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Assessment of management efficiency and infrastructure development of Ukraine

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C H R O N I C L E

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A B S T R A C T

The purpose of this article is to make an assessment on infrastructure development efficiency based on Data envelopment analysis (DEA) method. The proposed method allows assessing the level of current infrastructure conditions which provides production and social dimension of its stable development. The article substantiates the necessity of conducting an analytical assessment of infrastructure development level which identifies its weaknesses and determines potential of improving its performance indicators. An integral assessment of transport infrastructure efficiency is proposed. To assess the problems of infrastructure development provision, a comparative analyses and ordering the objects according to growth or decrease of the indicators is performed. The results of the research allow discovering the causes of harmful phenomena in the system of management and development, and identifies major trends and prospects of development.

1. Introduction

Growing importance of infrastructure's role in the intense development of the global economy is related to increase in consumer demand for infrastructure quality including transport, energetics, communication, information and other components. The level of infrastructure development reflects the social and economic well-being of the country and forms its national security. Therefore, it is crucial to identify the weaknesses and provide the guidance for development by applying methodological approach and taking into account its potential. Infrastructure development should be aimed at intensification of bringing into the sphere of particular regions' material production, thereby increasing territorial mobility of production factors, efficiency of economic space organization and prospective realization of intra-territorial division of labor, ensuring of appropriate life conditions for people. Rapid response to changeability of external factors is possible if independent infrastructure industries are capable in their complex interrelationships to provide sustainable economic development of both particular regions and the whole country are available.

2. Literature review

While studying infrastructure development, a number of specialists suggest negative reasons. They affect the infrastructure

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components' quality and its performance in general. Kumari and Sharma (2016) reviewed the research literature on infrastructure and related issues. Flyvbjerg (2007) identified the main issues in major infrastructure developments pervasive misinformation about the costs, benefits, and risks involved. A consequence of misinformation is cost overruns, benefit shortfalls, and waste. Paul (2003) examined the effects of public infrastructure which are measured in terms of both cost saving and output augmenting measures. The authors argued that lock-in, the escalating commitment of decision makers to an ineffective course of action, has the potential to explain the large cost overruns. Lock-in can occur both at the decision-making level and at the project level and can influence the extent of overruns (Cantarelli et al., 2010). Oyedele (2015, 2016) believed that infrastructure management (maintenance) is a great challenge facing sustainable development of infrastructure in Third World Cities. Developing nation's leaders' lack of vision had widened the gap in infrastructure demand and provision. Maintenance culture is also lacking in developing nations. The challenges are numerous and include finance, technology for development, maintenance and design. Most dynamic regions require greater investment in economic infrastructure, while the backward regions need social infrastructure (Ramirez & Vargas 2018).

By focusing on evaluation methods of sustainable infrastructure development, specialists describe several techniques capable of revealing specific nature of the facility. Ugwu and Haupt (2007) used the 'weighted sum model' technique in multi-criteria decision analysis (MCDA) and the 'additive utility model' in analytical hierarchical process (AHP) for multi-criteria decision-making, to develop the model for computing the sustainability index –a crisp value for evaluating infrastructure design proposals. Dovgal et al. (2017) proposed using one of the taxonomy methods. This modified developmental method allows determining the object state level in a general set of objects, and ordering the objects according to growth or decrease of this indicator. Karnouskos (2014) identified that the action items could be decided based on actual behavior of the infrastructure determined from the collected data and on predicted behavior from simulations of the infrastructure. Nijkamp (1986) proposed to analyze the effectiveness of infrastructure policy to provide a methodological framework and an empirical analysis of the expected impact of infrastructure on regional development. Scientometric analyses allow us to consider different areas of authors' researches depending on the most pressing issues chosen for consideration and practical use. It should be noted, that theoretical and methodological recommendations include the set of solutions and do not exclude value judgments. Various methods' analyses enable to extend the range of studying the problem and to optimize its solution. For example, Flyvbjerg (2013), in his research demonstrated the need, the theoretical basis, a practical methodology, and a real-life example for how to de-bias project management using quality control and due diligence based on the outside view. Other authors point out that while the information systems scholarly and practice literatures both stress the importance of senior executive engagement with IT management, the recommendations for doing so remain, at best, are limited and general (Masli et al., 2016).

