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TECHNICAL EFFICIENCY OF SMALL AND MEDIUM SIZED ENTERPRISES IN MACHINERY SECTOR OF THE SLOVAK REPUBLIC*

Abstract. *The main aim of this paper is to determine the effectiveness of the surveyed enterprises by Data Envelopment Analysis (DEA) models and formulate concrete recommendations for the studied small and medium-sized enterprises (SME) in the machinery sector.*

We chose SME as object for investigation according to Commission Recommendation 2003/361/EC. The object for investigation is chosen, because the machinery sector has in the development of the Slovak economy key role – employing the highest number of workers, creating a substantial part of GDP, and its products constitute the largest share of exports. According to SK NACE Rev. 2, we focus on the engineering industry, especially on the category number 28 – Manufacture of Machinery and Equipment.

Keywords: *enterprises efficiency; economic performance; DEA models; engineering enterprises.*
JEL Classification: *C14*

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ТЕХНИЧЕСКАЯ ЭФФЕКТИВНОСТЬ МАЛЫХ И СРЕДНИХ ПРЕДПРИЯТИЙ В СЕКТОРЕ МАШИНОСТРОЕНИЯ СЛОВАЦКОЙ РЕСПУБЛИКИ

Аннотация. Основной целью статьи является определение эффективности рассматриваемых предприятий с помощью моделей анализа среды функционирования (АСФ) и предложение конкретных рекомендаций для повышения эффективности мелких и средних предприятий (МСП) отрасли машиностроения.

В качестве объекта исследования мы выбрали МСП в соответствии с Рекомендациями Европейской Комиссии 2003/361/ЕС. Этот объект рассматривался потому, что машиностроение в экономике Словацкой Республики занимает ключевое положение – в отрасли занято наибольшее количество сотрудников, на ее предприятиях создается существенная часть ВВП, машиностроительная продукция составляет значительную долю экспорта страны. Мы сосредоточили свое внимание, в частности, на такой категории машиностроения, как «Производство машин и оборудования».

Ключевые слова: эффективность предприятий, экономический результат, АСФ модели, машиностроительные предприятия.

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ТЕХНІЧНА ЕФЕКТИВНІСТЬ МАЛИХ І СЕРЕДНІХ ПІДПРИЄМСТВ У СЕКТОРІ МАШИНОБУДУВАННЯ СЛОВАЦЬКОЇ РЕСПУБЛІКИ

Анотація. Основною метою статті є визначення ефективності підприємств за допомогою моделей аналізу середовища функціонування (АСФ) та вироблення конкретних рекомендацій для підвищення ефективності малих і середніх підприємств (МСП) галузі машинобудування. Об'єктом дослідження ми обрали МСП відповідно до Рекомендацій Європейської Комісії 2003/361/ЕС. Цей об'єкт розглядався тому, що машинобудування в економіці Словацької Республіки займає ключове положення – у галузі зайнята найбільша кількість співробітників, на її підприємствах створюється істотна частина ВВП, машинобудівна продукція становить значну частку експорту країни. Ми зосередили свою увагу, зокрема, на такій категорії машинобудування, як «Виробництво машин та устаткування».
Ключові слова: ефективність підприємств, економічний результат, АСФ моделі, машинобудівні підприємства.

Introduction. Most of researches, considering management of corporate performance in 21st century, focus on determinants of efficiency (Lesakova, 2004; Gosselin, 2005; Neumaierova, & Neumaier, 2005; Wagner, 2009). The concept of corporate performance is based on the idea of the unification of corporate production activities as human resources, material and capital resources, to achieve the common goal of positive results in terms of financial performance of the company. The entities providing business assets to the company will continue doing it only in case of their appreciation regarding the alternatives of their possible application. Achieving performance is related to the ongoing value creation, and if the value created by the application of assets will be at least equal to the expectations of stakeholders who have provided them, will continue to be available to the company and ensure its further existence. We must take into account that research results are largely affected by changes in the dependent variables. To determine the efficiency of the manufacturing companies in the article we deal with DEA models. The efficiency is defined as the proportion between what the production company reached with its operations and incurred tangible and intangible resources. Even in the context of evaluating the effectiveness there is currently a single, comprehensive and universal model (Banker et al., 1982; Cooper et al., 2004; Jablonsky & Dlouhy, 2004; Hebak et al., 2005). Selecting DEA model as an effectiveness evaluation tool was affected mainly by its biggest advantage, namely the possibility of an individual evaluation of production units efficiency compared with the whole set.

