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TECHNICAL AND SCALE EFFICIENCY OF SUGAR AND CONFECTIONARY PRODUCERS IN 2006-2016. DOES THE SIZE AND LEGAL STATUS OF ENTERPRISE MATTERS?

EFEKTYWNOŚĆ TECHNICZNA I SKALI PRODUCENTÓW CUKRU I WYROBÓW CUKIERNICZYCH W LATACH 2006-2016. CZY MA ZNACZENIE WIELKOŚĆ I STATUS PRAWNY PRZEDSIĘBIORSTW?

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Słowa kluczowe: przedsiębiorstwa, sektor spożywczy, efektywność techniczna

JEL codes: L25, L66, O32

Abstract. The article empirically examines how the size and legal status of an enterprise influence the technical and scale efficiency of Polish food producers. Technical and scale efficiency indices are measured using the non-parametric DEA method. The study is based on the annual financial reports of 52 sugar and confectionery producers operating in 2006-2016. The analysis covers all enterprises in the sector, as well as groups of larger and smaller enterprises (distinguished by the median of assets), as well as groups of capital companies and cooperatives. Research has shown that enterprises were characterized by relatively high technical efficiency and scale efficiency in the range, respectively, between 82 and 93% and between 93 and 98%. All enterprises operated more efficiently in more favorable macroeconomic conditions. The level of enterprises' technical and scale efficiency depends on the value of their assets and the legal status. Larger enterprises were less technically effective than smaller ones, but they made greater use of the effect of scale. Capital companies were more effective than cooperatives, but to a lesser extent used economy of scale.

Introduction

Technical and scale efficiencies are important measures in determining performance of enterprises and the sector in which they operate. The high technical efficiency of a company enables favorable transformation of inputs into outputs. High scale efficiency indicates that the company effectively uses its facilities and expands the value of outputs in order to minimize unit costs. The analysts consider it beneficial to control the effectiveness of enterprises, both service and production, including food industry enterprises.

The food industry in Poland has undergone a significant transformation after entering the European Union. An improvement in efficiency is considered as a primary condition in maintaining competitiveness on the common EU market. This goal can be achieved, inter alia, due to the enhancement in technology and managerial methods, as well as the optimization of operating costs and search for economies of scale.

The aim of this article is to assess the level of technical efficiency (the Variable Return to Scale – VRS version) and scale efficiency of food production enterprises in Poland in 2006-2016 and to examine if their values depend on the size of the enterprise's operations and the legal status. The non-parametric Data Envelopment Analysis (DEA) method was applied for measuring the efficiency of enterprises. The estimations were carried out using the statistical program STATA (the DEA package). The research covered the sector of food producers of the subsection "Production of sugar and confectionery products". The sector was chosen due to the relatively large group of enterprises accessible in the database, as well as significant weight and contribution to the production of the entire food sector.

The sample consisted of 52 enterprises of which 44 were capital companies (joint stock companies and limited liability companies) and 8 cooperatives. Additionally, in order to assess

the impact of the size of the enterprise on its effectiveness, the sample was also divided into two groups: “large enterprises” and “small enterprises”, respectively with higher and lower assets than the median for the sample. The annual financial data were obtained from the EMIS database (<https://www.emis.com>). According to the author of this work, the research on the efficiency of enterprises operating in this section of the food sector is rather limited. This article aims to fill in the missing gaps and makes a significant contribution to efficiency research concerning the sector of food producers.

In the remaining part of this paper a literature review on methods of measuring efficiency and their applications in the food sector is presented. Next, the economic situation of the analyzed sector and the research methodology, and further the results and their discussion. The entire analysis is summarized in the conclusions.

Technical and scale efficiency of food enterprises – literature review

Efficiency is considered an important and useful measure characterizing an enterprise's performance. High levels of efficiency indicate a high ability of the company to transform its inputs into the outputs. Efficient companies are competitive and able to maintain their market position. Efficiency assessment is considered as a complementary tool for traditional firm evaluations based solely on financial indicators. Measurement of efficiency enables a synthetic evaluation of a company's management.

The research by Chien Chen et al. [2015] indicates that the estimation of the company's efficiency is crucial for the strategic evaluation of each economic sectors. It makes it possible to identify the best contractors in the industry and sources of their competitive advantage. Efficiency is also considered as supplementary tool for the fundamental firm's assessment. C. Chen et al. [2015] states that focusing solely on financial indicators could lead to an underestimation of the assessment of the firm's market competitiveness.

