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Do high tariffs provide high efficiency: a case of Ukrainian electricity distribution companies

Abstract: The paper aims to test the hypothesis whether high tariffs lead to a high efficiency of electricity suppliers. The authors test this hypothesis on a case of 29 Ukrainian electricity distribution companies. Using the data envelopment analysis and correlation coefficients, grouping the super-efficiency scores, the authors found that in most regions of Ukraine the increase in tariffs no longer leads to increased efficiency. This indicates a weakness of tariff policy in most of the electricity distribution companies. The case showed that rising tariffs can cause a decline in revenue, net income and an increase in accounts payable. This does not allow the electricity distribution companies to provide high efficiency.

Apart from this, despite improving the financial performance of most companies, the electricity distribution industry in Ukraine as a whole remains unprofitable. However, the high percentage of foreign investors in this industry indicates a significant potential for increasing the efficiency

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of Ukrainian energy companies. The government control of the electricity distribution companies more often provides medium efficiency, while the management by foreign investors often provides a high efficiency. The absence of the major owner and the presence of blocking stakes in any investor (government, domestic or foreign investors) has a negative impact on the efficiency of energy companies.
Although the case is limited to one country and 29 companies, this study can serve as a model for wider testing of the research hypothesis in other markets and countries.

Keywords: electricity, energy distribution, efficiency, tariff policy, companies, Ukraine

Introduction

At present no business or household can do without electricity. Electricity is most often irreplaceable by other energy resources, and therefore, tariffs on it affect both individuals and the entire economy of any country. Given the natural monopoly position of electricity suppliers in many countries, the electricity prices – tariffs should be regulated by the government. Obviously, high tariffs reduce the efficiency of the electricity consumers (Lin and Liu 2013) and lead to deepening energy poverty in a country (Goncharuk and Cirella 2020).

However, do high tariffs lead to a high efficiency of electricity suppliers?

This study aims to answer this question. Using the case of the Ukrainian electricity market, we will test the hypothesis whether high tariffs led to high efficiency of electricity distribution companies.

1. Literature review

A lot of studies on the efficiency evaluation of electricity distribution companies are available in the scientific literature. On the one hand, the authors from various countries tested advanced tools for efficiency evaluation (for instance on the Indian market, Bobde and Tanaka 2018) or just applied well-known methods for this (for instance on the Brazilian market, Boente and Lustosa 2019). Some of them considered one country (Çelen 2013; Cullmann and Von Hirschhausen 2008) or a region (Totare and Pandit 2010), the others compare efficiency between two (Hattori et al. 2005) or more countries (Gomez and Rivier 2000).

On the other hand, many authors studied the electricity tariff policy, comparing it between various regions (e.g. Hayat et al. 2016; Şirin 2017; Pu et al. 2020) or countries (e.g. Abdullah et al. 2018).

However, no one of them considered how electricity tariffs influence the efficiency of electricity distribution companies. Hence in this study, we will try to clarify this on the example of Ukraine.

This study is original and makes it possible, using the case of Ukraine, to establish the relationship between electricity tariffs and the efficiency of electricity distribution companies in other countries. Apart from this, it will allow to make adjustments to the tariff policy of companies and the state regulator in the electricity market in order to ensuring the efficient work of the country's energy system.

2. Methodology

To achieve the goal of the study, we decided to divide the Ukrainian electricity market into four main regions and compare the average tariffs in different regions with the average efficiency estimates for them. Hence the point is to evaluate an efficiency of electricity distribution companies. Then we group them into regions and calculate the average efficiency for each region.

The various benchmarking methods are used to conduct a comparative analysis of the efficiency of electricity distribution companies in various studies. For example, Hattori (Hattori 2002) applied the stochastic frontier analysis (SFA) to evaluate the efficiency of Japanese and US electricity distribution. Recently, the SFA was also used by Wu (Wu 2020), Khetrapal (Khetrapal 2020), and Wanke et al. (Wanke et al. 2020) to analyze efficiency of electricity distribution in Asian countries. However, the SFA has an important lack – it only allows one output to be used. When using two or more outputs, it is better to use the data envelopment analysis (DEA).

