

Magdalena Ziolo

Efficiency assessment of capital expenditures of the municipalities using the DEA method : (Data Envelopment Analysis)

Ekonomiczne Problemy Usług nr 100, 253-261

2012

Artykuł został opracowany do udostępnienia w internecie przez Muzeum Historii Polski w ramach prac podejmowanych na rzecz zapewnienia otwartego, powszechnego i trwałego dostępu do polskiego dorobku naukowego i kulturalnego. Artykuł jest umieszczony w kolekcji cyfrowej bazhum.muzhp.pl, gromadzącej zawartość polskich czasopism humanistycznych i społecznych.

Tekst jest udostępniony do wykorzystania w ramach dozwolonego użytku.

MAGDALENA ZIOŁO

University of Szczecin

**EFFICIENCY ASSESSMENT OF CAPITAL EXPENDITURES
OF THE MUNICIPALITIES USING THE DEA METHOD
(DATA ENVELOPMENT ANALYSIS)¹**

Introduction

The spending of public funds by entities located within the public sector is a process which is accompanied by risk and numerous dysfunctional phenomena. Public entities often complain of mismanagement or even a waste of public resources. An attempt to change this state of affairs is the reform of public sector carried out by individual countries in the world with a common goal even though aimed at increasing the efficiency of the public entities. A key aspect in this area is to improve the efficiency of public spending, which is reflected in such orientation of the resulting implementation on the ground of the general government.

From the criterion of efficiency approach, public spending is a special category of capital expenditure, since it contributes to creating value-added processes of growth and development. The dominant role in the allocation of capital expenditure the local government plays especially at municipal level, due to the nature and characteristics of communes. The implementation of municipal investment in practice faces many limitations of various origins. One of the factors which have a significant impact on it is the dynamics of investment spending and economic efficiency of municipal investments.

¹ The article is a part of study regarding to sources of financing of communal investment and its efficiency. Scientific work financed from funds for science in the years 2010–2012.

This article aims to evaluate the efficiency of capital expenditure in the municipalities of the Westpomeranian Region between 2004–2009 using the DEA method.

1. *Data Envelopment Analysis as a tool supporting assessment of the efficiency of capital expenditures*

Data Envelopment Analysis is a nonparametric method² which was originally used to assess the efficiency of the strategic areas of the state (natural monopolies), such as air transport or health services. Today it is becoming widely used among others to evaluate the efficiency of public spending.³ The DEA method was first used in 1978, Americans A. Charns, W.W. Cooper, E. Rhodes, hence the basic model with the letters DEA method and the names of its precursors is known as CCR. The most common examples of the use of this tool are recorded in the banking and health services.⁴

The DEA method is commonly used to evaluate the efficiency of different spheres of activities, including assessment of the functioning of public sector entities.⁵ One advantage of this method is that taking into account the impact of external factors (eg. *environmental*) on the level of efficiency of stimulus objects. In view of this, the many definitions of the efficiency of DEA methods for this category are defined as the ratio of outcomes to inputs.

$$EFFICIENCY = \frac{\sum_{r=1}^s u_r OUTCOMES}{\sum_{i=1}^m v_i INPUTS},$$

² M. Pawłowska, S. Kozak, *Przystąpienie Polski do strefy euro a efektywność, poziom konkurencji oraz wyniki polskiego sektora finansowego*, "Materiały i Studia" 2008, Zeszyt nr 228, NBP, p. 19.

³ M. Zychowicz, *Ocena korzyści skali z zastosowaniem metody DEA*, "Bank" 2001, nr 6, p. 46–51.

⁴ M. Al-Shammari, *A multi-criteria data envelopment analysis model for measuring the productive efficiency of hospitals*, "International Journal of Operations & Production Management" 1999, Vol. 19, No. 9, p. 882.