Shaffer and Siegele (2009) in a research compared Austrian and German regions' environment with public transport infrastructure and their efficiency in using it. Authors relied on the infrastructure capital as a necessary condition to extend the regional production potential, how on the region's ability to utilize the existing and additional infrastructure capital in an efficient way. The wide range of methods suggested each method to be most appropriate to the particular research area. Comparative analyses were conducted and analytical assessment of quantitative and qualitative indicators affecting the infrastructure were provided to determine causation. While considering the researchers' views the presence of problematic aspects both for infrastructure components and for infrastructure as a whole worth noting. The conceptual approach to their solution should include not only planning, strengthening the development of separate segments, but also relationship of all the infrastructure objects including technical compliance, maintenance and control over functioning infrastructure facilities. Transport infrastructure is often mentioned as problematic one as it is most associated with normal functioning of production and social sphere. To date, great attention is being paid to its development as it is the priority area, which is in turns connected to attracting investment into the area able to provide long-term economic prospects.

The study's primary goal is to conduct a comparative analyses of road infrastructure objects by the method of DEA which will establish the DEA model of sustainable infrastructure development's analytical assessment. The attainment of this goal determines the solution of following issues:

* justification for the comparative analyses of infrastructure development as one of the problematic aspects and identifying competitive advantages of infrastructure in Ukraine;
* application of the method of DEA in determining qualitative indicators;
* application of the composite indicators to map out trends and prospects of sustainable infrastructure development.

3. Results and discussion

The improvement of the complex system with its own functional features of interdependent elements of ecological, energetic, economic, informational, production, social infrastructure is an objective need. Optimal combination of external and internal linkages, possibilities of production and social infrastructure spheres creates economic and national security of a country. The system of production, resource and logistic possibilities influences the level of economic activity, creates qualitative and quantitative indicators of social and economic development of a country. Within the context of globalization, special attention needs to be focused on innovation infrastructure requiring the application of modern technologies and financial resources. Developing countries are strongly depended on the external creditors and often find themselves in conditions when it is almost impossible for them to make their own decisions until they repay their external debts. Ukraine is no exception, according to the data of the Ministry of Finances of Ukraine (2019) the national debt was $ 48 480.3 million as at the end of 2019. The presence of such external debt and a number of other factors makes Ukraine less attractive to investors able to contribute to the development of capital-intensive infrastructure areas. The search for solution requires an assessment of current state, minimizing of the risk, identifying reserves for increasing competitiveness and sustainable infrastructure development. The goal of the basic model creation is an analytical assessment of groups of points in multidimensional spaces. Scott and Knott (1974) proposed various methods for identifying groups of points in multidimensional spaces. The demand for such methods comes especially from systematics engaged in classificatory or taxonomical problems, in which each of the multivariate individuals under study may be considered as a point in a multidimensional space with an assigned distance measure. Thus, classification of individuals consists in grouping of points. These groups are often called clusters (Caliński & Harabasz, 1974). Fraley and Raftery (1998) considered the problem of determining the structure of clustered data, without prior knowledge of the number of clusters or any other information about their composition. Cluster analysis is a generic name for a variety of mathematical methods. Numbering in the hundreds, which can be used to find out which objects in a set are similar. The best known of these research goals is the making of classifications. One reason that cluster analysis is so useful is that researchers in all fields need to make and revise classifications continually (Romesburg, 2004). Modern efficiency measurement originally introduced by Farrell (1957) who drew upon the work of Debreu (1951) and Koopmans (1951) to define a simple measure efficiency which could account for multiple inputs. He proposed that the efficiency consists of two components technical efficiency, which reflects the ability to obtain maximal output from a given set of inputs and allocative efficiency, which reflects the ability to use the inputs in optimal proportion, given their respective prices. These two measures are then combined to provide a measure of total economic efficiency. If uses quantities of inputs, defined by the point *P*, to produce a unit of output, the technical inefficiency could be represented by the distance *QP*, which is the amount by which all inputs could be proportionally reduced without a reduction in output. This is usually expressed in percentage terms by the ratio *QP/0P*, which represents the percentage by which all inputs could be reduced. The technical efficiency (*TE*) is most commonly measured by the ratio:

