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# DEA METHOD AS A TOOL OF RATING EFFICIENCY – CASE OF THE LUBELSKIE VOIVODESHIP COMMUNITIES

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**Abstract:**
The efficiency of functioning is a crucial issue not only in relation to private companies but in the local government units as well, which put more and more emphasis on efficiency nowadays. The local government unit, that is the community (NUTS5 in Nomenclature of Territorial Units for Statistics), is intended to efficiently and effectively meet the needs of its residents. The increase of community expectancy and limited resources it has, makes them to efficiently and reasonably manage their resources. There is a specific method of measuring the efficiency of the public sector unit is Data Envelopment Analysis (DEA). It is a nonparametric method, which uses linear programming to define the relative efficiency of analysed units. The purpose of the article is to analyse the communities' efficiency using the DEA method. The communities of the Lubelskie province were researched. The main efficiency measurement of the local government unit is the utility of performed actions influencing local society. Efficiency of individual communities and their change over the years were also researched and compared. The article is summarised with the conclusions from the research and possible solutions for the communities to improve their efficiency.

*Keywords: Data Envelopment Analysis, efficiency, public sector, NUTS5, nonparametric methods of efficiency measurement*

# 1. INTRODUCTION

Efficiency is one of the basic concepts used in economics. The roots of the efficiency concept should be sought in the doctrine of utilitarian philosophy. According to the main assumption of this branch - the utility principle – the behaviour is right, when it leads to the greatest amount of happiness. Because of its interdisciplinary character, it is difficult to define efficiency. Literature provides us with many definitions of this concept.

The efficiency can be defined as the most efficient usage of society resources to meet humans' needs. (Samuleson, Nordhaus, 1997) It can also be defined as an efficiency and efficiency measure of the goals' achievement level. (Stoner, Freeman, Gilbert, 1997) There are many important factors that need to be taken into consideration to assess unit's efficiency. One of the key factors is the expenses minimisation, which can be achieved due to the work efficiency increase, employees' qualifications increase and more efficient management. There are also other things that need to be expected, such as the level of assignments and socio-economic aims fulfillment, as well as the assessment in the quantitative aspect.

Local government is an essential economic and social component not only in the region scale, but in the whole state. Local governments spend the increasing part of its expenses on investments, leading to economic growth. The trend maintenance is dependent on the commune's financial possibilities and efficiency optimisation. Each unit has limited resources, which have to be spent reasonably due to increasing society needs. Local governments are forced to improve its efficiency constantly and to use its financial and human potential as well as possible. (Rapkiewicz, 2012, p. 7)

The success of local government units functioning is reflected in efficient and efficient fulfillment of its inhabitants' needs. Without a doubt, commune, as a basic local government unit, should also be efficient and effective, which means that it should achieve its statutory aims while minimising expenses. Goods and services provided by a public sector are strictly regulated – this is because of the fact, that the economic and social tasks realisation are financed with public funds. There is an increasing pressure on local governments to spend public resources reasonably and to make local government units more efficient. (Lubińska, 2007, p. 38)

The purpose of the article is to measure the efficiency of the communes situated in Lubelskie province. Commune, as a local government unit is equivalent to NUTS5 in Nomenclature of Territorial Units for Statistics. In Poland there are 2478 communes – 1563 rural communes, 611 urban-rural communes and 304 urban communes, whereas in Lubelskie province there are 213 communes – 170 rural communes, 23 urban-rural communes and 20 urban communes. The analysis was prepared with a usage of Data Envelopment Analysis (DEA), which is nonparametric method using linear programming to define the relative efficiency of analysed Decision Making Units (DMU).

