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Evaluation of The Effectiveness of Construction Works in Surkhandarya Region Using The Data Envelopment Analysis.

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Abstract

In this article, the efficiency of construction work performed in Surkhandarya region was assessed using the Data Envelopment Analysis (DEA) method. As a result of the assessment, efficiency frontier were identified and targets for the coming years were set.

Keywords*:* construction volume, DEA, data envelopment analysis, DMU, decision making unit, linear programming, benchmark.

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I. Introduction

The development of any industry is determined by its production efficiency. Efficiency refers to the level of use of fixed and current capital, and the level of full satisfaction of needs with the rational use of available resources in general. Similarly, the prospects for the development of the construction industry depend on its efficiency. High efficiency is achieved through the rational use of resources. Determining the efficiency of the industry is important for enterprises and organizations specializing in it, including manufacturers of construction materials, to make full use of available resources in their activities, to increase the volume and competitiveness of their products, to make various effective management decisions.

Typically, efficiency is determined by the ratio of the result achieved to the resources expended on it. However, there are a number of challenges in using traditional methods to compare the efficiency and effectiveness of multi-parameter facilities. In this case, the method of data envelope analysis (DEA) is useful. Data Envelopment Analysis (DEA) is a widely used comparison method in practice. It solves the problem of comparing the efficiency and productivity of multi-parameter objects using linear programming methods [1].

The efficiency of the construction industry also depends on the companies that are active in it and the results they achieve. In this paper, the efficiency of the construction industry is analyzed using the DEA method to achieve the highest performance when the enterprises active in the industry are at their lowest.

II. Literature review

B.D. Giyosov and B. Abdusamatov [4]in their research has studied the main aspects of the organization and implementation of investment activities in the development of the construction industry. The importance of organizing, planning, determining the size of the investment process for the development of the construction industry, forecasting the amount of investment in future areas of the construction industry, to study the level of impact of factors affecting construction activities through correlation analysis the resulting regression equations are shown as the solution.

AnarkulovF.A. [8] studied the factors of human resource efficiency in the construction industry, identified and grouped the factors that affect the effectiveness of human resource management in the industry. It is proposed to analyze the effectiveness of human resource management using economic and social criteria, general and specific efficiency indicators, as well as economic-mathematical methods.

KhusainovM.A., KhusainovT.M.[7] considered the issues of planning and organization of optimal use of the opportunities available to them on the basis of a comprehensive analysis of the activities of construction companies. In the study, the regression equation was constructed and an economic-mathematical model was formed on the basis of the obtained results.

The research of foreign scientists Jadigerova A.B.[5] explored the possibility of measuring the impact of factors of production, such as the cost of fixed assets and the number of workers, on the construction activity using the production function. Sitnikov I.V. [6] studied the dynamics of housing construction using ARIMA models.

However, the above studies have not sufficiently studied the efficiency of construction work. In this context, the issue of efficiency of construction work remains relevant today.

III. Methodology

Data Envelopment Analysis (DEA) was first proposed in 1978 by Charnes, Cooper, and Rhodes. It is a method of measuring efficiency that can be used to assess the relative effectiveness of decision-making units (DMUs) in enterprises. Examples of such units are banks, hospitals, tax authorities, schools, and universities. It is noteworthy that one of the advantages of DEA is that it can also be used in non-profit organizations [3].

The key concept in data envelopment analysis is efficiency, which is determined by dividing the weighted sum of all output parameters by the weighted sum of all input factors [1].

Let K input parameters and M output parameter data be available for each N object (the term "object" can mean regions, industries, enterprises, educational institutions, etc.).for the i-th object, they are represented by the columnar vectors $x_i$andy_i, respectively. In this case, the $K \times N$ size X matrix represents the input parameter matrix for all N objects, and the $M \times N$ size Y matrix represents the output parameter matrix for all N objects. Referring to the problem of mathematical programming, using the theory of two-sidedness, it can be formulated as follows [2]:

$$\min_{\theta,\lambda} \theta\,,$$
$$-y_i + Y\lambda \geq 0$$
$$\theta x_i - X\lambda \geq 0$$
$$\lambda \geq 0$$

where θ is the scalar and $\lambda$is the vector of variables of size $N \times 1$. The value of θ obtained as a result of solving the problem will be a measure of the efficiency of the i-object. In this case, the efficiency can not exceed 1. It should be noted that the alternative problem is solved N times, i.e. for each object. Objects with the same value of efficiency are located within the efficiency frontier. As a result, a partial-linear efficiency frontiercan be formed. Points corresponding to objects with less than one efficiency can be projected to the efficiency frontier so that each of these points is equal to a linear combination $(X\lambda, Y\lambda)$. [2]