$$TE_I = \frac{OQ}{OP'}, \tag{1}$$

which is equal to one minus *QP/O*. It will take a value between zero and one, and hence provides an indicator of the degree of technical inefficiency. A value of one indicates full technically efficient. The subscript *I* is used on the *TE* measure to show that it is an input-orientated measure (Coelli, 1996). If the input price ratio, is also known, allocative efficiency may also be calculated. The allocative efficiency (*AE*) operating at *P* is defined to be the ratio:

$$AE_I = \frac{OR}{OP'}. \tag{2}$$

The total economic efficiency (EE) is also defined to be the ratio:

$$EE_I = \frac{OR}{OP'}, \tag{3}$$

where the distance *RP* can also be interpreted in terms of a cost reduction. Note that the product of technical and allocative efficiency provides the overall economic efficiency:

$$TE_I^{'} AE_I = \left(\frac{OQ}{OP}\right)^{'}\left(\frac{OR}{OQ}\right) = \left(\frac{OR}{OP}\right) = EE_I. \tag{4}$$

All three measures are bounded by zero and one.

Data envelopment analysis (DEA) is a relatively new *data oriented* approach for evaluating the performance of a set of peer entities called Decision Making Units (DMUs) which convert multiple inputs into multiple outputs. The definition of a DMU is generic and flexible. Recent years have seen a great variety of applications of DEA for use in evaluating the performances of many different kinds of entities engaged in many different activities in many different contexts and in various countries (Cooper et al., 2004). DEA is considered for the best possible estimate of the comparable points. This makes it possible not only to identify the best one in the group but also to estimate more accurate rating for each point. After all, the objective is to measure the efficiency of resource utilization in whatever combinations are present (loose or tight) in the organizations as well as the technologies utilized (Charnes et al., 1978). DEA is a linear programming methodology to measure the efficiency of multiple decision-making units (Zhang et al., 2014). Based on the classification invariance property, a linear monotone decreasing transformation is used to treat the undesirable outputs. A directional distance function is used to estimate the efficiency scores based on weak disposability of undesirable outputs (Hua & Bian, 2007). We first consider the idea of *efficiency dominance*, for which we introduce the following designations.
Let $Xj = (x_1 j,..., xmj)^T$ and $yj = (y_1 j ,..., ysj)^T$ represent input and output vectors, respectively, for *j* th Decision Making Unit (DMU), $j = 1, \ldots, n$. The superscript *T* represents transpose. The DMU to be evaluated is designated as DMU_0 and its input-

output vector is denoted *(x_0, y_0)* (Cooper et al., 2002). Therefore, we may form a set of production feasibility, which constitutes of various principles such as fixed-scale efficiency, convexity and feasibility (Soltanifar & Farhadi 2014). The method DEA (CCR), was first introduced by Charnes et al. (1978) for measuring the relative efficiency of decision making units (DMU), which allows to understand how a given DMU works whenever a production function is available. Let us consider a production possibility set which consists of all convex combinations of (xj,yj), $j = 1, \ldots,$ n as follows:

$$CCR = \left\{ (x,y) / x = \sum_{j=1}^{n} x_j \lambda_j, y = \sum_{j=1}^{n} y_j \lambda_j, \sum_{j=1}^{n} \lambda_j = 1, \lambda_{j \geq 0, \forall j} \right\}. \quad (5)$$

