THE EVOLUTION OF THE EFFICIENCY OF THE SANITATION SERVICE PROVISION. LIMITS OF THE DATA ENVELOPMENT ANALYSIS METHODOLOGY

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Abstract: *This paper determines the evolution of the sanitation service provision at the level of 10 administrative-territorial units in Timis County during the period 2007-2017. In this respect we use the Data Envelopment Analysis methodology as a performant non-parametric method for determining efficiency. Subsequent to the general research goal, we demonstrate certain limitations of the methodology that can be remedied by an exhaustive mathematical approach. The results of the empirical analysis indicate small differences at the level of efficiency registered by the administrative-territorial units considered in the 11 years of the analysis and a lack of a trend to increase the efficiency level of the units. This work can be a guide for public decision-makers in the waste management area, for sanitation operators and attracts interest to citizens as users of the service.*

Keywords: Data Envelopment Analysis, Efficiency, Public administration, Sanitation service, Timis County;

JEL Codes: C33, G28, R51

Introduction

The provision of public goods and the management of public services are important tasks for a state. In accomplishing these tasks, the state must operate in an efficient and performant manner. The Functioning Treaty of the European Union by Article 14 and Protocol no. 26 annexed indicates that services of general economic interest play a major role in the values of the European Union. Thus, we consider that the community services of public utilities require special attention from the competent authorities.Law no. 215/2001 of the local public administration indicates that the management of the community services of public utilities is an aptitude of the local public administrations.Analyzing Law no. 51/2006 of the community utilities, we note that they consist of: (i) water supply; (ii) sewage and sewage treatment; (iii) collecting, channeling and discharging rainwater; (iv) sanitation of localities; (v) centralized system production, transport, distribution and supply of heat; (vi) public lighting; (vii) administration of the public and private domain of the territorial administrative units; (viii) local public transport. Of all these services, we focus on the sanitation service of the localities, the only community service which is mandatory by law and at the same time is the subject to structural changes and operations. Under these circumstances, we consider it appropriate to carry out a detailed analysis of the efficiency of the sanitation service.

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Efficiency analysis can be done through parametric and non-parametric methods. We consider non-parametric methods more suitable for this task, given that, unlike parametric methods, they do not start from a predefined form of the data. Non-parametric methods can identify the most appropriate model for the used data. Among non-parametric methods, we identify Data Envelopment Analysis (DEA) as a powerful methodology to determine efficiency for many reasons: (i) it determines efficiency by reference to the efficiency frontier; (ii) it determines inefficiency, so we can perform a dualistic analysis from the point of view of both efficiency and inefficiency, and (iii) it determines ways to streamline inefficient units by reference to the units identified as efficient. Marques et al. (2004) supports the use of DEA as a performant non-parametric method in the process of determining efficiency. In addition, the authors consider it necessary to study all relevant inputs and outputs that influence service delivery. In this way an exhaustive analysis is performed and the subjective dimension of the results is reduced.

This paper enriches the specialized literature from the field of efficiency analysis with an original study of the efficiency of the same administrative-territorial units in different years from 2007 to 2017. Moreover, we identify a limit of the DEA methodology regarding the selected variables and the individual decision units analyzed.

The paper is structured as follows: the first part presents relevantliterature for the chosen research theme. In the methodology and data section we present the set of data used as well as themathematical approach of the methodology.Results of the empirical analysisare presented in the third part of the paper and the last part presents the conclusions of our study.

Literature review

Romania's quality as a member state of the European Union requires a sustainable development process in the public sector. An important component for achieving performance in the public sector is the efficient provision of public services in general and of community services of public utilities in particular. Law no. 101/2006 of the sanitation service of the localities indicates that from all the community services of public utilities, the sanitation service is mandatory for all citizens. The development of the sanitation service is a necessity for Romania, the main problems identified at the level of waste management in Romania being: (i) non-compliant landfills; (ii) coverage of less than 90% in the provision of the service in rural areas; (iii) lack of selective waste collection process; (iv) the transport of waste on routes that are too long and facilitate pollution, (v) weak management by some local public authorities, and (vi) the lack of a process or project to remedy these deficiencies in organization and functioning.

In all counties of Romania, the Integrated Waste Management System was implemented, based on a European financing project that includes a set of strategic objectives for the development of the waste management: (i) the construction of waste treatment facilities and storage facilities,(ii) the establishment of the Intercommunity Development Associationand most importantly, (iii) the development of the quality of the provision of the sanitation service of the localities.. On this background, a process of developing the quality level of the sanitation service provision is assumed.

