STUDY AND ASSESSMENT OF TRANSPORT SYSTEM OPERATION EFFICIENCY

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Abstract

The article deals with an issue of complex systems operation efficiency, especially of the ones which are connected with transport. The operation of such systems aims at developing both passenger and load transportation in terms of safety, reliability, effectiveness and environment friendliness. These properties should be researched in a particular place and time that were earlier planned and selected. Operation effectiveness is an important component of widely understood social-economic and technological research, including assessment of the considered transport system. The concepts of operation efficiency, most frequently used in literature, express it as the relation between benefits (treated as profit or income in terms of economy) and costs. However, a ratio of two quantities, the first of which is evaluated positively, that is, aims at reaching the highest values and the other one being negative, is considered as the most important definition of efficiency. In some cases these quantities can assume constant values, treated as basic ones. It should be remembered, though, that in many cases the system goals are formulated in different terms than, e.g. economic ones. And the systems should be evaluated taking into consideration the goal achievement degree. The article deals with an analysis of distinguished values of selected assessment indices for an investigated transport system, and on this basis an assessment of the transport system operation efficiency, in a given period of time, has been made.

Keywords: *transport system, efficiency, effectiveness, quality*

1. Introduction

Research on efficiency covers the class of cognitive and practical problems connected with an analysis and assessment of systems. Efficiency is a significant element of widely understood social-economic and technical research including transport systems [4].

The most commonly used in literature notions of efficiency express it as a relation between benefits (in economic terms profit or income) and costs. It seems, though, that the most appropriate definition of frequency is a ratio of two quantities one of which being evaluated positively, that is, the one reaching whose values is being aimed at, whereas, the other negatively. In some cases these values can assume constant values treated as the basic ones. However, it is worth noticing that in many cases the system goals are formulated in different categories than, e.g. economic ones, where systems should be assessed in terms of the intended goals accomplishment degree [6].

Briefly speaking, an operating system is efficient if it produces a given effect. Although the above statement does not contain an element of assessment, effects can be positive or negative. The first ones are most frequently referred to as benefits, the latter ones outlays, costs, expenses or losses. In different periods of the system operation the relations between profits and costs may be different, in other words, this relation takes shape after finishing a given action. Operation in which profits outstrip costs is most desirable.

Thus, efficiency of operating systems is such its feature which accounts for the system rational capabilities to meet given demands (reaching intended goals, that is, functioning according to their design and requirements).

Accomplished efficiency, though, is referred to as the system feature defining the degree of its capability to reach set goals, in specified conditions.

Analyzing problems of system efficiency, the following postulates have been accepted [3]:

- operating system efficiency is the system feature,
- operating system efficiency is a measurable feature,
- efficiency is a feature which is the basis for comparison of systems of the same class,
- efficiency should express different aspects of the system operation in different time horizons,
- efficiency can be expressed depending on the system class, its goals (destination) and operating conditions.

Efficiency of systems can be considered from different points of view, thus the criteria of its assessment can be different. In connection with this, the following kinds of efficiency assessment criteria have been proposed:

- operational criteria – they are used for assessment of operation and achievement of intended goals or meeting given demands,
- economic criteria – used for assessment in economic terms, positive effects (profits) and negative (costs) of the system operation and for expression of the system investment – financial operation effects,
- information criteria – used for assessment of the system organization and the course of information processes and, roughly speaking, expression of the control system on the system operation,
- technical criteria – used for assessment of the system elements quality, and especially technical means, expressing, most generally, the influence of technology on the system operation,
- operating criteria – used for assessment of efficiency of accomplishment of controlled processes of technical objects operating, assessment of the elements functioning and operation means and expressing their influence on the system reliable operation in a given time.

Work of authors [1] is of the opinion that the below listed issues plays the key role in accomplishment of the operation efficiency decision making process:

- determination of variability values or intervals of established parameters,
- definition of the system limitations (internal and external),
- choice of efficiency assessment criteria,
- analysis of the solution variant choice,
- comparative analysis and the choice of a practical solution,
- determination of measurable effects resulting from implementation of the assessment of system efficiency.

Direct effects of the assessment subject can concern the technical object, the system - human and technical object or complex systems. The most frequently occurring (generalized) kinds of effects are [1]:

- new production capability,
- material consumption reduction,
- increase in work efficiency and frequently accompanying it employment reduction,
- improvement in natural environment protection,
- increasing availability and reliability of tools,
- improvement in work safety,
- improvement in work organization and safety,
- improvement in economic indexes values.