Let (x', y') ∈ CCR and (x", y") ∈ CCR. So, we can say that ('x, y') dominates (x", y") with respect to these production possibilities if and only if x' ≤ x" and y ' ≥ y" with strict inequality holding for at least one of the components in the input or the output vector. The CCR production feasibility set border presents the relative efficiency where any off-border DMU is stated as inefficient. The CCR model can be computed in two kinds of either input or output oriented. The input CCR aims to decrease the maximum input level with a ratio of θ so that, at least, the same output is produced, i.e.:

min θ

subject to:

$$\begin{aligned} & \theta X_p - \sum_{j=1}^{n} \lambda_j X_{ij} \geq 0, \\ & \sum_{j=1}^{n} \lambda_j Y_{rj} \geq Y_{rp}, \\ & \lambda_j \geq 0, j = 1, \ldots, n. \end{aligned} \quad (6)$$

Next model is an envelopment form of input CCR which is the relative efficiency of the DMU and it is possible to show the optimal value of θ, θ^*, is located between zero and one. In an input oriented DEA model, once the efficiency of a DMU unit, DMUp , lies in case of inefficiency, one may directs it towards the border to change it efficient. For the output oriented DEA model, the primary objective is to maximize the output level, φ, by using the same amount of input. The model can be formulated as follows,

min φ

subject to:

$$\begin{aligned} & \sum_{j=1}^{n} \lambda_j X_{ij} \leq X_{ip}, \\ & \sum_{j=1}^{n} \lambda_j Y_j \geq \varphi Y_{ip}, \\ & \lambda_j \geq 0, j = 1, \ldots, n. \end{aligned} \quad (6)$$

Authors proposed measure of the efficiency of any DMU is obtained as the maximum of a ratio of weighted outputs to weighted inputs subject to the condition that the similar ratios for every DMU be less than or equal to unity (Charnes et al., 1978). Also, one can encounter the literally various types of DEA method and the BCC where output oriented DEA model is used which is as follows:

$$\max h_0 = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}} \quad (8)$$

subject to

$$\begin{aligned} & \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, \\ & j = 1, \ldots, n, u_r, v_i \geq 0, r = 1, \ldots, s, i = 1, \ldots, m. \end{aligned}$$

where y_{rj}, x_{ij} (all positive) are the known outputs and inputs of the j th DMU and the $u_r, v_i \geq 0$ are the variable weights to be determined by the solution of this problem, by the data on all of the DMU's which are being used as a reference set. The efficiency of one member of this reference set of $j=1, \ldots, n$. DMU's is to be rated relative to the others. It is therefore represented in the functional, for optimization - as well as in the constraints - and further distinguished by assigning it the subscript '0' in the functional (but presetting its original subscript in the constraints). The indicated maximization then accords this DMU the most favorable weighting that the constraints allow. The experts use various indicators that could cluster by certain criteria for analytical assessment of the infrastructure development level. The exclusivity of the assessment of transport infrastructure is that it analyzes diverse and interrelated indicators, simultaneously. Let's apply the method of DEA, which allows a more accurate assessment of the best one among the compared objects on the example of road infrastructure. It should be noted that data from 24 regions of Ukraine were used for comparative analyses of road infrastructure indicators (Table 1).

Table 1
Objects for comparative analyses of road infrastructure indicators

No	Regions	No	Regions
R_1	Vinnytsia region	R_{13}	Mykolaiv region
R_2	Volyn region	R_{14}	Odesa region
R_3	Dnipro region	R_{15}	Poltava region
R_4	Donetsk region	R_{16}	Rivne region
R_5	Zhytomyr region	R_{17}	Sumy region
R_6	Zakarpattia region	R_{18}	Ternopil region
R_7	Zaporizhzhia region	R_{19}	Kharkiv region
R_8	Ivano-Frankivsk region	R_{20}	Kherson region
R_9	Kyiv region	$R2_1$	Khmelnytsk region
R_{10}	Kirovohrad region	R_{22}	Cherkasy region
R_{11}	Luhansk region	R_{23}	Chernivtsi region
R_{12}	Lviv region	R_{24}	Chernihiv region

Let's form the group of points serving as input data for further calculations (Table 2).

