Efficiency of activity of urban municipalities in Poland versus their income level

Jarosław Olejniczak, PhD

Department of Finance

Wrocław University of Economics, Poland

Aim of presented research:

The conducted research aimed to verify the **hypothesis about the existence of a relationship between income potential of municipalities and the (relative) efficiency of their expences.**

In the case of the undertaken **assessment of the local government units' efficiency**, **comparison of many inputs and outputs of their activity is necessary**, which in turn requires the usage of methods allowing the possibility of aggregation of criteria.

The essence of the DEA model is the possibility of taking into account various inputs and outputs characterizing the activity of one unit (DMU Decision Making Unit) and depiction of their empirical layout, as well as the choice of data envelope applying the best practice frontier.

This method thus enables us to find the theoretical frontier of production potential.

In general terms, efficiency in DEA model can be defined in the following way (Cooper et al. 2007):

$$Efficiency = \frac{\sum_{r=1}^{s} Weighted\_Output_r}{\sum_{i=1}^{m} Weighted\_Imput_i}$$

Where:

j – subsequent DMU

i – subsequent input

r – subsequent output

n – the number of researched objects (j=1,...,n)

m – the number of used input (i=1,...,m)

s – the number of activity output (r=1,...,s)

Charnes, Cooper and Rhodes (1978) analysed the issue of comparison of the outputs of different systems.

The starting point was defining efficiency as the proportion of the sum of weighted output to the sum of weighted input.

This approach does not require any knowledge about the efficiency functions.

By using empirical numbers of input and output, one searches for weights maximizing efficiency of an object. This leads to the formulation of a mathematic programming problem, the aim of which is to estimate efficiency of specific objects in regard of the entire group of objects.

Effectiveness of a given unit is measured in regard to other objects in the group – therefore to maintain comparability of changes in efficiency in subsequent periods, the stableness of the studied group's structure is important

Basic models of DEA include: CCR which assumes stable output of scale (1978), and BCC with variable output of scale (1984).

Both models can be either input or output oriented.

It is important to note that in Polish conditions, a characteristic feature of local government units is a significantly higher possibility of shaping the output (directions and effects of expenses) than the mere amount of expanses. Thus the output oriented model is the most appropriate one.

Stages:

1. The analysis of scientific literature with the purpose of establishing criteria which could be used as "input" and "output" (taking into account local specificity), isolation from the group of all urban municipalities in Poland of those municipalities, for which data was available for the whole experimentation period (2009-2016),

2. Correlation analysis proposed on the basis of the analysed literature on the topic of "output" ("O") – in order to avoid using variables which would be closely correlated,

3. Analysis of their income (own and general) per capita.

4. Additionally, the Malmquist index for each DMU as well as its average values for the whole collectivity throughout the years have been calculated.

Results of study

Tab.1:Variables set used in the research
Source: own elaboration
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Results of study

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

Results of study

According to the assumptions of the model, all measures meet the assumption of uniform direction of preferences, i.e. the increase of results from the point of view of the objective were assessed positively, and similar to the increase in output which, while maintaining the stability of results, were assessed negatively.

Out of 241 municipalities with city status in 2009, 4 municipalities were rejected due to their missing data. In addition, due to the sensitivity of the method of outliers, 45 municipalities were excluded from the group of studied entities for whom the value of at least one of the effects (Ojr) did not meet the quartile test condition

The first stage of research using the DEA CCR-O method showed that in the case of the studied municipalities a gradual increase in both the average value and the median relative effectiveness of these DMUs can be observed (Table 2). This means a relative decrease in discrepancies in the efficiency of the researched units.

Tab. 2: Basic descriptive statistics of the DEA CCR-O results in studied municipalities

Source: own elaboration

	2009	2010	2011	2012	2013	2014	2015	2016
Average	0.873	0.839	0.854	0.868	0.884	0.897	0.900	0.919
Median	0.887	0.843	0.868	0.877	0.893	0.914	0.916	0.934
Standard deviation	0.112	0.132	0.126	0.114	0.102	0.098	0.098	0.080
Variance	0.013	0.017	0.016	0.013	0.010	0.010	0.010	0.006
Mini	0.514	0.339	0.378	0.465	0.440	0.587	0.562	0.559