Assessing the quality of a service delivery can be analyzed from a dualistic perspective: (i) user perceived quality, analysed from the point of view of the utility for users and satisfaction degree regarding service provision. In this respect, we find relevant the study of Lobont et al. (2018) who applied a questionnaire to the level of 928 respondents in Timis county in 2017, pursuing two research directions: the efficiency of the sanitation service by reference to the satisfaction of the users and the level of bureaucracy identified in the provision of the sanitation service. The results of the study indicate a high level of satisfaction and a low degree of bureaucracy. (ii) Efficiency analysis by considering inputs and outputs relevant to service delivery.

We identify a rich literature with studies that determine the efficiency of community services of public utilitiesusing the Data Envelopment Analysis methodology.Emrouznejadet al. (2014)shows that DEA methodology has perhaps become the most pertinent non-parametric method of measuring productivity and efficiency. Furthermore, the authors highlight the advantage offered by DEA to evaluate extremely diverse inputs and outputs. Their consideration in the analysis should not necessarily be done in a pecuniary form. Thus, DEA is becoming a very useful tool for measuring public sector efficiency, being applicable both in the area of public goods and public services.Smith and Street (2005) highlights the importance of public decision-makers to identify ways to assess public sector efficiency. The authors recommend using Data Envelopment Analysis and Stochastic Frontier Analysis as useful methods. In addition, the authors suggest the importance of considering the weight or importance of each analyzed input and output as well as considering exogenous factors that can influence the results.

Nolan (2003) uses the DEA methodology to measure the relative efficiency of 11 municipal services at the level of 46 large and very large US cities over a 6-year period. The author emphasizes the importance of identifying the most relevant inputs that explain the efficiency scores. Scaratti et al. (2014) performs a highly complex study of the efficiency of water supply, sewerage and waste management services using DEA. The study assessed 39 municipalities with a population ranging from 20,000 to 50,000 in Brazil. The inputs considered in the waste management efficiency analysis were oriented towards: the cost / person, the cost of providing the sanitation service for the municipality, the recycling process and the coverage level of service provision. Outputs were oriented towards: the amount of collected waste / person, the amount of waste collected selectively and the waste mass recovered.

Brettenny and Sharp (2016) apply DEA to measure the efficiency of the water supply service in South Africa. The input considered by the authors is the operating costs, and the outputs are: the number of users, the length of the connection systems, the number of water consumption measuring devices, the water quantity and the repair costs. The results of the study indicate a relatively good efficiency in providing the water supply service.

Mohamed et al. (2017) analyzes the efficiency of solid waste management in Jengka Pahang City using DEA. The approach of the authors is an innovative one: they actually analyze the efficiency of using certain waste collection routes. They use 3 inputs: the length of the waste collection network, the collection time and the number of used garbage cans and 2 outputs: the collection frequency and the amount of waste. The results indicate 3 efficient routes that get

efficiency score 1 and 20 inefficient routes with efficiency score less than 1.Simoes (2005) uses the DEA to measure the efficiency of 29 sanitation services in Portugal in 2005. The inputs used were: operational and capital expenditures and the outputs were: collected waste and treated waste. The results indicated a high level of inefficiency.

Worthington and Dollery (2000) use DEA to determine the technical efficiency of the sanitation service, results showing that inefficiency is determined by densely populated areas.Dostalova (2014) applies the DEA methodology to assess the municipal waste collection process in the Czech Republic. The author considers as input the cost of operating the service, and as output variables: the population, the amount of collected waste, the surface of the localities and the number of waste collection containers. The results indicate a higher efficiency in the case of localities with a lower population and area. Thus, two outputs are identified that condition the achievement of efficiency.

Selection of inputs and outputs that are subject to DEA analysis should be done in a comprehensive manner so that no variables that influence service performance are forgotten. As it is treated in a complex way, DEA offers a realistic picture of the efficiency of a service.

Methodology and data

This paper analyzes the efficiency evolution of the sanitation service provision at the level of 10 administrative-territorial units in Timis County during 2007-2017. We use the Data Envelopment Analysis methodology through the DEA Solver Online Software. Subsequent to this research objective, we also identify a limitation of the methodology regarding the change of the results according to the decision units considered in the analysis.

Efficiency analysis has evolved from the simple calculationof productivity as a output/input report, toFarell's (1957) proposal to calculate the weighted sum of outputs/weighted sum of inputs for the situation where more outputs and inputs are analyzed to an extremely powerful efficiencyanalysis proposal: DEA. Charnes et al. (1978) develop the Data Envelopment Analisys (DEA) methodology, a non-parametric method based on a linear programming mathematical technique used to measure a decision making unit (DMU). We identify two basic models of DEA as the most commonly used: (i) CCR model developed by Charnes et al. (1978).

$$E_0 = \frac{\sum_r u_r y_{rj_0}}{\sum_i v_i x_{ij_0}} \rightarrow \max \quad E_0 = \frac{\sum_r u_r y_{rj_0}}{\sum_i v_i x_{ij_0}} \rightarrow \max$$

