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ANALYSIS OF THE EFFICIENCY OF PUBLIC TRANSPORTATION SYSTEM IN ROMANIA: A CASE STUDY OF BUCHAREST

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Abstract
The present paper examines the public transport network in Romania, particularly a detailed study of the transport systems in all the 41 counties of the country, with emphasis on the Bucharest region.
The main objective of the study is the evaluation of Bucharest Municipality in relation to all the other counties in the country, using the Data Envelopment Analysis (DEA) algorithm in order to obtain an overview of the overall efficiency in the urban transport networks.
The purpose of the research was to design a methodology using the DEA algorithm which will evaluate the general efficiency for the public transport network in Bucharest, as well as use a software program dedicated to the DEA model.
The results of the analysis can be used by public transport authorities to increase the profitability or the general efficiency of the network using an approach where the inputs and the outputs of the DEA algorithm are the most important variables.
Keywords: Bucharest, efficiency, DEA, public transport.

1. INTRODUCTION

Public transportation is a domain of major importance in any modern society, which also defines the quality of urban life. Individuals will always use the public transport networks in developed cities due to a number of reasons like: lower cost per trip, higher travel speed, transit accessibility or high geographic coverage of the network.

The demand for public transport along with users continuously increasing requirements impose an assessment's effectiveness for the public transport system in Bucharest.

Particularly, the public transport system in Romania consists of two main categories of networks:

1. Underground public transport network, which uses subway trains;
2. The public surface network, using buses, trams and trolleybuses.

First of all, the underground public transport system operates exclusively in Bucharest. In addition, the capital benefits from others modes of transportation, being the only city in the country to provide all four types of services.

Secondly, regarding the public transport within the city or between urban areas and periphery, it is not very developed in our country. In comparison, major European cities such as Munich, Berlin or Vienna have a dedicated infrastructure for this type of public transport, using transport vouchers common to other transport networks.

In terms of general statistics on the use of public transport in Romania, the network shows a positive trend in 2016, the number of users increasing by 8% compared to 2015, most of them preferring to use bus transportation.

Therefore, in 2016 1880.1 million individuals were transported with the public networks, from which 1071.9 million passengers (approximately 57%) used buses and minibuses.

Secondly, 459.1 million passengers preferred to use trams, while the ratio between trolleybuses (170 million individuals) and metro (179.1 million) was similar.

Under these circumstances, public transport operators need to use various medium and long-term strategies to ensure the steady growth of the competitiveness of their systems as well as diminishing the impact on the environment. Equally important is the gradual development of new inter-urban transit networks.

2. PURPOSE AND METHOD RESEARCH

In support of this research, the Data Envelopment Analysis (DEA) algorithm will be used, which involves using a set of comparable indicators in order to establish pertinent conclusions between input and output elements: „These outputs and inputs will usually be multiple in character and may also assume a variety of forms which admit only ordinal measurements (Charnes, et al., 1978)”.

Thus, a series of performance indicators for public transport networks at national level will be evaluated in this research. In addition, the efficiency of the systems will be measured compared to the networks in Bucharest.

On the other hand, concerning the difficulties encountered in the public transport system in Romania, the following should be mentioned:

- Technically outdated infrastructure;
- Failure to comply with the current pollution standards for public transport vehicles;
- Zero acquisitions of new trams and trolleybuses during 2013-2015 period;
- A limited number of dedicated lines for bicycles;
- The lack of transport routes dedicated exclusively to public transport vehicles.

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Altogether, the counties with the highest levels of overall efficiency, as well as the counties with the most unsatisfactory results will be identified in this analysis, thus achieving a classification of Bucharest Municipality in a general ranking across the country.

3. LITERATURE REVIEW

Similar studies on the topic of public passenger transport in Romania and its evolution, as well as on the transport analysis in Bucharest were carried out by Iordache (2009), Suditu, Ginavar and Iordăchescu (2010), Dragu, E. Roman and C. Roman (2013), Carlan, E. Rosca and A. Rosca (2014).

The specialized literature identifies a wide range of analysis on the topic of public transport worldwide. Even if every city has its own particularities, it is necessary to use a research method which can allow to evaluate the general efficiency individually.