Therefore, to evaluate the efficiency in this study we use the DEA method proposed by Charnes et al. (Charnes et al. 1978). Over the past three decades it has received widespread theoretical development and practical application in various fields of human activity (economics, education, health, military etc.). The choice of the DEA method is determined by the fact that it is a nonparametric method that does not require the explicit specification of functional relationships between costs and products, and the statistical distribution of inefficiencies. Unlike other benchmarking methods it does not require assumptions about the type of behavior of observed companies and allows efficient and inefficient companies to be determined, and a quantitative measure of their efficiency to be calculated. In addition, this method involves the simultaneous use of both monetary and quantitative indicators, which allows us to summarize the many heterogeneous inputs and outputs.

Scientists from different countries have used the DEA to evaluate a technical efficiency of electricity distribution companies (Qassim et al. 2005) and other energy companies (Goncharuk and lo Storto 2017). To build a complete ranking of efficiency, the DEA model of super-efficiency proposed by Andersen and Petersen (Andersen and Petersen 1993) will be used here, in which

one of the main shortcomings of most DEA models was avoided – limiting efficiency estimates by interval [0,1]. The mathematical form of the input-oriented super-efficiency model for m inputs, r outputs and n companies is the following:

$$\min z = \theta^{sup}$$

$$\text{subject to: } \sum_{j=1,\neq q}^{n} x_{ij}\lambda_j + s_i^- = \theta^{sup} x_{iq}, \quad \text{for} \quad i = 1,2,...,m \tag{1}$$

$$\sum_{j=1,\neq q}^{n} y_{ij}\lambda_j - s_i^+ = y_{iq}, \quad \text{for} \quad i = 1,2,...,r$$

$$\lambda, s^+, s^- \geq 0$$

where:

- θ^{sup} – super-efficiency score;
- x_{ij}, y_{ij} – inputs and outputs of company j;
- s_i^-, s_i^+ – slacks;
- λ_j – the weights.

This study considers the DEA super-efficiency model with the constant returns to scale (CRS). The necessary and sufficient conditions for the impossibility of CRS model were formulated by Zhu (Zhu 1996): the appearance of zero values in the subject area, i.e. the presence of zero inputs or outputs in the initial data. Thus, it is possible to avoid the impracticability of the models analyzed in this study, having excluded zero values of inputs and outputs from consideration. Since the efficiency analysis will use both quantitative and cost indicators as inputs and outputs, it will be evaluated not by technical or economic efficiencies, but hybrid ones, the features of which have been described by Goncharuk (Goncharuk 2007).

After determining the efficiency scores, the hypothesis of the relationship between the level of electricity tariffs and the level of efficiency of electricity distribution companies will be tested using correlation coefficients. Hence, it will be concluded whether a high tariff provides high efficiency to electricity distribution companies.

3. The Data

The data on 29 Ukrainian electricity distribution companies, including all regional monopolies, are used to perform an efficiency analysis.

Material inputs, number of employees, depreciation, total assets and accounts payable were used as inputs. The first three indicators reflect the use of basic production resources (material, labor and fixed capital), the fourth – the total value of property assets in operational activity, the fifth – is an important financial resource of Ukrainian energy companies, which characterizes the level of payment discipline and managerial skills.

The revenue from electricity sales, receivables and net profit were used as outputs. These indicators most fully reflect the results of operations and financial activity of companies, i.e. the net sales (paid and unpaid) and net financial result (profit/loss), the size of which depends on the properties of the operational process and the ability of company's management to effectively manage the company.

All inputs and outputs correspond to the necessary and sufficient conditions of impracticability of the applied DEA super-efficiency model.

The source of information is the financial statements of companies for the relevant year, the reliability of which is confirmed by audit reports. This takes the main disadvantage of the DEA method into account – high sensitivity to errors in the initial data, because this method does not involve error testing.

Descriptive statistics of the studied sample of electricity distribution companies for each input and output are shown in Table 1.

Table 1. Descriptive statistics of the sample of electricity distribution companies

Tabela 1. Statystyka opisowa dla wybranej grupy przedsiębiorstw zajmujących się dystrybucją energii elektrycznej

Inputs/Outputs	Average	Median	St. dev.
Material inputs	65,950	23,231	174,038
Total assets	710,991	417,633	823,591
Depreciation	28,691	21,673	23,028
Number of employees	4,412	3,698	3,087
Accounts payable	466,139	143,613	883,648
Net sales	851,316	437,200	1,021,756
Net Profit/Losses	–712	4,033	36,902
Receivables	266,823	76,452	549,939

Information on electricity tariffs is taken from the report of the National Electricity Regulatory Commission of Ukraine.