# 2. EFFICIENCY ASSESSMENT METHODOLOGY

## 2.1. Overview of the efficiency assessment methodology

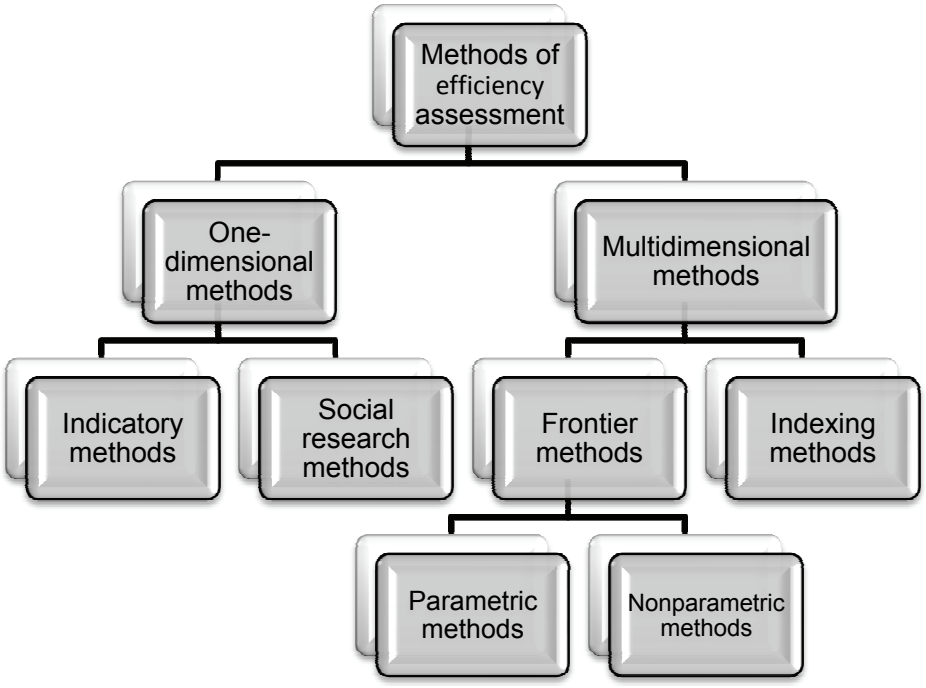
The measurement and analysis of the efficiency is the main subject of the economic calculation. Efficiency may be described as an effect of undertaken activities, which can be expressed as a relationship between gained effects and incurred expenses. (Becker, Becker, 2009, p. 6) There are different methods, which can be used to assess the efficiency. Each of the methods is based on different assumptions. First of them – the indicator method – comes down to construction of relations between particular amounts. In this case, it is important to assess the quantities and interpret them correctly. The interpretation of the result is based on the comparison of its values with the reference base.

Another way of efficiency assessment is the parametric approach, which is based on econometrical models. Models used in this approach introduce production function to the efficiency assessment. Parametrical methods include such models as Thick Frontier Approach (TFA) and Distribution Free Approach (DFA). The last described approach to the efficiency assessment is nonparametric approach, which uses linear programming and does not include random factor's impact on the unit's efficiency, as well as potential measurement mistakes. In this approach the relation between effects

and expenses is not described. Nonparametric methods, which are most commonly used are Data Envelopment Analysis (DEA) and Free Disposal Hull (FDH). (Lubimow-Burzyńska, 2014, pp. 117-118)

The efficiency assessment methods can be also divided into one-dimensional and multidimensional models. One-dimensional methods are connected to the organisation's assessment in the single criteria system. This group consists most of all of indicatory methods. Another important component included in this group are social research methods, which are related to quality aspects of unit's efficiency. Multidimensional methods enable criteria aggregation. Multidimensional analysis includes frontier methods, which consist of parametric and nonparametric methods, and indexing methods. (Ziębicki, 2014, pp. 84-85) The division of the efficiency assessment methods is presented on Picture 1.

**Picture 1:** Methods of efficiency assessment




Source: Own elaboration.

