2
21	0,122	0,122	0,997	-	2
22	1,000	1,000	1,000	-	2
23	0,002	0,004	0,396	drs	2
24	0,001	0,008	0,064	drs	2
25	0,003	0,009	0,367	drs	2
26	0,213	0,263	0,811	drs	5
27	0,002	0,008	0,275	drs	2
28	0,484	1,000	0,484	drs	5
29	0,231	1,000	0,231	irs	2
30	0,028	0,036	0,793	drs	5
31	0,002	0,005	0,368	drs	2
32	1,000	1,000	1,000	-	2
33	0,000	0,001	0,376	drs	5
mean	0,216	0,343	0,599		

In the second column of Table 1 it is represented the performance scores relative to a frontier constant return to scale and in the third column the performance scores relative to a frontier variable return to scale estimated. In the column “Scale” the ratio between the first two columns is presented (Charnes, Cooper, & Rhodes, 1978). Also, it is indicated the type of the scale, and namely “irs” for increasing return to scale and “drs” for decreasing return to scale, respectively.

As can be seen in Table 1, according to constant returns to scale technology, the companies 32 and 22, whose performance score equals to 1 are efficient and are located on the performance space frontier. The average value of financial performance within the sample, according to CRS option is 0,216, which is a not a very high index unfortunately. The total number of companies from the sample is actually 100 and this analysis was performed on all of them. As we can observe, the majority of

ratings considering the National Bank of Moldova regulation are between "2" and "5", which represent a reasonable amount of risk (Glasserman, 2003).

The analysis of performance frontier is made up by defining the enveloping companies using respective weights evaluation λ_k. Thus, for the company 22 (in Table 1) which is considered efficient and which can describe its own frontier, the financial performance is equal 1 and its original inputs and outputs values coincide with recommended values of these parameters. For the company 14, which has a financial performance of 0,178, the enveloping companies are 22, 65 and 80 (see *Figure 1*). Total sum of weights of enveloping companies 0,887, 0,068 and 0,046 in comparison with the reference company equals to 1.

Results for company: 14
Performance = 0.209
Scale efficiency = 0.852 (drs)
PROJECTION SUMMARY:

variable	original value	radial movement	slack movement	projected value
output 1	35231.000	133370.298	0.000	168601.298
input 1	2557.000	0.000	-252.195	2304.805
input 2	2423.000	0.000	-413.565	2009.435
input 3	3037.000	0.000	-2055.065	981.935
input 4	2354.000	0.000	0.000	2354.000
input 5	2040.000	0.000	0.000	2040.000
input 6	3654.000	0.000	-2034.429	1619.571

LISTING OF PEERS:

peer	lambda weight
22	0.887
65	0.068
80	0.046

Figure 1. Performance Frontier for company 14

The evaluation results try to capt the connection between the financial performance of each company and the credit risk that is attributed. On average, we can observe a tendency that shows a lower financial performance to a company that has a higher risk rating, thus a rather low creditworthiness. In this way, using this technique, a bank or a decision maker can infer the creditworthiness of any new company that applies for a credit line, using the DEA method and assess and quantify appropriately the credit risk and correctly price it, thus influencing the rate of return of the original loan.

The same methodology was applied to a sample of 530 Portuguese companies. Also, the DEA analysis was performed using the same factors as on the Moldovan sample of companies. The Table 2 below presents some of the results for Portuguese data set.

