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EFFICIENCY VS. THE LEVEL OF PER CAPITA INCOME OF URBAN-RURAL MUNICIPALITIES IN POLAND

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Abstract

The basic objective of the work was to verify the hypothesis regarding the existence of the correlation between the income potential of the municipalities and the efficiency (relative) of their activity. The basis for such a hypothesis were some concerns as to the validity of the assumed system of funding territorial local governments in Poland- in particular in the area of fiscal transfers. A nonparametric method for the evaluation of relative efficiency - the DEA CCR-O was used in the research. Then the correlation between efficiency scores and local government revenues per capita was measured. The study includes 573 urban-rural municipalities in Poland in the years 2009, 2013, and 2016. As variable "input" expenditures per-capita were adopted. As "outputs", 13 variables describing the basic areas of municipal activity were adopted. The results of the conducted analyses point to the existence of a correlation between the commune's revenue level and the effectiveness of its functioning. In the whole of the analysed period, the correlation fluctuated around -0.34 to -0.42 for total pc revenues and -0.26 to -0.32 for pc own revenues.

JEL classification: H2, H71
Keywords: DEA, local government, revenues

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Introduction

The issue of relevance of public funds at disposal of the local governments to the scale of tasks entrusted to them constitutes one of the more significant trends in research analysed by the subject literature. The efficiency of sources of own incomes of local governments is considered here, the methods and the scale of vertical redistribution (from the country down to the local governments), and the horizontal between the units at the same level. Relations between the volume of redistributed funds and the level of expenditure for tasks directly or indirectly related to the mechanism of supplementing the income are also analysed. Some authors discuss the issue of the relationship between the level of development of local governments and their income potential or the system of redistribution of public funds (Beata Guziejewska, 2007; Heller, 2008; Kańduła, 2017; Olejniczak, 2012; Olejniczak & Bednarska-Olejniczak, 2013). Furthermore, the issue of efficiency of public expenditure is pointed out as one of the main areas of theoretical deliberations and practical search related to public expenditure (Patrzałek, 2010, p. 233). However, the matter of practical measurement of efficiency of public expenditure has appeared in relatively few elaborations (Guziejewska, 2008; Jastrzębska, 2016), whilst only some of them (Kaczyńska, 2016; Karbownik & Kula, 2009; Olejniczak, 2018; Sekuła & Julkowski, 2015), made an attempt to use the nonparametric methods, Data Envelopment Analysis (DEA), in order to assess the relative efficiency of actions of local governments. In addition, there is a noticeable increase in interest in using the DEA method in assessing the efficiency of local government operations in many countries (Bostan, Onofrei, Popescu, Lupu, & Firtescu, 2018; Carcaba, Gonzalez, Ventura, & Arrondo, 2017; da Cruz & Marques, 2014; da Silva Nogueira, Saraiva, Silva, & Baptista Ribeiro, 2018; D'Inverno, Carosi, & Ravagli, 2018; Narbon-Perpina, Balaguer-Coll, & Tortosa-Ausina, 2019; Soko & Zoric, 2018). Thus, it seems purposeful to undertake research concerning the existence of dependency between the potential of profitable municipalities and the (relative) efficiency of their activity. One of the reasons for the research are doubts, noted also within the literature, as to the validity of the assumed system of funding territorial governments in Poland-in particular in the area of fiscal transfers (Poniatowicz & Wyszkowska, 2015). It should be underlined that research parallel to that presented in this paper was conducted on urban municipalities (Olejniczak, 2018).

Measurement of efficiency of expenditure of territorial local government units

The concept of efficiency of actions of local territorial government units within the national subject literature is not conclusively defined. This efficiency is considered most frequently from the organizational or financial perspective [more on this: (Skica, 2012, pp. 308–309). From the point of view of targets and scope of this article, the efficiency of territorial local government units will be considered in terms of relations between the level of budgetary expenditure of municipalities and the results of their activity, which is consistent with a broad definition of financial efficiency proposed by B. Guziejewska (Guziejewska, 2008, p. 72). What details the approach towards the measurement of financial efficiency of territorial local government units is the measurement of the efficiency of public expenditure considered as (Filipiak, 2012, p. 612):

1) financial efficiency (minimization of costs upon qualitatively and quantitatively defined effects)-that is narrowly understood financial efficiency,
2) technical efficiency (maximization of the effects upon specific expenditure with optimum production technology),
3) allocation efficiency (optimization of the basket of public goods delivered to a given local society, adequate to its preferences).