IV. Discussion and results

Today, construction sector is one of the most important sectors of the economy of Surkhandarya region. In 2021, 2486 enterprises and organizations (9.8% of the total number of enterprises in the region) operated in this area. The share of construction in the gross domestic product of the region was 8.8%.[4] The total volume of construction work in January-March amounted to 1074.49 billion soums, the growth rate was 105.7% (Figure 1). The volume of construction work is based on the structure of work carried out by large construction companies, small businesses and micro-firms, as well as the informal sector. Accordingly, 61.3% of the construction volume in the region is accounted for by small enterprises and micro-firms, 14.3%

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by large construction companies and the remaining 24.4% by the informal sector [9].

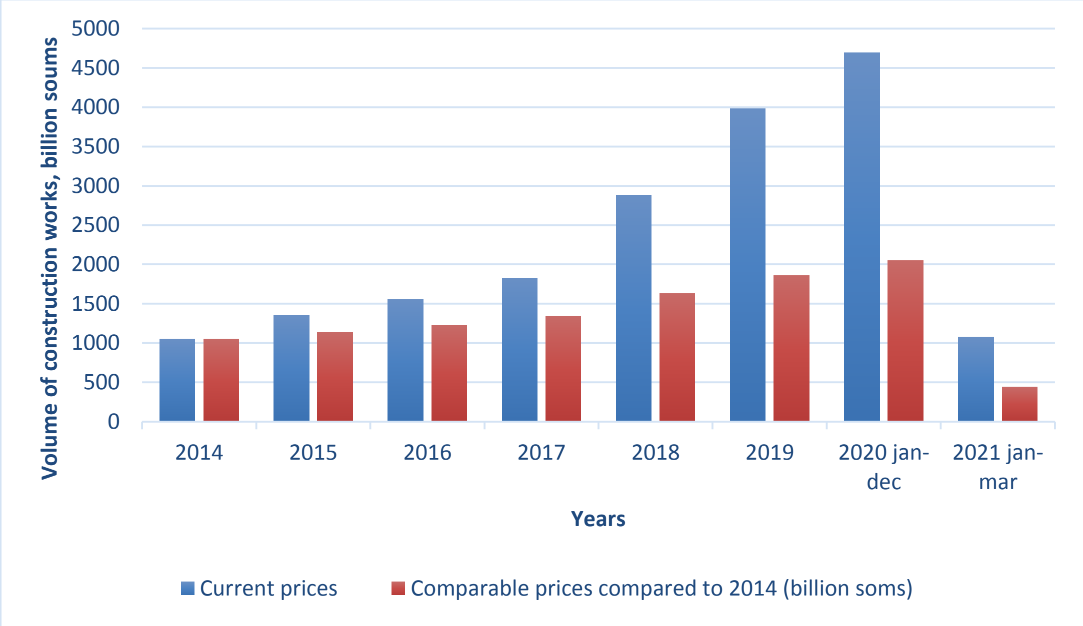

Figure 1. Dynamics of the volume of construction works carried out in Surkhandarya region in 2010-2021 (billion soums).

Source: Surxonstat.uz website of Surkhandarya regional statistics department.

In the analysis of the effectiveness of construction work in Surkhandarya region in 2014-2020, the number of enterprises active in this field was taken as input indicators and the volume of construction work as output indicators (Table 1).

Table 1

Active enterprises in the construction industry in Surkhandarya region and the volume of construction work carried out by them.

Years	Number of active enterprises in the industry	Volume of construction works (billion soums, at current prices)	Volume of construction works (billion soums, in comparable prices)	Growth of construction works (in percent)
2014	1231	1051,5	1051,5	107,7
2015	1102	1351,3	1136,5	118,9
2016	1171	1554,8	1225,5	106,7
2017	1301	1827,0	1342,1	107,3
2018	1470	2879,7	1631,0	129,7
2019	1747	3979,7	1859,8	121,2
2020	2268	4690,6	2046,7	107,1
2021	2486	1074,5	443,6	105,7

It is known that, every business strives to maximize profits. In this regard, the achievement of the maximum number of the least active enterprises determines the efficiency frontier.