Voivodeship	Percentage of inefficient DMUs							
	2009	2010	2011	2012	2013	2014	2015	2016
Dolnośląskie	88%	100%	96%	83%	88%	88%	88%	79%
Kujawsko-pomorskie	100%	100%	91%	100%	91%	91%	100%	91%
Lubelskie	75%	75%	75%	81%	75%	56%	75%	50%
Lubuskie	100%	100%	100%	100%	100%	100%	100%	100%
Łódzkie	73%	80%	80%	87%	93%	93%	80%	67%
Małopolskie	50%	50%	50%	83%	67%	67%	50%	50%
Mazowieckie	94%	88%	94%	88%	88%	82%	71%	100%
Opolskie	50%	100%	50%	100%	100%	50%	100%	100%
Podkarpackie	67%	75%	75%	75%	83%	67%	75%	75%
Podlaskie	70%	90%	60%	50%	50%	60%	60%	50%
Pomorskie	80%	87%	87%	87%	80%	80%	73%	80%
Śląskie	80%	75%	75%	85%	80%	85%	75%	65%
Świętokrzyskie	100%	100%	100%	75%	75%	75%	50%	50%
Warmińsko-mazurskie	86%	86%	100%	71%	86%	86%	79%	79%
Wielkopolskie	58%	42%	58%	58%	75%	58%	58%	58%
Zachodnio-pomorskie	100%	100%	88%	88%	88%	100%	100%	100%
Total :	81%	83%	82%	81%	82%	79%	77%	74%

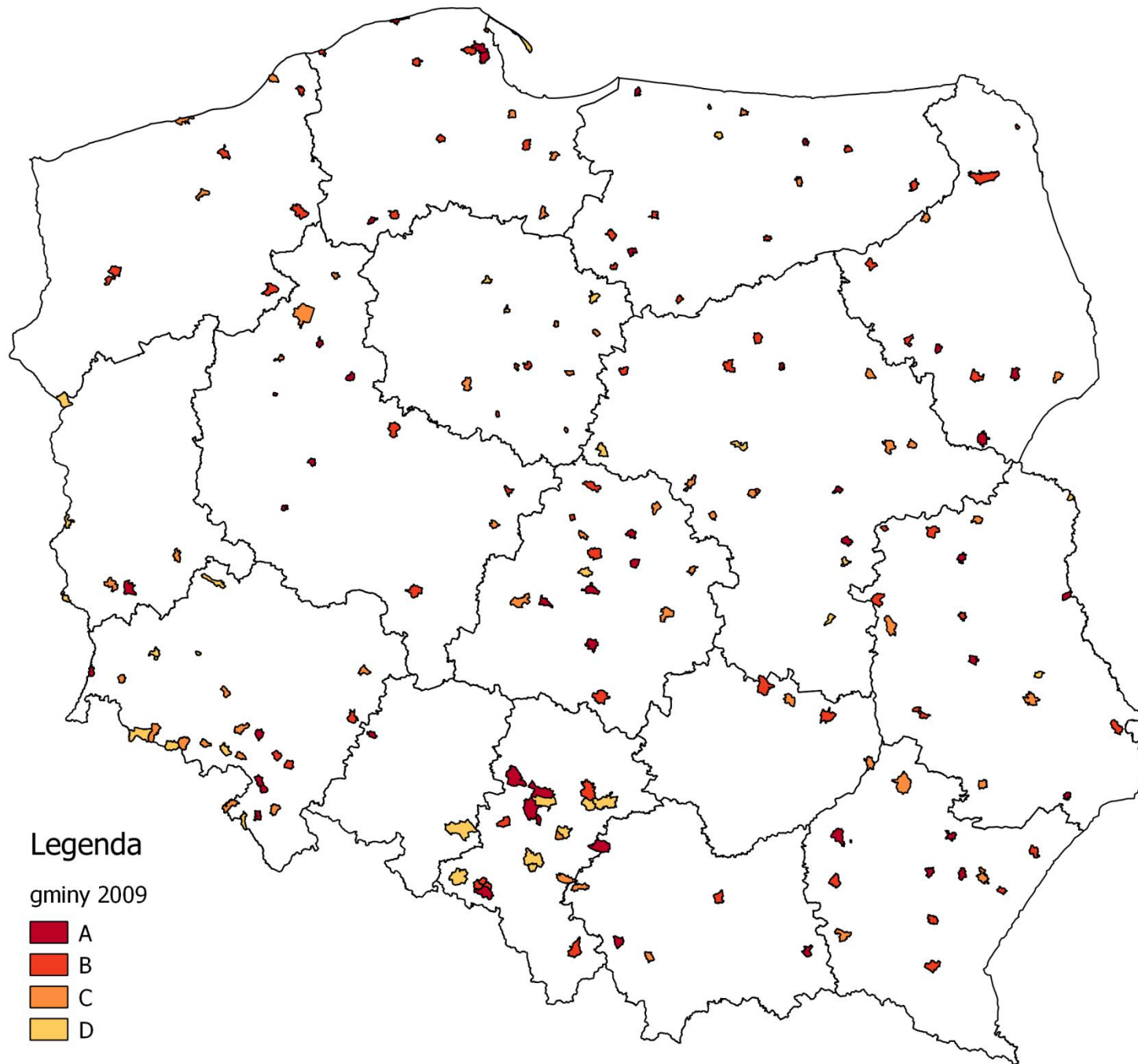| Voivodeship	Avg efficiency							