Table 2
A system of indicators reflecting the level of the road infrastructure development

Indicator	Comparative review
P_1	The length of public roads, thousand km
P_2	Road haulage , thousand ton-kilometres
P_3	Cargo transportation, thousand ton
P_4	Carriage of passengers by road transport (buses) inter- city, thousand
P_5	Carriage of passengers by road transport (buses) international lines, thousand

After forming the group of objects and the group of indicators which would be used for comparison, let's fill the table with the value of indicators necessary for the calculation (Table 3).

Table 3
The summary of input/output indicators

Regions	Indicator ('000s)				
	P_1	P_2	P_3	P_4	P_5
R_1	9	1783100	2920	7138	21
R_2	6	2770300	1340	9464	178
R_3	9	5138000	32440	6997	20
R_4	8	2125600	11270	2739	57
R_5	8	1117700	4330	5194	25
R_6	3	5073100	880	2483	105
R_7	7	1499600	3070	4029	11
R_8	4	1486400	1200	5252	154
R_9	9	6349200	5630	8374	15
R_{10}	6	1582100	4920	1677	0
R_{11}	4	482500	470	711	55
R_{12}	8	5317600	2580	13335	405
R_{13}	5	1656800	2130	3423	26
R_{14}	8	3828800	2900	7033	112
R_{15}	9	2732800	17180	2486	19
R_{16}	5	2154800	1710	8355	61
R_{17}	7	890300	1270	2963	5
R_{18}	5	1381100	1840	6191	34
R_{19}	9	4553900	3280	4444	201
R_{20}	5	1371000	1400	3923	3
R_{21}	7	2103000	3350	4215	5
R_{22}	6	3480900	4270	2707	0
R_{23}	3	1425500	700	2228	42
R_{24}	7	1272300	1190	2284	69

Source: *calculated by authors based on State Statistics of Ukraine: (Official site of the State Statistics Committee of Ukraine., n.d.; State Statistics Committee of Ukraine 2019).*

A commonly used method is ratios. Typically, we take some output measure and divide it by some input measure. Further, we present details of our implementation of DEA method for 24 regions in Ukraine. We can compare these branches and measure their performance using this data, taking into account that:

$$\text{Re} = \frac{EDMU_i}{EDMU_{best}}, 0 \le R_e \le 1.$$

We view branches as taking inputs and convert them, with varying degrees of efficiency into outputs. For our analysis we have a single input measure, the length of public roads, and an output measure: road haulage, cargo transportation, carriage of passengers by road transport (buses) inter-city and carriage of passengers by road transport (buses) international lines in thousand. The result of the using DEA, that contains most of the basic functions required by evolutionary computation, is defined as follows (Table 4):

Table 4

Listing of instruction File EG2.INS

eg2-dta.txt	DATA FILE NAME
eg2-out.txt	OUTPUT FILE NAME
24	NUMBER OF FIRMS
1	NUMBER OF TIME PERIODS
1	NUMBER OF OUTPUTS
1	NUMBER OF INPUTS
0	0=INPUT AND 1=OUTPUT ORIENTATED
1	0=CRS AND 1=VRS
0	0=DEA (MULTI-STAGE), 1=COST-DEA, 2=MALMQUIST-DEA, 3=DEA(1-STAGE), 4=DEA(2-STAGE)

Listing of Output File EG2. OUT. Consider on the example of a Zakarpattia region (Table 5):

Table 5

Results for R_6

```
Technical efficiency = 1.000
Scale efficiency     = 1.000  (crs)
PROJECTION SUMMARY:
        variable           original        radial         slack        projected
                              value      movement      movement            value
output   1              5073100.000         0.000         0.000      5073100.000
input    1                    3.000         0.000         0.000            3.000
LISTING OF PEERS:
peer              lambda weight
6                 1.000
```

We summarize the generalized indicators in Table 6.1, 6.2.