⁵ Yi-Chung Hsu, Chien-Chiang Lee, *The Performance of Public Spending in OECD Countries.*, p. 3–4 http://www4.nccu.edu.tw/ezkm11/ezcatfiles/cust/img/img/94_lee_article.pdf (11.07.2012).

u_r – weights determining the validity of the individual outcomes,

v_i – weights of determining the validity of the various inputs.

Measuring the efficiency of the method of estimation of border initially focused on defining the inputs and outputs selected for a given variables.⁶ DEA method involves bringing inputs which is different to the size effects of synthetic and calculating the coefficient of performance in a task which the linear programming objective function subject to optimization. Linear programming is to use a linear function for solving optimization. This function is used for approximating the results of optimization tasks. Optimization of many variables requires more complex functions and models in light of the above tasks will be subject to optimize the methods used for the development of multi-linear programming model, which optimizes the number of variables in parallel.⁷

The advantage of the DEA method is the ability to measure the efficiency of the variables expressed in different units of measurement without the need to unify. This is possible due to the fact mentioned earlier indicating that, unlike traditional methods, in this method the subject of optimization is efficiency of the ranks and not variables.

Efficiency assessment is carried out in three areas: technical efficiency, allocative efficiency and cost efficiency. Technical efficiency is the relationship between the productivity of the object, and the maximum productivity that can be achieved at the same cost, taking into account the technological playing field (production). This kind of efficiency can be focused on inputs, or outcomes.⁸ The efficiency of technology-oriented outcomes determines whether the expenditures of an entity achieves maximum results (to maximize results with certain level of effort). The efficiency of technology-oriented inputs indicates whether the minimum amount of effort achieved is the established size effects (minimize inputs while maintaining the specific outcomes).⁹

Allocative efficiency indicates whether a specific combination of inputs or outputs is what is desired for reasons of economics. Allocative efficiency measurement is done using the prices of inputs (input orientation) or the price effects (outcomes-oriented). When assessing the efficiency of their results is assumed

⁶ J. Baran, *Parametryczne i nieparametryczne metody badania efektywności skali spółdzielni mleczarskich*, "Roczniki Nauk Rolniczych" 2009, Seria G, T. 96, p. 101.

⁷ W. Radzikowski, *Badania operacyjne w zarządzaniu przedsiębiorstwem*, Toruńska Szkoła Zarządzania, Toruń 1997, p. 110.

⁸ A. Ćwiąkała-Małys, W. Nowak, *Sposoby klasyfikacji modeli DEA*, "Badania Operacyjne i Decyzje" 2009, nr 3, p. 10.

⁹ *Ibidem*.

as maximize, while minimizing costs. The analysis of the efficiency of their expenditures shall be minimized, while keeping unchanged the level of performance. Cost efficiency allows a comparison of actual costs incurred by the entity with the smallest cost price, which allows to obtain the same effects.

2. The methodology and results of the efficiency of capital expenditure in the municipalities of the Westpomeranian Region between 2004–2010

Methodology of the study, determined by the availability of complete and comparable statistics assumed for the calculation of the efficiency of the values of an averaged (2004–2010) relating to a group of municipalities of the Westpomeranian Region (114 units). Efficiency calculations were performed using PIM-DEA 3.0. Efficiency assessment addressed three areas of investment activity districts: water supply, sewerage, housing and basic education. The variables adopted for the purpose of this study are presented in Table 1.

Table 1 illustrates the variables, due to limited access to the data allow only a very general level and evaluate the efficiency of capital expenditure of examined municipalities. A similar problem concerns the national data on public sector efficiency.¹⁰

A set of groups of variables for the categories of rural, urban-rural, urban and city with powiat status the efficiency of both inputs (called in put oriented efficiency) and outputs (of output oriented efficiency) and a general study of the efficiency of (non efficiency oriented). Then correlation between efficiency of inputs and outcomes was evaluated.