4. The Results

Evaluation of super-efficiency and the corresponding ranking according to the data, allowed for the companies to be divided into three groups: with low, medium and high efficiency (Fig. 1).

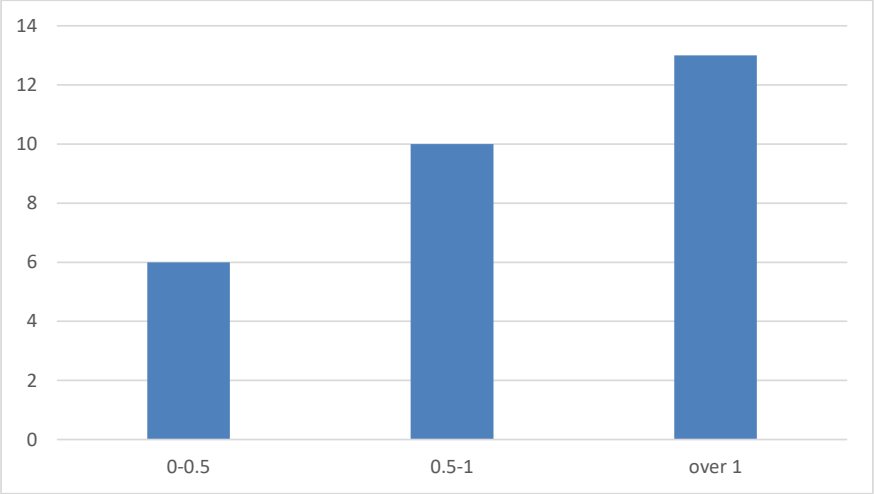

Fig. 1. Distribution of super-efficiency scores of electricity distribution companies

Rys. 1. Rozkład wyników superefektywności przedsiębiorstw zajmujących się dystrybucją energii elektrycznej

The number of companies with low efficiency is significantly lower than other groups. The average score of super-efficiency in this group was 0.453.

Considering the regional affiliation of efficient electricity distribution companies, it should be noted that they are mostly located in the eastern and southern regions of the country.

The majority of medium-efficient companies are controlled by the state, and foreign investors own only small stakes. Only half of the inefficient companies have the investor with controlling stakes, while all of the investors will have blocking stakes. This fact may indicate the existence of differences between investors, which negatively affect the efficiency of companies.

In the large and medium efficient companies blocking packages are owned only by the state, which allows it to maintain control over privatized companies of regional importance. However, in low-efficiency companies there is a variety of investors with a blocking package that expands the range of active owners and increases the likelihood of confrontation.

The high percentage of foreign investors in this industry, whose interest indicates a significant potential for increasing the efficiency of Ukrainian energy companies should also be noted.

Thus, government control is more likely and can provide an average level of efficiency in the field of electricity distribution, while management by foreign investors often provides high

efficiency. The absence of a major owner and the presence of blocking stakes in any investors (state, domestic or foreign investors) has a negative impact on the efficiency of electricity distribution companies.

Testing the hypothesis of the relationship between the level of tariffs for electricity supplied and the level of efficiency of electricity distribution companies gave the following results (Table 2).

Table 2. Correlation between electricity tariffs and average super-efficiency scores by groups of companies

Tabela 2. Korelacja między taryfami opłat za energię elektryczną a średnimi wynikami superefektywności w grupach przedsiębiorstw

Group of companies	Correlation coefficients	
	static	dynamic
Highly efficient	0.302	0.077
Medium efficient	0.578	–0.521
Low efficient	0.772	0.048
Northern and Central regions	–0.125	0.095
Western region	–0.487	–0.765
Eastern region	–0.957	–0.998
Southern region	0.877	–0.708

The relationship can be described as high only for certain groups of companies. However, we can identify some patterns that indicate the peculiarities of the impact of tariff policy on efficiency. The tariff policy was more in line with the level of efficiency of companies and affected the latter, especially for the low efficient group. That is, it plays an increasingly important role in ensuring efficiency of the electricity distribution companies.

Apparently, the growth of tariffs in the group with medium efficiency, where mostly state-owned companies are represented, often had the opposite effect on their efficiency, i.e. led to a slowdown or reduction of the latter. This indicates that the tariff policy in most state-owned energy companies is ill-considered and unjustified, which probably does not allow them to ensure high efficiency.