(1)

$$E_0 = \frac{\sum_r u_r y_{rj_0}}{\sum_i v_i x_{ij_0}} E_0 = \frac{\sum_r u_r y_{rj_0}}{\sum_i v_i x_{ij_0}} \leq 1$$

(2)

$$u_r \geq 0 \; u_r \geq 0$$

(3)

$$v_i \geq 0 \; v_i \geq 0$$

(4)

and (ii) the BCC model named after the authors Banker et al. (1984) who consider variable scale variations, which is why they also apply the dimension of the deviation from the constant return to scale, q_o

$$E_0 = \sum_r u_r y_{rj_0} E_0 = \sum_r u_r y_{rj_0} + q_0 \rightarrow q_0 \rightarrow \max$$

(5)

$$\sum_i v_i x_{ij_0} \sum_i v_i x_{ij_0} = 1 \quad (6)$$

$$-\sum_i v_i x_{ij_0} \sum_i v_i x_{ij_0} + \sum_r u_r y_{rj_0} \sum_r u_r y_{rj_0} + q_0 \leq 0 \; q_0 \leq 0 \quad (7)$$

$$u_r \geq 0 \; u_r \geq 0 \quad (8)$$

$$v_i \geq 0 \; v_i \geq 0 \quad (9)$$

$$q_0 \in R \; q_0 \in R \quad (10)$$

In our analysis, we usethe CCR model with input orientation and considered 5 input variables: (i) the monthly service fee / person, (ii) the coverage rate of the service, determined by calculating the number of households in the locality benefiting from the sanitation service from the total number of households in the locality, (iii) the population of the locality, (iv) the number of households in the locality and (v) the area of the locality, relevant to determining the length of collection routes for sanitation operators. We also took into account 2 output variables: (i) the collection rate of the sanitation tax and (ii) the average amount of annual waste at the local level. The variables considered for our analysis are specific for determining the efficiency of providing the service as an aptitude of the competent public authorities that manages service delivery and from the point of view of utility for citizens. The period chosen for the analysis coincides with the year of Romania's accession to the European Union until the last year for which the data were available.

In our study we chose Timis County and localities fromTimis county, being the largest county in Romania, one of the most developed counties in socio-economic terms and one of the 3 counties in Romania that succeeded to fully implement the Integrated Waste Management System and to delegate the entire waste management responsibility to the Waste Intercommunity Development Association Timis. The localities that are the subject of our study have been chosen to consider Sandu's(2011) innovative and relevant prototype which demonstrates that the localities that present similarities from a geographic location perspective are similar in terms of economic, social and administrative development. Thus, Lugoj is representative for the large localities in the county, Recas is representative for the small towns in the county, Giroc is representative for all the

periurban localities of Timisoara(county seat), Jebel is representative for the localities close to the county seat (approximately 20 km) and located on a European road. Moravita is representative for the localities situated on the outskirts of the county, very far from the county center and the county seat. PeciuNou is representative for localities located on a national road. Giera,Birda and Varias are located on a county road and are representative for localities located on county roads.

Results

We started the analysis by determining the efficiency of sanitation service provision at the level of each of the 10 administrative-territorial unitsfor 2007-2017 period. Fig.no. 1 shows the efficiency of the sanitation service provision in Birda. We observe an efficiency of 0(the smallest possible value) in the first 2 years of the analysis, 2007 and 2008, years in which the service was not performed in the locality. In the other years there are very high values of the efficiency level, the value 1 being the maximum value and indicating the total efficiency possible. There is no sustained increase in efficiency from one year to the next and the very low fluctuation in efficiency is not respecting a rule of evolution over time.