Table 1

The variables taking into account in DEA analysis
(municipalities in Westpomeranian Region)

Input	Outcome
Capital expenditures for water supply and sewerage	Length of water supply network (km) Length of sewerage network (km)

¹⁰ B. Karbownik, G. Kula, *Efektywność sektora publicznego na poziomie samorządu lokalnego*, "Materiały i Studia", Zeszyt nr 242, Narodowy Bank Polski, Warszawa 2009, p. 13.

Input	Outcome
Capital expenditures for housing	The number of persons per m ² flat Usable floor space per person (m ²)
Capital expenditures for basic education	Number of schools / Number of graduates

Source: own elaboration.

Different levels of efficiency between inputs and outcomes within the same sphere of action due to the impact of qualitative factors such as management, quality of decision-making preparation conditions and the level of knowledge-makers, access to information. An important role is played by the EU funds available under the operational programs, national and regional, which will significantly affect the cost-efficiency of public entities. Significant impact on increasing the efficiency of the expenditure of rural municipalities has financial support under the RDP (Rural Development Programme). The overall results of the average efficiency of capital expenditure for particular types of communities are shown in Table 2.

Table 2

Average efficiency of selected, capital expenditures of the municipalities located in Westpomeranian Region

Type of municipality	DEA VRS input	DEA VRS output
Water supply and sewerage		
Rural	42.407	46.342
Urban-rural	48.735	54.472
Urban	79.345	63.173
City with powiat status	94.837	84.680
Housing		
Rural	53.298	47.035
Urban-rural	58.977	62.131
Urban	85.521	97.314
City with powiat status	95.667	97.000
Basic education		
Rural	48.523	51.731
Urban-rural	46.458	42.449
Urban	79.345	60.384
City with powiat status	100.000	100.000
DEA CCR		
Rural	42.094	
Urban-rural	50.337	

Type of municipality	DEA VRS input	DEA VRS output
Urban	81.428	
City with powiat status	96.333	

Source: own elaboration based on PIM-DEA.

The highest efficiency of capital expenditure is on rights record of the city with powiat status and urban municipalities. A significantly lower level of efficiency is characterized by rural and urban-rural entities, characterized by the highest level of waste of public funds. The rural municipalities are the group of units characterized by the lowest efficiency ratio of public investment spending in every examined investment field.

The highest level of efficiency is noticeable for the categories of expenditure on housing. Comparable limits on the efficiency of capital expenditure incurred are in the sphere of water supply and sanitation and primary schools. Within each level of the municipalities studied, the efficiency of the results (with the exception of municipalities for primary category) exceeds the level of efficiency of investment. The correlation between inputs and outcomes variable are presented in Table 3.

Table 3

Correlation between inputs and outcomes for the municipalities located
in Westpomeranian Region

Type of municipality	Correlation input outcome
Rural	0.805
Urban-rural	0.813
Urban	0.938
City with powiat status	1.000

Source: own elaboration based on PIM-DEA.

The relationship between variable defined as input and outcome for all tested areas of expenditure show a strong correlation. This may be the result of high homogeneity tests adopted in the study. The highest level of correlation which occurs between input-output efficiency at the level of municipalities and cities with powiat status are in fact the smallest number of objects in terms of groups of units and the most homogeneous. Rural and urban-rural municipali-

ties are much more numerous, and more diverse group of individuals, hence the correlation level of respect for these entities is lower. The strongest correlation relationships exist between the efficiency of inputs and outcomes obtained in the area of spending on primary education (Table 4).

Table 4

Correlation among input outcome variables for the municipalities located in Westpomeranian Region

Type of municipality	Water supply and sewerage	Housing	Basic education
Rural	0.474	0.536	0.788
Urban-rural	0.666	0.346	0.646
Urban	0.785	0.471	0.757
City with powiat status	1.000	1.000	1.000

Source: own elaboration based on PIM-DEA.