Most commonly used methods of the models mentioned are indicatory and frontier ones. The main restriction of the indicatory methods usage is inability to analyse the few expenses' impacts, and as a result achieved effects, at the same time. Such analysis is possible thanks to frontier methods. (Ziębicki, 2014, pp. 84-85)

## 2.2. Data Envelopment Analysis Method

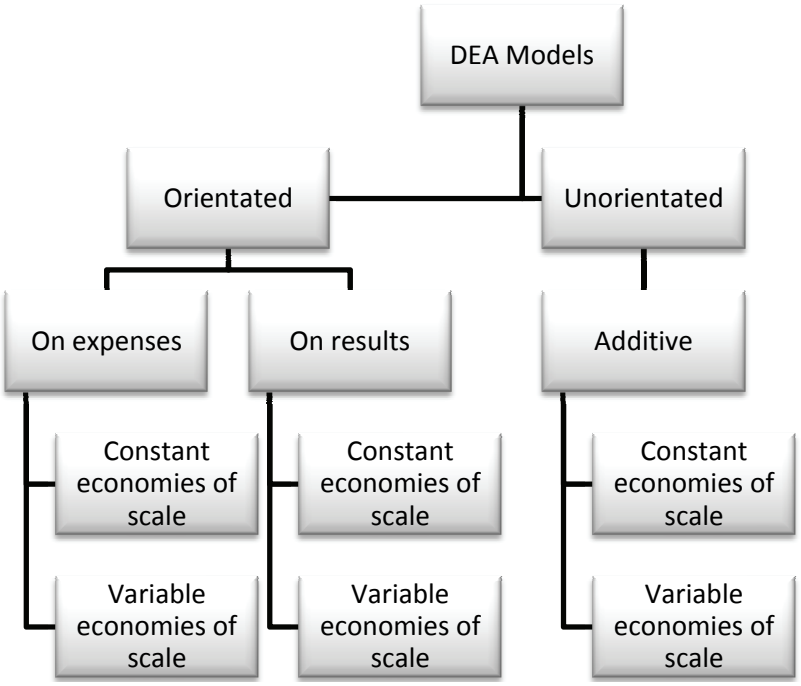
Each organisation's efficiency assessment is strongly related to the concept of productivity. Productivity is widely defined - it is treated as socio-economic concept of the multi-level structure. Productivity is expressed in economic, social, administrative and institutional activities' optimisation, which takes human and social factors into consideration. In case of the productivity concept it is important, that each system uses different types of resources in particular amounts and provides environment with a certain amount of produced goods and services.

In case of local government units' productivity analysis, it is assumed, that each of these institutions can be characterised by its input resources (expenses) and effects (outputs), as well as transformation processes, which convert resources into results. The more efficiently the resources essential for process realisation are used, the more productive the process becomes. The productivity measurement enables the assessment of material, financial and human resources, which are remaining at the unit's disposal, efficiency usage. It also enables the efficiency comparison to results achieved by other units from analysed sector. To sum up, the productivity measurement enables

realistic goals establishment and formulation of recovery programs to improve the existing situation to achieve established goals. (Nazarko, Komuda, Kuźmicz, Szubzda, Urban, 2008, pp. 90-91)

As mentioned before, Data Envelopement Analysis (DEA) is nonparametric method which uses (using) linear programming to establish the relative efficiency of analysed Decision Making Units. It is based on the concept of frontier efficiency. The method was used for the first time by A. Charmes, W. Cooper and E. Rhodes. They used linear programming to estimate technical efficiency measurements and created first model named CCR or CRS (constant return-to-scale). This method assumes constant economies of scale. Since the first usage, it was modified many times. (Kosmaczewska, 2011, pp. 132-133) The object of the DEA analysis is Decision Making Units, and the subject is the productivity of the expenses into effects transformation performed by DMUs. (Łękawa, 2012, p. 516) The division of the DEA models is presented on Picture 2.

**Picture 2:** DEA models




Source: Ćwiąkała-Małys, 2009, p. 10.