We can divide different entities into effective and ineffective. Another procedure arising from the achievements is to identify the source of inefficiency of a particular business entity and describe its potential to achieve the efficiency frontier in conjunction with changes in the available inputs and outputs.

Brief Literature Review. In scientific literature the DEA method is known as an important means of economic management enabling the evaluation of the efficiency of single producers in the framework of a given group (Banker et al., 1992). The method DEA is considered a relatively new nonparametric method evaluating efficiency, the performance or productivity of homogeneous production units, dealing with the production of the same or similar outputs and using the same or similar inputs (Cooper et al., 2004). DEA models enable to evaluate individually the rate of efficiency of examined production units in connection to the values of the whole set which is considered as the biggest advantage. It enables to divide the units into two groups – those which are efficient, and those which are not. At non-efficient organizational units it is possible to identify the source of non-efficiency and this way to determine the way how the unit can reach the limit of efficiency by reducing or by raising inputs or outputs. DEA methods have extensive possibilities of application, for example in state administration, health care, education, banking, in organizations, etc. (Hebak et al., 2005).

The basic aim of DEA models is to compare the productivity of firms or organizational units which we denote as DMU (Decision Making Unit). Each DMU uses for its activity a certain number of inputs and the result of the activity are certain outputs. Inputs are such variables which are used in a given activity and outputs present the end products. Generally we prefer smaller values of inputs and bigger values of outputs. The basic idea of DEA models classification is their focus on inputs or on outputs (Jablonsky & Dlouhy, 2004; Cooper et al., 2006). The term efficiency is used in different sectors of human activities (agriculture, health care, public administration, banking and financial sector, etc.) and it is often confused with the term productivity which also belongs to partial indicators of performance.

The advantage of DEA approach compared with econometric methods is first of all the fact that it is simpler to apply, there are no requirements on parametric methods (the assumption of normality of division, the extent of the set) and it does not require information about the prices of inputs and outputs. It achieves adequate results with small extents of sets of evaluated companies and if it is applied in combination with appropriate statistical tools (regressive analysis, analysis of variance, tests of mean values match etc.), we can answer a whole range of questions concerning the firm's efficiency.

Purposes. The main objective of this paper is to determine the effectiveness of the surveyed enterprises by DEA models and formulate concrete recommendations for the studied small and medium-sized enterprises (SME) in the machinery sector. From the basic theoretical research of business economic efficiency (Bourne, 2004; Curtis & Cobham, 2008; Lukacik, Lukacikova & Szomolanyi, 2010), we can formulate the following research questions. What combination of inputs and outputs is most important for the effective functioning of the enterprise? Are investigated enterprises able to transform the selected inputs and outputs efficiently? What are the possibilities for inefficient enterprises to improve its position in relation to their production? We formulated scientific problems on the basis of the theoretical background and set of research questions. SMEs do not sufficiently deal with raising the economic efficiency (Kafkova & Hudak, 2013).

The methodology of the work could serve as a source of business information and procedures to determine their economic efficiency and its increasing. The main subject of investigation in these companies is based on selected indicators and changes of their values to determine the reasons why a company is economically more efficient than other comparable companies in the survey sample. As in the short term (one year) we can't realistically evaluate research results and their impact on business efficiency, so we confine the research period interval of six years (2007-2012). We consider as essential to focus on economic efficiency defined by Sheffrin and Sullivan (2003, p. 15), hence the use of inputs manner geared towards maximizing the output of goods and services.

For the efficiency of the economic system we can consider the condition when maximum number of products and services were provided without further increasing the amount of inputs.

We chose as object for investigation the SMEs in the manufacturing of machinery and equipment according to the classification of SMEs Commission Recommendation 2003/361/EC. That classification established by the European Commission is binding and uniformly adopted in all EU countries. Geographically, the research area was designated for Kosice region and Presov region, and it is possible to establish a research in other regions of Slovakia. Object of investigation was chosen, because the engineering industry has in the development of the Slovak economy key role – it is employing the highest number of workers, creating substantial part of GDP, and its products constitute the largest share of exports (Statistical Office, 2013). Recession, the decline in consumption and the increase in debt have a direct impact on the enterprises functioning as the essential elements of global economy (Pukala, 2010). So main aim for them is to improve its financial results and provide conditions in which losses do not go beyond the inevitable ones (Pukala, 2012).