Analyses of enterprises' technical and scale efficiency have been particularly widespread since the 1980s. The development of these methods has led to the application of two ways for measuring efficiency: parametric and non-parametric. The parametric group of methods contains: Thick Frontier Approach [Berger, Humphrey 1991], Stochastic Frontier Approach [Aigner et al. 1977], Distribution Free Approach [Khoo-Fazari et al. 2013]. These methods are based on the estimation of the Cobb-Dougllass production function, which defines the relationship between inputs and outputs of a company's production process. Nonparametric methods do not require any assumptions regarding the functional dependency between inputs and outputs of the company. The efficiency frontier is determined based on empirical data, using linear programming. Nonparametric methods do not take into account the impact of random factors on efficiency and do not measure potential errors. The main nonparametric method is the Data Envelopment Analysis – DEA [Charnes et al. 1978].

According to the author of this paper, economic literature contains a rather limited number of studies examining the production performance of enterprises using parametric or non-parametric efficiency measures. The most common method of evaluating enterprises is an assessment using economic and financial indicators. These methods are often considered as fundamental analyses and include such measures as: labor productivity, profitability of assets and equity or the cost-effectiveness of the enterprise [Baran et al. 2016]. Food producers are also an infrequent field of study.

The technical and scale efficiency of the dairy sector in Poland in the period of 1999-2010 was tested by Joanna Baran [2013]. Based on the evaluation of 750 dairies, the research indicates that these entities operate with increasing scale efficiency. It also argues that further consolidation of the dairy sector might lead to an increase in the effectiveness of the entire sector and improvement of its economic results.

Likewise, Wiendlmeier examining milk processing enterprises in Germany indicates an existence of a favorable impact of the economy of scale on their performance [Wiendlmeier 2001].

The study additionally states that an increase in the production scale could help to achieve a significant reduction in unit costs of dairy products production. In turn, Sudarin Rodmanee and Wen-Chi Huang testing efficiency of the food industry enterprises in Thailand with the two-stage DEA analysis found that enterprises with low operating profitability show low efficiency as well [Rodmanee, Huang 2013]. In Poland, research was conducted using the non-parametric DEA method on meat processing enterprises operating in 2006-2011. The study indicates that during this period their average efficiency had an upward trend [Jarzębowski 2014]. Additionally the this model was applied in evaluating efficiency of the pig production [Szymańska 2009] and effectiveness of management and functioning of agriculture enterprises created on the basis of the state-owned farms [Kulawik, Józwiak 2007].

Subject and methodology of research

The performance of the sector of producers of sugar and confectionery products showed an improving trend during the period of 2006-2016 (see fig. 1). The sales of sugar and confectionery product producers rose from 1.2 to 1.4 billion euro and the sales of chocolate and sweets producers grew from 0.5 to 0.8 billion euro. The only drop in sales occurred in 2009, which

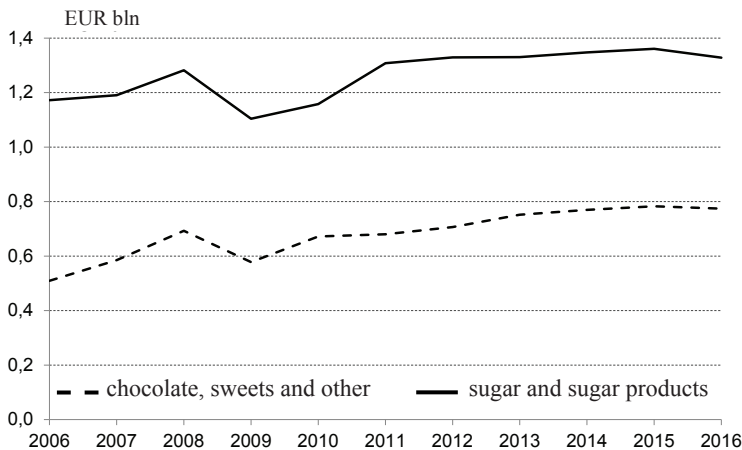


Figure 1. Sales of the producers of sugar and chocolate products in Poland
Source: own calculation based on EMIS data

could be considered as a result of the global financial crisis.