	2009	2010	2011	2012	2013	2014	2015	2016
Dolnośląskie	0.82	0.77	0.82	0.85	0.86	0.89	0.91	0.93
Kujawsko-pomorskie	0.81	0.75	0.78	0.76	0.84	0.83	0.86	0.90
Lubelskie	0.89	0.85	0.85	0.84	0.88	0.91	0.87	0.94
Lubuskie	0.79	0.75	0.74	0.79	0.80	0.85	0.85	0.89
Łódzkie	0.90	0.87	0.85	0.90	0.92	0.92	0.94	0.93
Małopolskie	0.92	0.95	0.91	0.91	0.91	0.91	0.92	0.91
Mazowieckie	0.85	0.83	0.84	0.85	0.88	0.89	0.88	0.87
Opolskie	0.81	0.70	0.87	0.82	0.87	0.90	0.89	0.91
Podkarpackie	0.92	0.87	0.92	0.89	0.89	0.88	0.91	0.93
Podlaskie	0.91	0.88	0.90	0.93	0.93	0.92	0.91	0.96
Pomorskie	0.90	0.85	0.83	0.84	0.87	0.90	0.90	0.90
Śląskie	0.86	0.87	0.88	0.90	0.88	0.90	0.87	0.92
Świętokrzyskie	0.86	0.67	0.81	0.85	0.91	0.93	0.94	0.95
Warmińsko-mazurskie	0.90	0.81	0.85	0.87	0.91	0.90	0.93	0.92
Wielkopolskie	0.93	0.95	0.94	0.92	0.92	0.92	0.94	0.95
Zachodnio-pomorskie	0.88	0.87	0.86	0.89	0.89	0.88	0.89	0.89
Total :	0.87	0.84	0.85	0.87	0.88	0.90	0.90	0.92

