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THE COMPARISON OF FINANCIAL RATIOS AND NON-CLASSICAL METHODS OF EFFICIENCY ESTIMATION[1]

WSKAŹNIKI FINANSOWE A NIEKLASYCZNE METODY OCENY EFEKTYWNOŚCI – PORÓWNANIE WYNIKÓW

Key words: technical efficiency, financial ratio, DEA method, SFA method
Słowa kluczowe: efektywność techniczna, wskaźniki finansowe, metoda SFA, metoda DEA

Abstract. The article compares the efficiency scores obtained using traditional financial indices, and the frontier approaches such as the Stochastic Frontier Analysis (SAF) and the Data Envelopment Analysis (DEA) methods. The comparative analysis is conducted on a group of the food industry companies for 2007 and 2008. Two financial ratios, namely the ROA and the ROS, are used as a classical measure of efficiency. These indices are chosen because of the convergence of variables are used in the ROA and the ROS and in the SFA and DEA models. Results show a slight correlation of the ROA and efficiency scores obtained using the DEA method. Correlation coefficients range from 0.38 to 0.48 at the significance level less than 0.05. For other correlation coefficients, the significance level exceeds the accepted critical level.

Introduction

Due to the growing interest among researchers in non-classical methods of efficiency measurement raises the question of the comparison field with the results of standard techniques (such as financial ratios). Therefore, the research has important cognitive and application impact.

If the financial ratios should give an overview of the financial situation of a company it should be noted that it is necessary to consider all complementary groups of indices[2], which is the weakness of this approach. In literature one can find believes that the financial indicators do not reveal the cause of occurring of some economic pheromones [Telep 2004]. In addition, the use of financial ratios does not allow conducting a meaningful comparison among enterprises. Cantner, Krüger and Hannusch shown that the financial indicators provide an efficiency comparison only by limited assumptions, namely to create economic indicators one needs to know, or adopt, the monetary expression of inputs and outputs [Cantner et al. 2007].

The existence of weaknesses in the use of financial indicators opens a field for further research. The ratio analysis that does not allow for multidimensional approach while assessing efficiency, is widely used [Kulawik 2008, Urban 2005, Dróżdż 2005]. In literature one can find many examples of studies on the efficiency of enterprises, organizations, administrative units, areas of the state, etc. In the context of surveyed communities both micro- and macro-economical analyzes are distinguished. Basing on the foreign literature review, one can state that applications of non-classical methods, both parametric and nonparametric, dominate among the researches on efficiency. However, in the Polish literature, applications of non-classical methods are a relatively new direction of researches.

The non-classical methods are applied by the Polish researchers in such areas like: food economics, agriculture and banking. One can highlight here the studies concerning efficiency of food processing companies [Bezat, Jarzębowski 2010, Gołębiowski et al. 1999], farms with dominating plant production [Bezat 2011, Jurek, Świtłyk 2002], management in agriculture [Kulawik 2008, Świtłyk 1999], companies of Agricultural Property Agency [Helta, Świtłyk 2008], and commercial farms [Bieńkowski et al. 2005]. The efficiency analysis of banking, based on the nonparametric methods, is conducted by e.g. Gospodarowicz [2009], Rogowski [1998], Kopczewski and Pawłowska [2008]. Among the publications, where the

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[2] To conduct the ratio analysis, classical financial ratios are used that can be divided into four ratio groups [Kasiewicz 1995]: liquidity, activity, profitability, debt ratio. It is essential to include all these groups so that the analysis will give the overall financial picture of a company. According to J. Telep, the ratio analysis is not a perfect tool for efficiency assessment – it does not allow making a unique comparison of companies [Telep 2004].

DEA method is applied, one can highlight also the studies by Guzik, concerning efficiency of non-profit organizations [Guzik 2009]. Basing on the foreign literature review, one can state that applications of non-classical methods, both parametric and nonparametric, dominate among the researches on efficiency. For instance in the field of agribusiness, Lakner and Brümmer apply the stochastic frontier approach for the panel data of German grassland farming [2008]; Latruffe, Balcombe, Davidowa and Zawalińska for Polish farms [Latruffe 2002], Kong, Marks and Wan for China [Kong et al. 1999].

The literature overview indicates that non-classical and classical methods are used parallel for assessment of enterprises performance. There is a strong need for examination if some relationship between results of non-classical (like the DEA and the SFA) methods and classical (like financial indices) methods exists.

Materials and methods

Methods for efficiency assessment can be divided into two main groups, these are: analyzes using financial ratios and frontier approaches – both parametric and nonparametric methods.