Among the most common used research methods for studying and evaluation the efficiency of a particular field or technology are the following:

1. Stochastic models;
2. Data Envelopment Analysis Methods: example - DEA.

Both types of analysis involves the use of mathematical algorithms, along with econometric models.

For this reason, in the present research, the use of a DEA model is considered the most appropriate.

The Data Envelopment Analysis method is based on Farell's (1957) concepts for measuring and evaluating efficiency, later developed in Charnes, Cooper and Rhodes (1978).

As has been noted, the studies conducted by Farell (1957) advanced the past analyzes from Debreu (1951) and Koopmans (1951), experimenting with methods of assessing the effectiveness of decision making units by using multiple inputs. Therefore, the authors developed the theory that efficiency is composed from two basic elements:

- The technical efficiency: which reflects the ability of the decision making unit to achieve maximum outputs based on a set of inputs;
- The allocative efficiency: which reflects the ability of the decision making unit to use the input data in optimal proportions, depending on their prices.

First of all, the two previously presented components provide a model for assessing the economic efficiency or the overall efficiency.

The model developed by Farell, from which the DEA method was developed, consists of using two input variables: (x1) and (x2), which produce an output variable (y), taking into account the premise of the constant return of the results to a scale of initial values. The author starts the analysis from the hypothesis of knowing the fully efficient firm, which allows the evaluation of the technical efficiency.

Under those conditions, given we know the inputs of entity analyzed, defined as a point P, which contributes to the production of outputs, the technical inefficiency rate for the decision unit can be described with the QP distance, which represents the value by which all the data input can be proportionally reduced without affecting or diminishing the output value.

Thus, the technical efficiency, noted with TE, can be evaluated according to the following calculation formula:

$$TE_I = \frac{0Q}{0P},$$

Figure 1 provides a graphical representations of the technical and allocative efficiency.

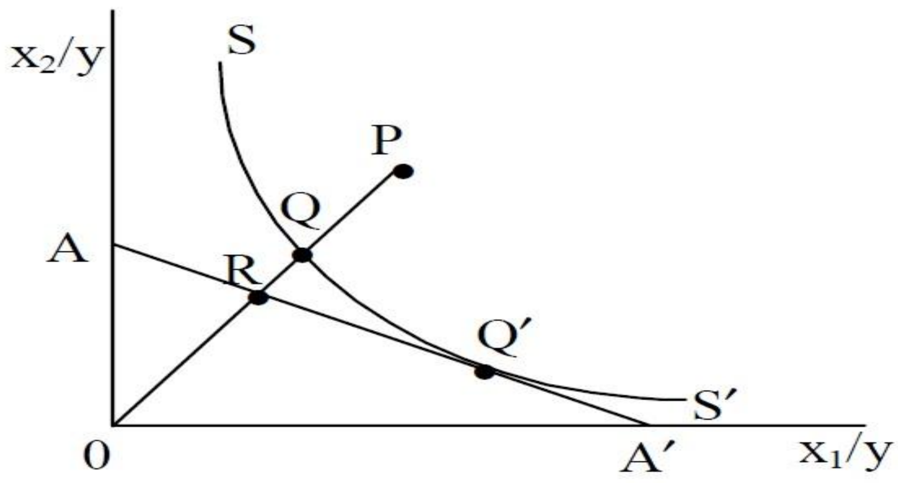

FIGURE 1. THE GRAPHICAL REPRESENTATIONS OF THE TECHNICAL AND ALLOCATIVE EFFICIENCY
Source - Author adaptation after (Coelli).

Where:

- x_1 and x_2 are the data quantities input;
- *y* represents a single output data;
- *P* represents all the input data;
- *SS′* represents the unit isoquant of the fully efficient firm;
- *AA′* represents the input price ratio.

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In effect, the point *Q* situated on the distance *0P* is considered technically efficient because it is situated on the efficient isoquant.