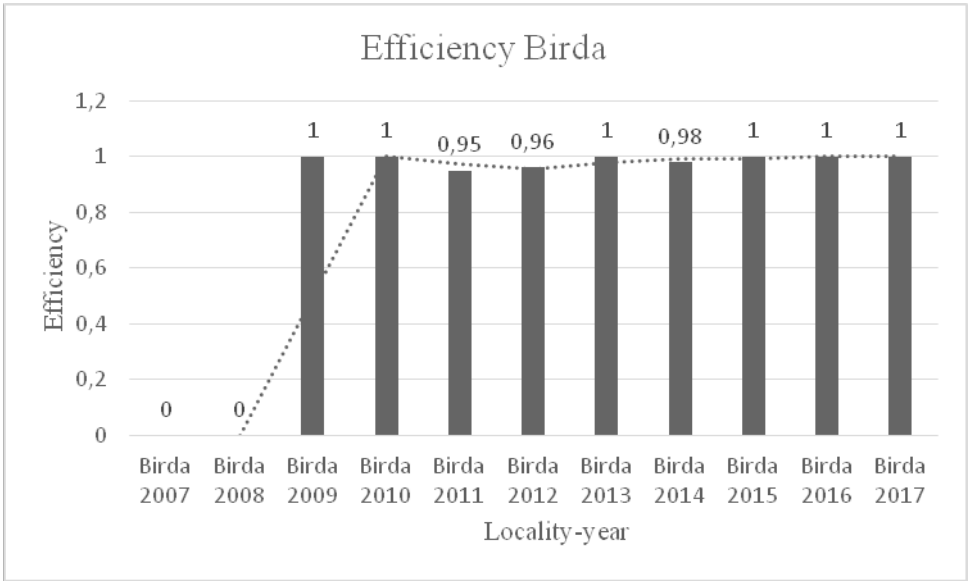

Figure no. 1 - **Evolution of efficiency in Birda**

In the case of Giroc (Fig. no. 2), we find a lower efficiency of 0.88 in two consecutive years, 2011 and 2012. Apart from this small exception, in most years there are high levels of efficiency, the locality being totally efficient in 7 of the 11 years of analysis.

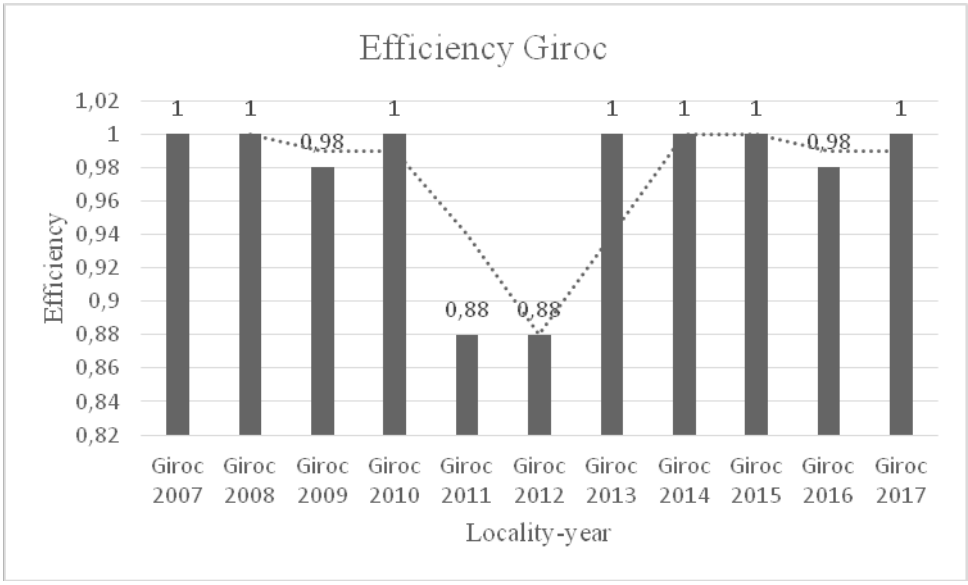

Figure no. 2 - **Evolution of efficiency in Giroc**

The lowest efficiency score in Jebel is 0.9, and the efficiency results are very high, but they do not show any increases as the years go by (Fig.no.3)

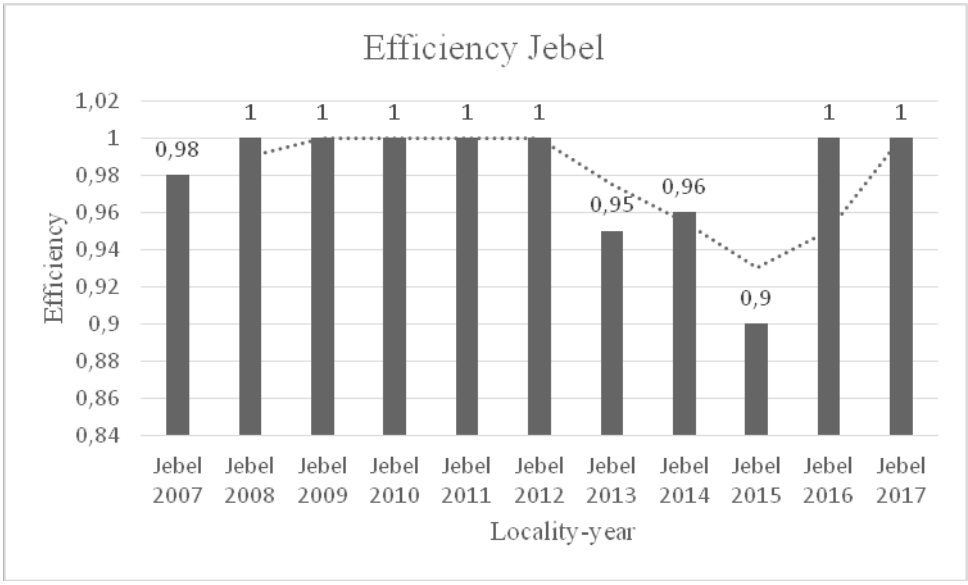

Figure no. 3 - **Evolution of efficiency in Jebel**

In Lugoj, we identify several breaks in the efficiency of the sanitation service provision, and the maximum efficiency is only recorded in 4 years out of the 11 analyzed. However, the lowest efficiency is 0.86 in 2009. (Fig. no. 4)