At the same time, it should be pointed out that due to the calculated level of efficiency indicators DMU can be divided into four categories (Table 4). On the basis of ordered values of efficiency indicators, the following groups of municipalities were distinguished ($\acute{e}$- the arithmetic mean, and δ_e- standard deviation of the DEA CCR-O efficiency indicator):

- group A (high efficiency): $e_j \geq \acute{e} + \delta_e$,
- group B (average efficiency): $\acute{e} \leq e_j < \acute{e} + \delta_e$,
- group C (low efficiency): $\acute{e} - \delta_e \leq e_j < \acute{e}$
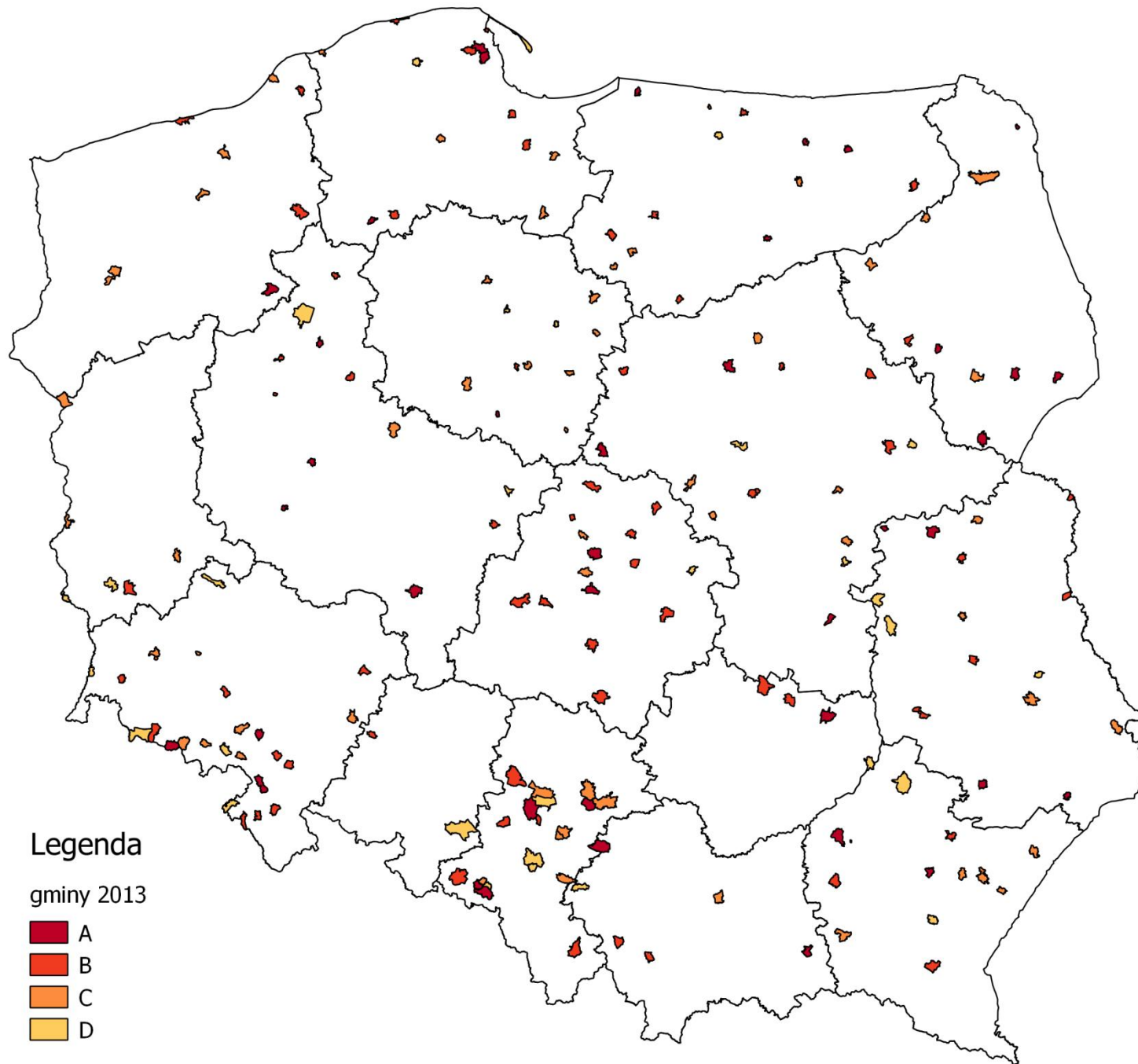- group D (very low efficiency): $e_j < \acute{e} - \delta_e$.

Tab. 4: Division of DMU into groups based on the value of performance indicators

Efficiency groups	2009	2010	2011	2012	2013	2014	2015	2016
A	45	42	43	44	39	44	44	50
B	61	55	60	56	65	62	66	59
C	56	66	57	62	58	56	53	56
D	30	29	32	30	30	30	29	27