It can be stated that the system effectiveness concerns mainly postulates formulated for rationality. An important issue are analyses of rationality of expectations as the postulate of rationality is inseparably connected with economic theories. In practice, there is no explicit answer to the question of rationality degree [10]. Rationality in terms of means and methods is closely related with goals, whereas, considering the issues separately leads to irrationality. Rationality of methods and means without purposefulness is unjustified. Rightness of goals, in turn, is only partly fulfilled without rationality of methods and means and does not guarantee their operation efficiency.

It can be accepted that effectiveness of an operating system largely depends on efficiency of the technical objects operating in it. Factors depending on operating efficiency of technical objects are the function of a variable which i the further part of the study will be called a basic function. It can be time or another physical value. Task Z_i or its part called E_f, accomplished within basic interval $\Delta b = <b, b>$, is a functional defined on a set of efficiency functions for this interval. This effect depends on the object functional qualities, the environment conditions, and control stimuli from Δb interval. Thus, it can be formed by the object operating decision maker through a proper choice of conditions for its operating and control [11, 12].

On the basis of the above considerations it can be concluded that the choice of such assessment indexes which thanks to attributes of significance will enable an overall assessment of technical objects in technical-economic terms, is not only of great importance but is also the basis of their operation efficiency.

2. The research object

An assessment of the transport system efficiency was made on the example of a municipal bus transport system performing transport tasks in the area of a city and in its suburbs with population of 100 000 inhabitants.

3. Research on transport system operation efficiency

For the purpose of the research there was made a choice of the most significant efficiency indexes specified to define efficiency level of a distinguished transport system. From the several considered assessment indexes only those were chosen which have the largest influence on the result of the carried out research as well as the transport system operation efficiency level. In table 3 there have been show percentage shares of costs for selected indexes in relation to the company overhead. In order to determine the tested system efficiency level it is necessary to define indexes referring to the sum of the profits that were gained by the enterprise in the considered period of time. The company income is shaped by indexes of values concerning:

- ticket sale,
- placement of adverts on transport means,
- hire of transport means,
- registration surveys of buses and trucks for individual customers,
- subsidies from the state [13].

The most important efficiency indexes describing costs incurred by the company in a given moment include:

- index defining fuel costs in relation to overhead costs of the company in a given time (t):

$$W_1 = \frac{K_1}{\sum K}, \tag{1}$$

where:
K_1 - fuel costs in time (t),
$\sum K$ - overhead costs carried by the company,

- index defining costs of salaries:

$$W_2 = \frac{K_2}{\sum K}, \tag{2}$$

where:
K_2 - costs connected with employee's salaries in time (t),
$\sum K$ - overhead costs of the company,

- index of costs connected with employment costs in time (t)

$$W_3 = \frac{K_3}{\sum K}, \tag{3}$$

where:
K_3 - costs of employment in the company,
$\sum K$ - overhead costs of the company,

- index of amortization costs in time (t), W_4 index includes expenses connected with additional employment costs such as: (retirement contribution, company fund of social assistance, employee's training, protection clothes):

$$W_4 = \frac{K_4}{\sum K}, \tag{4}$$

where:
K_4 - costs connected with amortization of the used vehicles,
$\sum K$ - overhead costs carried by the company,

- index of running the vehicles repairs (t):

$$W_5 = \frac{K_5}{\sum K}, \tag{5}$$

where:
K_5 - costs of the operated vehicles running repairs in time (t),
$\sum K$ - overhead costs of the company.

It should be mentioned that the remaining expenses concerning other indexes accounts for about 8%, and these include:

- electric energy costs,
- representation and advertisement.

On the basis of performed calculations of the specified indexes values in given time moments, there were obtained results of mean quarter shares of the company prime costs in its overhead costs during the considered years 2008 and 2009. Below, in Tab. 1-3 quantitative and percentage presentation of the company costs have been show for selected indexes, in the analyzed time period.