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Using the DEA method, we create a linear programming problem to calculate the efficiency of construction works, and it will be as follows for January-March 2021 (at current prices):

$$\max_{u,v} \theta = 1074{,}5u$$
$$2486v = 1$$
$$\begin{array}{llll} 1051{,}5u \le 1231v & (2014) & 2879{,}7u \le 1470v & (2018) \\ 1351{,}3u \le 1102v & (2015) & 3979{,}7u \le 1747v & (2019) \\ 1554{,}8u \le 1171v & (2016) & 4690{,}6u \le 2268v & (2020) \\ 1827{,}0u \le 1301v & (2017) & 1074{,}5u \le 2486v & (2021) \end{array}$$

In this case, all variables are non-negative variables. We will solve this problem for each year and get the following (Table 2):

Table 2

Results of efficiency determination using DEA method (at current prices)

DMU (years)	CCR(θ)	Effective DMU	$u$weight	$v$weight
2014	0,374967644	2019	0,000356603	0,000812348
2015	0,538285588	2019	0,000398346	0,000907441
2016	0,582854571	2019	0,000374874	0,000853971
2017	0,616458465	2019	0,000337416	0,000768640
2018	0,859948576	2019	0,000298624	0,000680272
2019	1,000000000	2019	0,000251275	0,000572410
2020	0,907878892	2019	0,000193553	0,000440917
2021	0,189735181	2019	0,000176580	0,000402253

The optimal solution for January-March 2021 is $u_{2021} = 0{,}000176580$and$v_{2021} = 0{,}000402253$. As can be seen from Table 2, while January-March 2021 had the best weights, the best results were achieved in 2019. Therefore, the 2019 indicators will serve as a benchmark for the coming years and will be the frontier of efficiency.[7]

In practice, while in January-March 2021, an increase of 105.7% over the previous year was achieved, the efficiency indicator $\theta_{2021} = 0{,}1897$ indicates that this period was ineffective in achieving results compared to 2019. Keep in mind, too, that January-March 2021 means an unfinished year, and it would be wrong to compare it to an entire year. In our example, the DEA analysis only identifies the target to be achieved by the end of 2021. Figure 1 shows a diagram of this situation. It describes the origin and the efficiency frontier that passes through the reference object, indicating that other objects must be brought to that frontier. In our case, it means that the indicators of the following years should be brought to this frontier. [9]

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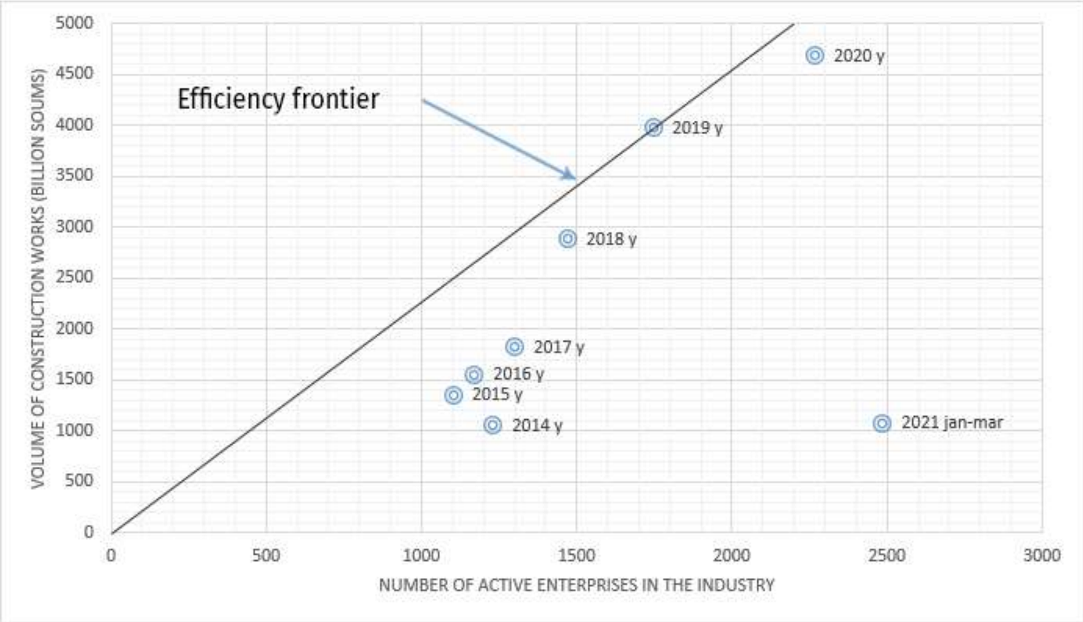

Figure 1. Efficiency frontier (at current prices)

To reach the efficiency frontier:

• Decrease the input value while keeping the output values constant (this is in the input-oriented models) - (point e1 in Figure 2)

• increase the output by keeping the input values constant (in these output-oriented models) - (point e2 in Figure 2)

• It is necessary to simultaneously increase the output and decrease the input (in non-directional models).