Furthermore, the ***AE***, which represents the **allocative efficiency** of the firm operating at *P* can be define by the next following ratio:

$$AE_1=\frac{0R}{0Q'}$$

Equally important is the ***RQ*** distance which represents the diminuation in the production costs if the company's production will take place at the allocatively and technically efficient point *Q′*, as an alternative of at the technically efficient, but innefficiently allocative point *Q*.

Given these points, the economic efficiency ***EE*** can be determined using the following formula:

$$EE_1=\frac{0R}{0P} .$$

To sum up, the DEA method is mainly used for activities that are difficult to quantify in terms of efficiency, thus being used internationally in social, economic or scientific studies. With this in mind, the literature proposes the analysis of data quantities in the form of decision making units- DMU.

First of all, all the input and output data are combined into one parameter in order to obtain an efficiency score within [0,1].

On the other hand, in addition to evaluating the efficiency scores, DEA method provides a series of instructions in the form of quantitative targets which can be used to improve the overall efficiency levels.

In addition, more advanced mathematical details on the DEA algorithm can be found in the research papers from Seiford and Thrall (1990), (1993), (1996), and also Lovell (1994).

In conclusion, the Data Envelopment Analysis is using the linear programming algorithm to evaluate the effectiveness of decision making processes.

4. SELECTING THE INPUT AND OUTPUT DATA

In the present research, for the decision making units (DMU) will be used a number of 41 counties, and for the input and output data will consider the following indicators:

1. Input data:
   - The population of the 41 counties analyzed;
   - The number of transport units in the circulating fleet (buses and minibuses, trams, trolleybuses).

2. Output data:

- The number of transported passengers.

With this in mind, the present research will focus on determine the output efficiency, analyzing the performance of the available transport systems in each county as well as the methods to improve the results.

Accordingly, a DEA method analysis will include two types of efficiency assessment:

Input orientation: the analysis is oriented to maximizing the input data while maintaining the current output levels;

Output orientation: the analysis is oriented to maximizing the output data while maintaining the current input data levels.

In addition, the DEA algorithm can use two different methods in order to evaluate the scale efficiency:

The CRS method, which uses the constant return of the incipient quantities (data) to the initial levels: *constant return to scale*.

The VRS method, which uses a variable level of data, increasing or decreasing: variable return to scale.

In assessing the efficiency of the transport network infrastructure, the aim is to maximize the average number of passengers transported on a daily basis. This aspect evaluates the resource's efficiency registered by the transport operators, as well as the service quality provided in all the 41 counties analyzed.

As a result, in the present research will be used the DEAP software:*DEAP - A Data Envolopment Analysis (Computer) Program*.

I. Efficiency analysis of public transport when using buses and minibuses

According to the results presented in Table 1, the most efficient counties in the public transport network using buses and minibuses are those whose scale efficiency approaches level 1.

Under those circumstances, for the counties where the indicator approaches the lower threshold of the computation interval, i.e. the level 0, the efficiency is considered significantly lower. Moreover, the last indicator (increasing or decreasing) examines the sensitivity of the analyzed county when modifying the input data.

Thus, for the increasing indicator, if a county records a change in the input data, it will increase the output data.

On the other hand, for the decreasing indicator, if a county records a change in the input data, the results of the output data will be decreased.

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TABLE 1 - EFFICIENCY ANALYSIS OF PUBLIC TRANSPORT WHEN USING BUSES AND MINIBUSES