From among the three above-mentioned efficiency dimensions of the activity of local government units, the allocation efficiency appears to be problematic in measurement. The analysis of this kind of effectiveness is possible mainly in the qualitative terms - referring to the subjective level of utility from consumption of a market basket of services supplied to residents. In this case, the definition of efficiency assessment criteria appears to be the primary problem, which may result to some extent from diverse preferences of individual local communities (their heterogeneity) in the consumption of public goods supplied by communes.

Considering the basic purpose of this article, it should be noted that the technical efficiency defined above associated with spending of public funds by municipalities will be the basic criterion for making

comparisons between individual communes. Assuming that the level of expenditures in particular municipalities is determined by both the structure and incomes, as well as the assumptions adopted by municipalities regarding preferences of residents and the structure of local government administration, it should be assumed that the relation of obtained results (effects) to the amount of expenditure will be different for individual communes. This leads to the possibility of indicating municipalities with the maximum relative efficiency as well as relatively ineffective communes. This approach is based on Farrell's technical efficiency concept (Farrell, 1957, p. 253 et seq.) as a measure describing the relation of the results obtained to the expenditure incurred in relation to the maximum that can be obtained under given conditions and given technology. When considering the measurement of technical efficiency, it should be noted that not always the maximization of effects is actually desired by the local community.

The assessment of the efficiency of public finance sector entities can be conducted using both one-dimensional and multidimensional methods (Ziębicki, 2014, p. 85). In the case of assessment of the efficiency of local government units, it is necessary to compare many of the effects of their activities, which will result in the need to use methods that take into account the possibility of aggregating criteria. In the source literature on the subject, both parametric methods (e.g. OLS - Ordinary Least Squares, SFA - Stochastic Frontier Analysis or TFA - Thick Frontier Approach) and non-parametric methods (e.g. DEA - Data Envelopment Analysis; FDH - Free Disposal Hull) are used for multidimensional measurement of entities' effectiveness (Ziębicki, 2014, p. 87). In the case of the latter, it is important that they do not require expenditures and effects to be expressed in monetary units. This means that it is possible to take into account many non-financial measures or indicators describing the effects of communes' actions, which are important from the point of view of the residents or municipality authorities. It is also indicated that nonparametric methods have an advantage over parametric methods in that they do not require a priori definition of a specific form of functional dependence between expenditures and results achieved by territorial self-governmental units. On the other hand, the advantage of DEA over the alternative nonparametric method of FDH is that FDH compares the efficiency of specific units, and DEA allows us to find the theoretical limit of production capabilities (Karbownik & Kula, 2009, p. 12).

The essence of the DEA model, as already noted, is the possibility to include multiple expenditures and many effects that characterize the activity of a given entity (DMU Decision Making Unit) and to present their empirical distribution and the selection of adequate data considering the best production practices (best practice frontier). Thus, this method enables us to find theoretical boundary of production possibilities. Generally speaking, within the DEA model, the efficiency may be defined in the following manner (Cooper, Seiford, Tone, & Zhu, 2007):

$$Efficiency = \frac{\sum_{r=1}^{s} Output_r}{\sum_{i=}^{m} Imput_i} \quad (1)$$

where i = alternate outlays,

r = alternate effect,

n = number of tested objects ($j=1,\ldots,n$),

m = number of used outlays ($i=1,\ldots,m$),

s = number of activity effects ($r=1,\ldots,s$).