According to the statistical classification of economic activities SK NACE Rev. 2 we focus on the engineering industry, especially on the category 28 – Manufacture of machinery and equipment (Statistical Office, 2013). The research sample of enterprises is defined as maximum and minimum number of employees (10 to 249 employees). SMEs make up the largest group of companies in this category.

Criteria for creating the survey sample are: operating on the Slovak market for at least six years, place of business in Kosice region or Presov region and must be small and medium enterprise (by number of employees). From the basic sample, we randomly selected 30 companies. This number was determined by us because of the intensity of processing data of a large number of enterprises. The main method used to meet the objective was the application of DEA models. The results of the application of models allow us to determine the location of firms in relation to their production possibility limit, and whether they are achieving it (effective enterprises) or are below its value (inefficient firms).

An important positive feature of the models is that we can work with several input and output variables when efficiency is evaluated. Positive and simplistic nature of the models is the absence of appropriate tests of normality with the ability to mix different types of input and output variables and options to handle numerically smaller sample than the reference one. The role of models is the calculation of efficiency of the selected enterprises in comparison with other enterprises of the sample. The disadvantage of DEA models is their inability to interpret deviation of the output from production possibility frontier (Majorova, 2007).

Results. Using four selected groups of inputs and outputs of the surveyed enterprises we have conducted calculations to determine their effectiveness with use of the DEA models. We performed 180 observations. The resulting values of calculated efficiency of surveyed enterprises are shown in Table 1 in the form of basic statistical characteristics. Comparing the results of all the models, most companies belonging to the group designated as effective businesses were in the third model (85%), where was achieved the highest efficiency of 0,764. With care on account variable Foreign Sources and Total Costs, the results of first model appear to be second best.

The worst results of efficiency were achieved in fourth model, where the examined enterprises reached the efficiency only in 65% of observations. The diversity of inputs and outputs caused the difference in the resulting values. The use of different sets of input and output variables may grant a wider view of the technical efficiency of evaluated objects.

The amount and type of variables used in the DEA models can significantly affect the calculation of technical efficiency, as can be seen in the following example (Table 2). In addition to the original four CCR DEA models, in which we used two to three input and output variables, we verify the CCR DEA model (input-oriented) with one input (total cost) and one output variable (total income). Based on a simplified CCR DEA model we compare the results of the technical efficiency of a variable number of input and output variables.

Unlike the first four models, the results of the fifth model, which uses only one input variable (cost) and one output variable (income), only 3% of the whole set of observations during the reporting period are marked as efficient. Minimum level of technical efficiency declined in the fifth model to 0,088 and the average rate of technical efficiency to 0,077. For the previous reasons, we propose the use of the studied models in the enterprises, public and government administration to identify and compare the efficiency of time and spatial terms, with subsequent analysis and optimization of input and output variables. While we compare the efficiency, it is necessary to consider several variants of input and output variables in terms of the needs of the organization. A larger number of input and output variables take into account the weight of more factors, which may not actually point out the weaknesses of the compared objects. In the input oriented model it is more appropriate to specify the input variables, and in the output oriented model to specify output variables.

So DEA models can optimally distribute the weight of individual variables in the model and the result is more precise correction of the variables in case of inefficiency of the organization. In recommendations for companies in the survey sample, we consider the results of calculating the technical efficiency of four CCR DEA models which show efficiency of input variables in the production of output variables. In the pursuing of business efficiency we must first establish criteria for the definition of efficient and inefficient enterprises, whereas the calculation of the four business models could be effective within one and ineffective in the second model. In the Table 3 companies are listed, including their efficiency, respectively inefficiency. Effective observation (θ_p) consists of 24 observations for each company taking into account the four CCR DEA models over 6 years. This means that the number of effective observations will assess the overall ability of the enterprise to achieve the value 1

Tab. 1: **Basic statistical characteristic of technical efficiency (whole sample)**

DEA model	I. model	II. model	III. model	IV. model
Min	0,621	0,523	0,764	0,602
Max	1	1	1	1
ø	0,967	0,949	0,979	0,938
σ	0,062	0,078	0,043	0,081
Effective SMEs, %	81	69	85	65