Tab. 1. Presentation of costs for selected indexes in moments of decision making

	W_1 (PLN)	W_2 (PLN)	W_3 (PLN)	W_4 (PLN)	W_5 (PLN)
year 2008					
I quarter (t_1)	1110636.59	1939490.53	523223.08	1155523.42	265483.13
II quarter (t_2)	1191963.28	1976622.56	599985.66	1103114.61	282963.68
III quarter (t_3)	1100849.37	2242242.71	542467.74	1259988.62	252228.35
IV quarter (t_4)	971509.97	2404983.95	517402.40	1054839.99	246933.04
year 2009					
I quarter (t_5)	965666.59	2078739.65	554573.59	593575.74	269995.16
II quarter (t_6)	886639.05	2163842.65	640678.68	589212.35	214045.40
III quarter (t_7)	922820.46	2288025.46	554341.0	594802.42	203929.73
IV quarter (t_8)	990846.54	2505151.13	516610.06	649534.39	202400.95

On the basis of data presented in Tab. 3, it can be observed that the share of W_2 index in the company overhead costs in 2008 and 2009 is the largest. This index applies to costs connected with employees' salaries. Next indexes W_1 and W_2 have similar values but their percentage share is significantly lower as compared to W_2 index. Nevertheless, their share in the company overhead costs in 2008 and 2009 is considerable. W_1 and W_4 indexes define outlays for fuel and amortization

Tab. 2. Mean values of selected indexes over the years 2008 and 2009

	2008	2009
Fuel costs, W_1	1093739.80 PLN	941493.16 PLN
Costs connected with employee's salaries, W_2	2140834.93 PLN	2258939.72 PLN
Costs of employment, W_3	545769.72 PLN	566551.55 PLN
Costs connected with amortization, W_4	1143366.66 PLN	606781.22 PLN
Costs of the operated vehicles running repairs, W_5	261902.05 PLN	222592.81 PLN

Tab. 3. Percentage share of selected costs in reference to the company overhead costs in the years 2008 and 2009

	W_1 (%)	W_2 (%)	W_3 (%)	W_4 (%)	W_5 (%)
year 2008					
I quarter (t_1)	19.03%	40.06%	8.96%	19.83%	4.55%
II quarter (t_2)	20.12%	39.48%	9.41%	18.95%	4.59%
III quarter (t_3)	19.89%	40.76%	9.19%	18.15%	4.42%
IV quarter (t_4)	19.16%	42.13%	8.95%	17.80%	4.29%
year 2009					
I quarter (t_5)	18.11%	47.03%	10.40%	11.17%	5.06%
II quarter (t_6)	18.12%	47.20%	11.09%	11.06%	4.49%
III quarter (t_7)	18.11%	47.54%	10.65%	10.87%	4.19%
IV quarter (t_8)	18.15%	48.29%	10.12%	10.87%	3.97%

of the operated fleet of vehicles which is of great importance for the system operation efficiency. The lowest share in costs are on the part of W_3 and W_5 indexes which denote costs of repairs and social assistance for employees, though, in a global approach these indexes assume significant values which affects the company efficiency level.

In Fig. 1. a chart showing a distribution of costs for selected indexes, with division into quarters of 2008 and 2009, has been presented.

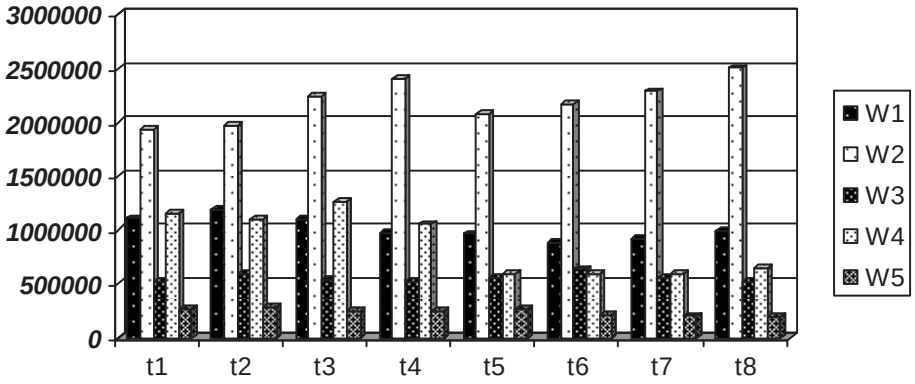

Fig. 1. Graphic representation of values of costs for selected indexes carried during the years 2008 and 2009

In the below presented figure there are shown mean values for selected indexes in the considered years 2008 and 2009. As can be seen in Fig. 2, W_2 index which refers to the employees' salaries assumes the highest values, throughout the considered time.

In Tab. 4, prognosis and accomplishment of the financial plan, assumed for the years 2008 and 2009, have been presented.