Financial efficiency[3] is determined by financial ratios and frontier approach enables assessment of technical efficiency (and eventually allocative efficiency if prices of inputs or outputs are known which implies the possibility of determining economic efficiency). Within the framework of the frontier approach, the parametric approaches and nonparametric approaches are distinguished, among which there are deterministic (e.g the DEA method) and stochastic (e.g the SFA method) methods. In the parametric approaches, contrary to the nonparametric ones, parameters are determined whose significance and distribution may be evaluated using statistical methods. In the stochastic methods, contrary to the deterministic ones, the random component is taken into account.

The first method – the SFA – is a widely used stochastic procedure for parametric creation of the efficiency frontier. The approach is stochastic – it considers additionally a random variable that allows distinguishing deviations from the efficiency frontier caused by inefficiency and statistic noises (measurement errors or random errors caused by e.g. weather) [Mortimer, Peacock 2002]. The SFA as a parametric approach requires assuming a specific function form a priori determining the input(s)-output relation. The frontier is estimated econometrically using ordinary last squares and its variants or maximum likelihood [Coelli et al. 2005].

The second method – the DEA – is a non-parametric, deterministic procedure for evaluating the frontier. Nonparametric procedures determine a frontier which "envelops" the observations and – according to J.M. Bates, D. Baines and D.K. Whynes – the data "speaks for itself" [Bates et al. 1996].

In the study the parametric SFA method was used and to refine the results – as a supplementary – the DEA method was applied. The DEA model specification was carried out on the basis of the results of the SFA method. By the SFA method a selected function describing interdependence between outputs and inputs was chosen (statistical verification of the selection of functional form was carried out based on the likelihood ratio test). The results were compared with the selected financial indicators (here the ROA and the ROS).

Results of the research

In the paper the efficiency scores obtained using traditional financial indices, and frontier approaches (the SFA – Stochastic Frontier Analysis and the DEA – Data Envelopment Analysis) were compared. The comparative analysis was conducted for a group of companies of the food industry for the year 2007 and year 2008.

Within the framework of obtaining the research objectives, financial data of individual, Polish, companies from food industry was applied. Financial statements published in the Polish Monitor B[4] were the source of the data (NACE group 14.27). The efficiency assessment was conducted on the basis of financial data from 42 objects from across Poland.

The purposeful selection of objects was used in the study. The selection criterion was achieving by a company the share of revenue from grain sales in the total revenue at a level above 50% which ensures homogeneity of the analyzed group. These companies reach together above 60% of revenue from grain trade in Poland which indicates the importance of the analyzed group on the Polish market. Inputs and output included in the analysis are presented in Table 1.

In the table 2 (for year 2007) and in table 3 (for year 2008) the basic statistics for analyzed group for inputs and output were presented.

[3] The term financial efficiency is applied in the ratio analysis by Wielicki and Baum 2009] and Kulawik et al. [2009].

[4] Companies that publish their financial statements in the Polish Monitor B meet at least two of the following conditions: average employment in full-time equivalent is equal to more than 50 employees, the sum of assets at the end of the financial year is equal to at least 2.500.000 euro, net sales income from goods and products, and financial operations is equal to at least 5.000.000 euro.

Table 1. The inputs and output applied in efficiency assessment
Tabela 1. Nakłady i efekt wykorzystane w ocenie efektywności

Inputs/*Nakłady*	**Designation/ *Oznaczenia***	**Output/ *Efekt***	**Designation/ *Oznaczenia***
Fixed assets value/*Wartość aktywów trwałych*	***X1***	net revenues from sales of goods and materials/ *przychody netto ze sprzedaży towarów i materiałów*	***Y***
Value of sold goods and materials/ *Wartość sprzedanych towarów i materiałów*	***X2***		
Operating costs less the value of sold goods and materials/ *Koszty działalności operacyjnej pomniejszone* o wartość sprzedanych towarów i materiałów	***X3***		

Source: own study
Źródło: opracowanie własne

Table 2. The input and output descriptive statistics in the sample for 2007
Tabela 2. Podstawowe statystyki nakładów i efektów w badanej próbie w 2007 r.

Descriptive statistics/*Statystyki*	**Values [PLN]/*Wielkości [zł]***			
	Y	***X1***	***X2***	***X3***
Mean/*Średnia*	79 090 505	9 190 052	72 068 917	12 934 668
Standard deviation/*Odchylenie standardowe*	158 740 996	14 701 618	151 508 012	18 083 027
Minimum/*Minimum*	173 534	117 038	159 723	122 612
Maximum/*Maksimum*	1 069 955 355	74 838 232	1 026 164 790	100 189 882

Source: own study
Źródło: opracowanie własne

Table 3. The input and output descriptive statistics in the sample for 2008
Tabela 3. Podstawowe statystyki nakładów i efektów w badanej próbie w 2008 r.