County no.	County	Technically efficiency using DEA-CRS	Technically efficiency using DEA-VRS	Scale efficiency	Return to scale
1.	Bihor	0.428	0.439	0.975	Increasing
2.	Bistrița-Năsăud	0.242	0.296	0.817	Increasing
3.	Cluj	1.000	1.000	1.000	-
4.	Maramureș	0.952	1.000	0.952	Increasing
5.	Satu Mare	0.329	0.369	0.891	Increasing
6.	Sălaj	0.570	1.000	0.570	Increasing
7.	Alba	0.117	0.130	0.902	Increasing
8.	Brașov	0.659	0.664	0.994	Increasing
9.	Covasna	0.081	1.000	0.081	Increasing
10.	Harghita	0.099	0.397	0.248	Increasing
11.	Mureș	0.581	0.588	0.989	Increasing
12.	Sibiu	0.538	0.570	0.944	Increasing
13.	Bacău	0.222	0.228	0.972	Increasing
14.	Botoșani	0.062	0.067	0.922	Increasing
15.	Iași	0.662	0.662	0.999	-
16.	Neamț	0.099	0.148	0.669	Increasing
17.	Suceava	0.326	0.336	0.969	Increasing
18.	Vaslui	0.300	0.333	0.900	Increasing
19.	Brăila	0.332	0.562	0.591	Increasing
20.	Buzău	0.124	0.130	0.960	Increasing
21.	Constanța	0.350	0.364	0.962	Decreasing
22.	Galați	0.305	0.324	0.943	Increasing
23.	Tulcea	0.279	1.000	0.279	Increasing
24.	Vrancea	0.200	0.252	0.792	Increasing
25.	Argeș	0.443	0.449	0.986	Increasing
26.	Călărași	0.059	0.091	0.647	Increasing
27.	Dâmbovița	0.150	0.165	0.913	Increasing
28.	Giurgiu	0.248	1.000	0.248	Increasing
29.	Ialomița	0.170	0.255	0.667	Increasing
30.	Prahova	0.989	0.994	0.995	Increasing
31.	Teleorman	0.009	0.012	0.706	Increasing
32.	**București-Ilfov**	**0.416**	**1.000**	**0.416**	**Decreasing**
33.	Dolj	0.459	0.461	0.996	Increasing
34.	Gorj	0.229	0.307	0.746	Increasing
35.	Mehedinți	0.032	0.053	0.606	Increasing
36.	Olt	0.613	1.000	0.613	Increasing
37.	Vâlcea	0.181	0.203	0.890	Increasing
38.	Arad	0.080	0.082	0.969	Increasing
39.	Caraș-Severin	0.200	0.240	0.835	Increasing
40.	Hunedoara	0.090	0.097	0.927	Increasing
41.	Timiș	0.595	0.602	0.988	Increasing
	Average	**0.337**	**0.460**	**0.792**	

Source: Author calculations based on using the DEAP software.

The first input-type indicator can be analyzed in Figure 2, which presents the number of inhabitants for each county in January, 2017.