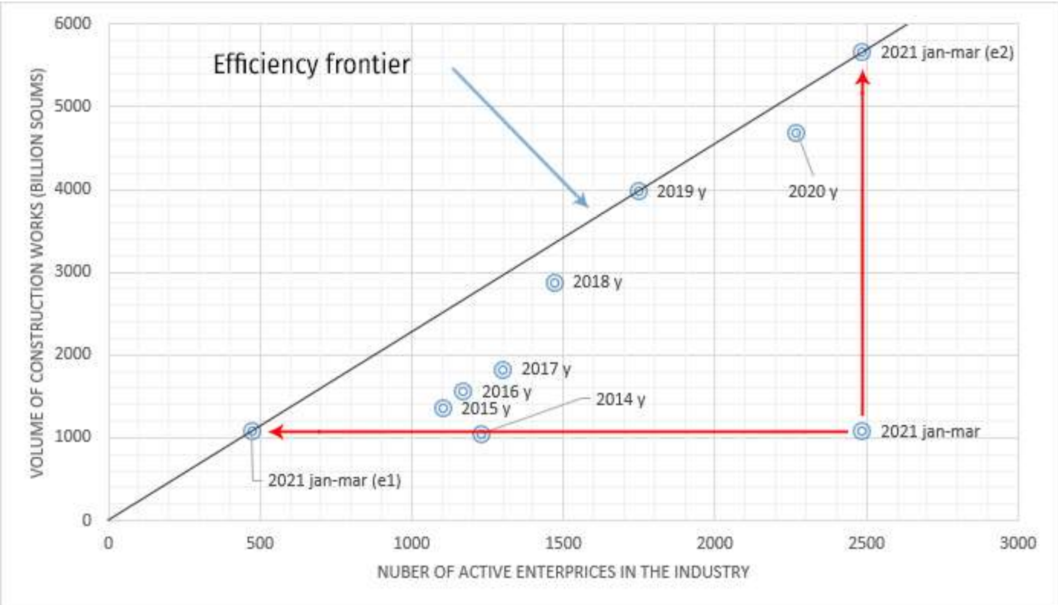

Figure 2. Efficiency points to be achieved in 2021.

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If the CCR model was focused on input, 18.97% of its current input indicators ($\theta_{2021} =$ 0,1897) would have been sufficient to reach the efficiency frontier in January-March 2021. In other words, the efficiency frontier would have been reached in 2021 if the number of active enterprises had reached 18.97% of the 2486, i.e. with 472 active enterprises (point marked in Figure 2 with “2021 (e1)”).).

In addition, the volume of construction work to achieve efficiency frontier in 2021 in the output-oriented models will be 5663.16 billion. soums.[5]

Thus, if the CCR model is input-oriented, we reduce the input performance while maintaining the output performance, and if it is output-oriented, we increase the output performance while maintaining the input performance (Table 3).

Table 3

Targets based on the results of determining the effectiveness by DEA method

DMU (years)	CCR(θ)	Targets for the input-oriented model		Targets for the output-oriented model	
2014	0,374967644	461,5852	1051,5	1231	2804,242
2015	0,538285588	593,1907	1351,3	1102	2510,377
2016	0,582854571	682,5227	1554,8	1171	2667,561
2017	0,616458465	802,0125	1827,0	1301	2963,703
2018	0,859948576	1264,124	2879,7	1470	3348,689
2019	1,000000000	1747,000	3979,7	1747	3979,7
2020	0,907878892	2059,069	4690,6	2268	5166,548
2021	0,189735181	471,6817	1074,5	2486	5663,156

Below we perform this analysis at comparable prices:

Table 4

Results of efficiency determination using DEA method (at comparable prices)

DMU (years)	CCR(θ)	Effective DMU	$u$weight	$v$weight
2014	0,769852	2018	0,000732159	0,000812348
2015	0,929489	2018	0,000817865	0,000907441
2016	0,943251	2018	0,000769673	0,000853971
2017	0,929761	2018	0,000692765	0,000768640
2018	1,000000	2018	0,000613121	0,000680272
2019	0,959455	2018	0,000515906	0,000572410
2020	0,813326	2018	0,000397393	0,000440917
2021	0,160807	2018	0,000362539	0,000402253

At comparable prices, the optimal solution for January-March 2021 is $u_{2021} =$ 0,000362539and$v_{2021} =$ 0,0004022253. As can be seen from Table 4, the best result was achieved in 2018. Therefore, the 2018 indicators will serve as a benchmark for the coming years and will be the frontier of efficiency.