For investigating the changes in the efficiency of the producers of sugar and confectionery products, the efficiency scores were calculated using the nonparametric DEA method. The DEA method is a technique which is used for constructing a frontier that can be used in the evaluation of relative efficiency of identical decision making units (DMUs). For this reason, a deviation of the DMUs from an ideal production output of virtual DMU is obtained. DEA might take into consideration either Constant Returns to Scale (CRS) applied by Abraham Charnes et al. [1978] or Variable Returns to Scale (VRS) elaborated by Rajiv Banker et al. [1984]. The CRS model assumes that enterprises transfer inputs into outputs in the same way, irrespective of its scale of operation. Oppositely the VRS model assumes that with the increase of the scale of its operation the enterprise can transfer inputs into outputs in a more efficient way. Additionally DEA assumes the efficiency can be improved by reducing the inputs (input-oriented version) or increasing the outputs (output-oriented version).

In this paper, the output-oriented VRS-DEA approach is applied. The choice is motivated by the fact that, apart from maximizing profits, one of the most important goals of food producers is to expand and maintain market share. In addition, the review of literature indicates that input-oriented DEA should be used mostly for the assessment of enterprises conducting regulated activities, e.g. energy or natural gas suppliers. In such cases, the production price is determined administratively and efficiency can be improved mainly by minimizing inputs.

The output-oriented DEA is recommended for the evaluation of the majority of market oriented enterprises [Murillo-Zamorano 2004]. The VRS-DEA efficiency score for the *i*th food sector enterprise is calculated by solving the following problem [Coelli et al. 2005]:

$$\text{Min}_{\theta, \lambda} \theta$$

subject to the conditions: $-y_i + Y\lambda \geq 0$
 $\theta x_i - X\lambda \geq 0$

with: $N1' \lambda = 1$
 $\lambda \geq 0$

where: y_i is the vector of outputs, x_i is the vector of inputs, $N1$ is the unitary vector with the $N \times 1$ dimension and λ is a vector of constants with the $N \times 1$ dimension. The computed parameter θ lies between 0 and 1. The computed efficiency score is equal to 1 if the entity is considered as efficient and otherwise inefficient. λ is the assigned weight to an entity.

Results and discussion

The first stage of the data analysis involves the calculation of the scale of efficiency and the technical efficiency in the VRS version. Taking into account the studies of [Chen et al. 2015] and [Rodmanee, Huang 2013] the following variables were included into calculations:

- Input 1: cost of material and product sold (thous. PLN);
- Input 2: cost of operation (thous. PLN);
- Input 3: fixed assets (thous. PLN);
- Output 1: sales (thous. PLN);
- Output 2: gross profit (thous. PLN).

The results indicate that technical efficiency of sugar and confectionery producers were high and stable during the analyzed period (fig. 2). Two significant drops in both types of efficiency appeared in 2008 and 2011-2012, what could be considered, among others, a probable result of the financial crisis of 2008-2009, the euro public finance crisis of 2011-2012 and the disturbance in the Polish food market affected by the EU sanctions imposed on the Russian Federation.

The group of small enterprises appeared to be, on average, slightly more technically efficient than the group of large enterprises (tab. 1). The sources of this advantage could be sought in the greater flexibility of smaller entities in adjusting the production process to the current circumstances. Taking into consideration the status of the enterprise, the results indicate that capital companies are significantly more technically efficient than cooperatives. Unlike the comparison of large versus small enterprises, capital companies were more effective than cooperatives in

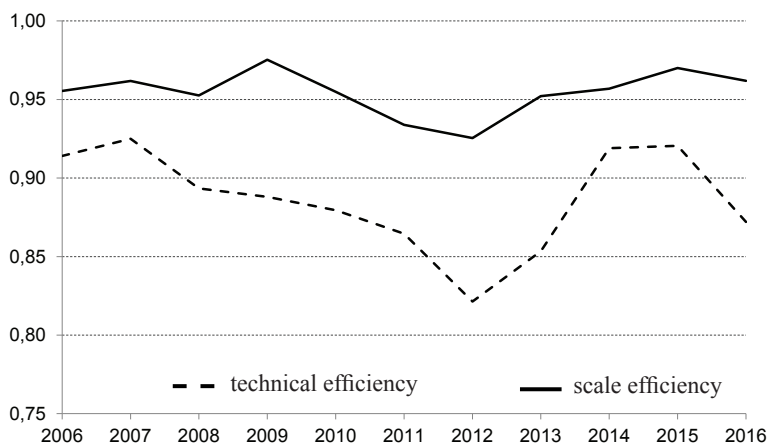


Figure 2. Technical and scale efficiencies of the sugar and confectionery producers in Poland
 Source: own calculation based on EMIS data