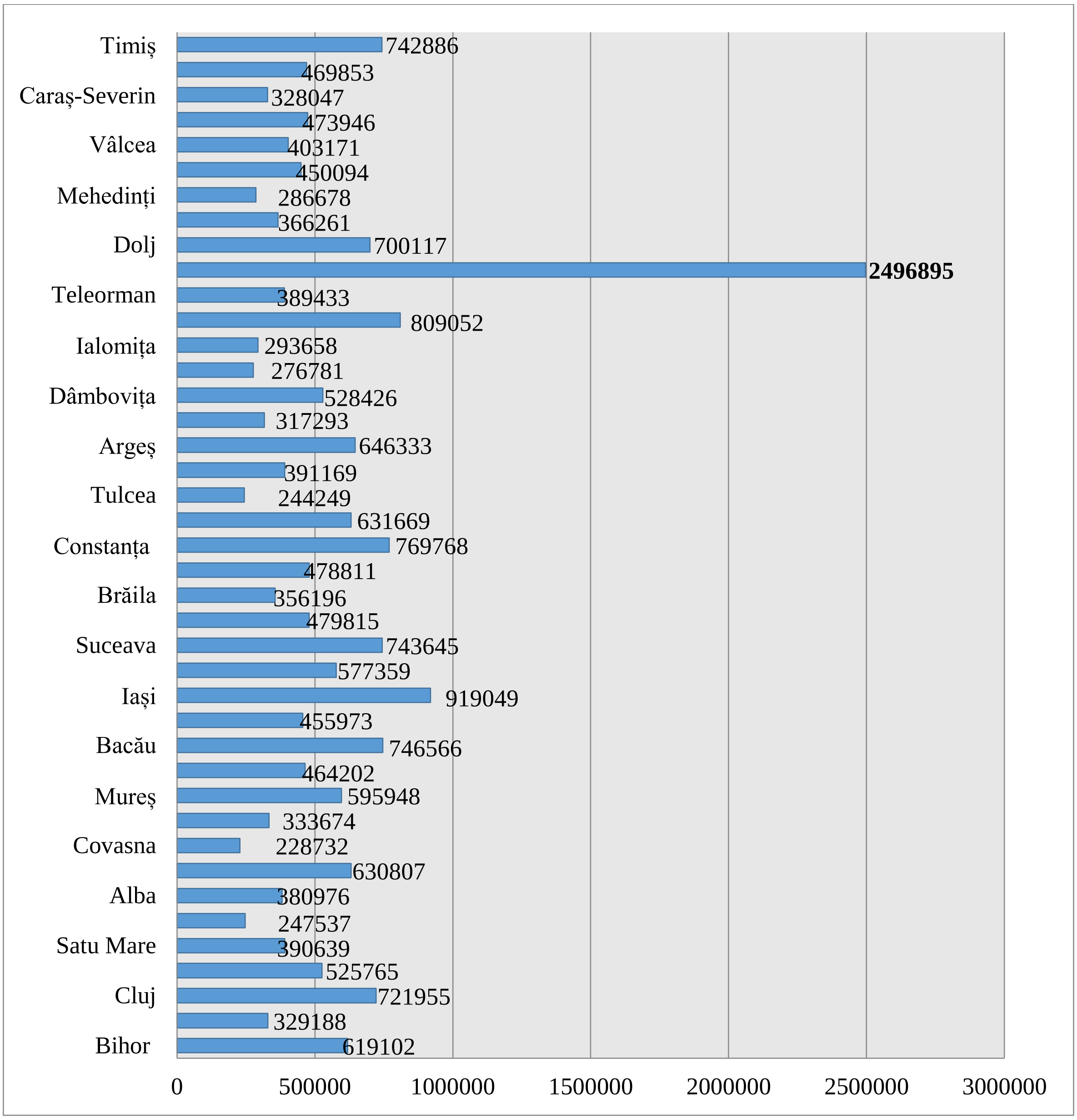

FIGURE 2 - THE NUMBER OF INHABITANTS FOR EVERY COUNTY
Source: Author adaptations after (Institutul Naţional de Statistică, 2017).

The relevance of the results is significant, revealing that the first rankings of the overall efficiency rating can be explained by a high number of passengers transported annually, related to the total number of transport units as well as the total population of the analyzed county. Table 2 presents the final ranking of the analyzed counties according to the results of the overall efficiency.

As a result, we can easily distinguish connections between counties in the same region of the country. Thus, the Central Region (represented by Sibiu, Alba, Mureş), along with the North - West (Cluj) and North - East (Iaşi) regions recorded higher average efficiency values due to increase economic development. In particular, this fact represent the contribution of each county to the country gross domestic product, the number of companies and their revenues.

TABLE 2 - EFFICIENCY ANALYSIS OF PUBLIC TRANSPORT WHEN USING BUSES AND MINIBUSES. FINAL RANKING

County no.	County name	Overall efficiency
1.	Cluj	1.000
2.	Iași	0.999
3.	Dolj	0.996
4.	Prahova	0.995
5.	Brașov	0.994
6.	Mureș	0.989
7.	Timiș	0.988
8.	Argeș	0.986
9.	Bihor	0.975
10.	Bacău	0.972
11.	Arad	0.969
12.	Suceava	0.969
13.	Constanța	0.962
14.	Buzău	0.960
15.	Maramureș	0.952
16.	Sibiu	0.944
17.	Galați	0.943
18.	Hunedoara	0.927
19.	Botoșani	0.922
20.	Dâmbovița	0.913
21.	Alba	0.902
22.	Vaslui	0.900
23.	Satu Mare	0.891
24.	Vâlcea	0.890
25.	Caraș-Severin	0.835
26.	Bistrița-Năsăud	0.817
27.	Vrancea	0.792
28.	Gorj	0.746
29.	Teleorman	0.706
30.	Neamț	0.669
31.	Ialomița	0.667
32.	Călărași	0.647
33.	Olt	0.613
34.	Mehedinți	0.606
35.	Brăila	0.591
36.	Sălaj	0.570
37.	**București-Ilfov**	**0.416**
38.	Tulcea	0.279
39.	Giurgiu	0.248
40.	Harghita	0.248
41.	Covasna	0.081

Source: Author calculations based on using the DEAP software.