It is an area of activity of municipalities subject (as compared to other categories of expenditure), the highest level of standardization and uniform, detailed arrangements governing law. A similar regularity was observed at a national level analysis of the municipalities, where it was stressed that the impact on efficiency of the results may have regulations and procedures to standardize behavior and nature of the proceedings in selected areas of activity of municipalities. An example might be just the education and upbringing, where legal regulations regulate the tasks of the municipalities in this area, and the system of education, curricula, and how the financing of the general subsidy (part of education) is subject to the same rules.¹¹

It should be emphasized that a nationwide study on the efficiency of public sector spending on such areas as investments in: education and upbringing, municipal economy and environmental protection and public administration have shown that the municipalities located on Polish territory north-west and south-east achieve the lowest efficiency ratios for rest of the country.¹² At the same time the highest average efficiency are characterized by large cities and specific areas that surround them, among others around Poznan, Lublin, Lodz and Silesia.

¹¹ *Ibidem*, s. 117.

¹² *Ibidem*, s. 118.

Measuring efficiency in general, allows for the classification of municipalities into two groups namely: efficient and inefficient units. Research into the causes of diversity efficiency of the expenditure made for Polish communes into account such factors affecting the cost-efficiency as:

- the size of the municipality;
- the presence of EU funds in the financing structure;
- the size of revenues;
- the quality of human capital;
- education of councilors;
- location;
- tourism.

Each of these factors contributes to the diversification of the efficiency of capital expenditures by public bodies. The direction of impact on the efficiency depends on the individual circumstances of the entity. In that case a horizontal redistribution mechanism may reduce the efficiency at the level of transferring public funds under a system of redistribution, and at the same time, depending on individual circumstances may reduce or increase the efficiency of spending covered by the support. The strong degree of influence on the "determined" legally and economically efficient use of public funds are qualitative factors such as human resources, quality of governance, the powers of authorities, etc.

Conclusions

Study on the efficiency of capital expenditures of municipalities of the Westpomeranian Region with using of the DEA method showed a link between the size and specificity of the entity, and the level of efficiency of its spending for investment. The lowest level of efficiency ratio (on the background of the population reviewed) carry small territorial units (rural profile generally). This may be due to budgetary and staff constrains faced by this kind of municipalities. Lack of own revenues, or lack of specialized personnel are factors that might limit the availability of external funds to finance investment and contribute absorption of EU funds, which largely determine the dynamics of the investment process.

The highest level of investment spending was characteristic for large territorial units, which is not in doubt. These units have more funds for investment because of the structure of their revenues and economies of scale resulting from

the implementation far more investment than it is in smaller units. Large cities and urban municipalities also have greater access to experienced staff, allowing them to raise the funding necessary to carry out foreign financing. These units also often use advanced financial management tools allow them to control and reduce investment costs.

OCENA EFEKTYWNOŚCI WYDATKÓW INWESTYCYJNYCH GMIN Z WYKORZYSTANIEM METODY DEA

Streszczenie

W warunkach ograniczoności środków publicznych ich efektywne wydatkowanie jest wysoce pożądane. Badanie efektywności wydatków inwestycyjnych gmin z uwagi na swoją specyfikę napotyka wiele ograniczeń, wśród których istotny jest wybór narzędzia oceny efektywności. Jedną z często wykorzystywanych w tym zakresie metod jest nieparametryczna metoda DEA, pozwalająca na dokonanie pomiaru efektywności środków wydatkowanych na inwestycje przez badane jednostki na tle populacji objętej analizą.

Celem artykułu jest przybliżenie założeń metody DEA oraz dokonanie pomiaru efektywności wydatków inwestycyjnych gmin województwa zachodniopomorskiego dla danych z okresu 2004–2009. Badaniem objęto zmienne w zakresie efektów i nakładów dotyczące takich obszarów aktywności gminy, jak: gospodarka wodościekowa, gospodarka komunalna (mieszkalnictwo), oświata i wychowanie (poziom szkół gimnazjalnych).

Tłumaczenie Magdalena Ziolo