Source: Own sources of the authors

Tab. 2: **Comparison of the statistical characteristics of models**

DEA model	I. model	II. model	III. model	IV. model	V. model
Inputs	3	2	3	3	1
Outputs	2	3	2	2	1
Min	0,593	0,483	0,632	0,556	0,088
Max	1	1	1	1	1
ø	0,896	0,952	0,913	0,932	0,75
σ	0,048	0,074	0,042	0,082	0,256
Effective SMEs, %	81	69	85	65	3

Source: Own sources of the authors

Tab. 3: **Comparison of the enterprise efficiency in selected period**

SMEs	1	2	3	4	5	6	7	8	9	10
θ_p	8	9	11	16	19	16	14	14	20	17
θ_T	17,82	17,83	18,57	19,69	19,89	19,72	19,53	19,30	20	19,75
θ_A	0,89	0,89	0,92	0,98	0,99	0,98	0,97	0,96	1	0,98
SMEs	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
θ_p	15	20	9	20	7	12	11	13	13	9
θ_T	19,31	20	18,83	20	18,08	19,96	18,18	19,21	19,44	19,28
θ_A	0,96	1	0,94	1	0,9	0,99	0,91	0,96	0,97	0,96
SMEs	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
θ_p	12	13	16	13	18	16	18	19	10	6
θ_T	18,89	19,17	19,34	18,78	19,80	19,50	19,95	19,88	18,28	18,32
θ_A	0,94	0,95	0,96	0,94	0,99	0,97	0,99	0,99	0,91	0,91

Source: Own sources of the authors

in all tested models during the 2007-2012. In Table 3 are also reflected the observations of a particular reporting period. A value of 1 represents the efficiency of the company ($\theta = 1$) and the value 0 inefficiency of the company ($\theta < 1$).

We consider all four models and for evaluating of the overall efficiency of $\theta = 1$ in a particular year, we entered the condition of at least three effective models in a given year. Total score (θ_T) is the sum of all the variables of technical efficiency for six years and the maximum score is 24. The average score (θ_A), on the other hand, shows the average reached value of technical efficiency, taking into account all four CCR DEA models in all the years. In evaluating the technical efficiency through CCR DEA models, we considered the basic statistical characteristics of the whole set of technical efficiency observations (720 observations), which is based on four CCR DEA models for 6 years in the 30 companies. Measures of technical efficiency within the entire set of observations ranged <0,1>, the minimum level of technical efficiency (θ) reached 0,523, the average value of θ was 0,966 and the standard deviation reached 0,07. Taking into account the overall score and average enterprises in the survey sample reflects the fact that the survey sample are not extremely inefficient firms, and thus the sample is considered as representative.

With use of the calculated values we register a maximum of 3 businesses as efficient (9, 12, 14) and the total score θ_T reached 20 and average score θ_A reached 1 – the maximum possible value. These three companies were efficient under all conditions during the period, and therefore represent a model of efficiency for other firms in the survey sample. The second group consists of efficient firms (5, 16, 25, 27, 28), which achieved total score $\theta_T \geq 19{,}5$ and average score $\theta_A \geq 0{,}99$.

These enterprises are still considered as efficient because they showed to be inefficient only in one year of the period. This means that despite the short-term decline in effectiveness to other companies in the survey sample were able to optimize their inputs and outputs in subsequent periods. Other businesses in the survey sample reached different levels of inefficiency during the period in different models. Because of the extent of the article it is not possible to take the results of all models. For this reason, we chose the third CCR DEA model (Table 4), which translates as the best when compared to variables in business efficiency. When calculating θ_3, 85% of observations proved as efficient, while at the same time the highest score and the average minimum rate of technical efficiency was achieved. This means that the opportunity to become an inefficient enterprise was lower than in other enterprises.

In calculations of third model in all years of the period were effective companies 4, 5, 8, 9, 10, 12, 14, 22, 25, 26, 27 and 28. As relatively efficient firms are also subjects, which reached an average level of technical efficiency $\theta_{3T} \geq 4{,}9$ (Enterprise 6, 7, 17, 19, 20, 21, 24). The in efficiency is reflected in those businesses just under two financial years and had no impact on the further development of enterprises. Based on the results in Table 4 the least efficient companies were 1, 11, 13, 15, 16, 18, 29 and 30. For this reason, we address the recommendations to just the least efficient enterprises in terms of optimizing the input and output variables in the third model. In presenting proposals we formulated the use of DEA models in financial analysis. The practical contribution is the comparison of different DEA models. Recommendations were formulated on the basis of the results of DEA models that businesses of the research sample can use for other purposes. Similarly, the companies can use their own method of measuring effectiveness through applied DEA models.