II. Efficiency analysis of public transport when using trams

As far as the transport by trams is concerned, it should be noted that not all Romanian counties offer this transport system network. For instance, from a total of 41 counties, only 11 counties provide public transport with trams.

According to the results presented in Table 3, the most efficient counties in the public transport network using trams are those whose scale efficiency approaches level 1.

TABLE 3 - EFFICIENCY ANALYSIS OF PUBLIC TRANSPORT WHEN USING TRAMS

County no.	County	Technically efficiency using DEA-CRS	Technically efficiency using DEA-VRS	Scale efficiency	Return to scale
1.	Bihor	0.576	0.597	0.964	Increasing
2.	Cluj	0.746	0.784	0.952	Increasing
3.	Botoșani	0.050	0.077	0.655	Increasing
4.	Iași	0.866	0.888	0.975	Decreasing
5.	Brăila	0.647	1.000	0.647	Increasing
6.	Galați	0.222	0.238	0.930	Increasing
7.	Prahova	1.000	1.000	1.000	-
8.	București-Ilfov	0.857	1.000	0.857	Decreasing
9.	Dolj	0.298	1.000	0.298	Increasing
10.	Arad	0.302	0.470	0.641	Increasing
11.	Timiș	1.000	1.000	1.000	-
	Average	**0.597**	**0.732**	**0.811**	

Source: Author calculations based on using the DEAP software.

Furthermore, Table 4 presents the final ranking of the analyzed counties according to the results of the overall efficiency.

TABLE 4 - EFFICIENCY ANALYSIS OF PUBLIC TRANSPORT WHEN USING TRAMS. FINAL RANKING

County no.	County name	Overall efficiency
1.	Timiș	1.000
2.	Prahova	1.000
3.	Iași	0.975
4.	Bihor	0.964
5.	Cluj	0.952
6.	Galați	0.930
7.	**București-Ilfov**	**0.857**
8.	Botoșani	0.655
9.	Brăila	0.647
10.	Arad	0.641
11.	Dolj	0.298

Source: Author calculations based on using the DEAP software.

As a result, we can find in the first positions two large centers of the country in the North-West region: Timis and Cluj, characterized mainly by the accelerated technical and economical development in recent years.

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Specifically, in the case of the Cluj-Napoca, all the major centers of economic interest can be reached in an average duration of 20 minutes using the public transport system (Ministerul Dezvoltării Regionale și Administrației Publice, 2013).

Moreover, the towns of Timisoara, together with Arad, make up the most important area in terms of the economic activities carried out in Romania, preceded only by the Bucharest-Ilfov region. All things considered, these results highlights the need for effective mobility, based on public transport systems able to efficiently satisfy user demands.

III. Efficiency analysis of public transport when using trolleybuses

Regarding the public transport system using trolleybuses, the situation is similar to the previos tram analysis. Therefore, from a total of 41 counties, only 10 counties have a trolleybus transport network.

In agreement with the results presented in Table 5, the most efficient counties in the public transport network using trams are those whose scale efficiency approaches level 1.

TABLE 5 - EFFICIENCY ANALYSIS OF PUBLIC TRANSPORT WHEN USING TROLLEYBUSES

County no.	County	Technically efficiency using DEA-CRS	Technically efficiency using DEA-VRS	Scale efficiency	Return to scale
1.	Cluj	1.000	1.000	1.000	-
2.	Maramureș	0.359	0.533	0.673	Increasing
3.	Brașov	0.316	0.378	0.835	Increasing
4.	Sibiu	0.107	1.000	0.107	Increasing
5.	Neamț	0.187	0.240	0.779	Increasing
6.	Galați	0.290	0.434	0.668	Increasing
7.	Prahova	1.000	1.000	1.000	-
8.	București-Ilfov	0.314	1.000	0.314	Decreasing
9.	Gorj	0.198	1.000	0.198	Increasing
10.	Timiș	1.000	1.000	1.000	-
	Average	**0.477**	**0.759**	**0.657**	

Source: Author calculations based on using the DEAP software.