The efficiency of a given entity is measured in comparison to other objects from the tested group-therefore, for the comparison of changes in efficiency in the subsequent periods, it is critical to maintain a fixed structure of the tested group. The basic models of DEA include CCR which assumes constant effects of scale (Charnes, Cooper, & Rhodes, 1978, pp. 429–444), and BCC with variable effects of scale (Banker, Charnes, & Cooper, 1984, pp. 1078–1092). Both above models may be outlay-oriented (input oriented) or effect-oriented (output oriented). The characteristic feature of the territorial local government units is a significantly higher possibility of shaping the effects (directions and effects of expenditure) than the volume of expenditure itself. From that point of view, it seems appropriate to use the model targeted at the effects (output oriented) which maximize the output upon specific expenditure. At the same time, in the case of considering the possibility of limiting part of the grant-subsidy transfers to territorial local governments one may take into consideration the use of a model oriented towards minimizing incurred expenditure while assuming fixed results (input oriented).

Purpose and research method

The basic objective of the work was to verify the hypothesis regarding the existence of the correlation between the income potential of the municipalities and

the efficiency (relative) of their activity. The basis for such a hypothesis were some concerns as to the validity of the assumed system of funding territorial local governments in Poland- in particular in the area of fiscal transfers. In order to verify this hypothesis, an analysis of relative efficiency of the activities of urban-rural municipalities in the years 2009, 2013, and 2016 was carried out by means of the DEA CCR-O method and subsequently the correlation between the obtained relative efficiency coefficients in individual municipalities and the level of their income (own and total) per capita was investigated. Variables applied in the research of relative efficiency via the DEA CCR-O method came from Local Data Bank of CSO (Central Statistical Office) and the System of Local Governments Analyses and were to reflect the main areas of municipalities' activities (Table 1). Due to the lack of available data at NUTS-5 level concerning the structure of the communication network (structure of municipal roads in the selected period was not reported within CSO bases), the total expenditure per capita of individual municipalities was corrected by this item of expenditure. Adequately for the sectional classification of individual groups of expenditure in the respective budgets of the municipalities, 14 variables were identified which described the effects, enabling the creating of 13 measures. In line with the assumptions of the model all measures fulfill the assumption of the unitary direction of preferences that increases in results from the point of view of the target of assessment to be positively assessed, similarly to the increase in expenditure, upon maintaining stability of results which will be assessed negatively (Guzik, 2009, p. 28).

Selection of variables (inputs and outputs) was performed by means of the expert method, in consideration of the so far conducted research by other authors and the data availability.

573 urban-rural municipalities performing the assumptions which condition the correctness of results of DEA model was subjected to the analysis. It is assumed that DMU under research ought to be of a homogeneous nature which limited the research scope to one type of municipalities. In addition, due to sensitivity of methods of outliers, the entities for which the value of at least one of the effects (Ojr) does not fulfill the conditions of the quartile test have been excluded from the group of researched entities (Chromiński & Tkacz, 2010, p. 89 et seq.), that is:

$$Qr1 - 1{,}5 * (Qr3 - Qr1) \leq Ojr$$
$$Ojr \leq Qr3 + 1{,}5 * (Qr3 - Qr1) \quad (2)$$

where j = alternate DMU,

Table 1: Variables used in the research

Area	Variable symbol	Category
Education and upbringing	O1	Children at the age from 3 to 5 years per 1 place in the kindergarten (converted)
	O2	Gross scholarisation coefficient (primary schools)
	O3	Percentage of chartered teachers
Health protection	O4	Medical centres per 10 thousand inhabitants (converted)
	O5	Relation between births and deaths within the municipality
Residential economy	O6	Number of persons per chamber (converted)
Social assistance	O7	Percentage of inhabitants using social environmental assistance (converted)
Communal economy and environment protection as well as Administration	O8	Number of inhabitants using the water supply network
	O9	Number of inhabitants using sewage network
	O10	Share of terrains covered by local spatial management plans in the general area
	O11	Unemployment coefficient within the territory of the municipality (converted)
	O12	Number of economic entities per 10 thousand Inhabitants
Culture and protection of national heritage	O13	Library book collections per 1 inhabitant

Source: Own elaboration

r = alternate effect,

Ojr = value of the observations for the *j*-th DMU and *r*-th effect,

Qr1 = first quartile for the *r*-th effect,

Qr3 = thrid quartile for the *r*-th effect.