A regional review of the energy market shows that, with the exception of the northern and central regions, rising electricity tariffs have negatively affected the efficiency of companies in the industry. Moreover, energy companies in the eastern region suffered the most: their efficiency declined inversely with rising tariffs, which was matched by falling revenues and rising accounts payable. A similar situation was observed in the western region, where the increase in tariffs was accompanied by a decrease in net income and an increase in accounts payable.

At the same time, while in the eastern and western regions high-efficiency companies set the lowest tariffs, and low-efficiency companies set the highest ones, in the southern region the

situation is reversed, there the principle of "high tariff – high efficiency" is more common. But even in the south, the increase in tariffs no longer leads to increased efficiency and the dynamic correlation is negative.

Conclusions

Based on the results of the study, the following conclusions can be drawn.

Despite some improvements in the financial performance of most companies, the industry as a whole remains unprofitable. However, the high percentage of foreign investors in this industry indicates a significant potential for increasing the efficiency of Ukrainian energy companies.

The government control more often provides a medium efficiency in the field of electricity distribution, while the management of foreign investors often provides high efficiency. The absence of a major owner and the presence of blocking stakes by any investor (government, domestic or foreign investors) has a negative impact on the efficiency of energy companies.

In most regions of Ukraine, where mostly state-owned companies are represented, the increase in tariffs no longer leads to increased efficiency, which indicates a weakness of tariff policy in most of the electricity distribution companies owned by the government. Rising tariffs here often cause a decline in revenue, net income and an increase in accounts payable. Apparently, this does not allow them to provide a high efficiency.

Although the case is limited to one country and 29 companies, this study can serve as a model for wider testing of the research hypothesis in other markets and countries. Thus, using this case study, the researchers can establish the relationship between electricity tariffs and the efficiency of electricity distribution companies in other countries. Moreover, it enables to make adjustments to the electricity tariff policy of companies and the state regulators at the electricity market in order to ensure the efficiency of the countries' energy systems.

The results obtained for this case can also be used to assess the relationship between the efficiency of energy companies and the level of energy poverty in the country (region). This will help to build a balanced tariff policy that takes the interests of counterparties in the electricity market into account. Apparently, our further research will be directed in this way.

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Czy wysokie taryfy zapewniają wysoką efektywność: przypadek ukraińskich firm zajmujących się dystrybucją energii elektrycznej

Streszczenie

Celem artykułu jest przetestowanie hipotezy, czy wysokie taryfy prowadzą do wysokiej efektywności dostawców energii elektrycznej. Autorzy testują tę hipotezę na przykładzie 29 ukraińskich dystrybutorów energii elektrycznej. Korzystając z analizy obwiedni danych i współczynników korelacji, grupując wyniki super efektywności, autorzy stwierdzili, że w większości regionów Ukrainy wzrost taryf nie prowadzi już do wzrostu efektywności. Wskazuje to na słabość polityki taryfowej w większości przedsiębiorstw zajmujących się dystrybucją energii elektrycznej. Analiza pokazała, że rosnące taryfy mogą spowodować spadek przychodów, dochodu netto i wzrost zobowiązań. Nie pozwala to firmom zajmującym się dystrybucją energii na zapewnienie wysokiej efektywności.

Poza tym, pomimo pewnej poprawy wyników finansowych większości firm, cała branża dystrybucji energii elektrycznej na Ukrainie jest nierentowna. Jednak wysoki odsetek inwestorów zagranicznych w tej branży wskazuje na duży potencjał wzrostu efektywności ukraińskich firm energetycznych. Kontrola rządu nad spółkami dystrybucyjnymi energii elektrycznej częściej zapewnia średnią efektywność, podczas gdy zarządzanie przez inwestorów zagranicznych daje często wysoką efektywność. Brak głównego właściciela i obecność pakietów blokujących u któregokolwiek inwestora (rządowego, krajowego lub zagranicznego) ma negatywny wpływ na efektywność spółek energetycznych.

Chociaż przypadek ogranicza się do jednego kraju i 29 firm, to badanie może służyć jako model do szerszego testowania hipotezy badawczej na innych rynkach i w innych krajach.

Słowa kluczowe: energia elektryczna, dystrybucja energii, efektywność, polityka taryfowa, przedsiębiorstwa, Ukraina