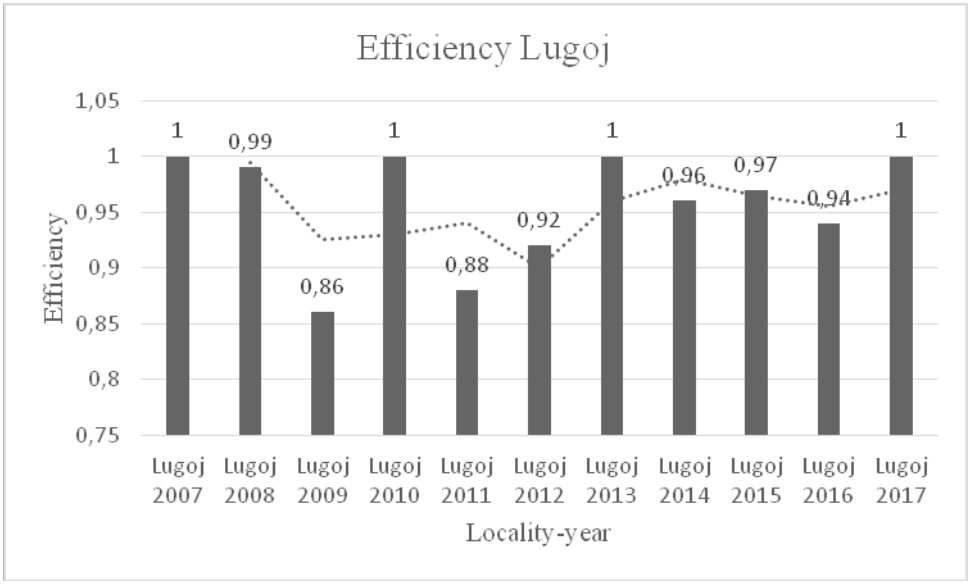

Figure no. 4 - **Evolution of efficiency in Lugoj**

In Varias we find variations in the level of efficiency from one year to the next, with the lowest efficiency being 0.85 in 2008. Nor does this situation have a progressive increase in efficiency from one year to the next (Fig. no. 5)

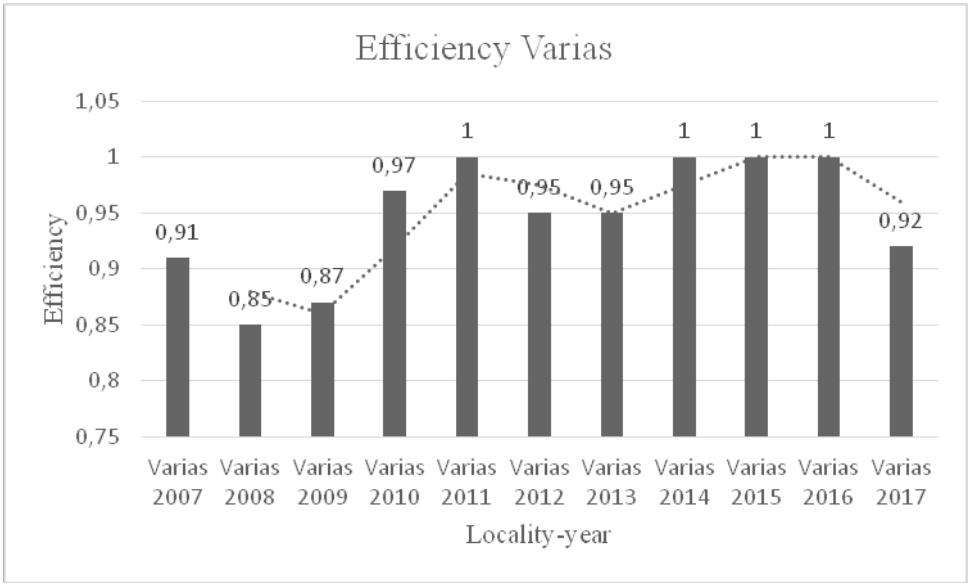

Figure no. 5 - **Evolution of efficiency in Varias**

We observe a very high level of efficiency of the sanitation service in the city of Recas, the lowest value being 0.96. Efficiency was not calculated for 2007 and 2008 when the service was not run in a way managed by the local public administration. (Fig. no. 6)