Table 6.1

DEA efficiency scores for P_2, P_3

DMU	TE							
	P_2				P_3			
	CRS	VRS	SEa	RtS	CRS	VRS	SEa	RtS
R_1	0.117	0.333	0.351	irs	0.090	0.376	0.239	irs
R_2	0.273	0.500	0.546	irs	0.062	0.515	0.120	irs
R_3	0.338	0.367	0.919	irs	1.000	1.000	1.000	-
R_4	0.157	0.375	0.419	irs	0.391	0.622	0.628	irs
R_5	0.083	0.375	0.220	irs	0.150	0.457	0.329	irs
R_6	1.000	1.000	1.000	-	0.081	1.000	0.081	irs
R_7	0.127	0.429	0.296	irs	0.122	0.488	0.249	irs
R_8	0.220	0.750	0.293	irs	0.083	0.765	0.109	irs
R_9	0.417	1.000	0.417	drs	0.174	0.434	0.400	irs
R_{10}	0.156	0.500	0.312	irs	0.227	0.628	0.362	irs
R_{11}	0.071	0.750	0.095	irs	0.033	0.750	0.043	irs
R_{12}	0.393	0.519	0.758	drs	0.089	0.415	0.215	irs
R_{13}	0.196	0.600	0.327	irs	0.118	0.648	0.183	irs
R_{14}	0.283	0.375	0.755	irs	0.101	0.423	0.238	irs
R_{15}	0.180	0.333	0.539	irs	0.530	0.678	0.782	irs
R_{16}	0.255	0.600	0.425	irs	0.095	0.632	0.150	irs
R_{17}	0.075	0.429	0.175	irs	0.050	0.439	0.115	irs
R_{18}	0.163	0.600	0.272	irs	0.102	0.637	0.160	irs
R_{19}	0.299	0.333	0.898	irs	0.101	0.384	0.263	irs
R_{20}	0.162	0.600	0.270	irs	0.078	0.620	0.125	irs
R_{21}	0.178	0.429	0.415	irs	0.133	0.496	0.268	irs
R_{22}	0.343	0.500	0.686	irs	0.197	0.607	0.325	irs
R_{23}	0.281	1.000	0.281	irs	0.065	1.000	0.065	irs
R_{24}	0.107	0.429	0.251	irs	0.047	0.437	0.108	irs
mean	0.245	0.547	0.455	x	0.172	0.602	0.273	x

Source: Authors' estimation from DEA

Table 6.2
DEA efficiency scores for P_4, P_5

DMU	TE							
	P_4				P_5			
	CRS	VRS	SEa	RtS	CRS	VRS	SEa	RtS
R_1	0.475	0.509	0.932	irs	0.046	0.333	0.138	irs
R_2	0.944	0.945	0.999	drs	0.586	0.703	0.834	irs
R_3	0.465	0.504	0.923	irs	0.044	0.333	0.132	irs
R_4	0.205	0.386	0.531	irs	0.141	0.375	0.375	irs
R_5	0.389	0.490	0.792	irs	0.062	0.375	0.165	irs
R_6	0,495	1.000	0.495	irs	0.691	1.000	0.691	irs
R_7	0.344	0.504	0.684	irs	0.031	0.429	0.072	irs
R_8	0.786	0.986	0.797	irs	0.760	0.954	0.797	irs
R_9	0.557	0.557	1.000	-	0.033	0.033	0.099	irs
R_{10}	0.167	0.500	0.335	irs	0.000	0.500	0.000	irs
R_{11}	0.106	0.750	0.142	irs	0.272	0.750	0.362	irs
R_{12}	0.998	1.000	0.998	drs	1.000	1.000	1.000	-
R_{13}	0.410	0.664	0.617	irs	0.103	0.600	0.171	irs
R_{14}	0.526	0.569	0.925	irs	0.277	0.390	0.710	irs
R_{15}	0.165	0.333	0.496	irs	0.042	0.333	0.125	irs
R_{16}	1.000	1.000	1.000	-	0.241	0.600	0.402	irs
R_{17}	0.253	0.452	0.561	irs	0.014	0.511	0.033	irs
R_{18}	0.741	0.853	0.869	irs	0.134	0.600	0.224	irs
R_{19}	0.295	0.408	0.725	irs	0.441	0.511	0.863	irs
R_{20}	0.470	0.698	0.673	irs	0.012	0.600	0.020	irs
R_{21}	0.360	0.513	0.703	irs	0.014	0.429	0.033	irs
R_{22}	0.270	0.513	0.527	irs	0.000	0.500	0.000	irs
R_{23}	0.444	1.000	0.444	irs	0.277	1.000	0.277	irs
R_{24}	0.195	0.429	0.456	irs	0.195	0.429	0.454	irs
mean	0.461	0.648	0.693	x	0.226	0.563	0.332	x