Source: own elaboration

Legenda

gminy 2009

- A
- B
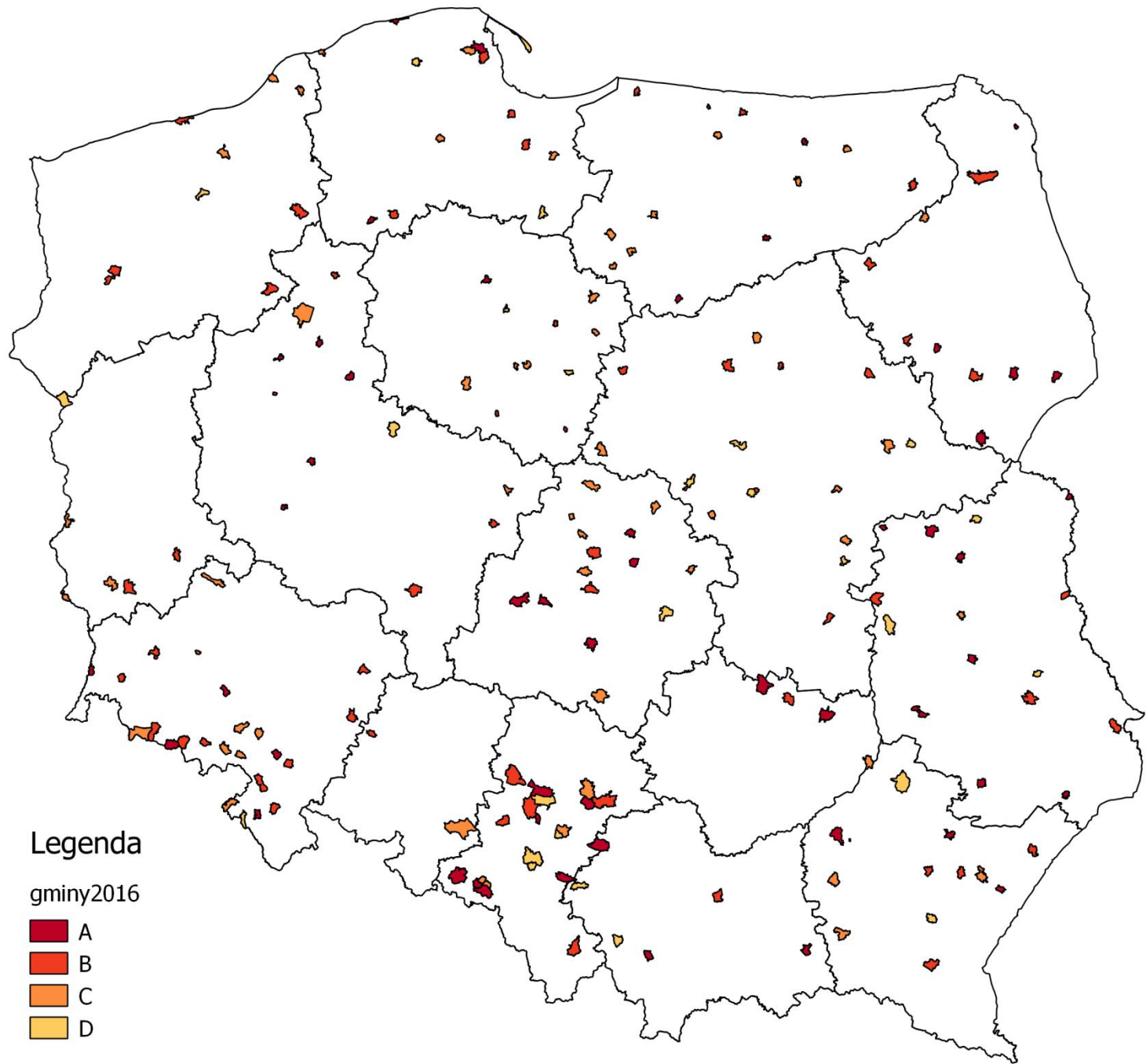- C
- D

Legenda

gminy 2013

- A
- B
- C
- D

Legenda

gminy2016

- A
- B
- C
- D

According to the assumptions of the work the research was carried out to verify the hypothesis that there is a relationship between the income potential of municipalities and the (relative) efficiency of their expenses. The basic research problem is to determine the correlation between the income of particular DMUs and their technical efficiency indicators

correlations	2009	2010	2011	2012	2013	2014	2015	2016
TR_DEA	-0.48665	-0.62479	-0.51396	-0.50347	-0.37828	-0.51751	-0.48142	-0.39833
OR_DEA	-0.36942	-0.36483	-0.33134	-0.28651	-0.23849	-0.27884	-0.31334	-0.23991

Type	H	M	N	L	Sum
A	2	10	26	7	45
B	2	15	37	7	61
C	9	23	20	4	56
D	16	4	8	2	30
Sum	29	52	91	20	192

Type	H	M	N	L	Sum
A	2	6	28	3	39
B	7	19	35	4	65
C	5	16	33	4	58
D	12	9	8	1	30
Sum	26	50	104	12	192

Type	H	M	N	L	Sum
A	6	5	35	4	50
B	2	17	38	2	59
C	5	23	27	1	56
D	10	7	5	5	27
Sum	23	52	105	12	192

Conclusions:

In closing, it should be stated that the conducted research has shown the existence of a relationship between the level of income per capita of the studied municipalities and their relative technical efficiency measured by the DEA CCR-O method. However, the obtained results should be treated with great caution due to both the imperfection of the method, the limited scope of the data to be obtained, exogenous factors that may influence the effects of the municipalities' activities and the specific preferences of the residents of particular municipalities. From the point of view of future research the possibility of using other DEA models and changes in their direction should be considered.

Thank You for attention.

Jarosław Olejniczak, PhD
Wroclaw University of Economics
jaroslaw.olejniczak@ue.wroc.pl