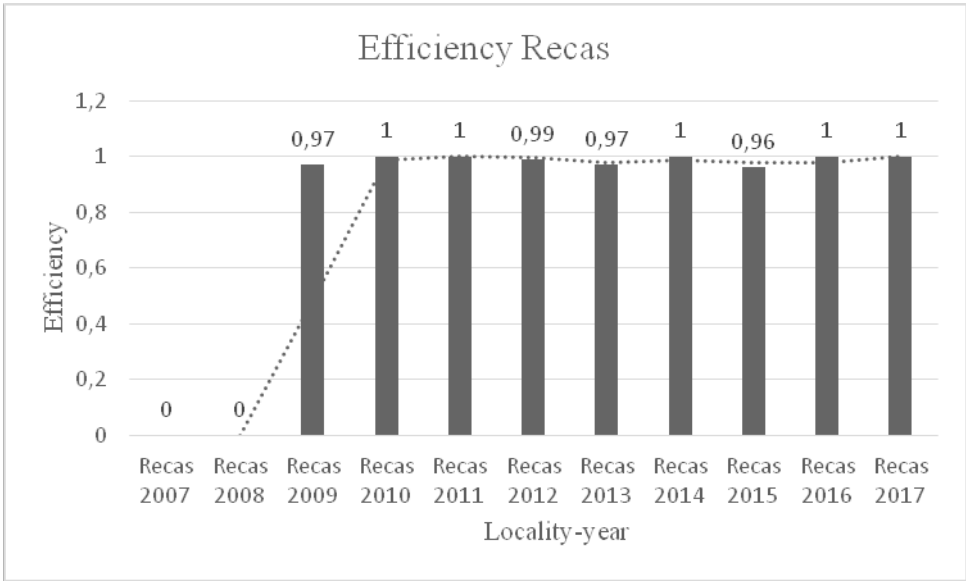

Figure no. 6 - **Evolution of efficiency in the city of Recas**

In the case of Moravita there is a similar situation, no service was provided in 2007 and 2008, and in the rest of the years the efficiency has high values. (Fig. no. 7)

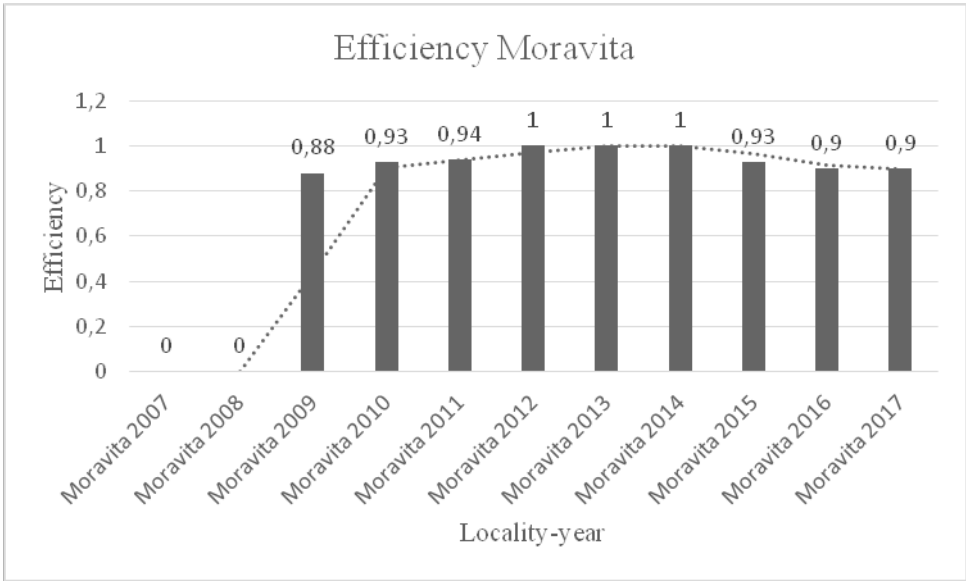

Figure no. 7- **Evolution of efficiency in Moravita**

In Giera we found a decrease in the efficiency score from 2011 in 2012 followed by a gradual increase until 2017. This evolution of the efficiency level of the sanitation service is natural, considering the necessity and the obligation of Romania in general and of all the administrative-territorial units in particular to develop the quality of community services, implicitly of the sanitation service of the localities (Fig. no. 8)