The analysis of variables' correlation has also been conducted in order to exclude the strongly correlated ($|r| \leq 0,7$). In the interest of keeping the comparability of relative efficiency, the municipalities that had changed their status from rural to urban-rural during the period of examination were excluded as well.

Because the purpose was to use the DEA model, it was assumed that the most favorable option was to use the result-oriented DEA model with consistent scale advantages (DEA CCR-O). Since the primary purpose of this work is not the identification of the factors that condition the efficiency improvement, but rather the comparison of the relative efficiency with the communes' income potential, the basic variety of the model was used. The study involved the use of the programme MaxDEA Basic v. 6.0 which, in the case of CCR-O, can transform the efficiency indicators within the range $<1,\infty)$ to $<0,1>$, where 1 refers to the most efficient units. Additionally, a presentation on the spatial distribution of units according to the efficiency and the level of income per capita was carried out.

Study results

The calculated indicators of relative efficiency differed to a small extent during the analysed period, both in terms of the median and the mean, whilst the two of them insignificantly decreased. At the same time, the interquartile range and the range of obtained results were slightly increasing. The extension of the range was caused by a relatively large decrease in minimal efficiency from 0,340 to 0,315, which is the highest percentage change in the values of all the described statistics

The results of the conducted analysis do not clearly confirm the argument about the existence of a strong relation between commune's income potential and (relative) efficiency of their activity. The analysis of

Table 2: The descriptive statistics for relative efficiency indicators obtained by DEA CCR-O method

	2009	2013	2016
Mean	0,820186	0,802297	0,798972
Median	0,823306	0,80956	0,801314
Q1	0,745850	0,714186	0,715388
Q3	0,921204	0,899132	0,902578
Standard deviation from population	0,128103	0,130536	0,129189
Variation	0,01641	0,01704	0,01669
Kurtosis	-0,09199	-0,1908	-0,1634
Skewness	-0,50509	-0,39489	-0,32604
Scope	0,659678	0,648064	0,684939
Minimum	0,340322	0,351936	0,315061
Maximum	1	1	1
Meter	573	573	573

Source: Own elaboration

Table 3: Correlation between the income per capita and the relative efficiency indicator

Year	Correlation Efficiency /Rown_pc	Correlation Efficiency/Rtot_pc
2009	-0,2866	-0,3698
2013	-0,3170	-0,4273
2016	-0,2633	-0,3467

Source: Own elaboration

the data indicates the existence of a medium negative correlation between relative efficiency obtained through the studied DMU, and their income per capita. In all of the studied periods, the value of correlations between the obtained indicators of efficiency and own income per capita of the studied DMU fluctuated between - 0,25 to - 0,32. The strongest correlation occurred between the relative efficiencies of DMU and their general income per capita. Its value fluctuated between – 0,35 to – 0,43.

For further analysis, the municipalities were divided into groups. The following municipality groups were created:

group A (high efficiency) = $e_j \geq \bar{e} + \delta_e$ (3)

group B (average efficiency) = $\bar{e} \leq e_j < \bar{e} + \delta_e$ (4)

group C (low efficiency) = $\bar{e} - \delta_e \leq e_j < \bar{e}$ (5)

group D (very low efficiency) = $e_j < \bar{e} - \delta_e$ (6)

where:

$\bar{e}$ = stands for arithmetic mean

δ_e = standard deviation of efficiency indicator DEA CCR-O

However, as can be observed (Table 4), high efficiency during the first period of testing was featured in 108 DMU in the next period (2013) it increased to 113 and subsequently went down to 105. This resulted from the decline of a part of DMU to the group of units of average efficiency, and the decline of another part of units to the group of DMU of low efficiency. At the same time, the number of DMU of very low efficiency also decreased. The study did not include the Malmquist index in order to determine the changes of efficiency in time, however, they included the analysis of the scale of DMU efficiency changes in the context of changing the classification according to the level of efficiency. The results are puzzling as transitions amongst municipalities appeared even between the extreme groups (D to A – Twardogóra, Sędiszów, or A to D – Zbąszynek, Myszyniec, Wołczyn). Still, the greatest "reshuffling" occurred between groups B and C.