*Table 2***.** Financial performance of Portuguese companies

Number of company	Performance using constant return to scale	Performance using variable return to scale	Scale	Type	Net income, thousand euro
1	0,665	1,000	0,665	drs	-414632
2	0,405	1,000	0,405	drs	77330
3	0,325	1,000	0,325	drs	67962
4	0,155	0,184	0,844	drs	28073
5	0,119	0,133	0,890	drs	23176
6	0,249	0,250	0,999	-	15770
7	0,137	0,146	0,943	drs	11537
8	0,237	0,282	0,840	drs	-51130
9	0,284	0,316	0,898	drs	-53395
10	0,106	0,115	0,928	drs	2473
11	0,243	0,250	0,973	drs	3537
12	0,196	0,197	0,994	irs	6035
13	0,711	1,000	0,711	drs	53142
14	0,319	0,474	0,673	drs	29509
15	0,316	0,353	0,895	drs	81069
16	0,162	0,163	0,995	irs	4385
17	0,148	0,150	0,986	irs	4140
18	0,438	1,000	0,438	drs	-12818
19	0,898	1,000	0,898	drs	-55002
20	0,140	0,419	0,335	drs	7591
21	0,507	1,000	0,507	drs	182023
22	0,039	0,051	0,771	irs	-86377
23	0,200	1,000	0,200	drs	8006
24	0,066	0,071	0,931	irs	-9754
25	0,230	0,256	0,896	irs	-107463
mean	0,331	0,677	0,526		

From Table 2, the first observation to be made is that the average performance using variable return to scale of the Portuguese firms is almost double than the efficiency of Moldovan sample of companies (0.677 compared to 0.343). Secondly, as no credit risk assessment was available for Portuguese firms, the profitability (as measure by Net Income, in thousands Euro) was considered. The profitability is measured with an absolute financial indicator instead of a financial ratio. This is due to the fact that the authors calculated if a firm is profitable or not, has a positive or negative net income. Usually, a profitable firm has a higher creditworthiness and vice versa. However, no statistically significant correlation could be observed between the efficiency calculated with DEA and the net income of a firm. For example, using the data from Table 2, the company number 1 has a performance using variable return to scale of 1.00 and negative net income. In the same time, the company number 4 has a much lower efficiency (0.184), but has positive profitability. This is probably also due to the fact that the Portuguese set of data represents firms from a wide range of industries and total revenue levels, as opposed to the Moldovan data, which is more concentrated on the small and medium enterprises of the agricultural sector.

CONCLUSIONS

On the basis of financial performance analysis in the sample of 100 Moldovan companies we can assert that the nonparametric technics of envelopment use mathematical programming models to build the performance space frontier P(x). According to the performed research we can conclude that:

1. When applying radial measure $DF_O(x, y)$ to determine the company's relative performance we have the possibility to make a more detailed evaluation than the one achieved with the help of economic indices traditionally used in the national practice of economic analysis and adding an important variable when considering credit risk
2. Unfortunately, because of rather obscure accounting practices of many of Moldovan small and medium firms, the DEA analysis shows a relatively low average of financial performance. This also represents a rather strong limitation of this paper. A more relevant credit risk assessment can be performed on a higher quality accounting data of Moldovan firms. Also, the fact that this paper considered only the financial analysis part, excluding information about credit history, collateral and payment behavior, represents another strong limitation. A statistical-based methodology that would incorporate all these would provide more accurate results.
3. It is also worth taking in consideration that the two frontiers, CRS and VRS are rather distant from each other, and we can assess that the companies carry on their activity not very close to the optimal scale and are rather scattered among the interval used
4. The proposed DEA methodology has its limitations when applied to a more diverse set of data. When trying to assess the profitability, and thus the creditworthiness, of Portuguese firms, the DEA methodology proved to be less efficient than for the Moldovan firms. The authors believe that this is due to the diversity of the Portuguese firms in terms of industries and Total Revenues/Assets. Another point to be made is that the Portuguese firms proved to be much more efficient than Moldovan companies, but, as mentioned, this efficiency calculated with DEA cannot still be connected to credit worthiness or profitability.

ACKNOWLEDGEMENTS

This research work was carried out with the support of the project 2015-1-PT01-KA107-012870 "ERASMUS+KA1 International Credit Mobility" of the Polytechnic Institute of Bragança, Portugal and the State Agrarian University of Moldova, Republic of Moldova. We want also to acknowledge to Jorge Alves, a colleague that supplied us with the data for Portuguese sample.

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