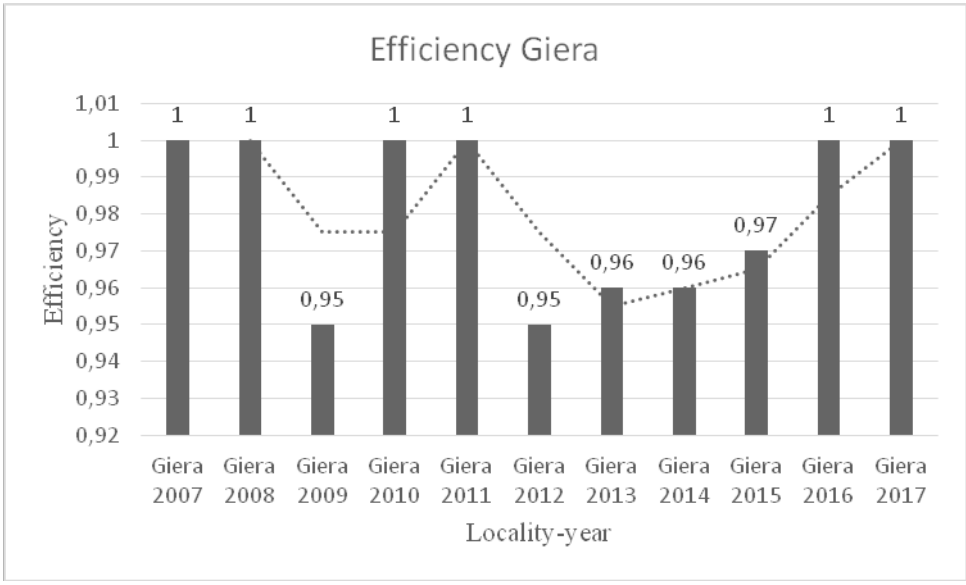

Figure no. 8 - **Evolution of efficiency in Giera**

The efficiency scores in Biled are very high, in 3 years it has a value of 0.99 and in the rest of the years it has maximum values.(Fig. no. 9)

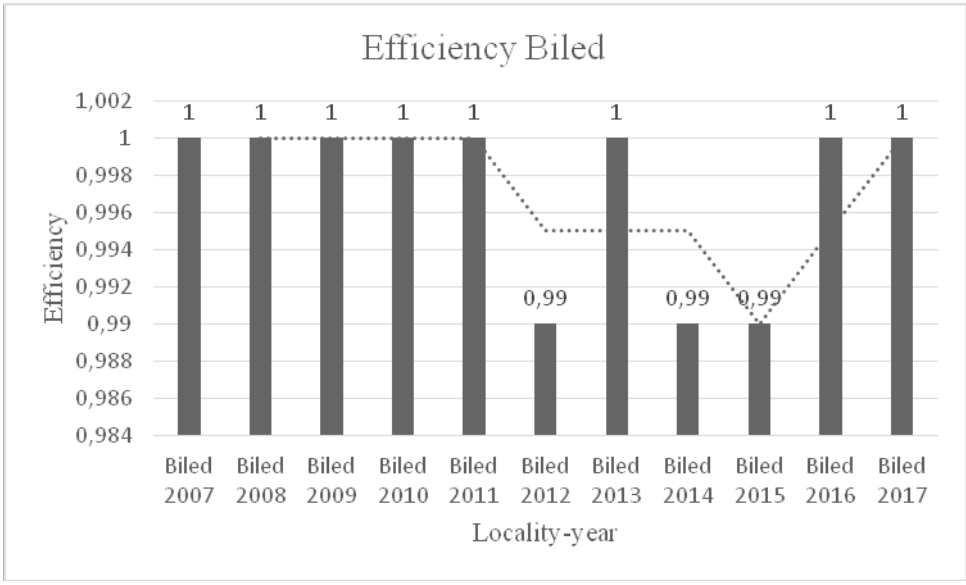

Figure no. 9 - **Evolution of efficiency in Biled**

There is a gradual increase in efficiency in Peciu Nou in the first 4 years of the analysis, followed by a decrease in 2012 and 2013. (Fig. no. 10)