Table 1. Technical efficiency of the sugar and confectionary producers broken into asset size and legal status in Poland in 2006-2016

Item	Years											Average
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Large enterprises	0.905	0.920	0.889	0.900	0.880	0.870	0.840	0.844	0.895	0.908	0.869	0.884
Small enterprises	0.926	0.926	0.893	0.891	0.879	0.859	0.803	0.862	0.939	0.933	0.875	0.890
Capital companies	0.929	0.940	0.902	0.900	0.888	0.875	0.841	0.872	0.933	0.931	0.887	0.900
Cooperatives	0.780	0.831	0.832	0.790	0.804	0.785	0.684	0.726	0.816	0.847	0.765	0.787
Food sector	0.914	0.925	0.893	0.888	0.880	0.865	0.821	0.853	0.919	0.921	0.872	0.886

Source: own calculation based on EMIS data

all the years of the analyzed period.

The analysis of the scale efficiency indicates that larger enterprises, on average, are slightly more scale efficient comparing to smaller ones (table 2). Such a result indicates that larger entities took advantage of the scale effect to a greater extent. In the case of the legal status division the scores of scale efficiency indicate that cooperatives use the scale effect to a broader extent. Similarly as stated by [Baran 2013] for the Polish dairy industry, the results indicate that capital companies have some room to increase the scale of their operations and consolidate within the industry to reduce the unit cost of production.

Table 2. Scale efficiency of the sugar and confectionary producers broken by assets size and legal status in Poland in 2006-2016

Item	Years											Average
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Large enterprises	0.964	0.960	0.941	0.974	0.957	0.942	0.924	0.964	0.969	0.972	0.959	0.957
Small enterprises	0.945	0.962	0.964	0.977	0.953	0.926	0.927	0.940	0.945	0.968	0.965	0.952
Capital companies	0.953	0.961	0.948	0.975	0.953	0.930	0.923	0.950	0.955	0.967	0.958	0.952
Cooperatives	0.979	0.968	0.984	0.982	0.974	0.960	0.942	0.970	0.972	0.991	0.986	0.973
Food sector	0.955	0.962	0.953	0.975	0.955	0.934	0.925	0.952	0.957	0.970	0.962	0.955

Source: own calculation based on EMIS data

Conclusions

On the basis of the study on the technical and scale efficiency of sugar and confectionery product producers operating in Poland in 2006-2016, with respect to the size and legal status of the enterprise, the following conclusions can be drawn:

1. Enterprises operate with high and considerably stable technical efficiency ranging from 82 to 93% and the value is to some extent influenced by the macroeconomic environment and the performance of the entire food sector.
2. Smaller enterprises operate slightly more efficiently comparing to larger ones. This could be a result of their greater flexibility to adjust to changes in the business environment. The advantage of capital companies over cooperatives in terms of technical efficiency is more visible over the entire analyzed period.
3. Larger enterprises use effects of scale to a greater extent than smaller ones. A lower scale efficiency of capital companies comparing to cooperatives indicates that companies have some room for expansion and consolidation to reduce unit operating costs.

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Streszczenie

W artykule analizowano wpływ wielkości i statusu prawnego przedsiębiorstwa na jego efektywność techniczną i efektywność skali polskich producentów żywności. Wielkości te mierzono przy użyciu nieparametrycznej metody DEA. Badanie oparto na rocznych sprawozdaniach finansowych 52 producentów cukru i wyrobów cukierniczych działających w latach 2006-2016. Analizą objęto wszystkie przedsiębiorstwa w sektorze, a także grupy większych i mniejszych przedsiębiorstw (wyróżnione medianą aktywów) oraz grupy spółek kapitałowych i spółdzielni. Badania wykazały, że przedsiębiorstwa osiągnęły względnie wysoką efektywność techniczną i efektywność skali, w przedziale odpowiednio od 82 do 93% i od 93 do 98%. Wszystkie przedsiębiorstwa działały sprawniej w korzystniejszych warunkach makroekonomicznych. Poziom efektywności technicznej i skali zależały od wartości aktywów i statusu prawnego przedsiębiorstwa. Większe podmioty były mniej skuteczne technicznie niż mniejsze, ale w większym stopniu wykorzystywały efekty skali. Spółki kapitałowe były bardziej efektywne niż spółdzielnie, ale w mniejszym stopniu korzystają z efektu skali.

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