Source: Authors' estimation from DEA

Here the total technical efficiency (TE_{CRS}) can be decomposed into pure technical efficiency (TE_{VRS}) and scale efficiency (SEa) Coelli, Rao, & Battese, (1998), where:

$$SE_a = \frac{TE_{CSR}}{TE_{VRS}}, \tag{10}$$

subject to:

crs=constant returns to scale, vrs = technical efficiency from VRS DEA, irs=increasing, drs=decreasing, RtS=returns to scale.

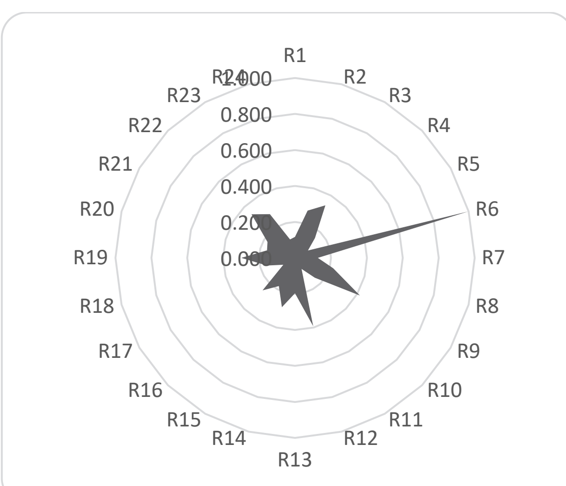

Fig. 1.1. Efficiency scores Road haulage the regions of Ukraine

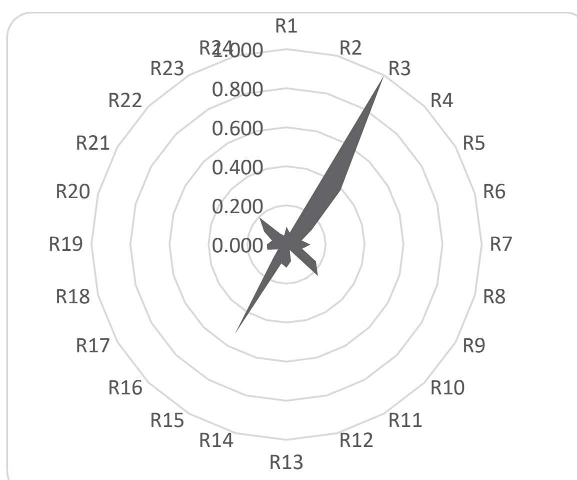

Fig.1.2. Efficiency scores Cargo transportation the regions of Ukraine

We can say, that technical efficiency (TE_{CRS}) Zakarpattia region have the highest cargo turnover coefficient per length of public roads. Whereas, Dnipro region has the highest ratio of cargo turnover per the length of public roads, and transportation of passengers by road transport (buses) in intercity traffic is best in Rivne region. Lviv region has the highest ratio of Carriage of passengers by road transport (buses) international lines. To find out whether a indicator reflecting is scale efficient and qualify the type of returns of scale, a DEA model under the non-increasing returns to scale, and the following rule can be applied (Fare et al., 1985) if SEa=1, then a indicators reflecting are scale efficient, both under CRS and VRS. The TE_{CRS} efficiency scores in most regions of Ukraine remain below sample average. For the CRS models, respectively minimum efficiency scores are P_2- 58%, P_3- 75%, P_4- 50%, and P_5- 63%, which are rather high rates for studies on this subject. The number of 100% efficient regions of Ukraine in the VRS model maximal is 4, i.e. 17 % of sample. The findings reveal a production technology with variables returns to scale. Twenty one regions of Ukraine are scale inefficient; in particular, 21 have decreasing returns to scale, while only 3 have increasing returns to scale, but not for all reflecting indicators. The result conducted makes it possible to range the obtained indicators in value and to represent them:

The analytical assessment of the researched objects of the road infrastructure in 24 regions of Ukraine illustrates the level of distribution of the sustainable development centers. Thus, by the results of the calculations Zakarpattia region, Dnipro region, Rivne region, Lviv region have entered the rating of max TE_{CRS}. Regions formed by us they have the positive largest (Table 7).