In the case of trolleybuses transport analysis in Romania, the study should begin by stating that the infrastructure has not undergone major changes in the last 10-15 years, which is the reason some of the local public administrations have decided to cancel these services.

Although it is the most environmentally friendly transport mode, important cities such as Constanţa, Iaşi, Sibiu, Satu Mare or Targoviste abandoned the use of trolleybuses during 2000-2010 period and completely dismantled the existing infrastructure. The reasons are similar and are based on the lack of public investment, technically outdated transport units or the increasing operating costs caused by frequent failures.

Table 6 presents the final ranking of the analyzed counties according to the results of the overall efficiency.

TABLE 6 - EFFICIENCY ANALYSIS OF PUBLIC TRANSPORT WHEN USING TROLLEYBUSES. FINAL RANKING

County no.	County name	Overall efficiency
1.	Cluj	1.000
2.	Prahova	1.000
3.	Timiș	1.000
4.	Brașov	0.835
5.	Neamț	0.779
6.	Maramureș	0.673
7.	Galați	0.668
8.	**București-Ilfov**	**0.314**
9.	Gorj	0.198
10.	Sibiu	0.107

Source: Author calculations based on using the DEAP software.

In conclusion, the trolleybus public network in Romania is currently present in only 11 counties. However, an economic efficiency analysis on this topic is absolutely necessary for any public transport operator.

First of all, from the point of view of the resources used for daily traveling the trolleybus system is highly important. Thefore, as the trolley's chassis and bodywork are similar to those from conventional buses, the propulsion is completely different, the trolleybuses using an electric motor while the buses use heavy, polluting and non-regenerative heat engines. Of course, the electric buses can be used in this comparison, but they are not widely spread in our country.

Secondly, the introduction of a trolleybus route requires significant investment, due to the necessity of an entire additional route above the street network.

As a result, the introduction of new pollution prevention laws and policies, along with stopping the use of diesel-powered vehicles in urban centers, trolleybuses can be brought back to the attention of transport operators due to their advantages: zero pollution during circulation, high transport capacity, noise reduction, easy use during the winter season, and so on.

IV. Efficiency analysis of public transport for counties that provide all the surface transport networks

At the present time, only 5 counties in Romania provides all the public surface transport networks, i.e. buses and minibuses, trams and trolleybuses.

This may be caused by the lack of infrastructure development in some regions of the country, especially as tram and trolleybus networks require their own rolling path, involving additional costs.

According to European Union standards, underdeveloped regions are defined as areas where gross domestic product - GDP per capita is less than 75% of the EU average.

Under these conditions, in the year 2016, only 2 regions in Romania have a GDP per capita that exceeds the European average of 75%: Bucharest and Ilfov County, being the only areas in the country that are not considered underdeveloped.

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These aspects are worth mentioning, as they may be some of the reasons for the outdated infrastructure and the overall reduced efficiency for the public transport systems.

In this order of ideas, Table 7 presents the efficiency analysis for all five counties, according to the transport modes used.

TABLE 7 - EFFICIENCY ANALYSIS OF PUBLIC TRANSPORT FOR COUNTIES THAT PROVIDE ALL THE SURFACE TRANSPORT NETWORKS

County no.	County name	Scale efficiency for public transport with buses and minibuses	Scale efficiency for public transport with trolleybuses	Scale efficiency for public transport with trams	Average
1.	Cluj	1.000	1.000	0.952	**0.984**
2.	Galați	0.943	0.668	0.930	**0.847**
3.	Prahova	0.995	1.000	1.000	**0.998**
4.	București-Ilfov	0.416	0.314	0.857	**0.529**
5.	Timiș	0.988	1.000	1.000	**0.996**

Source: Author calculations based on using the DEAP software.