Table 4 shows, that expenses planned for 2008 were higher than those for 2009. Whereas, accomplishment of the plan was satisfactory both in 2008 and 2009 from the point of view of predicted prognosis, since the company carried smaller costs than the assumed ones. The company

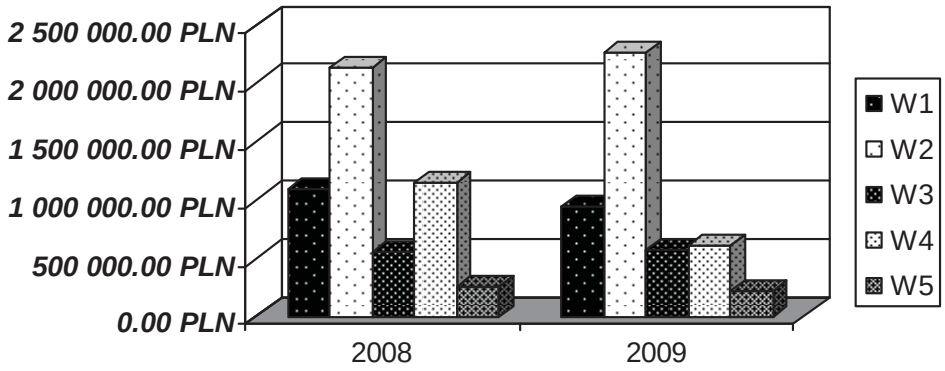

Fig. 2. Chart of mean values of costs for selected indexes over 2008 and 2009

Tab. 4. Comparison of the company overhead costs in relation to its financial plans in 2008 and 2009

	year 2008	year 2009
Prognosis	25,015,000.00 PLN	23,931,000.00 PLN
Realization	24,395,567.45 PLN	22,402,663.51 PLN
Costs in relation	529,383.81 PLN	875,944.14 PLN
Realization	97.52%	93.61%
Dynamics	+2.17%	+3.91%

financial result is positive and is, respectively, 2.17% in 2008 which is equal to 529,383.81 PLN, and 3.91% in 2009, which is equal to 875,944.14 pln.

4. Analysis of obtained results analysis

An analysis of the obtained tests results was made on the basis of indexes of costs carried by the company in reference to profits gained by it, in years 2008 and 2009.

The cost of fuel incurred by the company was accepted as W_1 index. It was observed that in 2008 these costs were higher than in 2009. However, it is worth noticing that W_4 index concerning amortization costs also has an influence on the fuel cost reduction. Outlays for a purchase of fuel account for 19.03% in 2008 and 18.11% in 2009, in reference to overhead costs connected with the company running.

W_2 index applies to costs of salaries. In 2008 there was noted an increase in this type of expenses, whereas, at the beginning of 2009 there followed a fall, and next increase at the end of 2009. Thus, it can be concluded that the company employs more people in the autumn and winter which results in a rise of employment costs.

An analysis of W_3 index shows comparable values in the considered time period, however, it's most rapid increase falls on II quarter, both in 2008 and 2009. It should be mentioned that this period coincides with the holiday season and it can be the cause of its value increase.

W_4 index concerns costs connected with the fleet amortization. It was found that in 2008 these expenses were significantly higher then in 2009. It was caused by the fact that the company purchased new buses in 2008 which increases amortization costs affecting the efficiency result. A purchase of new vehicles raises expenses of amortization, though, most often it reduces costs connected with, e.g. fuel consumption and with providing availability and reliability of used buses.

Costs connected with running repairs of the operated fleet, shaped over eight quarters of the considered time period was accepted as W_5 index. As can be seen, costs are decreasing with running time of the quarters of 2008. Referring it to W_4 and W_1 indexes it can be concluded that costs connected with a purchase and later amortization apply to a decrease in the costs of maintaining the vehicles in the state of serviceability.

Referring to the analyzed company income value, it should be noticed that, taking into consideration outlays, it brings profits providing transport services (Tab. 4). The company income was lower in 2008 than in 2009 which were mainly due to a purchase of new transport means.

5. Summary

In this study there has been made an assessment of chosen transport system operation efficiency. Indexes, significant in terms of costs connected with providing transport services and running a transport company, have been specified.

Financial analysis of the studied company, has proved that the examined system reaches a positive financial result in a given time period, which is of key importance for its functioning efficiency.

However, an analysis of an analogue transport system, in a comparable urban complex, with a similar number of inhabitants, where additionally a fuel station for outside clients was established, revealed that there is a possibility of generating additional incomes from selling fuels and other lubricants which could be purchased at prices more attractive than those of competitive companies. Establishing such a station could increase the company incomes, and thereby, the analyzed system efficiency level would increase as well.

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