Descriptive statistics/*Statystyki*	**Values [PLN]/*Wielkości [zł]***			
	Y	***X1***	***X2***	***X3***
Mean/Średnia	85 102 778	10 937 997	77 097 233	14 254 403
Standard deviation /*Odchylenie standardowe*	161 824 476	16 751 126	153 162 215	19 598 026
Minimum/*Minimum*	113 505	112 263	112 505	111 511
Maximum/*Maksimum*	988 036 073	68 139 284	942 709 226	109 822 578

Source: own study
Źródło: opracowanie własne

In the study two functional forms describing the inputs-output relation, namely the Cobb-Douglas and trans-logarithmic model were involved. The parameters were estimated with use of the maximum likelihood method. Comparison of the selected functional forms (the Cobb-Douglass and trans-logarithmic model) was carried out basing on the likelihood ratio statistics. Basing on the hypotheses' verification, it was stated that a model without restrictions on parameters – the trans-logarithmic model – better describes the inputs-output relation.

In the analysis, the trans-logarithmic model was applied with the following functional form:

$$\ln y_i = \beta_0 + \sum_{j=1}^{k} \beta_j \ln x_{ij} + \frac{1}{2} \sum_{j=1}^{k} \sum_{l=1}^{k} \beta_{jl} \ln x_j \ln x_l + v_i - u_i \quad (1)$$

where:
i – index indicating objects i=1,...,I, where I is a number of objects in a sample,
j – index indicating inputs j=1,...,l,
y_i *– output of an object i,*
x_{ij} *– input j of an object i,*
β *– vector of parameters to estimate,*
v_i *– random variable representing the random error, so called statistical noise,*
u_i *– a positive random variable associated with technical efficiency.*

The second step was a specification of the DEA model. A researcher has a wide range of models while using the DEA method. They differ mainly within the framework of returns to scale that are attributed to objects of a given sample. The selection of a model influences the values of the efficiency ratios and – similarly to the case of variables' selection – also bases on expertise or practices used among other researchers. In the case of verification nature of the DEA method, it was considered to adopt the same assumptions on returns to scale, as in the stochastic analysis.

In the context of the discussed assumptions, the NIRS-O[5] model were applied in the analysis. This approach aims at maximization of outputs by a given level of input(s). The NIRS-O model is presented in equations from (2) to (6).

$$\max_{\phi_k, \lambda_k} \phi_k \tag{2}$$

$$\phi y_k \leq \sum_{i=1}^{I} \lambda_{ik} y_i \tag{3}$$

$$x_{nk} \geq \sum_{i=1}^{I} \lambda_{ik} x_{ni} \tag{4}$$

$$\lambda_{ik} \geq 0 \tag{5}$$

$$\sum_{i=1}^{I} \lambda_{ik} \leq 1 \tag{6}$$

where:
k – index of an analyzed object,
Φ_k – multiplier of outputs level for an object k[6],
i – index of a subsequent object i=1,…,I, where I is a number of objects in the sample,
y_i – an output determining sales revenues of an object i,
n – index of a subsequent input,
x_{ni} – an input n used by an object i,
λ_{ik} – coefficient of the linear combination between objects i and k.

The last step was the calculation of two financial ratios, namely the ROA and the ROS. These indices were chosen because of the convergence of variables using in the ROA and the ROS as well in the SFA and the DEA models. The return on total assets ratio (the ROA) – used to assess the profitability of assets. This ratio indicates the company's ability (and more specifically – of its assets) to generate a profit. The return on sales ratio (the ROS) indicates the value of the net profit attributable to each unit of sold products and services.

Comparisons between the ROA and the ROS indicators and indicators of technical efficiency obtained with the SFA and DEA methods were determining by using the correlation coefficients of Spearman and Pearson. The values of correlation coefficients are shown in the table 4 (for year 2007) and in the Table 5 (for year 2008).

Table 4. The Spearman and Pearson correlation coefficient values for the ROA and ROS indices calculated using the SFA and DEA methods for 2007
Tabela 4. Zestawienie współczynników korelacji Spearmana i Pearsona pomiędzy wskaźnikami SFA, DEA, ROA i ROS w roku 2007

Coefficient/*Wskaźniki* correlation coefficient/ *współczynnik korelacji*		**ROA**		**ROS**	
		correlation coefficient/ *współczynnik korelacji*	**significance level/*poziom istotności***	**correlation coefficient/ *współczynnik korelacji***	**significance level/*poziom istotności***
SFA	Spearman correlation/ *korelacja Spearmana*	0.13	0.285	-0.20	0.109
	Pearson correlation/ *korelacja Pearsona*	-0.09	0.445	-0.06	0.652
DEA	Spearman correlation/ *korelacja Spearmana*	0.39	0.001	-0.33	0.009
	Pearson correlation/ *korelacja Pearsona*	0.38	0.002	-0.11	0.386

Source: own study
Źródło: opracowanie własne

[5] The NIRS-O model assumes non-increasing returns to scale and the output-oriented approach.
[6] It is the inverse of the efficiency ratio.