$\theta_{2021} = 0{,}1608$efficiency indicator means that 2021 is inefficient compared to 2018. Figure 3 shows a diagram of this situation.

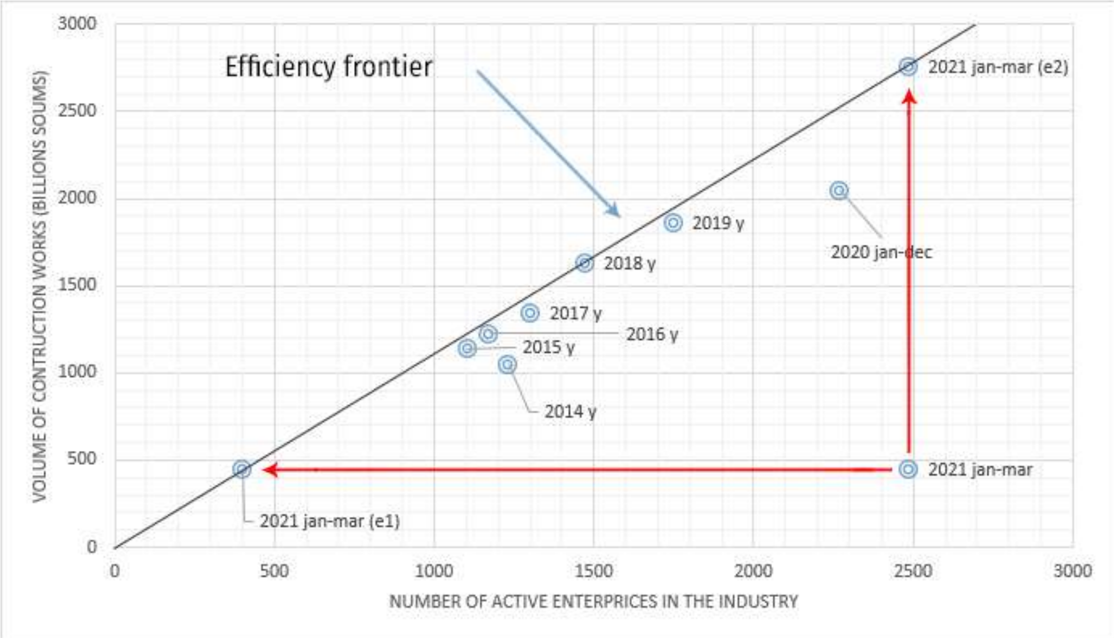

Figure 3. Efficiency points that can be achieved in 2021 (at comparable prices).

If the CCR model was focused on input, 16.08% of its current input indicators ($\theta_{2021} = 0{,}1608$) would be sufficient to reach the efficiency frontier in January-March 2021. In other words, in January-March 2021, the efficiency frontier would have been reached if the number of active enterprises had reached 16.08% out of 2486, i.e. with 400 active enterprises (point market in Figure 3 with "2021 (e1)).[7]

In order to achieve efficiency in the output-oriented models in 2021, the volume of construction work should reach 2758.32 billion soums (Table 5).

In this case, the general view of the efficiency frontier function is as follows:

$$y = 1{,}109542493x$$

Table 5

Targets based on the results of determining the efficiency using the DEA method (at comparable prices)

DMU (years)	CCR(θ)	Targets for the input-oriented model		Targets for the output-oriented model	
2014	0,769852	947,7039	1051,5	1231	1365,824
2015	0,929489	1024,313	1136,5	1102	1222,695
2016	0,943251	1104,528	1225,5	1171	1299,252
2017	0,929761	1209,618	1342,1	1301	1443,49

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2018	1,000000	1470,000	1631,0	1470	1631,00
2019	0,959455	1676,215	1859,8	1747	1938,338
2020	0,813326	1844,665	2046,7	2268	2516,4
2021	0,160807	399,7663	443,557	2486	2758,32

Conclusion

While analyzing the efficiency of the volume of construction work carried out in Surkhandarya region in 2014-2021 by the DEA method, the indicators of current prices and comparative prices showed different results. While the 2019 year'sindicators served as a benchmark in current prices, it was found that the best performance in 2018 was achieved in comparable prices compared to 2014 prices.

The volume of construction work for 2021 to achieve efficiency at current prices is 5663.16 billion. soums. It was also found that in order to achieve efficiency in 2021 at comparable prices, the volume of construction work should reach 2758.32 billion soums.

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