Conclusion. The economic efficiency of the enterprises existing in the current competitive environment is becoming an essential competitive advantage and affects the success of manufacturing enterprises by way of their organization and approach to managing manufacturing processes. Important characteristic feature of satisfaction of their customers are quality production, repeated shortening delivery times compared with competing companies and adherence to agreed deadlines.

So, efficiency relates to rationality in business activities and relates to compliance with the principles of business – the need to carry out socially useful production and ensure the performance of the company. Researches in the area of SMEs effectiveness in foreign scientific works are oriented more on agriculture. Methodology of work and the methods targeted at selected businesses in category Manufacture of Machinery and Equipment are based only partly on implemented and established practices of calculating the efficiency of manufacturing companies. Based on the identified problem of scientific research questions were answered as follows:

What combination of inputs and outputs is most important for the effective functioning of the business? We were dealing with the calculation of technical efficiency of manufacturing companies using DEA models. Input and output variables are different for each model, and we take into account the value of the available financial records of companies, allowing us to create a picture of their performance.

Are investigated businesses able to transform the selected inputs and outputs efficiently? Taking into account all the criteria set out for the studied business 30 firms whose financial data were processed for the period 2007 to 2012 remained in the survey sample. The final number of observations was 180. Consequently we identified efficient enterprises and inefficient

Tab. 4: **Results of technical efficiency of the third model**

SMEs	1	2	3	4	5	6	7	8	9	10
θ_{3T}	4,46	4,69	4,73	5	5	4,99	4,95	5	5	5
θ_{3A}	0,89	0,93	0,94	1	1	0,99	0,99	1	1	1
SMEs	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
θ_{3T}	4,71	5	4,67	5	4,74	4,75	4,97	4,81	4,96	4,93
θ_{3A}	0,94	1	0,93	1	0,94	0,95	0,99	0,96	0,99	0,98
SMEs	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
θ_{3T}	4,92	5	4,82	4,94	5	5	5	5	4,82	4,67
θ_{3A}	0,98	1	0,96	0,98	1	1	1	1	0,96	0,93

Source: Own sources of the authors

enterprises. In each year, 12 enterprises achieve efficiency and 8 were inefficient.

What are the possibilities for inefficient firms to improve their position in relation to their production possibility? We formulated for enterprises with the lowest number of positive results in the individual years concrete proposals resulting from the calculation of technical efficiency. Results confirm the assumption of importance of monitoring corporate performance in order to achieve the overall efficiency of the business. Efficient businesses reported the positive results in terms of corporate performance represented by a selected group of economic indicators. Positive results have been in the case of efficient enterprises mainly achieved in all selected indicators, which did not allow us to warrant a presumption of significant share of only some of them on the achieved efficiency.

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БАЗОВЫЕ СТРАТЕГИИ РОСТА ПРЕДПРИЯТИЙ РОЗНИЧНОЙ ТОРГОВЛИ (НА ПРИМЕРЕ ДОНЕЦКОЙ ОБЛАСТИ)

Аннотация. *В статье осуществлен анализ основных тенденций развития розничной торговли Донецкой области в 2006–2012 гг. Исследование показало, что более трети предприятий региона к 2012 году стали убыточными. Сделан вывод о необходимости разработки и реализации эффективных стратегий роста предприятий розничной торговли. Рекомендованы базовые стратегии роста для исследуемых предприятий.*
Ключевые слова: *стратегия роста, розничная торговля, динамика розничного товарооборота, рентабельность, финансовый результат.*

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БАЗОВІ СТРАТЕГІЇ ЗРОСТАННЯ ПІДПРИЄМСТВ РОЗДРІБНОЇ ТОРГІВЛІ (НА ПРИКЛАДІ ДОНЕЦЬКОЇ ОБЛАСТІ)

Анотація. У статті здійснено аналіз основних тенденцій розвитку роздрібної торгівлі Донецької області у 2006–2012 рр. Дослідження показало, що понад третина підприємств на початок 2012 року стали збитковими. Зроблено висновок про необхідність розробки і реалізації стратегій зростання на підприємствах роздрібної торгівлі. Рекомендовано базові стратегії зростання для досліджуваних підприємств.
Ключові слова: стратегія зростання, роздрібна торгівля, динаміка роздрібного товарообороту, рентабельність, фінансовий результат.