In the DEA method a finite number of units with equally defined expenses and results is analysed. Decision Making Units can be production, sales and service companies, and especially public sector units, where typical criteria based on financial coefficients are not adequate to assess this type of activities. Due to the fact, that public sector units are not set to make profit, their efficiency should be assessed by limited resources management efficiency, not only referring to financial coefficients. (Becker, Becker, 2009, pp. 6-7)

The efficiency in DEA model can be presented as the following formula:

where:
– number of effects,
– number of expenses,
– weights describing the importance of particular effects,
– weights describing the importance of particular expenses.

The DEA method does not require the former weights knowledge. The weights which maximise each objects efficiency are searched while making the calculations. The optimisation problem is solved by

setting the distance from the real production level from theoretically set efficiency frontier. The DEA methods enable setting the efficiency curve, also called production frontier. On the efficiency curve, there are the most efficient units from the given statistical community. They are said to be technically efficient. Unit's efficiency is measured in relation to other units from the analysed group. (Becker, Becker, 2009, p. 7)

# 3. THE EFFICIENCY ANALYSIS OF THE COMMUNES IN LUBELSKIE PROVINCE

## 3.1. The commune as a basic local government unit

Commune is the main local government unit in Poland. As mentioned before in Lubelskie province there are 213 communes – 170 rural communes, 23 urban-rural communes and 20 urban communes. Communes' range of activities includes all public issues of a local importance, not defined statutorily for other units. Commune's tasks are divided into communes own tasks and assigned tasks. Communes' own tasks are the ones regulated statutorily, whereas assigned tasks are delegated from the State authorities. The commune realises all tasks, that are not statutorily assigned to other local government units. Communes' inhabitants take part in governance by voting in local elections, referendum or through the communes authorities.

Commune's own tasks are public tasks performed by local government unit, which are meant to meet the needs of local community. They are divided into obligatory tasks, which need to be taken into consideration in the commune's budget. The commune cannot abandon fulfilling this tasks. The other group are facultative tasks, which are realised depending on the owned resources and local needs. (Dolnicki, 2009, 62 – 104).

Commune's own tasks include the case of:

- spatial order, real estate management, environmental protection
- commune's roads, streets, bridges, squares and traffic organization,
- water supply, sewerage, disposal and cleaning of urban waste water, maintaining cleanliness and order and sanitary landfills and disposal of commune's waste, supply of electricity, heat and gas,
- local public transport,
- health,
- social assistance, including the welfare centres and institutions,
- commune's housing,
- public education,
- culture, including local libraries and other cultural institutions and the protection of monuments and care of monuments,
- physical culture and tourism, including recreational areas and sports facilities,
- marketplaces,
- communes cemeteries,
- public order and citizens' safety and fire protection and flood control, including facilities and maintenance of the municipal magazine flood,
- maintenance of municipal buildings and public facilities,
- family policy, including the provision of social welfare, medical and legal care, for pregnant women,
- support and the promotion of the local government,
- commune's promotion,
- cooperation with NGOs,
- cooperation with local communities.

Commune's assigned tasks result from justified State's needs, which government cedes by laws or agreements on local government units and government administration.

## 3.2. Variables selection

The results received by the DEA method and their usefulness depends on the correctness of expenses and effects of analysed units activities specification. In case of local government unit analysis, it is treated as 'producer', which uses production factors, such as work and capital used to

produce public goods and services necessary for local community. Usage of this method, similarly as the usage of parametric methods, is related to the problem of variables and its number selection. The expenses and effects number increase, increasing the number of efficient units, which are not standard for inefficient unit. Such specification has no cognitive value. The variables selection in DEA model is related to the analysis purpose and data availability. (Łękawa, 2012, p. 520)

To prepare the assessment, the following characteristics were chosen:

- number of students per number of inhabitants,
- number of students per one computer with Internet access,
- number of children in kindergartens on the number of inhabitants
- amount of social assistance per capita,
- dynamics of expenditure on social assistance per capita,
- number of readers in libraries per 1,000 inhabitants,
- length of the active sewerage network,
- percentage of population with access to sewage.