Table 7

Top regions leaders and outsider by the level of development of the road infrastructure in Ukraine

Rating	Regions of Ukraine	
	max	min
Road haulage	Zakarpattia region	Luhansk region
Cargo transportation	Dnipro region	Luhansk region
Carriage of passengers by road transport (buses) inter- city	Rivne region	Luhansk region
Carriage of passengers by road transport (buses) international lines	Lviv region	Cherkasy region

The leader of our rating is Zakarpattia region, in southwestern Ukraine within the western part of the Ukrainian Carpathians and the Transcarpathian lowlands. It is bordered on the north by the Lviv region, on the east by the Ivano-Frankivsk oblasts of Ukraine. In the south with Romania, in the southwest with Hungary, in the west with Slovakia, in the northwest with Poland. Dnipro region, which claims to be the economic locomotive of Ukraine. The region has strong industrial and economic potential, high population rate which have caused the development of different types of transport communication. As well as Rivne is a historic city in western Ukraine and the historical region of Volhynia. Lviv region is also the center of industrial and agricultural development. It is one of the most densely populated in Ukraine, has its own recreation zones, borders on the Republic of Poland in the west. The anti-rating is headed by Lugansk region, which is located on the territory the military actions since 2014. The regions from the anti-rating have the same negative features, like narrow specialization or orientation of industry on imported raw materials; outdated technologies; dangerous production and law demand as a result. The transport communication contains transit routes, unlike the top-5 leaders with the routes of national and international importance. Despite the presence of the negative indicators which put regions into anti-rating, each of them has its own features. At the same time with the critical assessment the result may become the basis for detecting the regions ready to develop towards unlocking its potential: recreation activities, green tourism, organic production, green energetics. Transport communication as a strategically necessary component is able to provide the high level of development in any of potential areas. As to ensure our conclusions, the Trans-European Transport Network (TEN-T) policy addresses the implementation and development of a Europe-wide network of railway lines, roads, inland waterways, maritime shipping routes, ports, airports and railroad terminals. The ultimate objective is to close gaps, remove bottlenecks and technical barriers, as well as to strengthen social, economic and territorial cohesion in the EU. Besides the construction of new physical infrastructure, the TEN-T policy supports the application of innovation, new technologies and digital solutions to all modes of transport. The objective has been to improve the use of infrastructure, reduced environmental impact of transport, enhanced energy efficiency and increased safety (Regulation, 2013).

3. Conclusion

Assessing of infrastructure development efficiency, the Data envelopment analysis (DEA) method has allowed us assessing the level of current infrastructure conditions, identifying of negative phenomena and indicating the activities to prevent them in a region. The practical value of the research is that the given model can be used not only for analytical assessment of separate indicators and for the groups of indicators but also for the region as a whole. The use of the integral assessment method in identifying the qualitative indicators allows further detailed indicators and their modification influences the total level of the object development. Subsequently, methodology for applying (DEA) model may also be used to compare the level of development of several infrastructure industries to identify the most promising ones and to form the strategic objectives for sustainable development. Here, only one element of the system of infrastructure provision was considered, except road infrastructure which includes railway, air, river and sea transport, utilities infrastructure, electricity and water supply, information infrastructure (mobile communication and internet). To make strategically decisions it is necessary to conduct a complex assessment of all the above elements. This proves the relevance of the topic and defines the direction of our further researches. Research is a conscious and directed effort to increase understanding and discover new and better ways to achieve goals (Lemer et al., 1995).

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