Table 5. The Spearman and Pearson correlation coefficient values for the ROA and ROS indices calculated using the SFA and DEA methods for 2008
Tabela 5. Zestawienie współczynników korelacji Spearmana i Pearsona pomiędzy wskaźnikami SFA, DEA, ROA i ROS w 2008 r.

Coefficient/*Wskaźniki*		**ROA**		**ROS**	
		correlation coefficient/ ***współczynnik korelacji***	**significance level/*poziom istotności***	**correlation coefficient/** ***współczynnik korelacji***	**significance level/*poziom istotności***
SFA	Spearman correlation/ *korelacja Spearmana*	0.13	0.351	0.00	0.962
	Pearson correlation/ *korelacja Pearsona*	-0.02	0.912	-0.02	0.889
DEA	Spearman correlation/ *korelacja Spearmana*	0.48	0.000	-0.11	0.462
	Pearson correlation/ *korelacja Pearsona*	0.38	0.006	-0.20	0.155

Source: own study
Źródło: opracowanie własne

The obtained results show a slight positive dependence of the ROA and technical efficiency scores obtained by using the DEA method. Designated Spearman and Pearson correlation coefficients were ranged from 0.38 to 0.39 at the significance level below 0.01 for the year 2007 and from 0.38 to 0.48 at the significance level below 0.01 for the year 2008.

For the second index one can observe a slight negative dependence of the ROS and technical efficiency scores obtained by using the DEA method. Designated Spearman correlation coefficient amounted to -0.33 at the significance level below 0.01 for the year 2007.

For other variables, the significance level of calculated correlations scores exceeded the critical value, which in consequence prevents the interpretation of results.

The study shows that there is no statistically significant relationship between the selected financial indicators and technical efficiency scores obtained with the SFA and DEA methods,.

Conclusions

In the framework of the paper the comparison of the efficiency scores obtained using traditional financial indices, and the frontier approaches like the SFA method (the SFA – Stochastic Frontier Analysis) and the DEA method (the DEA – Data Envelopment Analysis) was carried out. Based on the results of the analysis the following conclusions regarding the efficiency of enterprises were formulated:

1. There is a slight positive dependence of the ROA and the technical efficiency scores obtained by the DEA method. The relationship was obtained for the data set from year 2007 and from year 2008.
2. A slight negative dependence of the ROS and technical efficiency scores obtained by using the DEA method can observe for the year 2007.
3. It was noted that the SFA scores and the ROA and the ROS indices are not correlated.
4. The obtained results confirmed that any strong relationship between results of non-classical frontier approaches of efficiency measurement and the classical financial ratios like e.g. the ROA or the ROS can be observed. This statement is not strange or unexpected, since the two approaches used in the paper rely on different methodological assumptions. The frontier approaches (like the DEA or the SFA method) allow calculating efficiency scores in a specified group of objects (each object is evaluated in comparison to the best one in the group or to the particular trend/function). In the case of financial indicators, each object is examined individually.

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Streszczenie

Celem podjętym w artykule było porównanie wartości wskaźników efektywności uzyskanych przy zastosowaniu klasycznych miar finansowych, jak i podejść granicznych (SFA – Stochastic Frontier Analysis oraz DEA – Data Envelopment Analysis). Analizę porównawczą przeprowadzono na grupie przedsiębiorstw z branży żywnościowej za lata 2007-2008. Jako klasyczne miary efektywności wykorzystano dwa wskaźniki finansowe, a ROA oraz ROS. Wskaźniki te zostały wybrane ze względu na zbieżność zmiennych w nich występujących i zmiennych włączonych do modeli SFA i DEA. Na podstawie uzyskanych wyników stwierdzono nieznaczną zależność wartości wskaźników ROA i wskaźników efektywności uzyskanych przy wykorzystaniu metody DEA. Wyznaczone współczynniki korelacji wynosiły od 0.38 do 0.48 na poziomie istotności poniżej 0,05. W przypadku pozostałych zmiennych poziom istotności wyznaczonych współczynników korelacji przekroczył przyjęty poziom krytyczny.

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