### 3.3. Analysis results

The subject of the analysis in the article is the communes efficiency analysis using the DEA method. There were communes from Lubelskie province analysed in the years 2009 – 2014. Table 1 contains Descriptive statistics of data included in synthetic indicator, which reflects social effects of the local government unit's efficiency in basic socio-economic areas. Analysis includes eight indicators gathered in four groups: Education, Public Assistance, Culture and Sanitary Services.

**Table 1:** Descriptive statistics of data included in WJST indicator

| Distribution parameter | Education | | | Public assistance | | Culture | Sanitary Services | |
|---|---|---|---|---|---|---|---|---|
| | W1 | W2 | W3 | W4 | W5 | W6 | W7 | W8 |
| Mean | 96,94 | 10,33 | 0,02 | 604,02 | 1,15 | 163,18 | 24,60 | 27,55 |
| Median | 94,53 | 8,59 | 0,02 | 493,63 | 1,04 | 150,00 | 14,50 | 19,50 |
| Quartile 1 | 87,12 | 6,15 | 0,03 | 425,33 | 1,00 | 109,00 | 6,70 | 6,58 |
| Quartile 3 | 101,02 | 12,77 | 0,08 | 587,91 | 1,09 | 195,00 | 28,00 | 38,00 |
| Standard deviation | 34,86 | 9,60 | 0,01 | 1135,52 | 1,55 | 88,10 | 44,39 | 27,02 |
| Skewness | 2,48 | 9,26 | 1,17 | 17,44 | 20,23 | 1,73 | 9,08 | 1,10 |
| Kurtosis | 13,31 | 132,55 | 3,55 | 333,19 | 463,18 | 5,42 | 107,57 | 0,15 |
| Standard variation coefficient | 0,15 | 0,39 | 1,49 | 0,16 | 0,05 | 0,29 | 0,73 | 1,61 |
| Positional variation coefficient | 0,36 | 0,93 | 0,46 | 1,88 | 1,34 | 0,54 | 1,80 | 0,98 |

W1 – number of students per number of inhabitants,
W2 – number of students per one computer with Internet access,
W3 – number of children in kindergartens on the number of inhabitants,
W4 – amount of social assistance per capita,
W5 – dynamics of expenditure on social assistance per capita,
W6 – number of readers in libraries per 1,000 inhabitants,
W7 – length of the active sewerage network,
W8 – percentage of population with access to sewage,
Source: Own elaboration based on data from Central Statistical Office.

The synthetic indicator WJST was used to characterise the social effects of commune's activities. The indicator is a relation of mean of nine standardised characteristics described in Table 1. The formula of the indicator presents as the following:

$$WJST = \frac{1}{8}\sum_{j=1}^{8}\frac{W_j}{\overline{W_j}}$$

The indicators value greater than 1 means that the commune achieved social effects on the higher level than the communes' average. The indicator's value of less than 1 means, that social effects are lower than the average.

The variable which characterises expenses are expenditures per capita. The descriptive statistics of expenses per capita and WJST indicator in years 2009 – 2014 is presented in Table 2.