Therefore, only 5 counties across the country provides all three surface transportation networks: Bucharest-Ilfov, Cluj, Galati, Prahova and Timis. A detailed analysis will be carried out further. As a result, Table 8 presents the rankings of the analyzed counties according to the results of the overall efficiency.

TABLE 8 - EFFICIENCY ANALYSIS RANKINGS OF PUBLIC TRANSPORT FOR COUNTIES THAT PROVIDE ALL THE SURFACE TRANSPORT NETWORKS

County no.	County name	General efficiency
1.	Prahova	0.998
2.	Timiș	0.996
3.	Cluj	0.984
4.	Galați	0.847
5.	București-Ilfov	0.529

Source: Author calculations based on using the DEAP software.

However, the Bucharest-Ilfov region benefits from the presence of underground transport network, which is considered very efficient, because with only 4% of the total network in Bucharest, it manages to transport daily about 20% of the transport users.

Under these circumstances, following the integration of the Bucharest-Ilfov underground transport efficiency, the ranking of the counties does not change, but the general efficiency of the capital increases by 22.3%. The information is presented in Table 9.

TABLE 9 - EFFICIENCY ANALYSIS RANKINGS OF PUBLIC TRANSPORT FOR COUNTIES THAT PROVIDES ALL THE SURFACE TRANSPORT NETWORKS INCLUDING BUCHAREST TRANSPORT UNDERGROUND SYSTEM

County no.	County name	General efficiency
1.	Prahova	0.998
2.	Timiș	0.996
3.	Cluj	0.984
4.	Galați	0.847
5.	**București-Ilfov**	**0.647**

Source: Author calculations based on using the DEAP software.

Nevertheless, the analysis must exceed the statistical level, thus specifying that the latest network expansion of the Bucharest underground system to the surrounding metropolitan areas has led to one of the fastest economic growth in Romania, specifically in the Ilfov County.

Under these conditions, a radical improvement for the connections between the capital and the new periphery would be ensured, which would increase the flow of people using the public systems. Therefore, in addition to enhance the overall efficiency, the use of personal or private vehicles would be gradually reduced, with direct influence on urban traffic decongestion.

In conclusion, the continuous development for the transport infrastructure at national level must be a priority for the public transport administrations, in order to increase the accessibility and the transit opportunities for individuals.

5. CONCLUSIONS

In conclusion, using the DEA efficiency algorithm, we can analyze the performance of an urban transport system based on the initial set of inputs and outputs data. In addition, the research presents the modalities in which the algorithm can be used to compare public local authorities performances, as well as the methodology required for a decision-maker to assess the efficiency of public transport system.

All things considered, the DEA method obtained the results for the efficiency of the public transport networks using buses and minibuses, trams and trolleybuses, analyzing each county individually as well as in relation to other statistical data.

In particular, the algorithm involves the use of linear programming to investigate the influence between inputs: on the one hand, the population of the counties and the number of the means of transport in the circulating park, and on the other hand the output used, respectively the number of users of the transport system.

Secondly, it was possible to evaluate an efficiency ranking for all the 41 counties, as well as to design a set of potential values for the efficiency that each region can achieve if the value of some inputs are changed.

The main purpose of this study is the evaluation of Bucharest Municipality in relation to all the other counties of the country, in order to obtain an overview on the overall efficiency of the urban transport networks.

In essence, by examining the best performing local public authorities, we can analyze how the operators with unsatisfactory results can redress or even improve their current activity.

In other words, an initiative at national level is needed to support the urban transport in all major cities using sustainable policies both economically and energetically. Such national policies directly result in increased levels of attractiveness for users as well as diminishing the use of personal transport.

Given these points, the research results contribute to the evaluation of the overall efficiency of the transport network in Bucharest and its positioning in relation to other public transport systems in Romania. Moreover, the study presents a series of analyzes that can underpin the improvement of the competitiveness of public transport networks in Romania.

Additionally, the analysis can be repeated at any time with officially updated statistical data to observe the trend or changes in the overall efficiency of transport operators.

Finally, the DEA model can be applied to a further research or study in another field, providing a detailed methodology of efficiency evaluation, as well as software programs dedicated to the DEA algorithm.

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