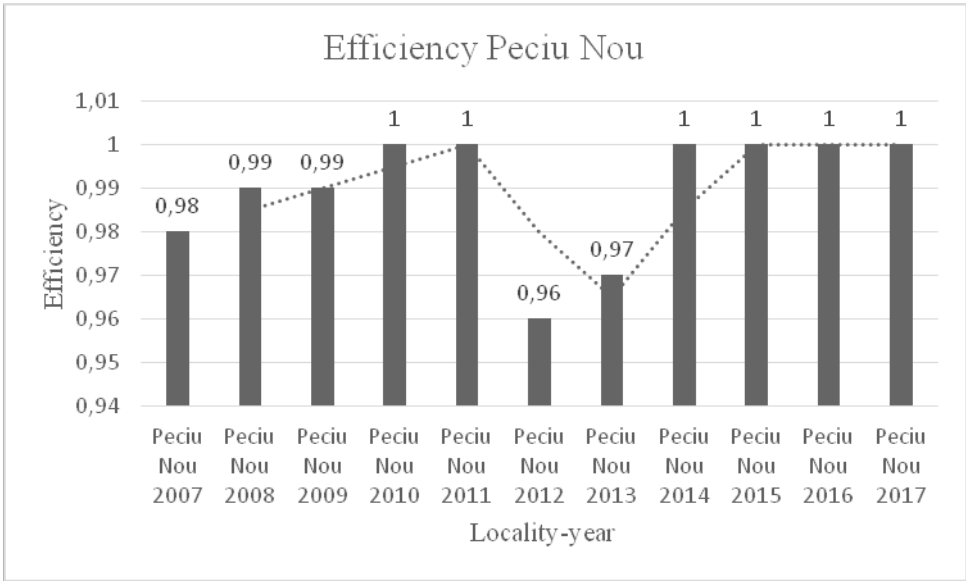

Figure no. 10- **Evolution of efficiency in Peciu Nou**

We also carried out an analysis of the efficiency of the sanitation service provision for the year 2017 for all 10 administrative-territorial unitsconsidered. The results indicate 8 administrative-territorial units with maximum efficiency and 2 with lower efficiency: Varias of 0.83 and Recas of 0.72 (Fig.no.11)

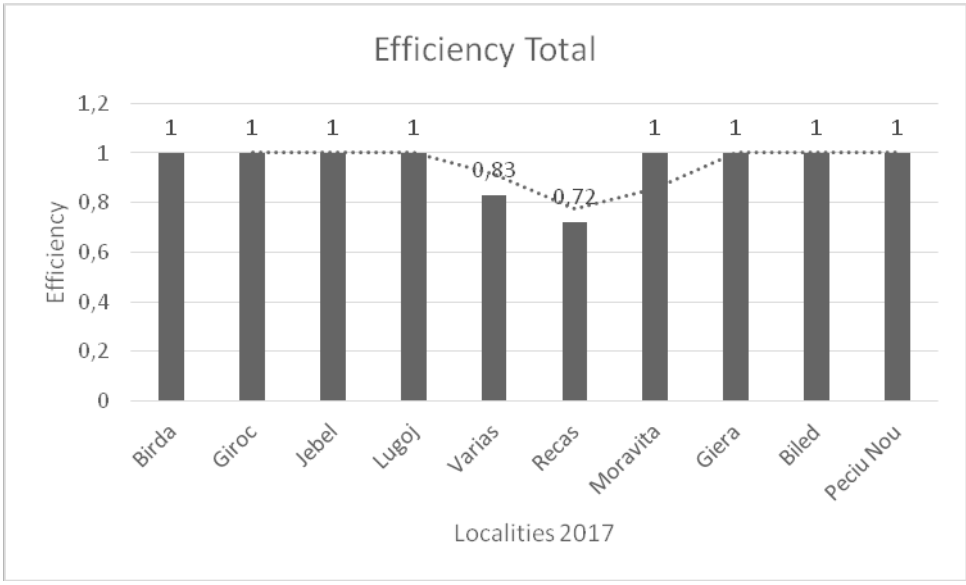

Figure no. 11 - **Efficiency of all localities in 2017**

The efficiency results provided by the Data Envelopment Analysis methodology are strongly influenced by the individual decision units considered in the analysis(in our case the administrative-territorial units). Including or excluding a single unit greatly changes the results.In the case of Recas, the score recorded in 2017 (when the individual decision units considered in the analysis were composed of the same city with data from different years) was of maximum efficiency 1. When we conducted the analysis considering the data of the 10 administrative-

territorial units in 2017, Recashad an efficiency score of 0.72.The same phenomenon happened in the case of Varias, which initially had an efficiency score of 0.92 and then 0.83 in 2017 considering other individual decision units.

Conclusions

The sanitation service of the localities is the only community service of public utilities that is mandatory for all citizens. This suggests the opportunity to carefully analyze the efficiency of providing this service. We have identified non-parametric methods as more suitable for efficiency analysis, and DEA is a pertinent solution that provides extremely useful information on efficiency, inefficiency and efficiency measures. The results of the empirical analysis indicate high values of the localities' efficiency in the analysis, without a sustained process of increasing the efficiency from one year to the next. This contradicts the process that Romania has undertaken to develop the quality of public services in general and the sanitation service in particular.

DEA has certain limits considering the results obtained depending by the individual decision units chosen. Thus, DEA does not use a single measure of reporting and analysis, it does not have a set of good practices that has the value of maximum efficiency, and all other decision units to be assessed in relation to that set of good practices.As a consequence, DEA has a relatively high subjective character. Moreover, the DEA's results are very different depending on the inputs and outputs used, therefore a measure to reduce the risk of obtaining subjective scores is intended to consider all inputs and outputs related to the studied phenomenon.

This paper brings a novelty by analyzing the evolution of efficiency at the level of the same administrative-territorial units for a period of 11 years. The results of this study may be of interest to public decision-makers in the management services area but also to citizens as users of public services.This paper is a basis for further research on the analysis of the evolution of sanitation services as Romania fulfills its strategic objectives for the development of community services.

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