**Table 2:** Descriptive statistics of expenses per capita and WJST indicator in years 2009 – 2014

| Distribution parameter | 2009 | | 2010 | | 2011 | |
|---|---|---|---|---|---|---|
| | Y | WJST | Y | WJST | Y | WJST |
| Mean | 2523,565 | 0,999662 | 3132,762 | 0,999576 | 3120,972 | 0,996449 |
| Median | 2425,88 | 0,890612 | 2913,36 | 0,874759 | 2954,82 | 0,918695 |
| Quartile 1 | 2246,93 | 0,76664 | 2636,665 | 0,73218 | 2611,725 | 0,788562 |
| Quartile 3 | 2649,54 | 1,052318 | 3382,09 | 1,050189 | 3400,715 | 1,055961 |
| Standard deviation | 544,6573 | 0,431303 | 1357,164 | 0,536246 | 814,0642 | 0,374171 |
| Skewness | 5,764383 | 4,08143 | 10,55032 | 5,438509 | 3,569852 | 3,924075 |
| Kurtosis | 53,91378 | 27,64091 | 135,1075 | 42,25402 | 22,74621 | 26,27067 |
| Standard variation coefficient | 0,215829 | 0,431449 | 0,433216 | 0,536473 | 0,260837 | 0,375505 |
| Positional variation coefficient | 0,082982 | 0,160384 | 0,127932 | 0,181769 | 0,133509 | 0,145532 |
| Distribution parameter | 2012 | | 2013 | | 2014 | |
| | Y | WJST | Y | WJST | Y | WJST |
| Mean | 2998,227 | 0,997241 | 3005,456 | 0,999557 | 3254,941 | 0,999288 |
| Median | 2925,95 | 0,867873 | 2912,87 | 0,883691 | 3110,54 | 0,898769 |
| Quartile 1 | 2660,105 | 0,754274 | 2663,535 | 0,780081 | 2908,345 | 0,800198 |
| Quartile 3 | 3198,82 | 1,060138 | 3256,395 | 1,049252 | 3473,95 | 1,054052 |
| Standard deviation | 530,5314 | 0,57857 | 539,9547 | 0,459756 | 570,3983 | 0,422476 |
| Skewness | 2,374756 | 7,528346 | 2,37956 | 4,261757 | 1,765251 | 4,807116 |
| Kurtosis | 11,42795 | 78,05711 | 10,02981 | 25,65013 | 4,344977 | 34,25722 |
| Standard variation coefficient | 0,176948 | 0,580171 | 0,179658 | 0,459959 | 0,175241 | 0,422777 |
| Positional variation coefficient | 0,092058 | 0,176215 | 0,101766 | 0,152299 | 0,090917 | 0,141223 |

Source: Own elaboration based on data from Central Statistical Office.

The communes' relative efficiency was calculated with the usage of DEA model oriented on the expenses. This model assumes the minimisation of expenses to achieve particular level of the effects and the constant economies of scale. Table 3 presents the fragment of communes from Lubelskie province rank in years 2009 and 2014. Next to the commune's names there are symbols (1), (2) and (3). Symbol (1) means that it is urban commune, (2) being rural commune and (3) stands for urban-rural commune. The table presents first and last ten places from the rank.

Table 3 provides with information, that in Lubelskie province the most efficient (communes) are rural ones. Both in 2009 and in 2014 they are at the first ten places in the rank. Most of the communes in Lubelskie province do not have stable level of efficiency in analysed years. The situation of the efficiency change is perfectly visible on the example of Tomaszów Lubelski (2). This commune was first in the rank in 2009. In 2014 it fell down to 195th place.