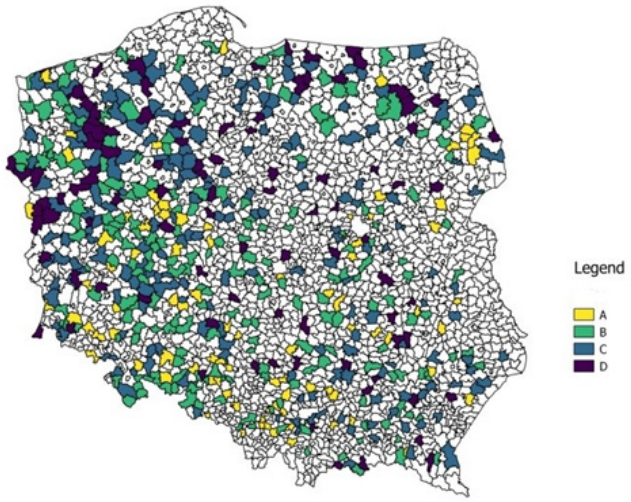
Figures 1, 2, and 3 represent the regional distribution of the researched communes, with reference to the level of efficiency obtained by particular communes, according

Table 4: Correlation between the income per capita and the relative efficiency indicator

	2009	2013	2016
A. high efficiency	108 (18,8%)	113 (19,7%)	105 (18,3%)
B. average efficiency	185 (32,3%)	181(31,6%)	185(32,3%)
C. low efficiency	184 (32,1%)	182 (31,8%)	191 (33,3%)
D. very low efficiency	96 (16,8%)	97 (16,9%)	92 (16,1%)

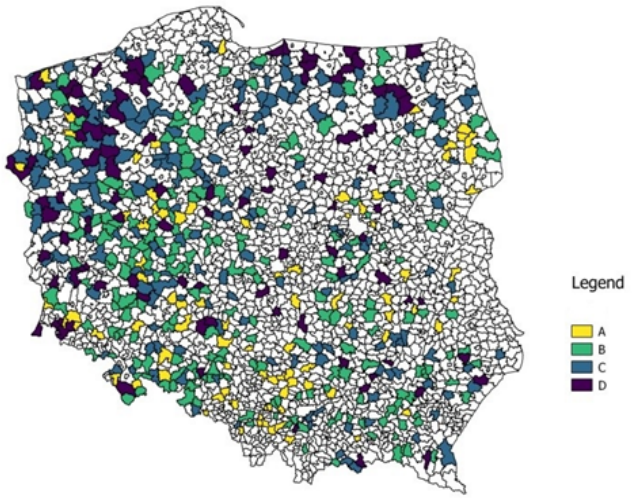
Source: Own elaboration

Chart 1: The regional distribution of municipalities in terms of the level of efficiency in 2016



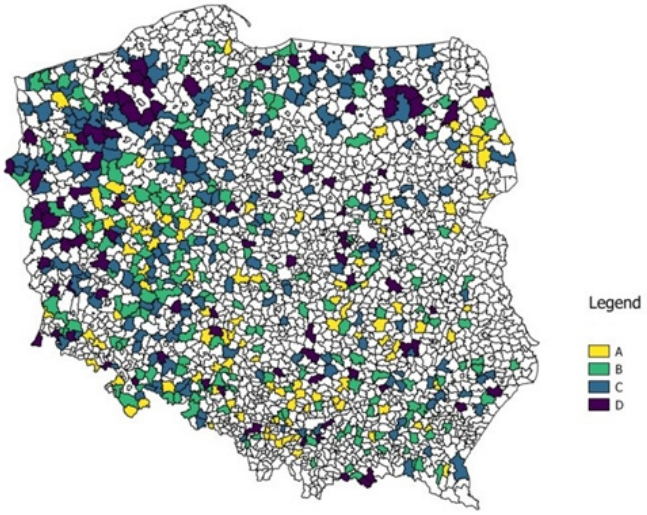
Source: Own elaboration

Chart 2: The regional distribution of municipalities in terms of the level of efficiency in 2013



