Data Envelopment Analysis for efficient traffic management

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Abstract. The paper describes the Data Envelopment Analysis method. It demonstrates its application to study the efficiency of traffic management. The paper solves the problem of increasing the efficiency of a T-junction by increasing exit capacity and optimizing the number of exit traffic lanes. An output-oriented DEA model is applied to solve this problem. The sample uses indicators from 56 similar T-junctions with three entry traffic lanes and a different number of exit traffic lanes.

1 Introduction

High population density, and as a result, high-speed car traffic in large cities, causes a number of social and economic problems. It leads to a decrease in the quality of life of citizens. Scientists from different countries have dealt with this problem in their research [1-4]. But so far it has not been possible to solve traffic problems in large cities completely [5-8]. Accordingly, the feasibility of increasing the efficiency of traffic systems in cities with high traffic is obvious. One of the tools for solving this problem can be the Data Envelopment Analysis (DEA) method.

The paper proposes to apply the DEA method to solve the problem of increasing the efficiency of the most complex junctions of the same type. The sample objects for solving the problem of increasing the efficiency applying the DEA method will be T-junctions with different numbers of entry and exit traffic lanes.

2 Problem statement

The traffic problem in large cities is quite acute for almost all countries. High-speed car traffic in large cities causes a great number of social and economic problems, leading to a decrease in the quality of life of citizens. Therefore, traffic regulation is rather relevant problem due to the increase in traffic flows.

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The application of DEA method in setting up traffic will make it possible to optimize transport flows and redistribute them from more traffic-heavy zones to less traffic-heavy ones. The results of this study can also be used in road construction when designing junctions and traffic roundabouts.

Therefore, the authors believe that this problem is quite relevant.

3 Research questions

Then, the authors describe the purpose and objectives of this study. The next section will describe the essence of the DEA method and the features of its application to study the efficiency of traffic management. The experimental part will present the data obtained on solving the problem of increasing the efficiency of a T-junction by increasing exit traffic capacity and optimizing the number of exit traffic lanes. The data obtained from research on the effectiveness of T-junctions and propose settings to improve their efficiency will be analyzed. In the final section, the authors will present conclusions about the possibility of applying this method to study the efficiency of traffic management.

4 Purpose of the study

The purpose of the study is to analyze the efficiency of a T-junction.

The following tasks will be solved in accordance with this purpose:

- DEA method will be described;
- features of applying the DEA method to study the efficiency of traffic management will be considered;
- problem of increasing the efficiency of the T-junction will be solved by increasing exit traffic capacity and optimizing the number of exit traffic lanes;
- data will be carried out and presented to solve the problem of increasing the efficiency of the T-junction by increasing exit traffic capacity and optimizing the number of exit traffic lanes;
- possibility of applying the DEA method to study the efficiency of traffic management will be substantiated.

5 Research methods

The DEA method is a boundary method for studying the efficiency of complex systems, which makes it possible to construct an efficiency boundary based on the efficiency indicators of the objects under study and to increase the efficiency of inefficient sample objects by calculation based on their main indicators [9,10].

This study presents the application of DEA method to improve the efficiency of traffic system. The results of this study can be used in the future to construct an intelligent traffic system.

The paper proposes to apply the DEA method to solve the problem of increasing the efficiency of the most complex intersections of the same type. The sample objects for solving the problem of increasing efficiency applying the DEA method will be T-junctions with different numbers of entry and exit traffic lanes.

The inputs for developing a DEA model are as follows:

- number of traffic lanes at entries (input 1).

The outputs will be as follows:

- number of vehicles leaving the junctions along all exit traffic lanes per unit of time (output 1);

– number of exit traffic lanes (output 2).

5.1 Experiment

The experiment solves the problem of increasing the efficiency of a T-junction by increasing exit traffic capacity and optimizing the number of exit traffic lanes. The output-oriented DEA model is applied for this problem solving. The authors apply the BCC model for calculations. Indicators from 56 similar T-junctions with three entry traffic lanes and a different number of exit traffic lanes are used in the sample.

Table 1 presents results of calculating the operating efficiency of a T-junction using the DEA method. The authors present results of only 8 similar T- junctions in the table for clarity and simplification the presentation of the results.

Table 1. Example of calculating the operating efficiency of a T-junction applying the DEA method.

Object	Efficiency	Parameter	Indicator (fact)	Indicator (recommended)	Deviation
1	0.586	Output1	64	112	48
		Output 2	2	4	2
		Input1	2	3	1
2	0.834	Output 1	91	112	21
		Output 2	3	4	1
		Input 1	2	3	1
3	0.989	Output 1	110	112	2
		Output 2	4	4	0
		Input 1	3	3	0
4	1	Output 1	112	112	0
		Output 2	4	4	0
		Input 1	3	3	0
5	0.678	Output 1	79	112	33
		Output 2	3	4	2
		Input 1	2	3	1
6	0.802	Output 1	85	112	27
		Output 2	3	4	1
		Input 1	2	3	1
7	0.956	Output 1	106	112	6
		Output 2	4	4	0
		Input 1	3	3	0
8	0.768	Output 1	76	112	36
		Output 2	2	4	2
		Input 1	3	3	1

The table demonstrates that the efficient junction for the given traffic capacity is object 4 in the table. It has an efficiency indicator of 1. The number of exit traffic vehicles is 112, with four exit traffic lanes and three entry traffic lanes. For other junctions, the efficiency indicator is less than one. The table presents the actual indicators of inputs and outputs and the recommended ones. Recommended indicators are indicators of inputs and outputs to achieve the efficiency for the given object. So, for example, it is recommended to increase the number of transport vehicles at the exit from 64 to 112 to achieve efficiency for the junction number 1. Also, it is recommended to increase the number of exit traffic lanes from 2 to 4 and the number of entry traffic lanes from 2 to 3. In the future, the presented DEA model, as well as its more complex combinations, can be applied to construct an intelligent traffic system.

6 Conclusion

The paper solves the problem of analyzing the efficiency of a T-junction. The DEA method is described and the peculiarities of applying the DEA method to study the efficiency of traffic management are considered. The problem of increasing the efficiency of the T-junction by increasing exit traffic capacity and optimizing the number of exit traffic lanes has been solved. Data have been carried out and presented to solve the problem of increasing the efficiency of a T-junction by increasing exit traffic capacity and optimizing the number of exit traffic lanes. The possibility of applying the DEA method to study the efficiency of traffic management is substantiated.

The study presents one of the simplest models with one input and two outputs to demonstrate clearly the possibility of applying the DEA method to improve the efficiency of the traffic system. In the future, the presented DEA model, as well as its more complex combinations, can be used to construct an intelligent traffic system.

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