**Table 3:** The fragment of communes' rank in years 2009 and 2014

| 2009 | | | | 2014 | | | |
|---|---|---|---|---|---|---|---|
| Place in the ranking | Commune | Indicator | Place in the ranking in 2014 | Place in the ranking | Commune | Indicator | Place in the ranking in 2009 |
| 1 | Adamów (2) | 1,000 | 195 | 1 | Adamów (2) | 1,000 | 14 |
| 2 | Rybczewice (2) | 0,984 | 2 | 2 | Nielisz (2) | 0,890 | 10 |
| 3 | Tomaszów Lubelski (2) | 0,945 | 27 | 3 | Stary Zamość (2) | 0,734 | 26 |
| 4 | Wojciechów (2) | 0,938 | 17 | 4 | Goraj (2) | 0,702 | 71 |
| 5 | Turobin (2) | 0,881 | 62 | 5 | Uchanie (2) | 0,701 | 17 |
| 6 | Łopiennik Górny (2) | 0,874 | 94 | 6 | Batorz (2) | 0,686 | 67 |
| 7 | Hrubieszów (2) | 0,873 | 19 | 7 | Krasnystaw (2) | 0,683 | 51 |
| 8 | Konopnica (2) | 0,865 | 11 | 8 | Trzeszczany (2) | 0,673 | 16 |
| 9 | Miączyn (2) | 0,849 | 86 | 9 | Hrubieszów (2) | 0,665 | 70 |
| 10 | Nielisz (2) | 0,846 | 56 | 10 | Siennica Różana (2) | 0,662 | 71 |
| … | … | … | … | … | … | … | … |
| 204 | Włodawa (1) | 0,240 | 149 | 204 | Wola Uhruska (2) | 0,245 | 133 |
| 205 | Tomaszów Lubelski (1) | 0,227 | 195 | 205 | Biłgoraj (1) | 0,221 | 206 |
| 206 | Biłgoraj (1) | 0,210 | 205 | 206 | Zwierzyniec (3) | 0,215 | 149 |
| 207 | Puławy (1) | 0,186 | 208 | 207 | Świdnik (1) | 0,206 | 197 |
| 208 | Puchaczów (2) | 0,175 | 172 | 208 | Puławy (1) | 0,198 | 207 |
| 209 | Podedwórze (2) | 0,169 | 87 | 209 | Biała Podlaska (1) | 0,161 | 211 |
| 210 | Chełm (1) | 0,149 | 212 | 210 | Trawniki (2) | 0,148 | 25 |
| 211 | Biała Podlaska (1) | 0,125 | 209 | 211 | Wola Mysłowska (2) | 0,147 | 22 |
| 212 | Zamość (1) | 0,117 | 91 | 212 | Chełm (1) | 0,126 | 210 |
| 213 | Lublin (1) | 0,057 | 213 | 213 | Lublin (1) | 0,089 | 213 |

Source: Own elaboration based on data from Central Statistical Office.

The efficiency is specified relatively, which means that each year its level is referred to the most efficient commune. It is difficult to assess how exactly the efficiency changes, but the trends in the efficiency changes in reference to other units can be clearly seen. The reason for the fluctuations in the efficiency level can be investments conducted in the researched areas. Especially investments in the area of education, health and sanitary services can lead to measurable effects, which result in efficiency level increase. Another reason for the fluctuations can be the change in local authorities, which may result in the efficient resources usage improvement or deterioration.

## 4. CONCLUSIONS

The local government units efficiency is more and more often analysed due to the higher expectations from the society for local authorities. The attention is more often paid to the efficient usage of resources, which are allocated by communes. It is important that the incurred expenses bring measurable effects for the society.

The systematic assessment of the local government units brings benefits not only for authorities, which dispose the limited resources, but especially for analysed units. DEA analysis enables to get information about unit's efficiency in relation to other comparative units from the sector. The usage of

the DEA analysis is reasonable due to its multidimensional character, which enables to take into account both quantitative and qualitative characteristics.

Although DEA is a very effective method, it also has certain limitations. First of all, since DEA is an extreme point technique, even small disruption (such as measurement error) can cause significant problems. It is worth mentioning that DEA method allows to measure efficiency only in a relation to other Decision Making Units. Using this method does not result in defining absolute efficiency but only efficiency compared to the theoretical maximum. DEA is a nonparametric technique, statistical hypothesis tests are difficult and are the focus of ongoing research. Another problem is that a standard formulation of DEA creates a separate linear program for each DMU, which can cause large computational problems.

The conducted analysis shows, that the commune's efficiency in Lubelskie province is variable. Only few units remains on stable in the rank. The resources disposers in particular units should take care of constant improvement of the resources usage, so that the needs of the local society are fulfilled on the highest possible level. Due to the fact, that human needs are endless and the commune's resources are limited, the complete needs fulfillment is impossible. However, constant care about efficient resources usage will result in the improvement of local authorities perception in society, as well as on the life quality improvement.

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