Source: Own elaboration

Chart 3: The regional distribution of municipalities in terms of the level of efficiency in 2009



Source: Own elaboration

to one of the four categories affiliation. As it can be observed, a characteristic feature reoccurring in the subsequent years is the concentration of municipalities with similar efficiency indicators. It should not be forgotten that the presence of urban-rural municipalities is more characteristic for western regions of Poland rather than eastern ones, which is depicted by the high concentration of these communes.

The analysis of the averaged values in voivodeships proves the existence of differentiation between the regions whereby distinct tendencies in the creation of the level of efficiency are visible. The highest average efficiency (between 0,82 and 0,92) was obtained by the municipalities in Śląskie, Opolskie, Wielkopolskie, Małopolskie, and Podlaskie voivodeships whereby the last two showed an incremental decline of average efficiency during the studied period. The only voivodeship in which the average efficiency was increasing was the Dolnośląskie voivodeship. The group of voivodeships with the lowest average efficiency (between 0,71 and 0,75) included Lubuskie, Zachodniopomorskie, and Warmińsko-Mazurskie voivodeships.

It is worth noting that in 2009, 10 of the voivodeships had their average efficiency higher than the average

Table 5: Average relative efficiency of communes' activity in voivodeships

	2009	2013	2016
Dolnośląskie	0,81	0,82	0,83
Kujawsko-pomorskie	0,78	0,76	0,71
Lubelskie	0,84	0,82	0,80
Lubuskie	0,73	0,71	0,73
Łódzkie	0,83	0,80	0,79
Małopolskie	0,88	0,87	0,84
Mazowieckie	0,83	0,79	0,79
Opolskie	0,86	0,84	0,86
Podkarpackie	0,83	0,80	0,80
Podlaskie	0,87	0,88	0,82
Pomorskie	0,81	0,78	0,79
Śląskie	0,89	0,92	0,88
Świętokrzyskie	0,84	0,82	0,81
Warmińsko-mazurskie	0,74	0,71	0,73
Wielkopolskie	0,86	0,83	0,83
Zachodniopomorskie	0,75	0,72	0,75
Poland	**0,82**	**0,80**	**0,80**

Source: Own elaboration

for the whole country. In 2013 it was down to only 8 voivodeships, and in 2016 – 7. This reflects the previously mentioned changes in the number of municipalities in particular groups.

Conclusions

The analysis conducted in this study indicates the existence of a relation between communes' income potential and (relative) efficiency of their activity. This relation has a character of a moderate negative correlation between the relative efficiency acquired through the tested DMU and their income per capita. In all of the tested periods, the value of the correlation between the obtained indicators and personal income per capita of the tested DMU fluctuated between -0,26 and -0,32 whereas a stronger correlation appeared between the relative efficiency of DMU and their income per capita. Its value fluctuated between -0,35 and -0,43.

Application of the DEA CCR-O model encountered significant limitation resulting from a difficulty in accessing the data on DMU activity on the level of NUTS-5, which results in the fact that the set of measures of effects possible to include in the model is definitely too narrow. The obtained results allow us to conclude that using the nonparametric method in order to determine the efficiency of communes, and consequently, to determine the adequacy of the amount of accumulated income compared to the effects of the activity may have constituted an additional (but not the only) criterion in the mechanism of the commune's participation in public revenue. It seems, however, that the basic problem is the deficit of proper databases, as well as the absence of establishment of the services reference standard, which influences the decisions on allocation of public finances by the communes. In future studies, it would be necessary to compare the results obtained for rural municipalities and other types of municipalities. Use of other methods, such as Topsis, should be considered to evaluate problems.

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